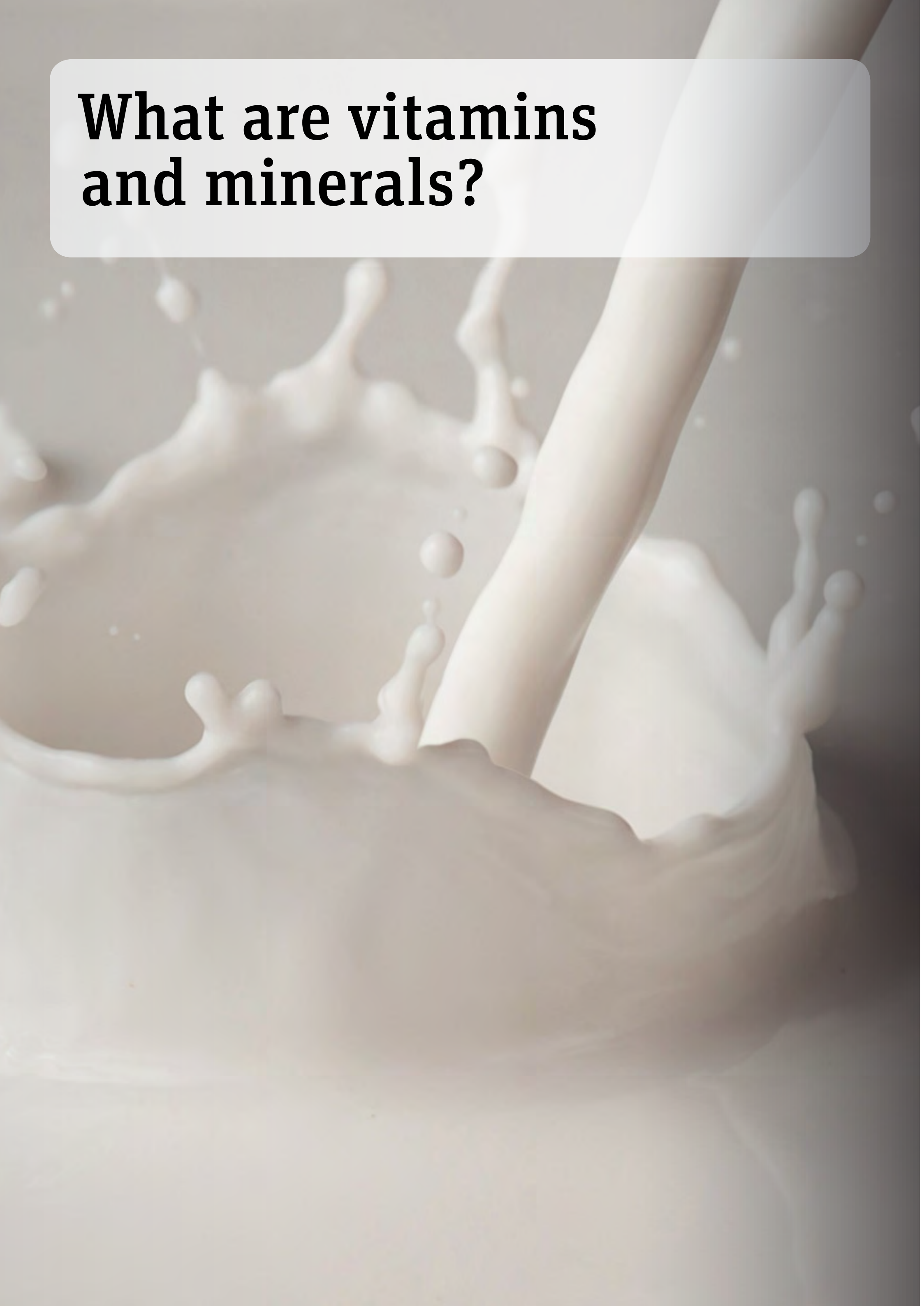
Vitamins and minerals:
a brief guide

A *Sight and Life* publication

What are vitamins and minerals?



Vitamins are organic nutrients that are essential for life. Our bodies need vitamins to function properly. We cannot produce most vitamins ourselves, at least not in sufficient quantities to meet our needs. Therefore, they have to be obtained through the food we eat.

A mineral is an element that originates in the Earth and always retains its chemical identity. Minerals occur as inorganic crystalline salts. Once minerals enter the body, they remain there until excreted. They cannot be changed into anything else. Minerals cannot be destroyed by heat, air, acid, or mixing. Compared to other nutrients such as protein, carbohydrates and fat, vitamins and minerals are present in food in tiny quantities. This is why vitamins and minerals are called micronutrients, because we consume them only in small amounts.

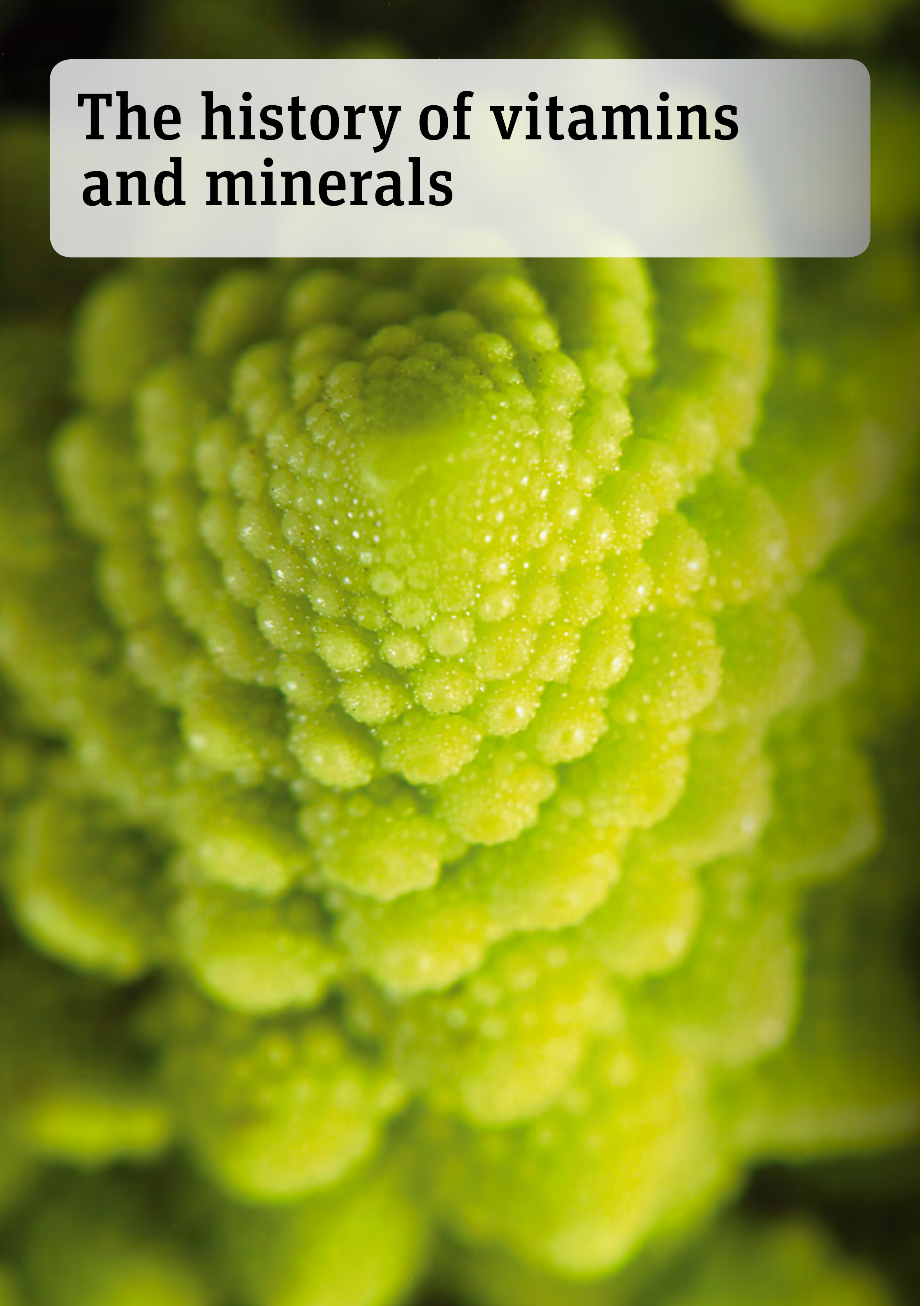
Each of the vitamins and minerals known today has specific functions in the body, which makes them unique and irreplaceable. No single food contains the full range of vitamins and minerals, and inadequate nutrient intake results in deficiencies. A variety of foods is therefore vital to meet the body's vitamin and mineral requirements.

Of the known vitamins, four are fat-soluble. This means that fat or oil must be consumed for the vitamins to be absorbed by the body. These fat-soluble vitamins are A, D, E and K. The others are water-soluble: these are vitamin C and the B-complex, consisting of vitamins B_1, B_2, B_6, B_{12}, niacin, folic acid, biotin, pantothenic acid and choline.

Minerals are divided into two categories: macrominerals and trace minerals/trace elements. As implied by their name, macrominerals are required by the body in larger quantities (more than 100 mg daily) than trace elements. To meet our requirements for some macrominerals we need to consume sufficient and varied food. The trace minerals are so named because they are present in relatively small amounts in the body. If we were to pool the requirements for trace minerals, they would produce only a bit of dust, hardly enough to fill a teaspoon. Yet they are no less important than the macrominerals or any of the other nutrients. The trace mineral contents of foods depend on soil and water composition and on how foods are processed.

