Chapter

Vitamins

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Abstract

This chapter is going to explain a part of the nutrients the human body needs. They are organic compounds called vitamins. Those compounds will be clarified, as well as their benefits, deficiencies, chemical structure, and why the body needs them crucially. Vitamins is an exceptionally vital recognized name required in certain amounts in the body, some of them exist as a complicated natural compounds found in herbal meals. It plays a key function in regular metabolism, the absence of which in the diet causes deficiency and several diseases. Vitamins are differentiated from the trace elements, also found in the weight-reduction plan in small quantities for health, growth, replica, and other crucial metabolism.

Keywords: vitamins, water-soluble vitamins, fat-soluble vitamins, deficiency, benefits, dosage

1. Introduction

The human body is a magnificent machine, and to function well, the body needs certain supplements. Vitamins are one of the most essential elements for the body. There are nutrients that the body can make on its own, and there are others that the body is not able to make. Vitamins are one of the nutrients that the body is unable to make, so they must be consumed from aliments. Vitamins are an organic molecule, which is an essential micronutrient that an organism needs for its metabolism to function. They are divided into two groups, fat-soluble vitamins and water-soluble vitamins. The first group contains vitamins A, D, E, and K, while the second consists of thiamin (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxal, pyridoxamine, pyridoxine (B6), biotin-cobalamin (B12), folic acid, and ascorbic acid [1–10].

2. Fat-soluble vitamins

They are a type that is absorbed well into the blood stream via fatty nourishments and are stored in limited amounts; they can be easy to separate and disposed out from the body through urine [8–10].

2.1 Vitamin A

Vitamin A is a yellow viscous liquid alicyclic alcohol $C_{20}H_{30}O$ that contains one more double bond in a molecule than vitamin A1 and is less active biologically in mammals and that occurs especially in the liver oil of freshwater fish. It consists of three biologically active molecules, retinol, retinal (retinaldehyde), and retinoic acid, all derived from the plant precursor molecule, β-carotene (**Figure 1**) [11, 12].

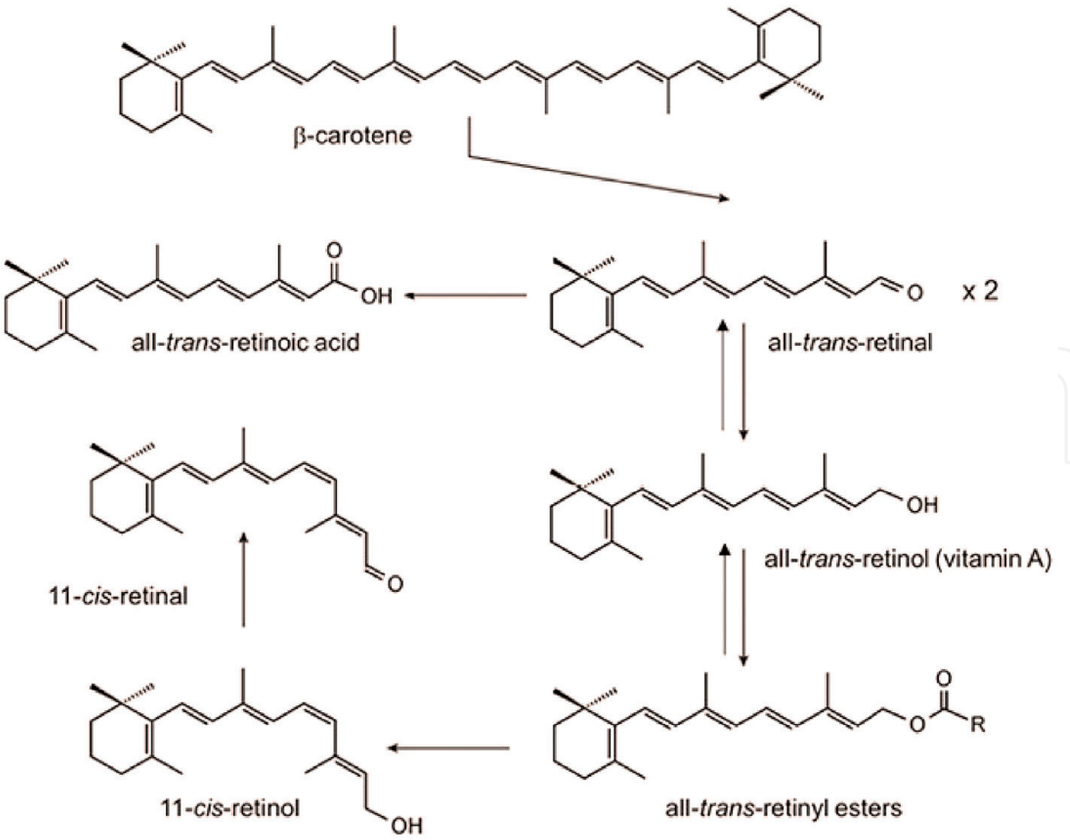


Figure 1.
Types of vitamin A.

Retinol also functions in the synthesis of certain glycoproteins and mucopolysaccharides necessary for mucous production and normal growth regulation. Retinol is the predominant, active form of vitamin A found in the blood. Retinyl palmitate is the storage form of the vitamin [13].

This vitamin is important to the body for playing an effective role in growth and development, the visual system, immunity, and reproduction as well as supplying epithelial cellular integrity. Most of the vitamin A is stored in the liver in the form of retinyl esters. Sources of vitamin A vary from vegetables to fruits and are found in animal-sourced foods, such as eggs, oily fish, liver, cheese, and butter. The lack of this vitamin can leave severe effects on the function of the body such as night blindness, decreased resistance to infections, and extremely dry skin, hair, or nails. Just deficiency can be harmful; the overuse of vitamin A can be toxic and lead to hypervitaminosis. An average dose of this vitamin needed for the body is 0.7 mg for men and 0.6 mg for women on a daily diet. Women who have been through menopause and older men, who are more at risk of osteoporosis, should avoid having more than 1.5 mg of vitamin A per day from food and supplements [7, 13, 14].

