

Introduction to Vitamins

[See online here](#)

Vitamins are the organic compounds which are required in small quantities for normal growth, reproduction and maintenance of the human body. They are different from other organic food stuff because they do not go through the degradation processes to provide energy, and do not enter the tissue structure. Moreover, several B vitamins act as a coenzyme in various metabolic reactions of the body. Vitamins are also different from hormones as they are not produced by the body and have to be taken through diet. They are classified on the basis of their biological and chemical activity.



Overview

There are **13 vitamins** in total that a human body needs. They are as follows:

1. Vitamin A
 - **B vitamins:**
2. Vitamin B1 - Thiamine
3. Vitamin B2 - Riboflavin
4. Vitamin B3 - Niacin
5. Vitamin B5 - Pantothenic acid
6. Vitamin B6 - Pyridoxine
7. Vitamin B7 - Biotin
8. Vitamin B9 - Folate (Folic Acid)

9. Vitamin B12 – Cobalamin
10. Vitamin C
11. Vitamin D
12. Vitamin E
13. Vitamin K

They are **classified based on the biological and chemical activity** that they perform. They are classified as:

- **Fat soluble** (vitamins A, D, E and K)
- **Water soluble** (B vitamins, vitamin C and vitamin A in its beta-carotene form)

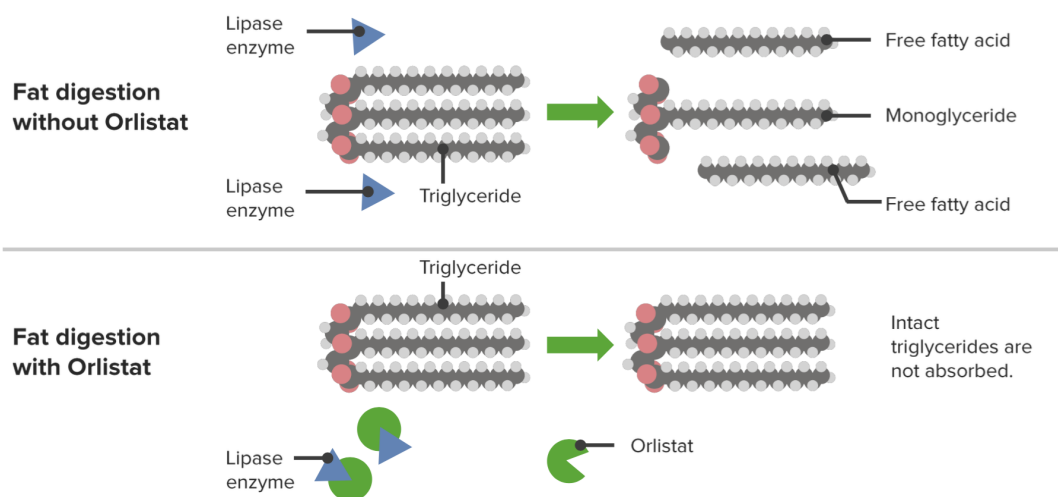
Fat soluble vitamins are **hydrophobic** and **lipid soluble**. They travel to the general body circulation through the lymphatics of small intestine absorbed in fat globules known as the **chylomicrons**. These are easily stored in the body.

Therefore, an increased intake of fat soluble vitamins predisposes a person to **hypervitaminosis**. Main storage sites are [liver](#) and fat tissue. Only a small quantity of these vitamins is required, but a deficiency can lead to certain diseases, such as [rickets](#).

Digestion of these vitamins is by the **pancreatic enzymes**. Absorption of fat-soluble vitamins requires adequate liver and pancreatic secretions. Too much of fat in the stool, i.e., **steatorrhea** can be caused by:

- [Pancreatitis](#)
- [Pancreatic cancer](#)
- [Liver disease](#)
- [Crohn's disease](#)
- [Celiac disease](#)
- [Cystic fibrosis](#)
- [Gallstones](#)

Common causes of steatorrhea



Basically, anything that reduces enzymes secretion from THE pancreas leads to steatorrhea.

Water-soluble vitamins cannot be stored in the body, and a daily intake of these vitamins is necessary. They are **hydrophilic** and dissolve in the body where they travel freely. Any excess of these vitamins is simply excreted by the kidneys and later via urine; therefore, toxicity is less common.

Vitamin A – Retinol, Retinoic Acid, Retinal

It is a name referring to many molecules such as Retinol, Retinoic Acid, and Retinal. They are all known as retinoids. It is found in fruits and vegetables as pro-vitamin A carotenoid.

- **Dietary source:** butter, milk, cheese, egg yolk, tomatoes, carrots, spinach, mangoes and corn
- **Daily requirement:** 400 µg for 2,000 calorie intake
- There is a higher requirement for growing children, [pregnant women](#), and in hepatic disease.