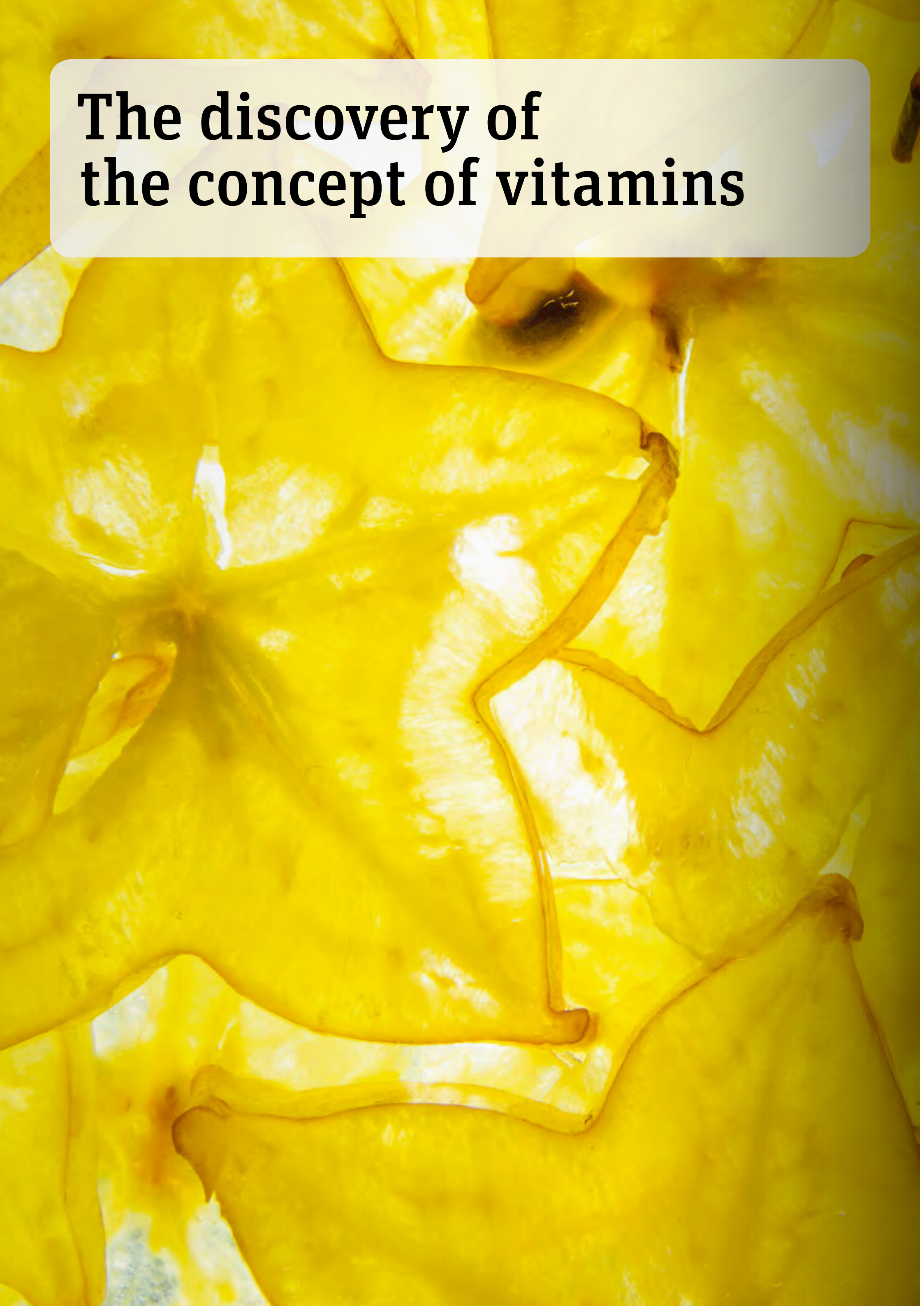
There are over two dozen minerals that are used by the body in various roles. In this booklet, we highlight only the minerals whose intake might become inadequate if access to a diverse diet is restricted.

The history of vitamins and minerals



Vitamin	Chemical name	Year of discovery	Who	Country
Fat-soluble				
Vitamin A	Retinol	1913	Elmer McCollum and Marguerite Davis	United States
Vitamin D	Calciferol	1922	Elmer McCollum	United States
Vitamin E	Tocopherol	1922	Herbert M Evans	United States
Vitamin K	Phylloquinone	1929	Henrik Carl Peter Dam	Denmark
Water-soluble				
Vitamin B_1	Thiamin	1897	Christiaan Eijkman	Netherlands
Vitamin B_2	Riboflavin	1922	Unknown	Unknown
Vitamin B_3	Niacin	1936	Conrad Elvehjem	United States
Vitamin B_5	Pantothenic acid	1931	Roger J Williams and R W Truesdail	United States
Vitamin B_6	Pyridoxine	1934	Paul György	United States
Vitamin B_7	Biotin	1931	Paul György	Germany
Vitamin B_9	Folic acid	1941	Henry Mitchell	United States
Vitamin B_{12}	Cobalamin	1926	George Whipple, George Richards Minot and William Murphy	United States
Vitamin C	Ascorbic acid	1928	Albert Szent-Györgyi	England
Choline	–	1862	Adolph Strecker	Germany

Mineral		Year of discovery	Who	Country
Macrominerals				
Calcium		1808	Humphrey Davy	England
Magnesium		1755	Joseph Black	England
Phosphorus		1669	Hennig Brand	Germany
Potassium		1807	Humphrey Davy	England
Trace minerals				
Chromium		1798	Louis Nicolas Vauquelin	France
Copper		9000 BC	ns	Iraq
Fluoride		1886	Henri Moissan	France
Iodine		1811	Bernard Courtois	France
Iron		5000 BC	ns	–
Selenium		1817	Jöns Jacob Berzelius	Sweden
Zinc		1746	Andreas Marggraf	Germany



The discovery of the concept of vitamins

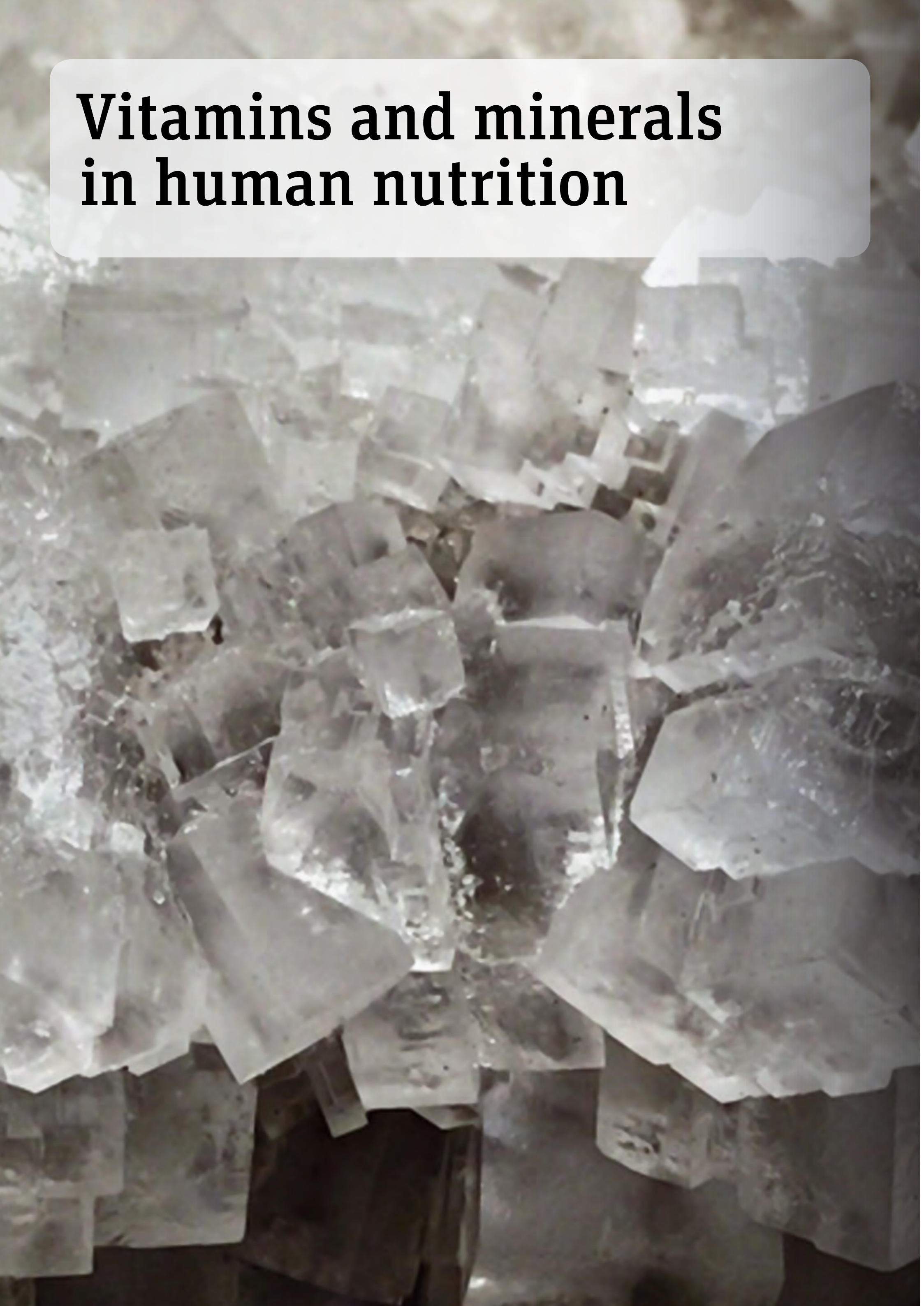
A century ago, a Polish-American scientist attempted to isolate the first vitamin (B_1) from rice bran. Casimir (born Kazimierz) Funk named his discovery “vitamine”, believing that this was an amine (nitrogen compound) vital for life. This coinage has come down to us in the slightly altered form of “vitamin” - even though most vitamins were later shown not to be amines. Funk’s breakthrough discovery played a decisive role in the development of nutrition, which the world now takes for granted.

Funk (1884 –1967) was the first scientist to suggest the existence of an entire family of organic substances essential for life, and the first to give these substances a name that made their function clear.

In a distinguished scientific career spanning two world wars, Funk studied and worked in Europe and the United States. He had roles in academia and industry, and improved manufacturing methods for commercial drugs. Although he never received a Nobel Prize for his work, the Polish Institute of Arts and Sciences of America presents the Casimir Funk Natural Sciences Award annually to a Polish-American scientist.

In 1921, the British biochemist Sir Jack Cecil Drummond suggested combining the use of letters of the alphabet with the term “vitamin” to denote a range of related organic micronutrients. These nutrients consequently became known as vitamins A, B, C and so on.