2.2 Vitamin D

Vitamin D is a steroid vitamin, which promotes the intestinal absorption and metabolism of calcium and phosphorus. There are two main types of vitamin D, Vitamin D_2, which is synthesized by plants and is not created by the human body. Vitamin D_3, which is made in large amounts in the skin when daylight strikes uncovered skin. Moreover, it can be ingested from animal sources. As well as there other types like ergosterol, dehydrocholesterol, and the biologically active form of the hormone 1,25-dihydroxy vitamin D_3 termed calcitriol.

Vitamin D is not active itself (it is a prohormone); it is modified to yield biologically active forms, such as calcitriol. Calcitriol (derived from vitamin D) is a transcription factor, influencing expression of proteins involved in calcium absorption and transport [15–17] (**Figure 2**).

Vitamin D is required to maintain normal blood levels of calcium and phosphate, which in turn is needed for the normal mineralization of the bone, muscle contraction, nerve conduction, general cellular function in all cells of the body and supporting lung function, and cardiovascular health. It may also protect against a range of diseases and conditions, such as type 1 diabetes. Vitamin D also modulates the transcription of cell cycle proteins, which decrease cell proliferation and increase cell differentiation of a number of specialized cells of the body (e.g., osteoclastic precursors, enterocytes, and keratinocytes). This property may explain the actions of vitamin D in bone resorption, intestinal calcium transport, and skin. Vitamin D also possesses immunomodulatory properties that may alter responses to infections in vivo. These cell-differentiating and immunomodulatory properties underlie the reason why vitamin D derivatives now are in use successfully in the treatment of psoriasis and other skin disorders. Oily fish, such as salmon, sardines, herring, and mackerel, contain a fair amount of vitamin D as well as red meat, liver, egg yolks, and fortified foods, such as most fat spreads and some breakfast cereals. Another source of vitamin D is dietary supplements [15–18].

The simplest way to get all the vitamin D the body needs is from direct sunlight. The absence of this very vitamin in an adult daily diet can result in hypovitaminosis

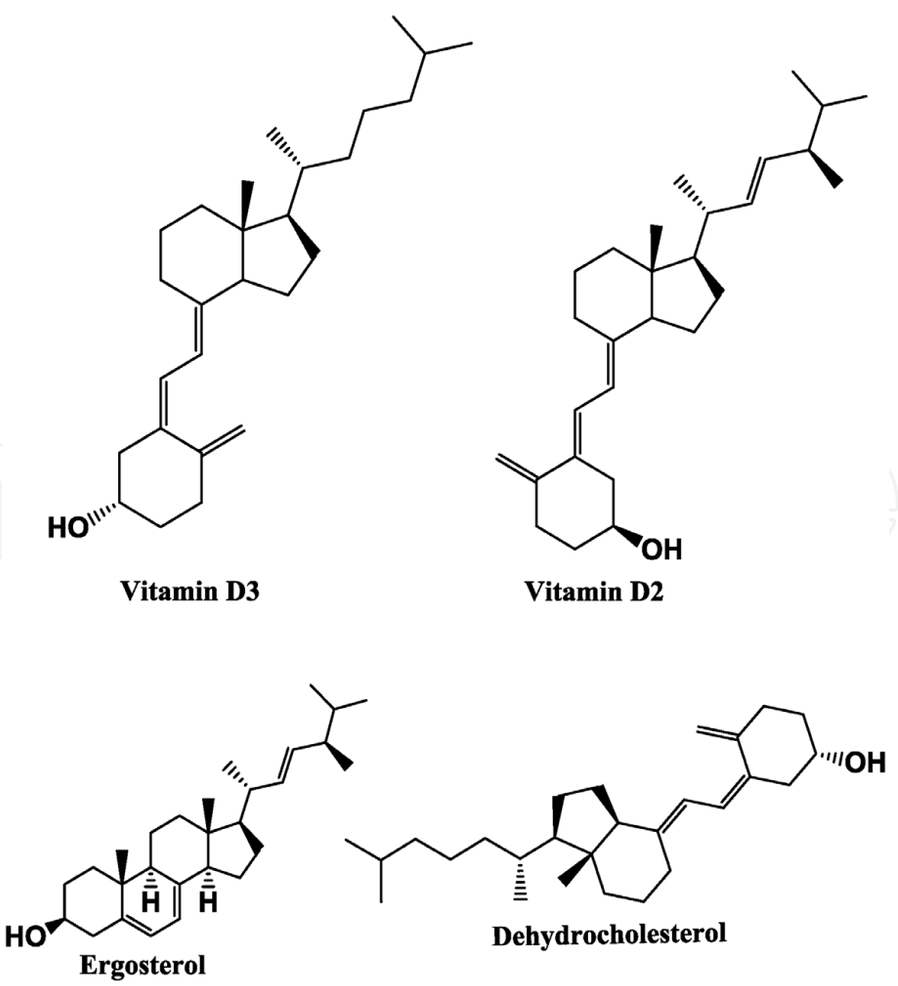


Figure 2.
Types of vitamin D.

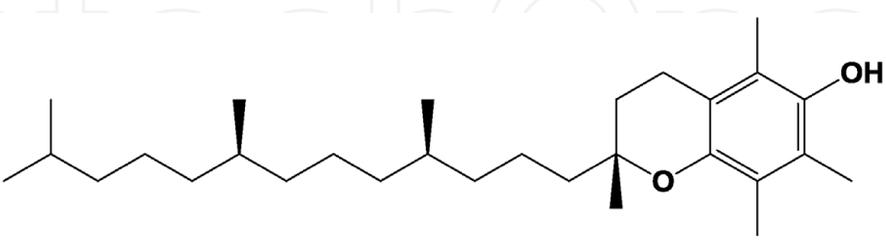
D, which leads to loss of bone density, which can contribute to osteoporosis and fractures (broken bones). In children, a severe vitamin D deficiency can cause delays in growth as well as rickets, a disease where the bones become soft and bend. Furthermore, vitamin D deficiency has been in link with several cancers, type 1 diabetes, multiple sclerosis, high blood pressure, and thyroid problems. A daily dose of vitamin D 1000 IU should prevent very low vitamin D levels and should be sufficient to help most aging adults get the benefit [17–19].

2.3 Vitamin E

Vitamin E is a major lipid-soluble antioxidant in the cell's antioxidant defense system and is exclusively obtained from the diet. The term "vitamin E" refers to a family of eight naturally occurring homologs synthesized by plants from homogentisic acid. All are derivatives of 6-chromanol and differ in the number and position of methyl groups on the ring structure known as tocopherols (**Figure 3**) [20].

