B vitamins

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B vitamins are a class of water-soluble vitamins that play important roles in cell metabolism. Though these vitamins share similar names, research shows that they are chemically distinct vitamins that often coexist in the same foods. In general, dietary supplements containing all eight are referred to as a **vitamin B complex**. Individual B vitamin supplements are referred to by the specific name of each vitamin (e.g. B_1, B_2, B_3 etc.).

Each B vitamin is either a cofactor (generally a coenzyme) for key metabolic processes or is a precursor needed to make one.

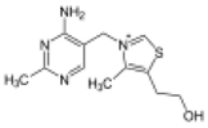
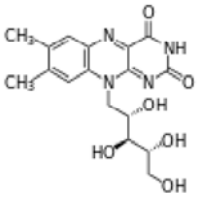
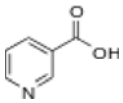
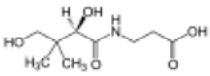
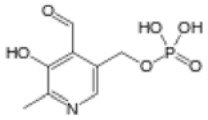
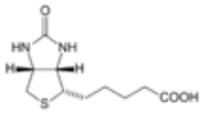
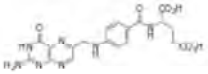
Contents

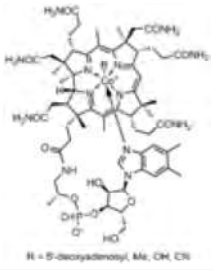
List of B vitamins

B number	Name	Thumbnail description
Vitamin B_1	thiamine	A coenzyme in the catabolism of sugars and amino acids.
Vitamin B_2	riboflavin	A precursor of cofactors called FAD and FMN, which are needed for flavoprotein enzyme reactions, including activation of other vitamins.
Vitamin B_3	niacin, nicotinic acid, nicotinamide riboside	A precursor of coenzymes called NAD and NADP, which are needed in many metabolic processes.
Vitamin B_5	pantothenic acid	A precursor of coenzyme A and therefore needed to metabolize many molecules.
Vitamin B_6	pyridoxine, pyridoxal, pyridoxamine	A coenzyme in many enzymatic reactions in metabolism.
Vitamin B_7	biotin	A coenzyme for carboxylase enzymes, needed for synthesis of fatty acids and in gluconeogenesis.
Vitamin B_9	folic acid	A precursor needed to make, repair, and methylate DNA; a cofactor in various reactions; especially important in aiding rapid cell division and growth, such as in infancy and pregnancy.
Vitamin B_{12}	various cobalamins; commonly cyanocobalamin or methylcobalamin in vitamin supplements	A coenzyme involved in the metabolism of every cell of the human body, especially affecting DNA synthesis and regulation, but also fatty acid metabolism and amino acid metabolism.

Note: other substances once thought to be vitamins were given numbers in the B-vitamin numbering scheme, but were subsequently discovered to be either not essential for life or manufactured by the body, thus not meeting the two essential qualifiers for a vitamin. That is why those numbers (4, 8, 10, 11) no longer appear in the classification.

B vitamin molecular functions

Vitamin	Name	Structure	Molecular Function
Vitamin B_1	thiamine		Thiamine plays a central role in the generation of energy from carbohydrates. It is involved in RNA and DNA production, as well as nerve function. Its active form is a coenzyme called thiamine pyrophosphate (TPP), which takes part in the conversion of pyruvate to acetyl coenzyme A (CoA) in metabolism.[1]
Vitamin B_2	riboflavin		Riboflavin is involved in the energy production for the electron transport chain, the citric acid cycle, as well as the catabolism of fatty acids (beta oxidation).[2]
Vitamin B_3	niacin		Niacin is composed of two structures: nicotinic acid and nicotinamide. There are two co-enzyme forms of niacin: nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). Both play an important role in energy transfer reactions in the metabolism of glucose, fat and alcohol.[3] NAD carries hydrogens and their electrons during metabolic reactions, including the pathway from the citric acid cycle to the electron transport chain. NADP is a coenzyme in lipid and nucleic acid synthesis.[4]
Vitamin B_5	pantothenic acid		Pantothenic acid is involved in the oxidation of fatty acids and carbohydrates. Coenzyme A, which can be synthesised from pantothenic acid, is involved in the synthesis of amino acids, fatty acids, ketones, cholesterol,[5] phospholipids, steroid hormones, neurotransmitters (such as acetylcholine), and antibodies.[6]
Vitamin B_6	pyridoxine, pyridoxal, pyridoxamine		The active form pyridoxal 5'-phosphate (PLP) (depicted) serves as a cofactor in many enzyme reactions mainly in amino acid metabolism including biosynthesis of neurotransmitters.
Vitamin B_7	biotin		Biotin plays a key role in the metabolism of lipids, proteins and carbohydrates. It is a critical co-enzyme of four carboxylases: acetyl CoA carboxylase, which is involved in the synthesis of fatty acids from acetate; pyruvate CoA carboxylase, involved in gluconeogenesis; β-methylcrotonyl CoA carboxylase, involved in the metabolism of leucine; and propionyl CoA carboxylase, which is involved in the metabolism of energy, amino acids and cholesterol.[7]
Vitamin B_9	folic acid		Folic acid acts as a co-enzyme in the form of tetrahydrofolate (THF), which is involved in the transfer of single-carbon units in the metabolism of nucleic acids and amino acids. THF is involved in pyrimidine nucleotide synthesis, so is needed for normal cell division, especially during pregnancy and infancy,