Vitamins and minerals in human nutrition



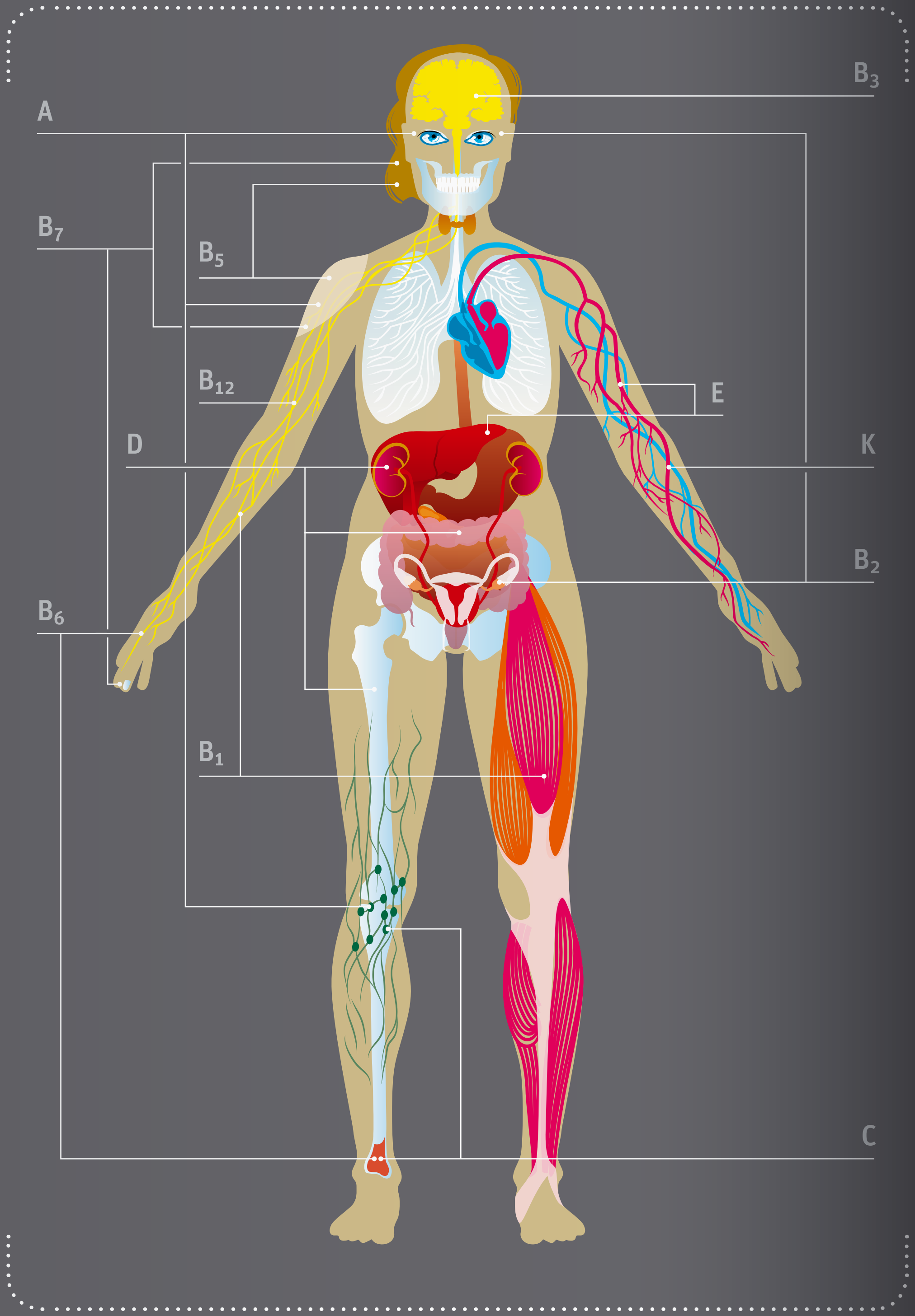
While plants and micro-organisms can themselves produce the vitamins necessary for the metabolism, humans and animals lost this ability during the course of evolution. Because they lack the enzymes necessary to make vitamins in the body, humans and animals have to ingest them via the diet (with the exception of vitamin D, which is synthesized via the action of sunlight). Choline is the most recent addition to the group of essential nutrients.

It was recognized more than 3,500 years ago that foods containing vitamins are essential for health and well-being. The earliest records to have come down to us on this subject relate to the use of specific foods like liver – which contains vitamin A – to prevent diseases such as night blindness. Nevertheless, the concept of vitamins *per se* was quite unknown until very recently.

Since the beginning of the 20th century, our knowledge of the function of vitamins and minerals in our bodies has increased significantly. This understanding is reflected in the award of 20 Nobel Prizes in the vitamin field between 1928 and 1967.

Only five percent of the weight of a human being is mineral matter. Yet minerals are vital for many bodily functions such as building bones, making hormones and regulating heartbeat. Minerals are indispensable for healthy growth and development.

Most of the minerals in our diets come from plant or animal sources. Plants obtain minerals from the soil. Because soil mineral content varies geographically, the mineral content of plants will depend on where the plant grew and how much fertilizer it received. Minerals may also be present in the water we drink, and this also varies with geographic location.



Vitamins and associated body functions

Vitamin A
Eyes, immune system, skin, genes, growth

Vitamin D
Skin (formed in), intestines, kidneys, bones

Vitamin E
Antioxidant, blood cells, stored in liver

Vitamin K
Blood (clotting)

Vitamin B$_1$
Energy metabolism, nerve and muscle activity

Vitamin B$_2$
Energy metabolism, growth and reproduction, vision

Vitamin B$_3$
Energy metabolism, neurological processes

Vitamin B$_5$
Skin and hair, wound healing, blood lipid profile

Vitamin B$_6$
Nerve activity, blood formation, DNA

Vitamin B$_7$
Hair, nails, skin

Vitamin B$_9$
DNA synthesis

Vitamin B$_{12}$
Nerve activity, neurotransmitters

Vitamin C
Antioxidant, iron absorption, immune system

Choline
Nerve activity, gene expression

Vitamin

A

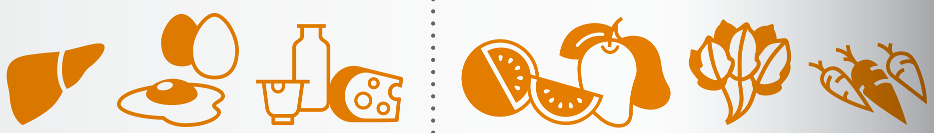
Retinol | Carotenoids

Year of discovery: **1913**

Elmer McCollum and Marguerite Davis

Primary natural sources

Animal products | **Fruit | Vegetable products**



Liver | Egg yolk | Dairy products

Melon | Mangoes | Spinach | Carrots

Fat-soluble

Vitamin A

Retinol | Carotenoids

Vitamin A plays a central role in our vision, skin, genes, growth, and immune system. It is especially important during the early stages of pregnancy in supporting the developing embryo. Infections and fevers increase the requirement for vitamin A.

Three different forms of vitamin A are active in the body: retinol, retinal, and retinoic acid. These are known as retinoids. The cells of the body can convert retinol and retinal to the other active forms of vitamin A as needed. Each form of vitamin A performs specific tasks. Retinol supports reproduction and is the major transport form of the vitamin. Retinal is active in vision and is also an intermediate in the conversion of retinol to retinoic acid. Retinoic acid acts like a hormone, regulating cell differentiation, growth, and embryonic development. Foods derived from animals provide retinol in a form that is easily digested and absorbed. Foods derived from plants provide carotenoids, some of which have vitamin A activity. The body can convert carotenoids like β-carotene, α-carotene and β-cryptoxanthin into vitamin A. The conversion rates from dietary carotene sources to vitamin A are 12:1 for β-carotene and 24: 1 for β-cryptoxanthin.

The primary sources of vitamin A

Retinol is found in liver, egg yolk, butter, whole milk, and cheese. Carotenoids are found in orange-flesh sweet potatoes, orange-flesh fruits (i.e., melon, mangoes, and persimmons), green leafy vegetables (i.e., spinach, broccoli), carrots, pumpkins, and red palm oil.

Bioavailability of vitamin A

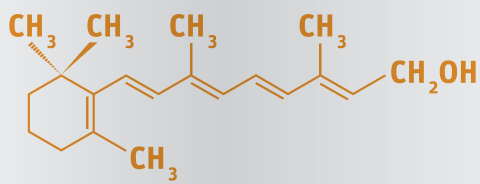
The bioavailability of vitamin A derived from animal sources is high – about 70–90% of the vitamin A ingested is absorbed by the body. Carotenoids from plant sources are absorbed at much lower rates – between 9% and 22% – and the proportion absorbed decreases as more carotenoids are consumed.

Dietary fat enhances the absorption of vitamin A. Absorption of β-carotene is influenced by the food matrix. β-carotene from supplements is more readily absorbed than β-carotene from foods, while cooking carrots and spinach enhances the absorption of β-carotene. Diarrhea or parasite infections of the gut are associated with vitamin A malabsorption.

Risks related to inadequate or excess intake of vitamin A

About 90% of vitamin A is stored in the liver. Vegetarians can meet their vitamin A requirements with sufficient intakes of deeply colored fruits and vegetables, with fortified foods, or both. Vitamin A deficiency is a major problem when diets consist of starchy staples, which are not good sources of retinol or β-carotene, and when the consumption of deeply colored fruits and vegetables, animal-source foods, or fortified foods is low. Vitamin A plays a role in mobilizing iron from liver stores, so vitamin A deficiency may also compromise iron status.

Excessive intakes of pre-formed vitamin A can result in high levels of the vitamin in the liver – a condition known as hypervitaminosis A. No such risk has been observed with high β-carotene intakes.



Vitamin

D

Calciferol

Year of discovery: **1922**

Elmer McCollum

Primary natural sources

Animal products

Oily fish | Egg yolk | Beef

Fruit | Vegetable products

Mushrooms

Fat-soluble

Vitamin D
Calciferol

With the help of sunlight, vitamin D is synthesized by the body from a precursor derived from cholesterol. Vitamin D is therefore not an essential micronutrient, given the right season and enough time in the sun. The active from of vitamin D is actually a hormone that targets organs – most notably the intestines, kidneys, and bones. In the intestine, vitamin D is involved in the absorption of calcium and phosphorus. In the bone, it assists in the absorption of calcium and phosphorus, helping bones grow denser and stronger as they absorb and deposit these minerals.

The primary sources of vitamin D

Sunlight – exposure to ultraviolet B (UVB) rays is necessary for the body to synthesize vitamin D from the precursor in the skin.

There are a few foods that are natural sources of vitamin D. These sources are oily fish, egg yolk, veal, beef, and mushrooms.

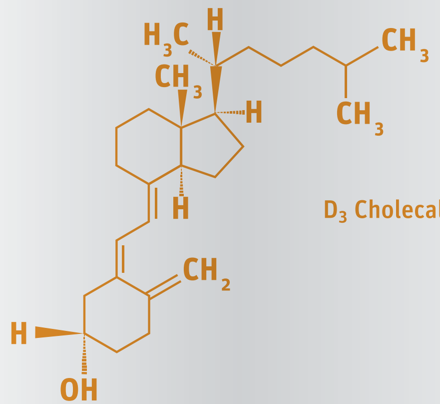
Bioavailability of vitamin D

There is very little information on the bioavailability of vitamin D. It is assumed that the food matrix has little effect on absorption. Bioavailability also varies among individuals and depends on the level of circulating vitamin-D-binding protein.