This particular vitamin plays a huge role in protecting cell membranes and other fat-soluble parts of the body (LDL cholesterol) from oxidation; it also may reduce the risk of heart disease, discourage development of some types of cancer, promote normal growth and development, and promote normal red blood cell formation. It can also act as an anti-blood clotting agent and plays some role in the body's ability to process glucose. In addition, it is recognized to aid the process of wound healing. This vitamin is found in wheat germ oil, vegetable oils, nuts and seeds, whole grains, and egg yolk, in addition to leafy green vegetables [21, 22].

Vitamin E is mainly stored in the liver before released into the blood stream for use. Vitamin E is essential to the central nervous system. It is among the body's main antioxidants, and a deficiency results in oxidative stress, which can lead to muscle weakness. A deficiency can cause certain neurons, called the Purkinje neurons, to break down, harming their ability to transmit signals, which causes walking difficulties. Numbing and tingling also is a sign of deficiency, and the damage to nerve fibers can prevent the nerves from transmitting signals correctly, resulting in these sensations, which is also called peripheral neuropathy. The deficiency can also cause weakness of light receptors in the retina and other cells in the eye, and this can lead to loss of vision over time as well as immune system problems. The recommended daily dosage of this vitamin for males is 30 IU and for females 24 IU [22–24].



alpha-Tocopherol

Figure 3.
Vitamin E.

2.4 Vitamin K

Vitamin K refers to a group of chemically similar fat-soluble compounds called naphthoquinones: vitamin K1 (phytonadione) is found in plants and is the primary source of vitamin K for humans through dietary consumption, vitamin K2 compounds (menaquinones) are made by bacteria in the human gut, and vitamin K3 (menadione) is a water-soluble preparation available for adults only (**Figure 4**).

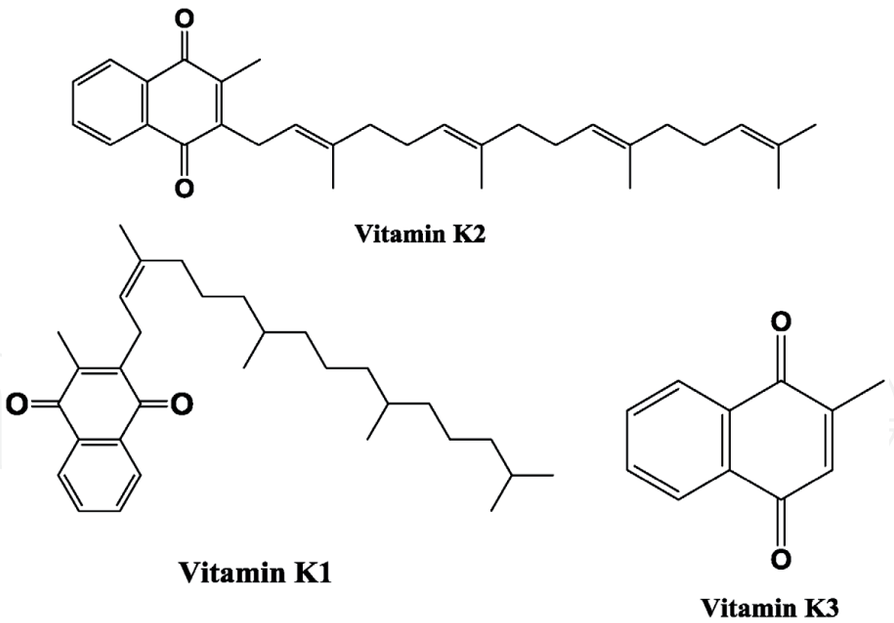


Figure 4.
Types of vitamin K.

Vitamin K is necessary for the liver to produce the coagulation factors II, VII, IX, and X as well as the clotting factors protein C, protein S, and protein Z [25, 26].

The body needs vitamin K to produce prothrombin, a protein and clotting factor that is important in blood clotting and bone metabolism. Vitamin K1, or phylloquinone, comes from plants. It is the main type of dietary vitamin K. A lesser source is vitamin K2, or menaquinones, which occurs in some animal-based and fermented foods. The body is in need for both types of vitamin K to produce prothrombin, a protein that plays crucial roles in blood clotting, bone metabolism, and heart health. Vitamin K also helps facilitate energy production in the mitochondria of cells. Vitamin K has antioxidant properties. It protects cellular membranes from damage due to excess free radicals, in a process known as peroxidation. It is in use in synthesizing gamma-carboxyglutamate, a posttranslationally modified amino acid in prothrombin. Green vegetables contain the highest amounts of vitamin K like kale, spinach, turnip greens, collards, and green leaf lettuce vegetables, but there are many other good sources like fish, liver, meat, eggs, and cereals (contain smaller amounts). Vitamin K is made as well by the bacteria in the lower intestinal tract. Vitamin K deficiency is very rare. It occurs when the body does not properly absorb the vitamin from the intestinal tract. Vitamin K deficiency can also occur after long-term treatment with antibiotics. In adults, primary vitamin K-deficient states that manifest as bleeding are almost unknown, except when the absorption of the vitamin is impaired, resulting in an underlying pathology. Vitamin K deficiency bleeding is a problem that occurs in some newborns. It happens during the first few days of life. This condition used to be named hemorrhagic disease of the newborn. About toxicity, natural vitamin K seems free of toxic side effects. This apparent safety is designated out by the common clinical administration of phylloquinone at doses of 10–20 mg or greater. The recommended daily dosage for male adults is 120 mcg and for female adults is 90 mcg [26–29].

3. Water-soluble vitamins

3.1 Thiamin (B1)

Thiamin is one of the B vitamins. The B vitamins are a group of water-soluble vitamins that are part of many of the chemical reactions in the body. It plays a role by

producing energy from carbohydrates and helping in proper nerve function as well as stabilizing the appetite and promoting growth and good muscle tone. It is also involved in the flow of electrolytes into and out of muscle and nerve cells. Thiamin is rapidly converted to its active form, thiamin pyrophosphate (TPP) (**Figure 5**), in the brain and liver by specific enzymes, thiamine phosphotransferase [30, 31].