Functions

- **Role in vision:** rhodopsin has a role in night vision, and retinal is a part of it
- **Role in epithelialization:** it prevents keratinization of epithelial cells
- Helps in **bone and teeth formation**
- Required for **growth**
- Plays a role in the **metabolism of DNA and protein synthesis**
- **Skin** becomes dry and scaly in a deficiency of vitamin A

Therapeutic uses

- Oral leukoplakia
- [Acute myeloid leukemia](#)
- [Acne](#)

Deficiency

- **Nyctalopia** (poor night vision)
- Dry and scaly skin
- Decreased endochondral bone formation and osteoblastic activity

Toxicity

- Nausea
- [Headaches](#)
- Irritability
- Teratogenicity
- Skin and hair problems

Vitamin E – Tocopherols

It refers to a group of compounds that include tocopherols and tocotrienols. Of all the types γ -tocopherol is the most common in diet while α -tocopherol is the most active type.

- **Dietary source:** wheat, sunflower, grape seed, canola, almond, margarine, cottonseed oil, spinach and corn oil
- **Daily requirement:** 10 mg for 2,000 calorie intake
- There is a higher requirement in pregnancy and [lactation](#)

Functions

- It has **antioxidant properties** and contributes to the **oxidation of free fatty acids**.
- Involved in **aerobic cellular respiration**
- Combines with reactive oxygen species and works in conjugation with vitamin C
- More oxygen to RBCs

Therapeutic uses

- Nocturnal muscle cramps
- [Atherosclerosis](#)
- [Fibrocystic breast disease](#)
- Intermittent claudication

Deficiency

- [Hemolytic anemia](#)
- [Muscular dystrophy](#)
- Hepatic necrosis
- Immune impairment

Excessive intake

- Interferes with vitamin K and impacts **clotting**. Consider to be synergistic with warfarin and can lead to blood loss
- May can increase in oxidant activity, cell breakdown and increased mortality in cancer
- Leads to vitamin K deficiency due to inhibition in synthesis

Vitamin K – Quinone

- **Dietary source:** fish, meat, broccoli, parsley, lettuce, kale, collards
- It is synthesized in the body by the **normal intestinal flora**. Newborns cannot produce vitamin K due to the sterile gut
- **Daily requirement:** 80 µg for 2,000 calorie intake

Functions

- Promotes **blood coagulation**. Factor II, VII, IX and X require vitamin K
- It is an important co-factor in **oxidative phosphorylation**
- It enhances the capacity of calcium-binding proteins to deposit calcium in the concerned tissues
- **Deficiency:** There is a rare chance of deficiency. Prolonged use of [antibiotics](#) and other drugs such as warfarin

Vitamin D – Calciferol, Calcitriol

- **Dietary source:** fish liver oil, egg yolk, margarine, lard
- **Daily requirement:** 5 µg for 2,000 calorie intake. Sun exposure is very

important for conversion into an active form.

- There is a higher requirement in infants, children, pregnant and lactating women.

Activation

From the surface of the skin 7-dehydrocholesterol is converted into **cholecalciferol** (vitamin D3) in the presence of sunlight. It then combines with vitamin D2 (ergocalciferol) and gets converted to 25-hydroxyvitamin D3 (calcidiol) in the [liver](#). A process is known as hydroxylation that is further carried out in the kidney to convert it into 1,25-dihydroxy vitamin D3 (calcitriol). This is the active form.

Functions

- **Absorption of calcium and phosphate** from the intestines
- Enhanced **mineralization** of the bones
- **Absorption of calcium and phosphate** from the renal system
- Vitamin D **lowers the pH in the colon**
- It has a role in **increasing the citrate content of blood and bones**



[Image](#): "Vitamin D deficiency causes rickets in children." by http://wellcomeimages.org/indexplus/obf_image/s/41/45/54127c3cb9dbd83c3e5ca87e90e6.jpg
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Deficiency

- [Rickets](#) in children
- [Osteomalacia](#) in adults
- Renal osteodystrophy

Toxicity

Hypervitaminosis D occurs if it is taken in large doses, 500 times that of the normal dose.

Toxicity produces immediate and delayed effects.

- **Immediate effects:** [anorexia](#), [constipation](#), lassitude, thirst, polyuria, nausea, [vomiting](#), [diarrhea](#)
- **Delayed effects:** metastatic calcification, urinary lithiasis

Vitamin B1 – Thiamine

- **Dietary source:** rice, peas, beans, whole white bread, bran, prunes, nuts, liver, meat, eggs and milk. It is also synthesized by the intestinal flora
- **Daily requirement:** 1.4 mg. This is related to the carbohydrate content taken in the diet, not the caloric value of food
- Dietary requirements increase in the case of a hemorrhage, increased alcohol intake, prolonged illness and the use of [antibiotics](#), increased caloric burnout, fever, [hyperthyroidism](#) and pregnancy and [lactation](#).