Risks related to inadequate or excess intake of vitamin D

Inadequate exposure to sunlight is the primary risk factor for poor vitamin D status. The use of sunscreen, higher levels of melanin in skin (i.e., dark skin), skin coverings (clothes, veils), and time of day are factors that decrease exposure to UVB rays. The distance from the equator is also a factor for UVB exposure; people living in latitudes above or below 40 degrees from the equator will be unable to form vitamin D from the skin precursor during the winter months. Breast milk is a poor source of vitamin D. Children who are exclusively breastfed and have no or little sun exposure require vitamin D supplements to meet their vitamin D requirements.

One of the main roles of vitamin D is to facilitate the absorption of calcium and phosphorus. Consequently, a vitamin D deficiency creates a calcium deficiency, with significant consequences to bone health. Among children and adolescents, it may cause rickets and adversely affect peak bone mass. In adults, vitamin D deficiency increases the risk of osteomalacia and osteoporosis.



D_3 Cholecalciferol

Vitamin

E

α-Tocopherol
Year of discovery: **1922**
Herbert M Evans

Primary natural sources

Animal products

Dairy products | Eggs

Fruit | Vegetable products

Vegetable oils | Leafy green vegetables | Fruits

Fat-soluble

Vitamin E
α-Tocopherol

The most active form of vitamin E is α-tocopherol, which acts as an antioxidant (i.e., stops the chain reaction of free radicals producing more free radicals). Vitamin E protects cell membranes, proteins, and DNA from oxidation and thereby contributes to cellular health. It prevents oxidation of the polyunsaturated fatty acids and lipids in the cells. Vitamin E is stored in the liver and is safe even at high intakes.

The primary sources of vitamin E

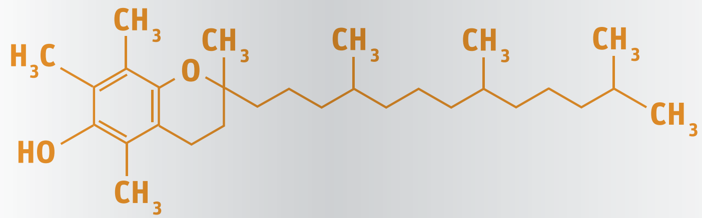
Vitamin E in the α-tocopherol form is found in edible vegetable oils, especially wheat germ, and sunflower and rapeseed oil. Other good sources of vitamin E are leafy green vegetables (i.e., spinach, chard), nuts (almonds, peanuts) and nut spreads, avocados, sunflower seeds, mango and kiwifruit.

Bioavailability of vitamin E

Vitamin E is a fat-soluble nutrient. As such, absorption of this vitamin is enhanced in the presence of fat in a meal.

Risks related to inadequate or excess intake of vitamin E

Individuals whose diets consist mostly of starchy staples – with inconsistent intake of edible oils or other vegetable sources of vitamin E – are at a higher risk of inadequate vitamin E intake. Vitamin E deficiency leads to red blood cell breakage and nerve damage. Recent studies from Bangladesh link low vitamin E blood levels to an increased risk of miscarriage. In other studies vitamin E supplementation has been successfully used for the treatment of non-alcoholic fatty liver disease, a condition widespread in overweight and obese people. Excessive intake of vitamin E from food is very rare.



Vitamin

K

Phylloquinone | Menaquinones
Year of discovery: **1929**
Henrik Carl Peter Dam

Primary natural sources

Animal products

Vegetable products

Dairy products | Meat | Liver

Leafy vegetables | Cabbage | Vegetable oils

Fat-soluble

Vitamin K
Phylloquinone | Menaquinones

Vitamin K acts primarily in blood clotting, where its presence can make the difference between life and death. More than a dozen different proteins and the mineral calcium are involved in making a blood clot. Vitamin K is essential for the activation of several of these proteins. When any of the blood clotting factors is lacking, hemorrhagic disease (uncontrolled bleeding) results. Vitamin K also participates in the metabolism of bone proteins, most notably osteocalcin. Without vitamin K, osteocalcin cannot bind to the minerals that normally form bones, resulting in poor bone mineralization. Vitamin K is stored in the liver.

The primary sources of vitamin K

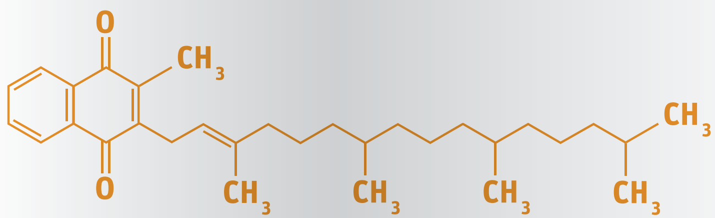
Vitamin K is found in plant foods as phylloquinone (K_1). Bacteria in the lower intestine can synthesize vitamin K as menaquinone (K_2), which is absorbed by the body. Sources of phylloquinone are green leafy vegetables (i.e., parsley, spinach, collard greens, and salad greens), cabbage, and vegetables oils (soybean, canola, olive). Menaquinones are also found in fermented foods such as fermented cheese, curds, and natto (fermented soybeans).

Bioavailability of vitamin K

Absorption of vitamin K from food sources is about 20%, and dietary fat enhances absorption.

Risks related to inadequate or excess intake of vitamin K

Vitamin K is poorly transferred via the placenta and is not found in significant quantities in breast milk, so newborn infants are especially at risk for bleeding. This innate vitamin K deficiency is treated with intramuscular injection or oral administrationof phylloquinone. Supplementation with vitamin K has been found to be beneficial for improving bone density among adults with osteoporosis because it drives synthesis of a special protein called matrix Gla protein.



K_1 Phylloquinone

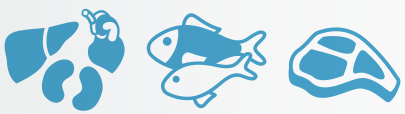
Vitamin

B_1

Thiamin
Year of discovery: **1897**
Christiaan Eijkman

Primary natural sources

Animal products



Offal | Fish | Meat

Fruit | Vegetable products

Whole grain cereals | Fruits | Nuts

Water-soluble

Vitamin B_1

Thiamin

Thiamin is a sulfur-containing vitamin that participates in energy metabolism, converting carbohydrates, lipids and proteins into energy. Thiamin also plays a key role in nerve and muscle activity.

The primary sources of vitamin B_1

Offal (liver, kidneys, heart), fish, meat (pork), whole grain cereals, leafy green vegetables, asparagus, eggplant, fruits , legumes (beans and lentils), nuts, soymilk, squash, brewer's yeast.

Bioavailability of vitamin B_1

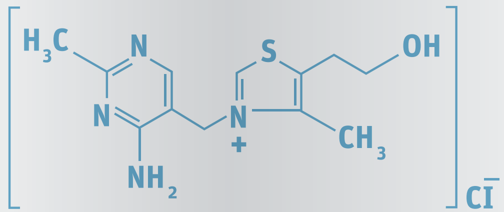
There is no data on bioavailability of vitamin B_1, but we know that levels in foods are very susceptible to heat, cooking times, and length of storage. Vitamin B_1 is also lost in the milling process, where the bran layer and some of the germ layer that contain vitamins are removed from grains.

Risks related to inadequate or excess intake of vitamin B_1

People who consume diets consisting of primarily refined grains (mostly milled flours and polished rice) are at risk for thiamin deficiency. The risk of inadequacy is less when food manufacturers fortify refined grains with vitamin B_1.

Clinical vitamin B_1 deficiency is called beriberi, a condition which still occurs in South-East Asia. In beriberi, there is damage to the nervous system characterized by muscle weakness in the arms and legs, or damage to the cardiovascular system which is characterized by dilated blood vessels, causing the heart to work harder and the kidneys to retain salt and water, resulting in edema.

No adverse effects have been associated with excessive thiamin intakes.



Vitamin

B_2

Riboflavin
Year of discovery: **1922**
Unknown

Primary natural sources

Animal products

Eggs | Meat | Milk | Dairy products

Fruit | Vegetable products

Whole grain cereals | Green leafy vegetables

Water-soluble

Vitamin B_2

Riboflavin

Vitamin B_2 participates in oxidation-reduction reactions, by accepting and then donating two hydrogen molecules, which are necessary for releasing energy from carbohydrates, fats and proteins. Vitamin B_2 stimulates growth and reproduction, plays a role in vision, and in the conversion of vitamins B_6, folic acid, and niacin into their active coenzyme forms.

The primary sources of vitamin B_2

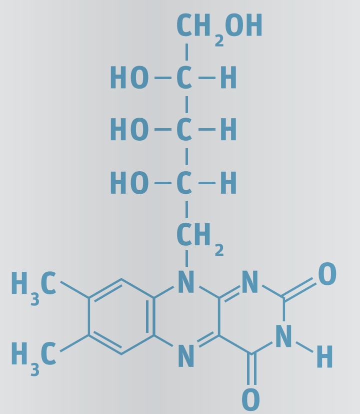
Vitamin B_2 is found in offal (liver, kidneys, heart), eggs, meat, milk, yogurt, cheeses, whole grain cereals, dark green leafy vegetables, and brewer's yeast.

Bioavailability of vitamin B_2

Vitamin B_2 from foods is highly available; bile salts, which are released when we consume fats, increase the rate of absorption of vitamin B_2. Vitamin B_2 is sensitive to light but remains stable under heat and refrigeration. The milling process reduces the content of vitamin B_2 in cereal grains.

Risks related to inadequate intake of vitamin B_2

Individuals whose food intake relies primarily on refined cereals, the elderly, chronic dieters, and individuals who exclude milk products from their diet are at risk for inadequate intakes. Vitamin B_2 requirements are increased during periods of strong growth, such as in pregnancy and lactation. Vitamin B_2 deficiency co-occurs with other nutrient deficiencies and it may precipitate deficiencies in vitamin B_6 and niacin. People with cardiovascular disease, diabetes or cancer are at risk for vitamin B_2 deficiency.



Vitamin

B_3

Niacin
Year of discovery: **1937**
Conrad Elvehjem

Primary natural sources

Animal products

Fish | Meat | Milk | Eggs

Fruit | Vegetable products

Avocados | Nuts | Whole grain cereals

Vitamin B_3

Niacin

Niacin acts as coenzyme in energy-transfer reactions, especially the metabolism of glucose, fat, and alcohol. Niacin is similar to the riboflavin coenzymes in that it carries hydrogen molecules (and their electrons) during metabolic reactions. It also protects against neurological degeneration. Niacin is unique in that it can also be synthesized from the amino acid tryptophan. It occurs in two forms: niacinamide and nicotinic acid.