There are many natural ways to add thiamine-rich foods to an everyday diet. Food sources of thiamine include beef, liver, dried milk, nuts, oats, oranges, pork, eggs, seeds, legumes, peas, and yeast. Foods also are fortified with thiamine. Some foods that are fortified with B1 are rice, pasta, breads, cereals, and flour. The relieving thing about thiamin is that it's non-toxic even at high dosage. However, the deficiency can be worrying because it leads to loss of appetite, weakness, and tiredness. Also causes insomnia, loss of weight, in addition to depression and gastrointestinal problems. Moreover, the deficiency leads to neurological problems and beriberi, which is a muscle atrophy. Furthermore, we must mention Wernicke-Korsakoff syndrome, which is a disease most commonly found in chronic alcoholics due to their poor dietetic lifestyles. A recommended daily dosage of thiamin for body requirement is 1.0–1.5 mg for normal adults [32–34].

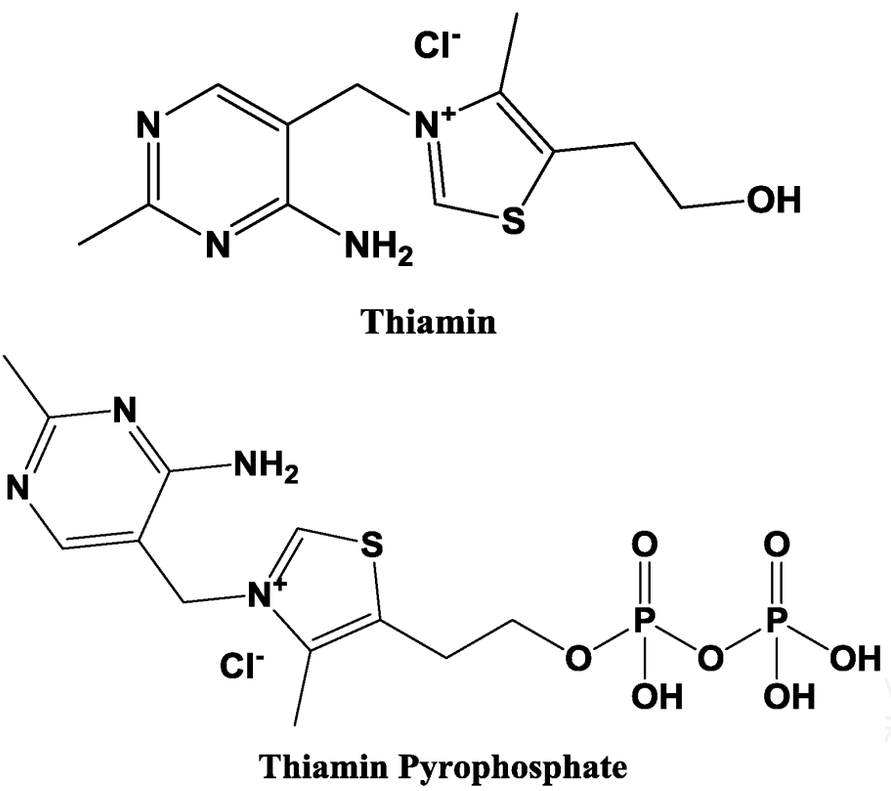


Figure 5.
Types of vitamin B1.

3.2 Riboflavin (B2)

Vitamin B2 is an organic compound that is not stored by the body except in insignificant amounts. It must be replenished daily. It is the precursor of coenzymes flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) (**Figure 6**). The enzymes that require FMN or FAD and $FADH_2$ as cofactors are termed flavoproteins. Several flavoproteins also contain metal ions, termed metalloflavoproteins. It contributes in energy production carbohydrate, fat, and protein metabolism and also in the formation of antibodies and red blood cells, not to mention respiration and maintenance of good vision and alleviating skin, nails, and hair, plus improving eye fatigue [35–37].