			which are times of rapid growth. Folate also aids in erythropoiesis, the production of red blood cells.[8]
Vitamin B_{12}	cobalamin		Vitamin B_{12} is involved in the cellular metabolism of carbohydrates, proteins and lipids. It is essential in the production of blood cells in bone marrow, and for nerve sheaths and proteins.[9] Vitamin B_{12} functions as a co-enzyme in intermediary metabolism for the methionine synthase reaction with methylcobalamin, and the methylmalonyl CoA mutase reaction with adenosylcobalamin.[10]

B vitamin deficiency

Several named vitamin deficiency diseases may result from the lack of sufficient B vitamins. Deficiencies of other B vitamins result in symptoms that are not part of a named deficiency disease.

Vitamin	Name	Deficiency effects
Vitamin B_1	thiamine	Deficiency causes beriberi. Symptoms of this disease of the nervous system include weight loss, emotional disturbances, Wernicke's encephalopathy (impaired sensory perception), weakness and pain in the limbs, periods of irregular heartbeat, and edema (swelling of bodily tissues). Heart failure and death may occur in advanced cases. Chronic thiamin deficiency can also cause Korsakoff's syndrome, an irreversible dementia characterized by amnesia and compensatory confabulation.
Vitamin B_2	riboflavin	Deficiency causes ariboflavinosis. Symptoms may include cheilosis (cracks in the lips), high sensitivity to sunlight, angular cheilitis, glossitis (inflammation of the tongue), seborrheic dermatitis or pseudo-syphilis (particularly affecting the scrotum or labia majora and the mouth), pharyngitis (sore throat), hyperemia, and edema of the pharyngeal and oral mucosa.
Vitamin B_3	niacin	Deficiency, along with a deficiency of tryptophan causes pellagra. Symptoms include aggression, dermatitis, insomnia, weakness, mental confusion, and diarrhea. In advanced cases, pellagra may lead to dementia and death (the 3(+1) D's: dermatitis, diarrhea, dementia, and death).
Vitamin B_5	pantothenic acid	Deficiency can result in acne and paresthesia, although it is uncommon.
Vitamin B_6	pyridoxine, pyridoxal, pyridoxamine	seborrhoeic dermatitis-like eruptions, pink eye, neurological symptoms (e.g. epilepsy)
Vitamin B_7	biotin	Deficiency does not typically cause symptoms in adults but may lead to impaired growth and neurological disorders in infants. Multiple carboxylase deficiency, an inborn error of metabolism, can lead to biotin deficiency even when dietary biotin intake is normal.
Vitamin B_9	folic acid	Deficiency results in a macrocytic anemia, and elevated levels of homocysteine. Deficiency in pregnant women can lead to birth defects. Lucy Wills discovered Folic acid in 1933.
Vitamin B_{12}	cobalamin	Deficiency results in a macrocytic anemia, elevated methylmalonic acid and homocysteine, peripheral neuropathy, memory loss and other cognitive deficits. It is most likely to occur among elderly people, as absorption through the gut declines with age; the autoimmune disease pernicious anemia is another common cause. It can also cause symptoms of mania and psychosis. In rare extreme cases, paralysis can result.

B vitamin side effects

Because water-soluble B vitamins are eliminated in the urine, taking large doses of certain B vitamins usually only produces transient side-effects. General side effects may include restlessness, nausea and insomnia. These side-effects are almost always caused by dietary supplements and not foodstuffs.