The primary sources of vitamin B_3

Primary sources are offal (liver), fish, meat, milk, eggs, whole grain cereals, legumes, fruit (avocados, figs, dates, prunes), and nuts.
Other: Synthesized from tryptophan

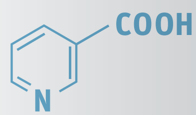
Bioavailability of vitamin B_3

Absorption of niacin depends on the food source. Niacin from meat, liver, beans and fortified products is highly bioavailable. About 30% of the niacin in grains is bioavailable, though additional niacin can be released if the food undergoes alkali treatment (limewater/calcium hydroxide). Compared to other water-soluble vitamins, niacin is less susceptible to losses during food storage. It is fairly heat resistant, so it can withstand reasonable cooking times. However, like other water-soluble vitamins, it will leach into cooking water.

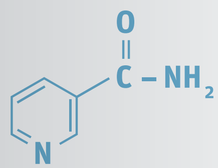
Risks related to inadequate or excess intake of vitamin B_3

Individuals whose diets to not meet their energy needs are therefore at risk of deficiency, as are individuals whose staple diet relies primarily on (untreated) maize or barley, and chronic alcoholics. Severe niacin deficiency results in a disease called pellagra and its symptoms are dermatitis, diarrhea, dementia and eventually death.

Risk of excessive intake is unlikely if niacin is consumed from food sources. However consumption of niacin in the form of nicotinic acid from multiple sources at high levels, including dietary supplements, pharmaceutical doses, and fortified foods, may result in adverse effects such as flushing, nausea and vomiting, liver toxicity, blurred vision and impaired glucose tolerance.



Nicotinic Acid



Nicotinic Amide

Vitamin

B_5

Pantothenic Acid

Year of discovery: **1931**

Roger J Williams and RW Truesdail

Primary natural sources

Animal products

Meat | Milk | Fish

Fruit | Vegetable products

Tomatoes | Broccoli | Mushrooms

Water-soluble

Vitamin B_5

Pantothenic Acid

Vitamin B_5 is part of the structure of coenzyme A, the “crossroads” compound in several metabolic pathways, and is involved in more than 100 different steps in the synthesis of lipids, neurotransmitters, steroid hormones, and hemoglobin. Vitamin B_5 is important for maintenance and repair of tissues and cells of the skin and hair, helps in healing of wounds and lesions, and pantethine, which is a form of vitamin B_5, normalizes blood lipid profiles.

The primary sources of vitamin B_5

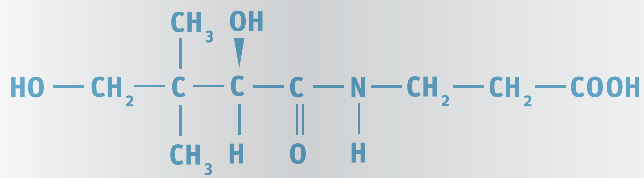
Vitamin B5 is found in offal (liver, kidneys), meat (chicken, beef), egg yolk, milk, fish, whole grain cereals, potatoes, tomatoes, broccoli, mushrooms.
Other: synthesized by intestinal microorganisms but the contribution of this to nutrient status is unknown.

Bioavailability of vitamin B_5

Bioavailability of pantothenic acid from food sources is about 50%. Although vitamin B_5 is quite stable if heated, extended cooking times and prolonged high temperatures (such as boiling temperatures) can cause greater loss of the vitamin. Pantothenic acid is also destroyed in the process of freezing, canning, or refining.

Risks related to inadequate or excess intake of vitamin B_5

Vitamin B_5 deficiency is very rare and symptoms involve a general failure of all the body’s systems. Symptoms include fatigue, nausea, vomiting, headaches, tingling sensations (“burning feet” syndrome). No adverse effects have been reported with high intakes of vitamin B_5.



Vitamin

B 6

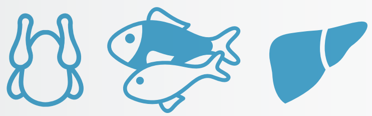
Pyridoxine

Year of discovery: **1934**

Paul György

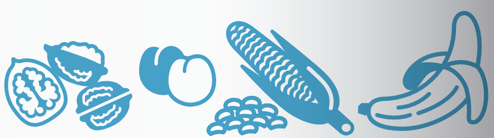
Primary natural sources

Animal products



Chicken | Fish | Liver

Fruit | Vegetable products



Nuts | Chickpeas | Maize | Bananas

Vitamin B_6

Pyridoxine

Vitamin B_6 is required for the majority of biological reactions (i.e., amino acid metabolism, neurotransmitter synthesis, red blood cell formation). It occurs in three forms: pyridoxal, pyridoxine, and pyridoxamine. All can be converted to the coenzyme PLP (pyridoxal phosphate), that transfers amino groups from an amino acid to make nonessential amino acids, an action that is valuable in protein and urea metabolism. The conversions of the amino acid tryptophan to niacin or to the neurotransmitter serotonin also depend on PLP. In addition, PLP participates in the synthesis of the heme compound in hemoglobin, of nucleic acids in DNA and of lecithin, a fatty compound (phospholipid) that provides structures to our cells. Vitamin B_6 is stored in muscle tissue.

The primary sources of vitamin B_6

There are many good sources of vitamin B_6, including chicken, liver (cattle, pig), fish (salmon, tuna). Nuts (walnut, peanut), chickpeas, maize and whole grain cereals, and vegetables (especially green leafy vegetables), bananas, potatoes and other starchy vegetables are also good sources.

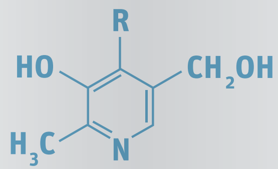
Bioavailability of vitamin B_6

If consuming a mixed diet, the bioavailability of vitamin B_6 is about 75%. Vitamin B_6 is destroyed by heat but it remains stable during storage.

Risks related to inadequate or excess intake of vitamin B_6

Deficiency of vitamin B_6 alone is uncommon; usually it occurs in combination with a deficit in other B-vitamins. Individuals at risk for poor intakes are alcoholics and those taking tuberculosis medication. Signs of vitamin B_6 deficiency include microcytic anemia due to inadequate synthesis of hemoglobin, depression, nerve problems, and irritability.

No adverse events have been observed with high intakes of vitamin B_6 (from food or supplements).



R = CH_2 OH = Pyridoxine

R = CHO = Pyridoxal

R = CH_2 NH_2 = Pyridoxamine

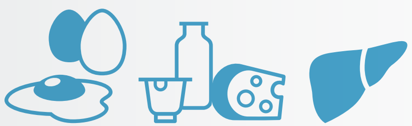
Vitamin

B_7

Biotin | Vitamin H
Year of discovery: **1931**
Paul György

Primary natural sources

Animal products



Eggs | Milk | Dairy products | Liver

Fruit | Vegetable products

Vegetables | Nuts | Peanuts

Water-soluble

Vitamin B_7

Biotin | Vitamin H

Biotin plays an important role in metabolism as a coenzyme that transfers carbon dioxide. This role is critical in the breakdown of food (carbohydrates, fats and proteins) into energy. Biotin is involved in many cellular reactions, particularly in fat and protein metabolism of hair roots, finger nails, and skin.

The primary sources of vitamin B_7

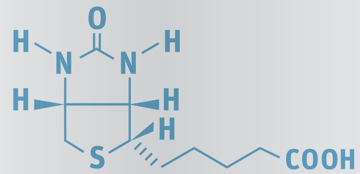
Eggs, milk, vegetables, cereals, nuts (almonds, walnuts, peanuts), liver, kidney, yeast, soybeans.
Other: synthesized by intestinal bacteria.

Bioavailability of vitamin B_7

In foods, biotin is found as the free form or bound to dietary proteins. The bioavailability of biotin depends on the ability of protein enzymes in the stomach to convert protein-bound biotin to free biotin. Biotin is not sensitive to light, heat, or humidity.

Risks related to inadequate or excess intake of vitamin B_7

Experts have yet to quantify the amount of biotin in natural foods. Deficiency due to lack of dietary intake is rare in healthy populations. Symptoms of deficiency include general fatigue, nausea, neurological problems, poor skin and hair quality. No adverse effects have been reported with excessive intakes of biotin.



Vitamin

B$_9$

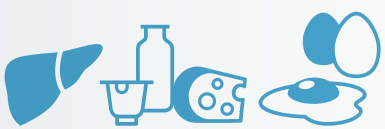
Folate (including folic acid and naturally occurring folates)

Year of discovery: **1941**

Henry Mitchell

Primary natural sources

Animal products



Liver | Dairy products | Egg yolk

Fruit | Vegetable products

Leafy vegetables | Peanuts | Beans | Oranges

Water-soluble

Vitamin B$_9$

Folate

Folate refers to the naturally occurring forms (pteroylglutamic acid) as well as the forms found in fortified foods and supplements (folic acid). Folic acid is the most stable form of folate. The primary function of folate is as a coenzyme, THF (tetrahydrofolate), that transfers single-carbon compounds for DNA synthesis and repair and in energy and amino acid metabolism. Folate and vitamin B$_{12}$ are interconnected in their capacity to donate and receive these single-carbon compounds, which are called methyl groups. For example, THF with a methyl group donates its carbon compound to vitamin B$_{12}$. This action transforms vitamin B$_{12}$ into an active coenzyme, which will in turn catalyze the conversion of homocysteine to methionine. Without vitamin B$_{12}$, folate in its methyl form becomes trapped inside cells, unavailable to support cell growth. Folate is essential for brain development and function.

The primary sources of folate

Dark green leafy vegetables, beans, lentils, asparagus, wheat germ, yeast, peanuts, oranges, strawberries.

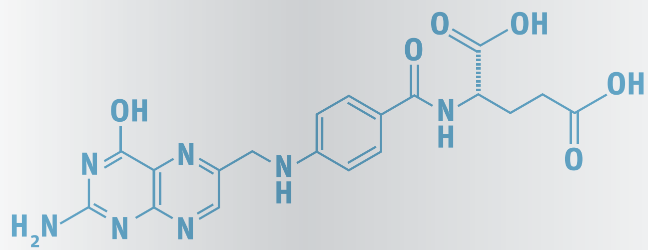
Bioavailability of folate

Folic acid from supplements is 100% bioavailable, if taken without food, and 85% bioavailable when taken with food. Naturally occurring folates in food are 50% bioavailable, but the natural forms are highly unstable. Folate is easily destroyed by heat and oxygen.

Risks related to inadequate intake of folate

Individuals with diets that lack sufficient quantity and variety of green leafy vegetables and legumes are at risk for inadequate folate intake. Folate requirements are increased during pregnancy, especially in the first couple of weeks of gestation. Folate deficiency is highly associated with the risk for neural tube defects in the growing fetus. Thus, women of child-bearing age and pregnant women are advised to meet folate requirements using a combination of natural foods (folate forms) and fortified foods or supplements (folic acid). In many western countries, governments have mandated flours to be fortified with folate.