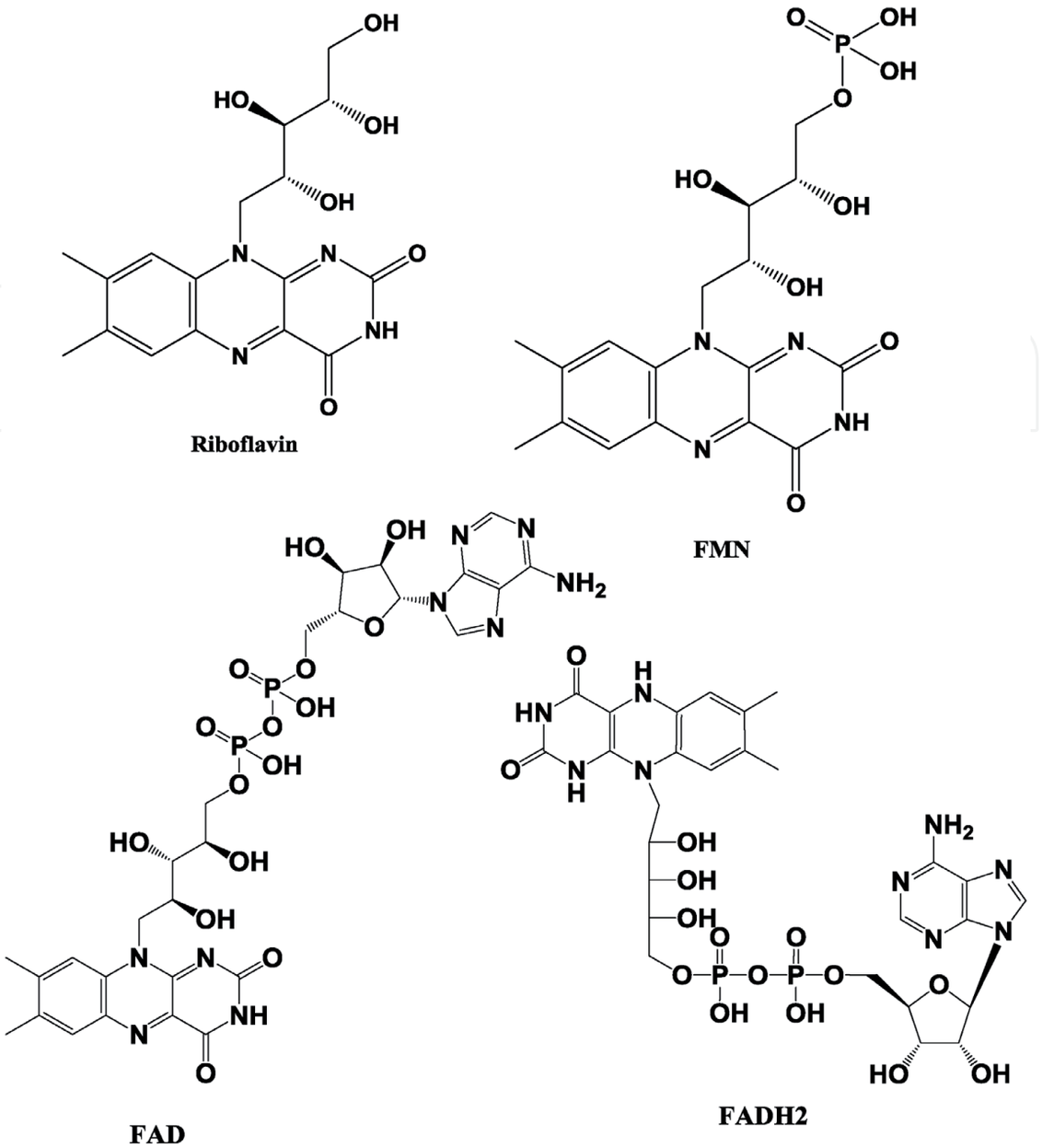


Figure 6.
Types of vitamin B2.

Riboflavin decomposes when exposed to visible light. This characteristic can lead to riboflavin deficiencies in newborns treated for hyperbilirubinemia by phototherapy. Sources of riboflavin are present in large amounts in meat, fish, eggs, vegetables, dairy foods, and grain products. The deficiency of B2 is common due to poor diet. The resulting side effects of the deficiency of riboflavin are itching, burning eyes, cracks and sores in mouth and lips. In addition to bloodshot eyes, dermatitis, oily skin, and digestive disturbances. Moreover, normocytic anemia is associated with pure red cytoplasia of the bone marrow. The toxicity of this vitamin is not an issue due to limited intestinal absorption. The required daily dosage of B2 for adolescent and adults is 1.0–1.3 mg [10, 37, 38].

3.3 Niacin (B3)

Niacin (nicotinic acid and nicotinamide), or known as vitamin B3, is required for the synthesis of the active forms of vitamin B3, nicotinamide adenine dinucleotide (NAD+), and nicotinamide adenine dinucleotide phosphate (NADP+).

Both NAD+ and NADP+, also known as NADPH (reduced form), function as cofactors for numerous dehydrogenases (**Figure 7**) [38, 39].

Niacin is an essential nutrient required for normal metabolism, energy production, maintenance of skin and tongue, and also improvement of circulation and maintenance of nervous system as well as the health of the digestive tract. This vitamin is divided into two types, nicotinic acid and niacinamide (nicotinamide) (**Figure 8**). It helps build proteins in the skin and lock in moisture to prevent environmental damage. The use is frequent in cosmetics and personal care products due to its wonderful effectiveness and treatments to skin and hair flaws and problems. It is important to mention that niacin is highly toxic in large doses and can lead to no good; doses of only 50–100 mg nicotinic acid can cause dilation of blood vessels and potentially painful tingling ("niacin flush"), diarrhea, nausea, vomiting, and long-term liver damage. In spite of the danger, nicotonic acid regulates the cholesterol with the assistance of inositol hexaniacinate, which is a supplement that regulates cholesterol without high toxicity. Nicotinamide is nearly always safe to take, although a few cases of liver damage have been in report due to doses of over 1000 mg/day [10, 39].

This vitamin is consumed through meat like liver, fish, and pork and peanuts, whole wheat, brown rice, mushrooms, and vegetables like green peas and potatoes, as well as fruits that are enriched in B3 like avocado. Deficiency can lead to pellagra, which is a dangerous disease. The symptoms are marked by dementia,

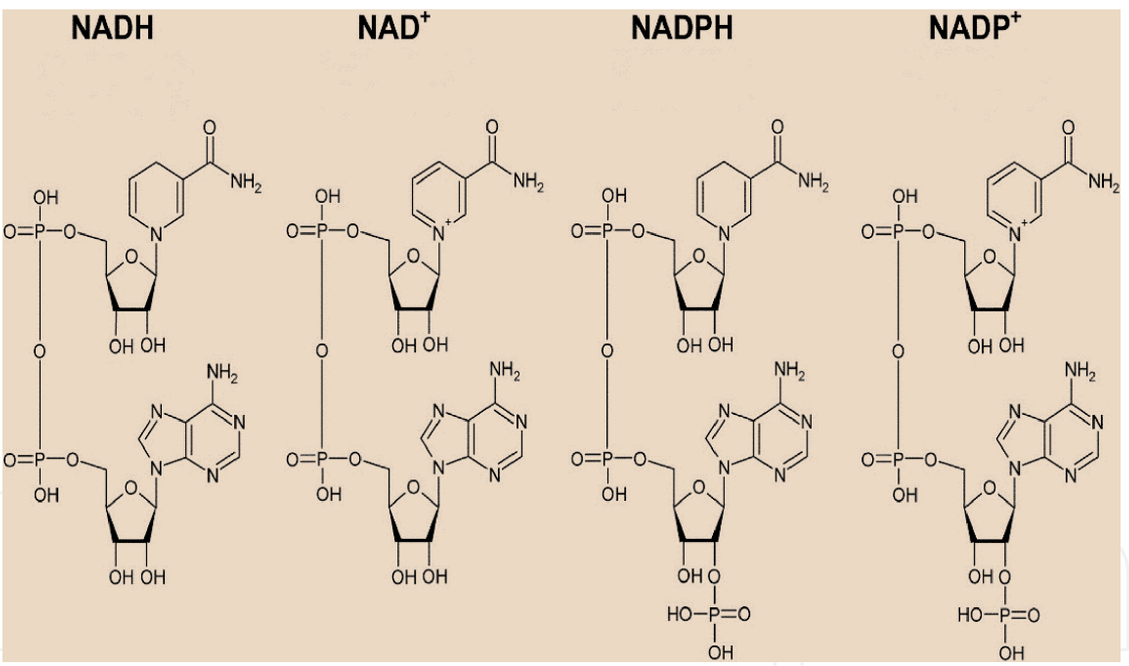


Figure 7.
Structures of NADH, NAD+, NADPH, and NADP+.