Vitamin	Name	Tolerable Upper Intake Level	Harmful effects
Vitamin B_1	thiamine	None[11]	No known toxicity from oral intake. There are some reports of anaphylaxis caused by high-dose thiamin injections into the vein or muscle. However, the doses were greater than the quantity humans can physically absorb from oral intake.[11]
Vitamin B_2	riboflavin	None.[12]	No evidence of toxicity based on limited human and animal studies. The only evidence of adverse effects associated with riboflavin comes from *in vitro* studies showing the production of reactive oxygen species (free radicals) when riboflavin was exposed to intense visible and UV light.[12]
Vitamin B_3	niacin	35 mg/day from supplements, drugs or fortified food [13]	Intake of 3000 mg/day of nicotinamide and 1500 mg/day of nicotinic acid are associated with nausea, vomiting, and signs and symptoms of liver toxicity. Other effects may include glucose intolerance, and (reversible) ocular effects. Additionally, the nicotinic acid form may cause vasodilatory effects, also known as flushing, including redness of the skin, often accompanied by an itching, tingling, or mild burning sensation, which is also often accompanied by pruritus, headaches, and increased intracranial blood flow, and occasionally accompanied by pain.[13] Medical practitioners prescribe recommended doses up to 2000 mg per day of niacin, usually in time release format, to combat arterial plaque development in cases of high lipid levels.[14]
Vitamin B_5	pantothenic acid	None	No toxicity known
Vitamin B_6	pyridoxine, pyridoxal, pyridoxamine		
Vitamin B_7	biotin	None	No toxicity known
Vitamin B_9	folic acid	1 mg/day [15]	Masks B_{12} deficiency, which can lead to permanent neurological damage[15]
Vitamin B_{12}	cyanocobalamin	None established.[16]	Skin and spinal lesions. Acne-like rash [causality is not conclusively established].[16][17]

B vitamin sources

B vitamins are found in whole unprocessed foods. Processed carbohydrates such as sugar and white flour tend to have lower B vitamin than their unprocessed counterparts. For this reason, it is required by law in many countries (including the United States) that the B vitamins thiamine, riboflavin, niacin, and folic acid be added back to white flour after processing. This is sometimes called "Enriched Flour" on food labels. B vitamins are particularly concentrated in meat such as turkey, tuna and liver.[18] Good sources for B vitamins include legumes (pulses or beans), whole grains, potatoes, bananas, chili peppers, tempeh, nutritional yeast, brewer's yeast, and molasses. Although the yeast used to make beer results in beers being a source of B vitamins,[19]

their bioavailability ranges from poor to negative as drinking ethanol inhibits absorption of thiamine (B_1),[20][21] riboflavin (B_2),[22] niacin (B_3),[23] biotin (B_7),[24] and folic acid (B_9).[25][26] In addition, each of the preceding studies further emphasizes that elevated consumption of beer and other alcoholic beverages results in a net deficit of those B vitamins and the health risks associated with such deficiencies.

The B_{12} vitamin is of note because it is not available from plant products, making B_{12} deficiency a legitimate concern for vegans. Manufacturers of plant-based foods will sometimes report B_{12} content, leading to confusion about what sources yield B_{12}. The confusion arises because the standard US Pharmacopeia (USP) method for measuring the B_{12} content does not measure the B_{12} directly. Instead, it measures a bacterial response to the food. Chemical variants of the B_{12} vitamin found in plant sources are active for bacteria, but cannot be used by the human body. This same phenomenon can cause significant over-reporting of B_{12} content in other types of foods as well.[27]

Another popular means of increasing one's vitamin B intake is through the use of dietary supplements. B vitamins are also commonly added to energy drinks, many of which have been marketed with large amounts of B vitamins[28] with claims that this will cause the consumer to "sail through your day without feeling jittery or tense."[28] Some nutritionists have been critical of these claims, pointing out for instance that while B vitamins do "help unlock the energy in foods," most Americans acquire the necessary amounts easily in their diets.[28]

Because they are soluble in water, excess B vitamins (such as may be ingested via supplements) are generally readily excreted, although individual absorption, use and metabolism may vary…"[28] The elderly and athletes may need to supplement their intake of B_{12} and other B vitamins due to problems in absorption and increased needs for energy production. In cases of severe deficiency, B vitamins, especially B_{12}, may also be delivered by injection to reverse deficiencies.[29] Both type 1 and type 2 diabetics may also be advised to supplement thiamine based on high prevalence of low plasma thiamine concentration and increased thiamine clearance associated with diabetes.[30] Also, Vitamin B_9 (folic acid) deficiency in early embryo development has been linked to neural tube defects. Thus, women planning to become pregnant are usually encouraged to increase daily dietary folic acid intake and/or take a supplement.[31]