Because folate is critical for cell growth and repair, especially for cells with a short life span, such as cells in the mouth and digestive tract, visible signs of folate deficiency include digestive problems. Other symptoms are tiredness, loss of appetite, fewer but larger red blood cells (megaloblastic or macrocytic anemia), and neurological problems. A vitamin B$_{12}$ deficiency will provoke a folate deficiency because it means vitamin B$_{12}$ is not available to donate its methyl group to convert folate into its active form.



Vitamin

B_{12}

Cobalamin
Year of discovery: **1926**
George Whipple, George Richards Minot and William Murphy

Primary natural sources

Animal products

Shellfish | Fish | Liver | Meat | Milk | Dairy products

Vitamin B_{12}
Cobalamin

Vitamin B_{12} functions as a coenzyme in the conversion of homocysteine to methionine, in the metabolism of fatty acids and amino acids, and in the production of neurotransmitters. It also maintains a special lining that surrounds and protects nerve fibers, and bone cell activity depends on vitamin B_{12}.

Folate and vitamin B_{12} are closely related. When folate gives up its methyl group to B_{12}, it activates this vitamin.

The primary sources of vitamin B_{12}

Vitamin B_{12} is found only in foods of animal origin, except where plant-based foods have been fortified. Rich sources of vitamin B_{12} include shellfish, liver, game meat (venison and rabbit), some fish (herring, sardines, salmon, trout), milk and milk products.

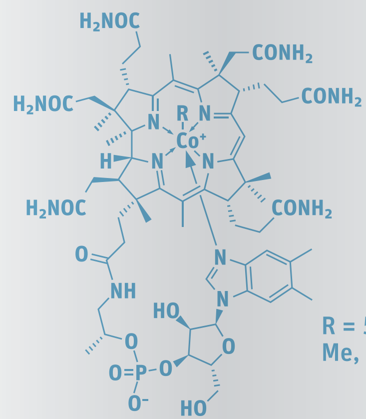
Bioavailability of vitamin B_{12}

While there is insufficient data on the absorption of vitamin B_{12}, experts assume that about 50% of vitamin B_{12} is absorbed by adults with a healthy digestive tract. Inadequate absorption occurs when there is not enough acid in the stomach, or when a protein called intrinsic factor is not produced in the stomach. Conventional cooking methods involving high heat (e.g. microwave) and long cooking times may result in some vitamin B_{12} losses.

Risks related to inadequate or excess intake of vitamin B_{12}

About 10–30% of older adults are estimated to have chronic inflammation of the stomach, a condition that impairs the absorption of vitamin B_{12}. It is advised that older adults consume fortified foods or supplements to meet their vitamin B_{12} requirements. Vegans (individuals who do not consume animal-source foods), who do not take fortified foods or supplements, will develop vitamin B_{12} deficiency. However, it can take several years to develop a vitamin B_{12} deficiency because the body recycles much of its vitamin B_{12} by reabsorbing it over and over again. Infants born to vegan mothers are also at risk for deficiency if their mother's vitamin B_{12} status was low during pregnancy. Vitamin B_{12} requirements are increased for individuals who are HIV-positive with chronic diarrhea.

Symptoms of vitamin B_{12} deficiency include anemia, general fatigue, loss of appetite, gastric atrophy, neuromuscular pain, neurological problems (gait, memory loss). No adverse effects with excessive intakes of vitamin B_{12} have been reported.



R = 5'-deoxyadenosyl, Me, OH, CN

Vitamin

C

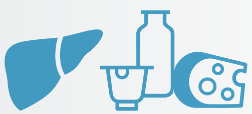
Ascorbic Acid

Year of discovery: **1926**

George Whipple, George Richards Minot and William Murphy

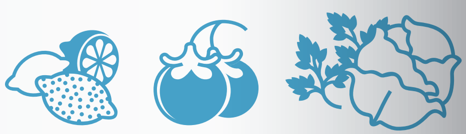
Primary natural sources

Animal products



Liver | Milk | Dairy products

Fruit | Vegetable products



Citrus Fruits | Tomato | Green leafy vegetables

Water-soluble

Vitamin C

Ascorbic Acid

Vitamin C parts company with the B-vitamins in its mode of action. It acts as an antioxidant or as a cofactor, helping a specific enzyme perform its job. High levels of vitamin C are found in pituitary and adrenal glands, eyes, white blood cells, and the brain. Vitamin C has multiple roles - in the synthesis of collagen, absorption of iron, free radical scavenging, and defense against infections and inflammation

The primary sources of vitamin C

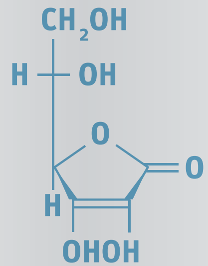
Fruits (especially citrus fruits), cabbage-type vegetables, green leafy vegetables, lettuce, tomatoes, potatoes, and liver (ox /calf).

Bioavailability of vitamin C

Levels of vitamin C in foods depend on the growing conditions, season, stage of maturity, cooking practices, and storage time prior to consumption. Vitamin C is easily destroyed by heat and oxygen. Absorption levels depend on the amounts consumed. About 70–90% of vitamin C is absorbed. If intakes exceed 1000 mg/day, absorption levels drop to 50%.

Risks related to inadequate intake of vitamin C

Individuals who do not consume sufficient quantities of fruits and vegetables are at risk for inadequate intakes of vitamin C. Because smoking generates free radicals, individuals who smoke have elevated requirements for vitamin C. Vitamin C deficiency can cause scurvy; signs of scurvy are bleeding gums, small hemorrhages below the skin, fatigue, loss of appetite and weight, and lowered resistance to infections.



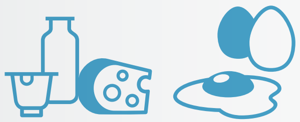
Water-soluble nutrient

Choline

Choline
Year of discovery: **1862**
Adolph Strecker

Primary natural sources

Animal products



Dairy products | Eggs

Fruit | Vegetable products

Peanuts

Choline

Strictly speaking, choline is not a vitamin, but an essential nutrient that is often grouped under the B-vitamins. Although the body can make choline, dietary intake of choline is necessary to meet the body's needs for this nutrient. Choline also acts as a methyl donor. Choline has several functions, including fat and cholesterol metabolism, cell structure and cell integrity, cellular signaling, neurotransmission, and gene expression. In pregnancy, choline is important for brain development of the growing fetus.

The primary sources of choline

Choline can be found in many foods, mainly in milk, eggs and peanuts. It is also part of lecithin, which is used as an emulsifier in food processing.

Bioavailability of choline

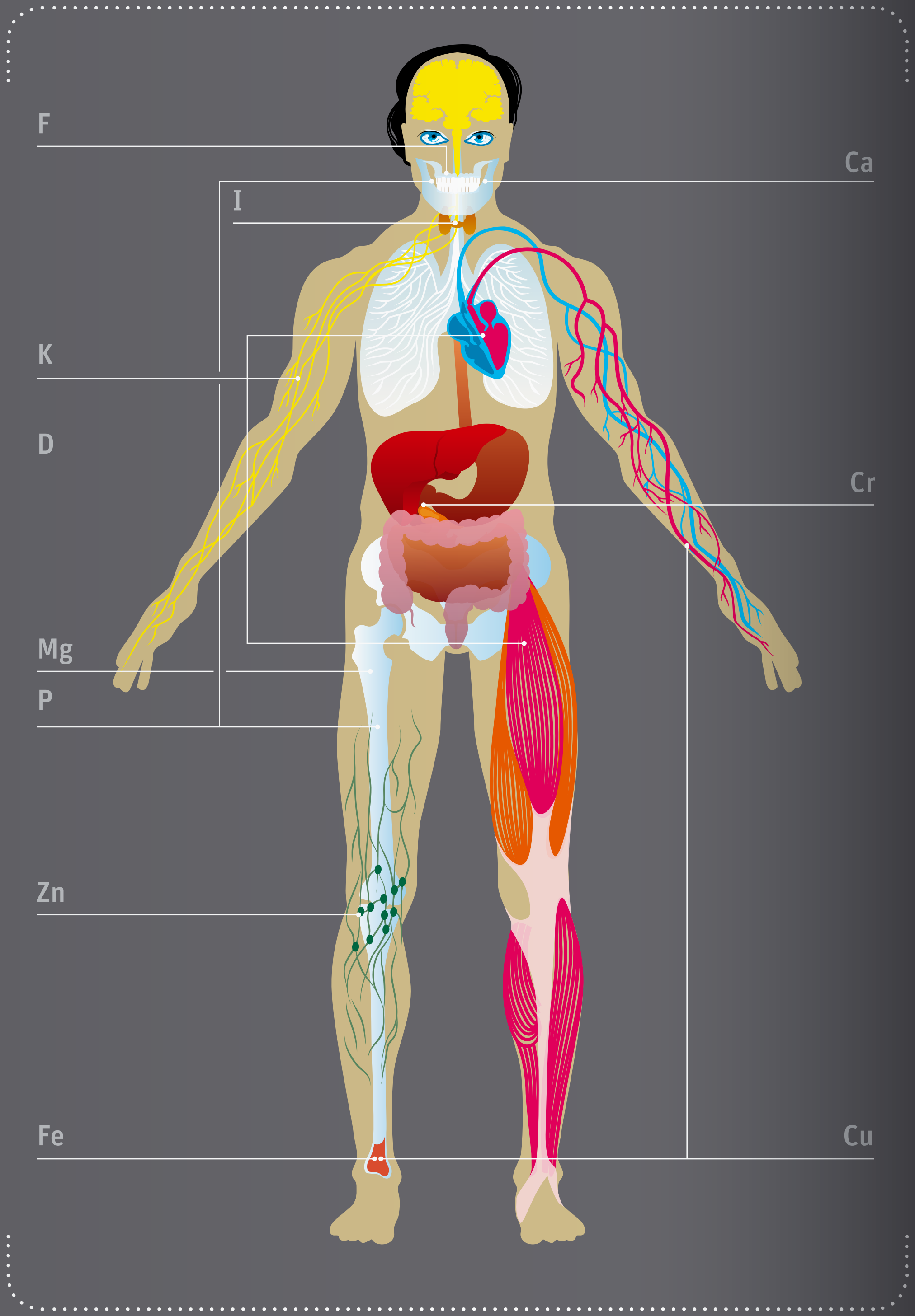
There is no information on bioavailability.