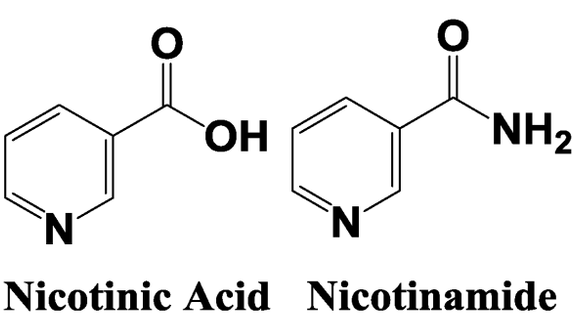


Figure 8.
Types of B3.

diarrhea, and dermatitis, also known as "the three Ds." If left untreated, pellagra can be fatal. Besides pellagra, deficiency causes gastrointestinal disturbance, loss of appetite, headache, insomnia, and mental depression. Moreover, it can be the reason of fatigue, aches, pains, nervousness, and irritability. The recommended daily dosage of a stable diet for vitamin B3 is 16 mg/day for males +14 years and for females +14 years 14 mg/day [39–41].

3.4 Pantothenic acid (B5)

Pantothenic acid (**Figure 9**) is vitamin B5. The word pantothenic comes from the Greek "pantou," meaning everywhere. Nearly all foods contain small quantities of pantothenic acid. It is one of the eight water-soluble B vitamins, which enables the body to break down carbohydrates into glucose to produce energy and to make red blood cells. This acid is formed from ß-alanine and pantoic acid. Pantothenic acid is required for the synthesis of coenzyme A (CoA) and component of the acyl carrier protein (ACP) domain of fatty acid synthase, in addition to its need for the metabolism of carbohydrate by the TCA cycle and all fats and proteins [38, 42].

Moreover, vitamin B5 also takes action in converting food into glucose, synthesizing cholesterol and forming sex and stress-related hormones in the adrenal glands. In addition, vitamin B5 helps maintain healthy skin, hair, eyes, and digestive system and also assists the body in using other vitamins. Furthermore, it can be in use for skin care as some studies have shown that vitamin B5 works as a moisturizer on the skin and enhances the healing process of skin wounds and acne. In addition, some studies suggest that vitamin B5 intake can help lower cholesterol and levels of blood triglycerides or fats. Almost all plant- and animal-based foods contain pantothenic acid in varying amounts, though food processing can cause a significant loss. Vitamin B5 is mainly found in members of the cabbage family, poultry, white and sweet potatoes, whole-grain cereals, and yeast, in addition to milk, lentils, and legumes. Deficiency is rare but can cause symptoms like headache, fatigue, irritability, impaired muscle coordination, gastrointestinal problems, and paresthesia, which is a tingling and numbing feeling in the feet, hands, legs, and other parts of the body. The recommended daily intake for this acid is 1.7–5.0 mg; large doses of pantothenic acid do not cause symptoms, other than possible diarrhea [43, 44].

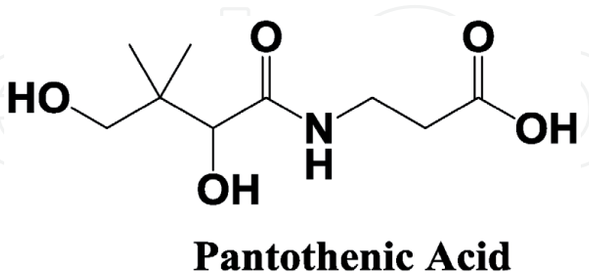


Figure 9.
Vitamin B5.

3.5 Pyridoxal, pyridoxamine, and pyridoxine (B6)

Pyridoxine is one of the vitamin B6 groups which also includes pyridoxal and pyridoxamine; all three compounds are efficiently converted by pyridoxal kinase to the biologically active form of vitamin B6, which is pyridoxal phosphate (**Figure 10**). Pyridoxal phosphate functions as a coenzyme, a substance that enhances the action of an enzyme and thereby helps catalyze and speed a biochemical reaction [38, 45].

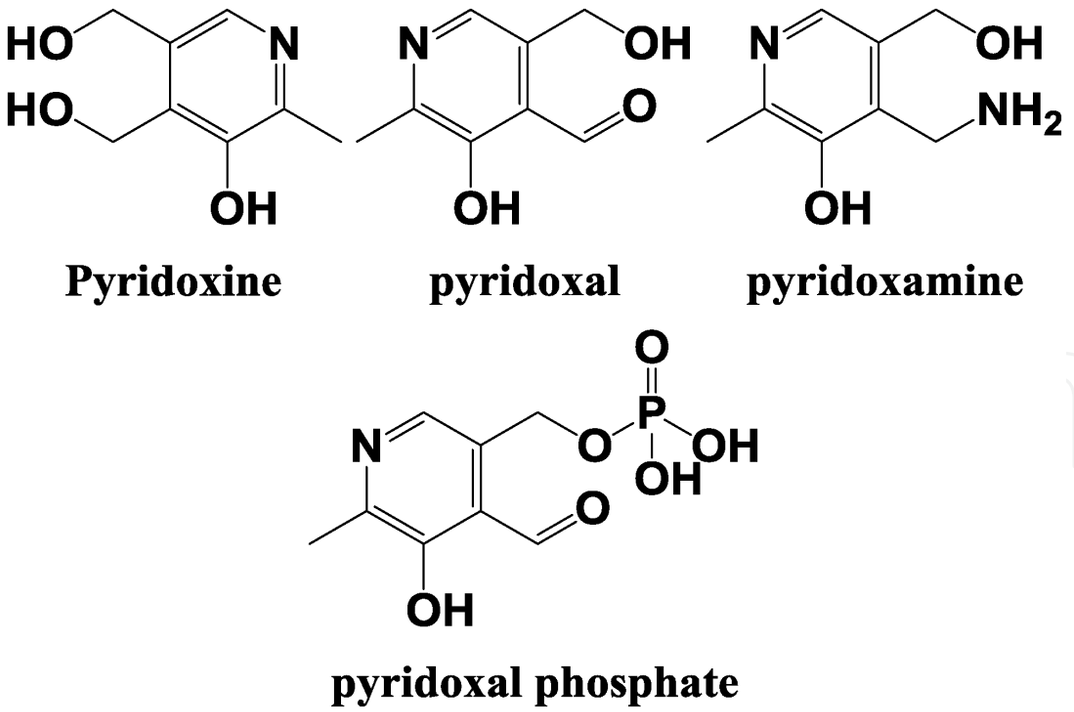


Figure 10.
Types of vitamin B6.