B vitamin discovery dates

B number	Name	Thumbnail description
Vitamin B_1	thiamine	Casimir Funk discovered thiamine in 1912.
Vitamin B_2	riboflavin	D.T. Smith and E.G. Hendrick discovered riboflavin in 1926. Max Tishler invented methods for synthesizing it.
Vitamin B_3	niacin or nicotinic acid	Conrad Elvehjem discovered niacin in 1937.
Vitamin B_5	pantothenic acid	Roger J. Williams discovered pantothenic acid in 1933.
Vitamin B_6	pyridoxine, pyridoxal, pyridoxamine	Paul Gyorgy discovered vitamin B_6 in 1934.
Vitamin B_7	biotin	Dean Burk was a codiscoverer of biotin.
Vitamin B_9	folic acid	Lucy Wills discovered folic acid in 1933.
Vitamin B_{12}	various cobalamins; commonly cyanocobalamin or methylcobalamin in vitamin supplements	Various scientists over several decades developed our knowledge of vitamin B_{12}.

Related compounds

Many of the following substances have been referred to as vitamins as they were once believed to be vitamins. They are no longer considered as such, and the numbers that were assigned to them now form the "gaps" in the true series of B-complex vitamins described above (e.g., there is no vitamin B_4). Some of them, though not essential to humans, are essential in the diets of other organisms; others have no known nutritional value and may even be toxic under certain conditions.

- **Vitamin B_4**: can refer to the distinct chemicals choline, adenine, or carnitine.[32][33] Choline is synthesized by the human body, but not sufficiently to maintain good health, and is now considered an essential dietary nutrient.[34] Adenine is a nucleobase synthesized by the human body.[35] Carnitine is an essential dietary nutrient for certain worms, but not for humans.[36]
- **Vitamin B_8**: adenosine monophosphate (AMP), also known as adenylic acid.[37] Vitamin B_8 may also refer to inositol.[38]
- **Vitamin B_{10}**: *para*-aminobenzoic acid (pABA or PABA), a chemical component of the folate molecule produced by plants and bacteria, and found in many foods.[39][40] It is best known as a UV-blocking sunscreen applied to the skin, and is sometimes taken orally for certain medical conditions.[39][41]
- **Vitamin B_{11}**: pteryl-hepta-glutamic acid (PHGA; chick growth factor). Vitamin Bc-conjugate was also found to be identical to PHGA.
- **Vitamin B_{13}**: orotic acid.[42]
- **Vitamin B_{14}**: cell proliferant, anti-anemia, rat growth factor, and antitumor pterin phosphate named by Earl R. Norris. Isolated from human urine at 0.33ppm (later in blood), but later abandoned by him as further evidence did not confirm this. He also claimed this was not xanthopterin.
- **Vitamin B_{15}**: pangamic acid,[42] also known as pangamate. Promoted in various forms as a dietary supplement and drug; considered unsafe and subject to seizure by the US Food and Drug Administration.[43]
- **Vitamin B_{16}**: dimethylglycine (DMG)[44] is synthesized by the human body from choline.

- **Vitamin B_{17}**: pseudoscientific name for the poisonous compound amygdalin, also known as the equally pseudoscientific name "nitrilosides" despite the fact that it is a single compound. Amygdalin can be found in various plants, but is most commonly extracted from apricot pits and other similar fruit kernels. Amygdalin is hydrolyzed by various intestinal enzymes to form, among other things, hydrogen cyanide, which is toxic to human beings when exposed to a high enough dosage. Some proponents claim that amygdalin is effective in cancer treatment and prevention, despite its toxicity and a severe lack of scientific evidence.[45]
- **Vitamin B_{20}**: L-carnitine.[44]
- **Vitamin B_f**: carnitine.[37]
- **Vitamin B_m**: *myo*-inositol, also called "mouse antialopaecia factor".[46]
- **Vitamin B_p**: "antiperosis factor", which prevents perosis, a leg disorder, in chicks; can be replaced by choline and manganese salts.[36][37][47]
- **Vitamin B_T**: carnitine.[48][36]
- **Vitamin B_v**: a type of B_6 other than pyridoxine.
- **Vitamin B_W**: a type of biotin other than d-biotin.
- **Vitamin B_x**: an alternative name for both pABA (see vitamin B_{10}) and pantothenic acid.[36][41]

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