Risks related to inadequate or excess intake of choline

A varied diet should provide enough choline for most people, but strict vegetarians (who consume no milk or eggs) may be at risk of inadequate choline intake. Inadequate intake of choline can lead to liver dysfunction and muscle damage. During pregnancy choline is especially important as it is involved in fetal brain development. There is some data to suggest that maternal choline status might be related to neural tube defects. Choline biosynthesis declines in women during the menopause. Recent research has linked low choline blood levels to an increased risk of stunting (short-for-age) in children from Malawi.

Choline and folate interact at the level where homocysteine is converted to methionine. If the metabolism of one of these methyl donors is disturbed, it disrupts the metabolism of choline.

Excess intake of choline is rare but can result in a fishy body odor, vomiting, salivation, hypotension and liver toxicity.



Minerals and associated body functions

Calcium (Ca)
Bones and teeth

Magnesium (Mg)
Bones, energy metabolism

Phosphorus (P)
Bones, teeth, energy metabolism, genes

Potassium (K)
Nerve and muscle activity, blood pressure

Chromium (Cr)
Metabolizing starches and fat, insulin activity

Copper (Cu)
Energy metabolism, blood formation

Fluoride (Fluorine, F)
Teeth and bones

Iodine (I)
Thyroid function

Iron (Fe)
Blood production

Selenium (Se)
Antioxidant

Zinc (Zn)
Gene expression, immune function

20

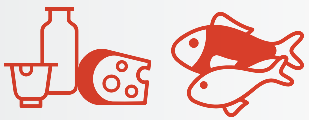
Ca

40.08

Calcium (Atomic number: 20 | Group 2: alkaline earth metal)
Year of discovery: **1808**
Humphrey Davy

Primary natural sources

Animal products



Dairy products | Fish

Fruit | Vegetable products

Green Leafy vegetables

Calcium

Calcium is the most abundant mineral in the body. Ninety-nine percent of the body's calcium is in the bones and teeth. Calcium is an integral part of bone structure, necessary to create a rigid frame to hold the body upright and for movement. Calcium in the bones also serves as a bank from which the body can withdraw calcium to compensate for low intakes. The remaining 1% of the body's calcium is in the body fluids, where it helps regulate blood pressure and muscle movement.

The body needs calcium for healthy bones. Bones are gaining and losing minerals continuously in an ongoing process of remodeling. Calcium forms crystals on a matrix of the protein collagen. This process is called mineralization. During mineralization, as the crystals become denser, they give strength and rigidity to the bones. Most people achieve a peak bone mass by their late 20s, and dense bones best protect against age-related bone loss and fractures. Calcium is important at all life stages, and most especially during periods of linear growth, infancy, childhood and puberty, as well as pregnancy and lactation.

Calcium in the blood helps to maintain normal blood pressure. Calcium is also involved in the regulation of muscle contraction, transmission of nerve impulses, secretion of hormones and activation of some enzyme reactions.

The primary sources of calcium

Milk and milk products, small fish (with bones), calcium-set tofu (bean curd),
and legumes, spinach, Chinese cabbage, kale, broccoli.

Bioavailability of calcium

Calcium absorption by the body is enhanced by the presence of vitamin D and decreased in the presence of oxalic and phytic acid in foods. Thus, foods with high content of calcium that are also rich in oxalic acid (e.g., spinach, sweet potatoes, rhubarb, and beans) or phytic acid (e.g., seeds, nuts, grains) will result in a lower absorption of calcium compared to foods with no inhibitors, such as milk and milk products. Diets high in sodium or phosphorus (e.g., cola beverages) also negatively affect calcium levels in the bone.

Risks related to inadequate intake of calcium

Because calcium is critical to muscle contraction and nerve impulses, the body tightly regulates blood calcium levels. If calcium intake is low, the body will draw on calcium in the bones. Poor chronic intake in calcium results in osteomalacia, in which bones become weak owing to lack of calcium. Insufficient calcium in bones can also result from an inadequate supply of vitamin D, which is essential for absorption of calcium and its deposition in the bones. Thus, adequate calcium and vitamin D intake is vital for bone integrity and for bone growth.

12

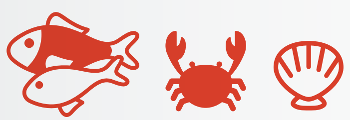
Mg

24.31

Magnesium (Atomic number: 12 | Group 2: alkaline earth metal)
Year of discovery: **1755**
Joseph Black

Primary natural sources

Animal products



Seafood

Fruit | Vegetable products

Dark green vegetables | Nuts | Whole grains

Magnesium

More than half the body's magnesium is found in the bones, where it plays an important role in development and maintenance of bone. Much of the rest of the mineral is found in the muscles and soft tissues, with only 1% in the extracellular fluid. Bone magnesium serves as a reservoir for magnesium to ensure normal magnesium blood concentrations.

Magnesium is involved in more than 300 essential metabolic reactions such as synthesis of our genetic material (DNA/RNA) and proteins, in cell growth and reproduction, and in energy production and storage. Magnesium is important for the formation of the body's main energy compound adenosine triphosphate (ATP). Our cells need ATP for all their processes.

The primary sources of magnesium

Nuts, legumes, whole grains, dark green vegetables, and seafood.

Bioavailability of magnesium

Magnesium absorption will decrease in diets with low intakes of protein. As with calcium, foods high in fiber that contain phytic acid will also decrease absorption of magnesium.

Risks related to inadequate or excess intake of magnesium

Magnesium deficiency in healthy individuals who are consuming a balanced diet is quite rare because magnesium is abundant in both plant and animal foods and the kidneys are able to limit urinary excretion of magnesium when intake is low. Severe magnesium deficiency (hypomagnesemia) can impede vitamin D and calcium homeostasis. Certain individuals are more susceptible to magnesium deficiency, especially those with gastrointestinal or renal disorders, those suffering from chronic alcoholism, and older people.

Magnesium toxicity is rare. The upper limit of magnesium can only be exceeded with non-food sources such as supplements or magnesium salts.

15

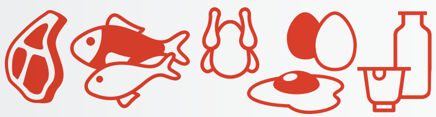
P

30.97

Phosphorus (Atomic number: 15 | Group 15: polyatomic nonmetal)
Year of discovery: **1669**
Hennig Brand

Primary natural sources

Animal products



Meat | Fish | Poultry | Eggs | Milk

Fruit | Vegetable products

Sunflower Seeds

Phosphorus

About 85% of phosphorus in the body is combined with calcium in the bones and teeth. In all body cells, phosphorus is part of a major buffer system (phosphoric acid and its salts). Phosphorus is also part of DNA and RNA, which are essential components of all cells. Phosphorus assists in energy metabolism in the form of adenosine triphosphate (ATP). The ATP molecule uses three phosphate groups to do its work. Many enzymes and the B-vitamins become active only when a phosphate group is attached. Lipids found in the cell walls also use phosphorus. These phospholipids give cells their fluid structure, which is necessary for the transport of compounds into and out of cells.

The primary sources of phosphorus

Phosphorus is found naturally in many foods. Animal-source foods such as meat, fish, poultry, eggs, and milk are excellent sources, as are sunflower seeds.

Bioavailability of phosphorus

Phosphorous is absorbed well from most foods, especially animal-source foods. In plant seeds containing phytic acid/phytate, only 50% of the phosphorus is available for humans. Individuals who consume large amounts of dairy products or cola beverages have higher intakes of phosphorus, which may interfere with calcium metabolism.

Risks related to inadequate intake of phosphorus

Because phosphorus is so widespread in food, dietary phosphorus deficiency is seen mostly in cases of malnutrition, anorexic individuals, or alcoholics. Symptoms of phosphorus deficiency are poor appetite, anxiety, and irritability. In children, phosphorus deficiency may manifest as decreased growth and poor bone and tooth development.

19

K

39.10

Potassium (Atomic number: 19 | Group 1: alkali metals)
Year of discovery: **1807**
Humphrey Davy

Primary natural sources

Animal products

Meat

Fruit | Vegetable products

Tomato | Pumpkin | Leafy Greens | Grains

Potassium

Potassium is the body's principal positively charged ion (cation) inside our cells. Its major role is to keep us alive. Potassium is essential for maintenance of normal fluid and electrolyte balance, enzyme reactions, cell integrity, and muscle contraction. Potassium and sodium are pumped across the cell membrane, a process that drives nerve impulse transmission.

The potassium found in natural, unprocessed foods is often linked to an organic anion (e.g. citrate). Organic anions play an important role in buffering the acids produced by the body in metabolizing meats or protein-rich foods. These acids can demineralize the bone and increase the risk of kidney stones.

The primary sources of potassium

Fruits and vegetables, especially vine fruits (tomato, cucumber, zucchini, eggplant, pumpkin), leafy greens and root vegetables, grains, meat, legumes.

Risks related to inadequate or excess intake of potassium

Moderate potassium deficiency is linked to increases in blood pressure, increased risk of kidney stones, bone demineralization, and stroke. Certain types of diuretics (e.g., thiazide diuretics or furosemide), alcoholism, severe vomiting or diarrhea, overuse or abuse of laxatives, anorexia nervosa or bulimia, magnesium depletion, and congestive heart failure (CHF) are associated with a higher risk for potassium deficiency.

Potassium toxicity does not result from overeating foods high in potassium but can result from overconsumption of potassium salts or supplements (including some protein shakes and energy drinks) and from certain diseases or treatments.

24

Cr

51.99

Chromium (Atomic number: 24 | Group 6: transitional metal)
Year of discovery: **1798**
Louis Nicolas Vauquelin

Primary natural sources

Animal products

Egg yolk

Fruit | Vegetable products

Green beans | Broccoli | Nuts | Whole grains

Chromium

Chromium is an essential mineral that participates in the metabolism of glucose and fats. Like iron, chromium assumes different charges. Cr^{3+} is the most stable form and is commonly found in foods; other Cr charges, like Cr^{6+}, are toxic. Chromium helps maintain blood glucose levels by enhancing the activity of the hormone insulin.

The primary sources of chromium

Chromium is found in egg yolk, whole grains, high-bran cereals, green beans, broccoli, nuts, and brewer's yeast.

Diets rich in simple sugars may actually increase urinary excretion of chromium due to enhanced insulin secretion.

Bioavailability of chromium

The low pH of the stomach enhances chromium availability. Vitamin C enhances chromium absorption.

Risks related to inadequate intake of chromium

Chromium deficiency in humans is very rare. Cases of chromium deficiency have been described in a few patients on long-term intravenous feeding who did not receive supplemental chromium in their intravenous solutions.