Vitamin B6 is important to the body for it plays a huge role in the production of red blood cells, the conversion of tryptophan to niacin (B3), and the immunity and nervous system functions. Moreover, it reduces muscle spasms, cramps, and numbness as well as maintains a proper balance of sodium and phosphorus in the body. Good sources of this vitamin is just like most other vitamins, it can be found in whole-grain cereals, eggs, vegetables, soya beans, peanuts, milk, and potatoes as well as meat like poultry, pork, and fish. The risks of the deficiency are rare but can lead to nervousness, insomnia, loss of muscle control, muscle weakness, and arm and leg cramps, in addition to water retention and skin lesions. The recommended daily dosage of this vitamin is 1.4 mg a day for men and 1.2 mg a day for women [38, 45, 46].

3.6 Biotin-cobalamin (B12)

Biotin is a water-soluble B-complex vitamin that helps the body metabolize proteins and process glucose. Biotin is also known as vitamin B7 or vitamin H (**Figure 11**). It is also involved in the metabolism of fatty acids, a type of molecule found in fats and oils and leucine, an essential amino acid that humans cannot synthesize [46].

Biotin has a number of benefits to the human body like lowering cholesterol, regulating blood sugar, improving the skin health, as well as strengthening hair and

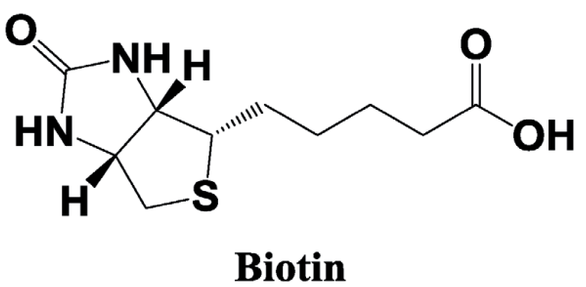


Figure 11.
Vitamin B12 (biotin).

nails. A research has found that biotin can treat multiple sclerosis, a serious disease that affects the central nervous system, if taken in high doses as studies have shown. Biotin is largely found in egg yolks, cheese, legumes such as soybeans and peanuts, leafy greens, and cauliflower. Moreover, it also exists in mushrooms, nuts and nut butters, as well as animal liver and kidney. Biotinidase deficiency (BTD) is the most common cause of biotin deficiency. BTD is a rare inherited disorder where the body is not able to use biotin and leads to biotin deficiency, which developed by a mutation in the BTD gene. This gene instructs the body on how to make the enzyme biotinidase, which the body needs to extract biotin from food. Biotin deficiency includes thinning hair, progressing to loss of hair across the body, and a scaly, red rash around body openings, including the eyes, nose, mouth, and anus, as well as development of conjunctivitis. The daily requirement of this vitamin is within 5–30 mcg, for both men and women; the dosage differs according to age [47, 48].

Cobalamin is an essential nutrient and natural water-soluble vitamin of the B-complex family that must combine with an intrinsic factor for absorption by the intestine; vitamin B12 (cyanocobalamin) (**Figure 12**) is necessary for

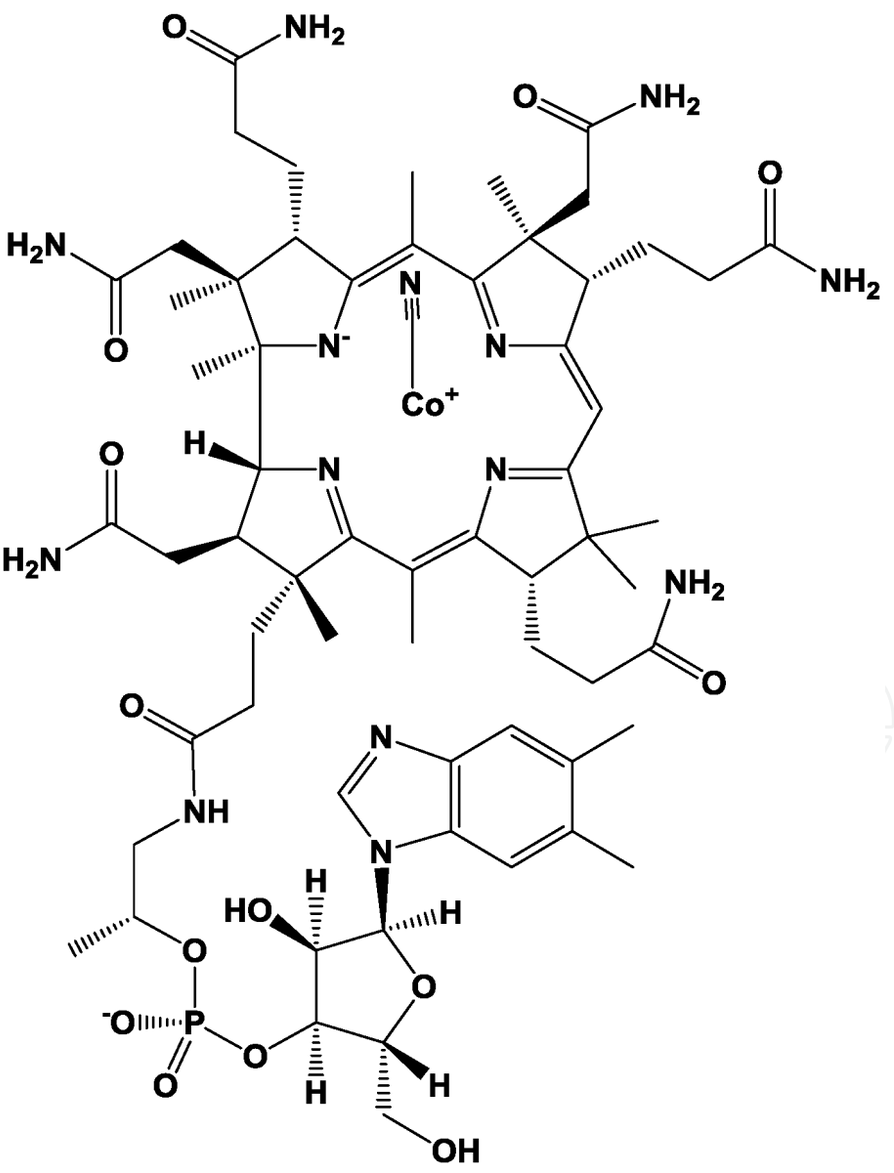


Figure 12.
Vitamin B12 (cobalamin).