Functions

- It is a coenzyme in multiple metabolic reactions of the body, e.g., oxidative decarboxylation, the trans-ketolation reaction in glucose metabolism, etc.
- Required for the activity of enzyme **tryptophan pyrolyse** (tryptophan metabolism)

Deficiency

Deficiency is rare due to the wide distribution in foods. **Beriberi** is the result of thiamine deficiency. It has the following three types:

1. **Dry Beriberi**

- Symmetrical muscle wasting
- Peripheral neuropathy
- Confusion
- Difficulty in speech
- Involuntary eye movements

2. **Wet Beriberi**

- Signs and symptoms of dry Beriberi, along with **shortness of breath**, **rapid heart rate**, **edema in lower legs** and **cardiac failure**.

3. **Wernicke-Korsakoff**

- Confusion
- Nystagmus
- [Ataxia](#)
- Confabulation
- Mammary body damage
- Aphasia

Vitamin B2 – Riboflavin

- **Dietary source:** yeasts, beans, peas, green vegetables, nuts, liver, kidney, milk, crab meat and eggs
- **Daily requirement:** 1.6 mg for 2,000 calorie intake
- There is a higher requirement in the case of burns, acute illness, [broad-](#)

[spectrum antibiotics](#) use, [pregnancy](#) and lactation.

Functions

- Acts as a coenzyme in certain H-transfer reactions in the metabolism
- Red blood cell production

Deficiency

Vitamin B2 deficiency is rare but may manifest as the following:

- [Stomatitis](#)
- Chapped and fissured lips
- Angular stomatitis
- Scaly skin rashes (scrotum, nasolabial folds, vulva)
- Photophobia
- Normochromic normocytic anemia

Vitamin B3 – Niacin

- **Dietary source:** liver, meat, fish, kidney, legumes, coffee, tea and nuts
- It is also **synthesized from tryptophan** and in a limited amount by the gut flora.
- **Daily requirement:** 18 mg for 2,000 calorie intake
- There is a higher requirement in illness, infection, high corn or maize diet, pregnancy and lactation.

Functions

- **Synthesis and formation of NAD⁺ and NADP** which further act as co-enzymes in different metabolic reactions
- Nicotinamide formation
- Cholesterol production
- Nerve function

Deficiency

- Dermatitis
- [Diarrhea](#)
- [Dementia](#): It can result from B3 or tryptophan. It results in a disease called **Pellagra**. The following are the clinical features of Pellagra which are known as the 4Ds of pellagra
- Death

Therapeutic use

- To treat high cholesterol

Toxicity

- Skin irritation
- Liver damage

- Flushing of skin

Vitamin B5 – Pantothenic Acid

- **Dietary source:** kidney, yeast, egg yolk, liver, skimmed milk, chicken, royal jelly (richest source) and molasses
- **Daily requirement:** 6 mg for 2,000 calorie intake
- There is a higher requirement in case of burns, acute illness, severe injury, use of [broad-spectrum antibiotics](#), growing children, in convalescence, pregnancy and lactation

Functions

- Formation of active acetate, acetyl Co-A
- Formation of succinyl Co-A which is involved in heme synthesis and degradation of ketone bodies
- Involved in oxidation of fatty acids
- Plays a role in adrenal cortical function

Deficiency

It is rarely seen due to the wide distribution in food and its supply and synthesis by the gut flora, but can lead to **burning feet syndrome**.

Vitamin B6 – Pyridoxine

- **Dietary source:** yeast, rice polishings, egg yolk, royal jelly and cereal grains
- **Daily requirement:** 2 mg for 2,000 calorie intake
- There is a higher requirement in the second half of pregnancy and in antituberculous treatment with isoniazid

Functions

- Co-enzyme in transamination reaction and decarboxylation reactions
- Co-enzyme for deaminases and kynureninase
- Takes part in transsulfuration
- Co-enzyme for desulfhydrase
- Neurotransmitter production
- Protein metabolism (transaminases)
- Production of RBCs

Therapeutic uses

- Morning sickness of pregnancy
- [Muscular dystrophies](#)
- Hyperoxaluria
- Recurring oxalate stones of kidney
- Radiation sickness

Deficiency

The deficiency of vitamin B6 does not cause any disease, but the following clinical manifestations are seen:

- Decreased immunity
- Oxaluria
- Peripheral neuropathy
- [Epileptiform convulsions in infants](#)
- [Anemia](#)

Most common cause of deficiency is isoniazid treatment.