29

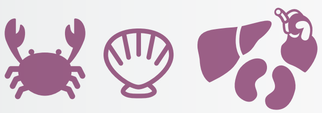
Cu

63.55

Copper (Atomic number: 29 | Group 11: transitional metal)
Year of discovery: **9000 BC**
ns

Primary natural sources

Animal products



Seafood | Organ meats (offal)

Fruit | Vegetable products

Legumes | Nuts | Whole grains

Copper

Copper is a constituent of several enzymes. Copper-dependent enzymes transport iron and load it into hemoglobin, a protein that carries oxygen through the blood. Copper-dependent enzymes release energy from glucose; provide a natural defense against free radicals that damage the body; manufacture collagen (required by skin and bone); inactivate histamine, which is responsible for allergic reactions; and degrade dopamine into a neurotransmitter so cells can “talk” to each other.

The primary sources of copper

Seafood, nuts, whole grains, seeds and legumes, and organ meats (offal).

Bioavailability of copper

Copper absorption depends on copper intake; absorption rates are approximately 50% when intakes <1 mg/day (which is about the recommended intake for adult males). High iron intake may lower the absorption of copper.

Risks related to inadequate or excess intake of copper

Copper deficiency in healthy humans is very rare. However, those at risk for copper deficiency are individuals with a rare genetic disorder, Menke’s disease, and children who are malnourished, those with prolonged diarrhea, or who are fed only cow’s milk. Because copper is needed to transport iron, clinical signs of copper deficiency include anemia. Other clinical signs are osteoporosis and other abnormalities of bone development, loss of pigmentation, neurological symptoms, and impaired growth. Excessive intakes of copper from foods are unlikely.

9

F

18.99

Fluoride (Fluorine) (Atomic number: 9 | Group 17: halogen)
Year of discovery: **1886**
Henri Moissan

Primary natural sources

Animal products

Seafood

Other products

Tea

Fluoride (Fluorine)

Fluoride is present in soils, water supplies, plants and animals. Fluoride is critical for healthy teeth and bones. Only a trace of fluoride is found in the body, but even at these tiny amounts, the crystalline deposits of fluoride result in larger and stronger bones and makes teeth more resistant to decay.

The primary sources of fluoride

Drinking water (if fluoride-containing or fluoridated), tea, seafood (especially if eaten with bones).

Bioavailability of fluoride

Fluoride bioavailability from water and dental products is very close to 100%. Calcium may reduce the absorption of fluoride by 10–25%.

Risks related to inadequate or excess intake of fluoride

In humans, the only clear effect of inadequate fluoride intake is an increased risk of dental caries (tooth decay) for individuals of all ages. Too much fluoride can damage the teeth, causing fluorosis. Teeth develop small white specks and in severe cases the enamel becomes pitted and permanently stained. Fluorosis only occurs during tooth development and cannot be reversed, making its prevention a high priority.

53

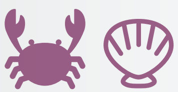
I

126.90

Iodine (Atomic number: 53 | Group 17: halogen)
Year of discovery: **1811**
Bernard Courtois

Primary natural sources

Animal products



Seafood

Other products

Iodized salt

Iodine

Traces of the iodine ion (called iodide) are indispensable to life. Iodide is an integral part of the thyroid hormones that regulate body temperature, metabolic rate, reproduction, growth, blood cell production, nerve and muscle function and more. By controlling the rate at which the cells use oxygen, these hormones influence the amount of energy released when the body is at total rest.
Most (70-80%) of the body's iodine is found in the thyroid.

The primary sources of iodine

Most foods have low iodine content. Iodized salt, seafood, plants grown in iodine-rich soil and animals fed those plants or feed containing iodine are good sources. Some foods may be sources of iodine if iodized salt is used in their preparation (e.g. bread).

Bioavailability of iodine

Normally, the absorption of iodine from foods is very high (>90%). Some foods (e.g., cassava, millet, lima beans, cabbage) contain substances called goitrogens. These substances inhibit the transfer of iodine to the thyroid gland and disrupt the production of thyroid hormones. If foods containing goitrogens are consumed in large quantities, they may limit the absorption and use of iodine by the body. In general, most people can tolerate higher intakes of iodine from food and supplements.

Risks related to inadequate intake of iodine

Iodine deficiency has adverse effects at all stages of development but is most damaging to the developing brain. In addition to regulating many aspects of growth and development, thyroid hormone is important for myelination of the nerves, which is most active before and shortly after birth. Thus during pregnancy, diets deficient in iodine may result in higher risk for mental retardation. Thyroid enlargement, or goiter, is one of the most visible signs of iodine deficiency.

26

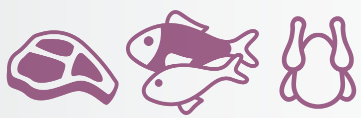
Fe

55.85

Iron (Atomic number: 26 | Group 11: transitional metal)
Year of discovery: **5000 BC**
ns

Primary natural sources

Animal products



Red meats | Fish | Poultry

Fruit | Vegetable products

Legumes | Grains

Iron

Iron's main role is to accept, carry and release oxygen. Most of the body's iron is found in two oxygen-carrying proteins – hemoglobin, a protein found in red blood cells, and myoglobin, which is found in the muscle cells. Iron also serves as a cofactor to enzymes in oxidation/reduction reactions (i.e., accepts or donates electrons). These reactions are vital to cells' energy metabolism.

Iron requirements fluctuate throughout the life course. Iron needs increase during menstruation, pregnancy, and periods of rapid growth such as early childhood and adolescence.

The primary sources of iron

Red meats, fish, poultry, shellfish, eggs, legumes, grains, dried fruits.

Bioavailability of iron

Iron is carefully regulated by the body and absorption rates vary by the size of a person's iron stores. The more iron-deficient a person is, the better the absorption rates. Conversely, in healthy individuals iron absorption shuts down when iron stores have been maximized.

Many factors affect the absorption of iron. Heme iron from animal-source foods is absorbed, on average, twice as well as inorganic iron (from plant sources). The absorption rates for inorganic iron are also influenced by the meal composition and the solubility of the iron form. Factors that enhance absorption of inorganic iron are vitamin C and animal protein. Factors that inhibit inorganic iron absorption include phytates (found in grains), polyphenols (found in teas and red wine), vegetable protein, and calcium (which also affects the absorption of heme iron). Food processing techniques to reduce the phytate content of plant-based foods, such as thermal processing, milling, soaking, fermentation, and germination, improve the bioavailability of inorganic iron from these foods.

Risks related to inadequate intake of iron

A lack of dietary iron depletes iron stores in the liver, spleen and bone marrow. Severe depletion or exhaustion of iron stores can lead to iron deficiency anemia. Certain life-stages require greater iron intake and if these are not met, the risk for iron deficiency is increased. For example, pregnancy demands additional iron to support the added blood volume, growth of the fetus and blood loss during childbirth. Infants and young children need extra iron to support their rapid growth and brain development. Because breast milk is low in iron, infants exclusively fed breastmilk may also be at risk for iron deficiency. Similarly, the rapid growth of adolescence also demands extra iron. Because of iron's role in energy metabolism, depletion of body iron stores may result in reductions of the available energy in the cell. The physical signs of iron deficiency include fatigue, weakness, headaches, apathy, susceptibility to infections, and poor resistance to cold temperatures.

34

Se

78.97

Selenium (Atomic number: 34 | Group 16: polyatomic nonmetal)
Year of discovery: **1817**
Jöns Jacob Berzelius

Primary natural sources

Animal products

Seafood | Meat | Dairy products

Fruit | Vegetable products

Nuts | Mushrooms | Whole grains

Selenium

Selenium is one of the body's antioxidant nutrients, protecting the body against oxidative stress. Oxidative stress is a natural by-product of the body's metabolism. Selenium also regulates thyroid hormone and oxidative reduction reactions of vitamin C. Selenium, along with vitamin E, works to reduce the free radicals that are generated through cellular processes.

The primary sources of selenium

Selenium is found in seafood, meat, whole grains, dairy, fruits, and vegetables. The selenium content in plant food varies according to selenium soil content. Animal-source foods are reliable sources of selenium because selenium is required by animals and thus added to their feed.

Bioavailability of selenium

Selenium from food sources is highly bioavailable.

Risks related to inadequate or excess intake of selenium

Overt selenium deficiency is very rare. Some endemic diseases in parts of Russia and China such as Keshan and Kashin-Beck disease are related to low selenium intakes. Individuals at risk for low selenium intakes are vegans who eat foods grown in low-selenium areas. Selenium is toxic in high doses and causes loss and brittleness of hair and nails, garlic breath odor and nervous system abnormalities.

30

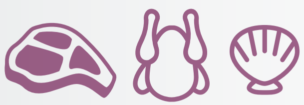
Zn

65.38

Zinc (Atomic number: 30 | Group 12: transitional metal)
Year of discovery: **1746**
Andreas Marggraf

Primary natural sources

Animal products



Meat | Poultry | Shellfish

Fruit | Vegetable products

Legumes | Mushrooms | Whole grains

Zinc

Almost all cells contain zinc and it is a vital nutrient for growth and development. The highest concentrations are found in muscle and bone. The body tightly regulates zinc levels. Stress and infections cause plasma zinc levels to fall.

Zinc participates in a variety of catalytic, regulatory, and structural functions. Zinc is a catalyst for about 100 enzymes. It is important in the structure of cell transport proteins such as vitamins A and D. Zinc regulates gene expression; stabilizes cell membranes, helping to strengthen their defense against oxidative stress; assists in immune function; participates in the synthesis, storage, and release of insulin; interacts with platelets in blood clotting; and influences thyroid hormone function. It is necessary for visual pigments; normal taste perception; wound healing; sperm production; fetal development; and behavior and learning performance.

The primary sources of zinc

Meats, some shellfish, legumes, whole grains, and some fortified cereals.

Bioavailability of zinc

Like iron, zinc absorption will depend on the zinc body pool, with those having poorer zinc status able to absorb zinc more efficiently in the gut. Foods rich in phytate lead to previously absorbed zinc being lost in the feces. High intakes of calcium, phosphorus, or iron also decrease the absorption of zinc. Protein may enhance absorption of zinc.

Risks related to inadequate intake of zinc

Individuals consuming unprocessed or minimally processed diets consisting of unrefined whole grains or unleavened whole bread and little animal-source foods are at greater risk for zinc deficiency. Zinc needs are higher in periods of growth and development, such as infancy, childhood, pregnancy and lactation. Zinc deficiency can occur even with only modest restrictions to zinc intake. Impaired growth velocity is the main clinical feature of zinc deficiency. Immune system functions and pregnancy outcomes improve with zinc supplementation. For example, zinc is often given as an adjunct therapy for diarrhea.

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