hematopoiesis, which is the process by which blood cells are formed and neural, in addition to metabolism, DNA and RNA production, as well as carbohydrate, fat, and protein metabolism. B12 improves iron functions in the metabolic cycle and assists folic acid in choline synthesis. B12 metabolism is interconnected with that of folic acid. This vitamin is mainly found in meat, for instance, fish, clams, beef, animal liver and kidney, as well as in eggs, dairies, and fortified nutritional yeast. Deficiency of cobalamin results to anemia, nerve damage, and hypersensitive skin. The recommended daily requirement of this vitamin for men and women of +14 of age is 2–3 mcg/day [47–49].

3.7 Folic acid (B9)

Folic acid is a form of vitamin B9 that can dissolve in water. It is a key ingredient in the making of the nucleic acid, which forms part of all genetic material. Its main functions are synthesis and repair of DNA and RNA, aiding rapid cell division and growth, enhancing brain health, and age-related hearing loss (**Figure 13**) [50].

Folic acid is essential to the body, and the deficiency of it can cause anemia, diseases of the heart and blood vessels and defects in the brain and spinal cord in a fetus. Folic acid is added to be in study with vitamin B12 in the prevention and treatment of cancer. It is also called folate. In addition, it is in consideration that folic acid plays a preventive role in a number of conditions like autism; a recent study connected folic acid deficiency with autism. It is fair to mention that folic acid is often used to support a methotrexate prescription for rheumatoid arthritis, which is a long-term, progressive, and disabling autoimmune disease. It causes inflammation, swelling, and pain in and around the joints and other body organs. This vitamin can be consumed through legumes, eggs, leafy greens, asparagus, beetroot, citrus fruits, beef liver, wheat germ-fortified grains, and others. The required daily dosage for the body is 0.1–0.4 mg [51, 52].

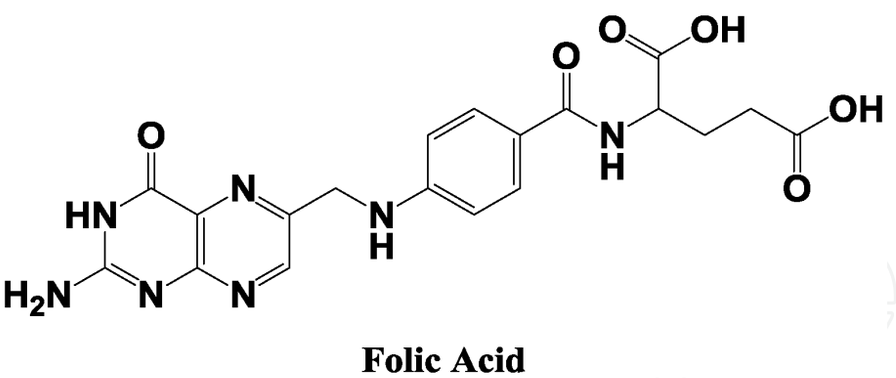


Figure 13.
Vitamin B9.

3.8 Ascorbic acid (vitamin C)

Vitamin C is also known as ascorbic acid, a water-soluble vitamin, one that is not able to be in storage by the body except in insignificant amounts. It must be replenished daily. It helps produce collagen, a protein needed to develop and maintain healthy teeth, bones, gums, cartilage, vertebrae discs, joint linings, skin, and blood vessels. Vitamin C is a powerful antioxidant that protects your cells from damage by free radicals produced by cigarette smoke, air pollution, excessive sunlight, and normal metabolism (**Figure 14**). Free radicals are considered to play a role in rapid aging and diseases such as cancer and heart disease [53–55].

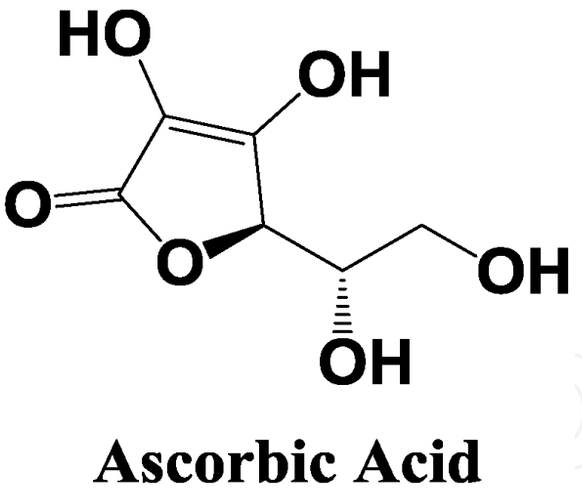


Figure 14.
Vitamin C.

It known that vitamin C helps metabolize proteins and its antioxidant activity may have a chance of reducing the risk of some cancers. Scurvy is the name for a vitamin C deficiency which results in anemia, fatigue, depression, and connective tissue defects like internal bleeding, petechiae, impaired wound healing, and gingivitis. Vitamin C is mainly found in citrus fruits such as orange, kiwi, lemon, guava, and grapefruit, and vegetables such as broccoli, cauliflower, Brussels sprouts, and capsicums are rich, natural sources of vitamin C. Other vitamin C-rich fruits include papaya, cantaloupe, and strawberries. The required intake of the vitamin is 45–60 mg for male and female, and the dosage differs according to age [54–58].

4. Conclusions

In conclusion, there are two types of vitamins, which are essential to the body, water-soluble vitamins and fat-soluble vitamins; both types play an effective part in the human body. Nobody can deny the necessity of these vitamins to the body in all ages, and the lack of it can result in severe damage in certain parts of the body according to which vitamin and age as well as the health status of each person.

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