Vitamin B7 – Biotin

- **Dietary source:** liver, milk, kidney, milk products, molasses, legumes, vegetables and royal jelly. Bacterial flora of intestines can also synthesize this vitamin.
- **Daily requirement:** 30 µg for 2,000 calorie intake
- There is a higher requirement in pregnancy and [lactation](#) and long-term antibiotic therapy.

Functions

- It is a co-enzyme for carboxylases enzyme
- Involved in CO₂ fixation reactions
- [Fatty acid metabolism](#)
- Cellular growth
- RBC production

Deficiency

There is no specific deficiency disease, but two conditions are related to biotin deficiency. These are:

- Genetic deficiency of holocarboxylase synthase
- Leiner's disease

Vitamin B9 – Folate (Folic Acid)

- **Dietary source:** liver, kidney, yeast, green leafy vegetables, cauliflower, spinach, wheat, meat and fish
- **Daily requirement:** 400 µg for 2,000 calorie intake
- There is a higher requirement in [pregnancy](#) and lactation, cancers and [hemolytic anemia](#).

Functions

- Role in one-carbon metabolism reactions. One carbon moiety can be utilized to form several compounds
- An important role in hematopoiesis
- Myelination
- DNA nucleotide production

Deficiency

- [Macrocytic anemia](#)
- Weakness
- [Growth retardation](#)
- [Granulocytopenia](#)
- [Thrombocytopenia](#)
- [Megaloblastic anemia](#) (decreased RBCs and hematocrit, increased homocysteine levels, increased MCV)
- Trimethoprim and methotrexate are the drugs that inhibit folate production

Excessive intake

- [Vitamin B12 deficiency](#)
- Renal damage

Vitamin B12 – Cobalamin

- **Dietary source:** liver, fish, egg, meat and kidney. It is not present in plants
- **Daily requirement:** 6 µg for 2,000 calorie intake
- There is a higher requirement in pregnancy, lactation and pernicious anemia

Absorption

Stomach acid and digestive enzymes are necessary to remove vitamin B12 from proteins. It then binds to **intrinsic factor** released by parietal cells of the stomach. Intrinsic factor chaperones B₁₂ to the terminal ileum where it is absorbed.

Functions

- Important for the conversion of homocysteine to methionine
- Nerve cell function
- RBCs production
- [Fatty acid oxidation](#)

Deficiency

It is due to the following factors:

- Pernicious anemia (an autoimmune disease affecting parietal cells)
- Metformin use
- [Crohn's disease](#)
- Bowel resection
- Use of antacid and proton pump inhibitors

Deficiency of B₁₂ leads to **megaloblastic anemia** because folate cannot be recycled.

Nervous system issues arise because of methylmalonic acid which causes demyelination. Peripheral numbness, spasticity, and loss of proprioception are seen in the case of deficiency.

Vitamin C – Ascorbic Acid

- **Dietary source:** citrus fruits, papaya, pineapple, banana, strawberry, cabbage, cauliflower, green peas, tomatoes and potatoes. Amla has the highest concentration of vitamin C.
- **Daily requirement:** 75 mg for 2,000 calorie intake
- There is a higher requirement during infections

Functions



Image: "Deficiency of vitamin C can produce Scurvy. One of the main clinical manifestations is swollen gums." by Herbert L. Fred, MD and Hendrik A. van Dijk - <http://cnx.org/content/m14986/latest/>. License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

- Involved in cellular oxidation-reduction reactions
- Important for collagen synthesis
- Required for the activity of osteoblasts and fibroblasts
- Cofactor in hydroxylation of tryptophan
- Tyrosine metabolism
- Helps in the maturation of RBCs along with folic acid
- Formation of tissue ferritin
- Iron absorption
- Important in electron transport system of the body
- Activates arginase and papain enzymes and inhibits beta amylase and urease activity
- Co-enzyme for dopamine hydroxylase
- Carnitine formation in liver
- Fatty acids alpha-oxidation
- Plays an important role during stress

Therapeutic uses

- Treatment of scurvy
- Methaemoglobinaemia
- [Wound healing](#)
- Treatment of infectious diseases

Deficiency

A low intake of vitamin C leads to a disease known as scurvy. **It has the following clinical manifestations:**

- Delayed wound healing
- Poor dentine formation
- Fragile capillaries
- Swollen and bleeding gums
- Poorly laid osteoid of bone
- Hypochromic microcytic anemia
- Painful swelling of joints and bones
- Loose teeth
- Bruising

References

Chatterjea, M. N., & Shinde, R. (2011). Textbook of medical biochemistry 8th edition (8th ed.). New Delhi: Jaypee Brothers Medical Publications (P).

[Recommended daily intake of vitamins and minerals](#) via lenntech.com

[Vitamins and minerals - B vitamins and folic acid](#) via nhs.uk

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Notes