

Module 3

Micronutrients: Vitamins & Minerals

Module coverage



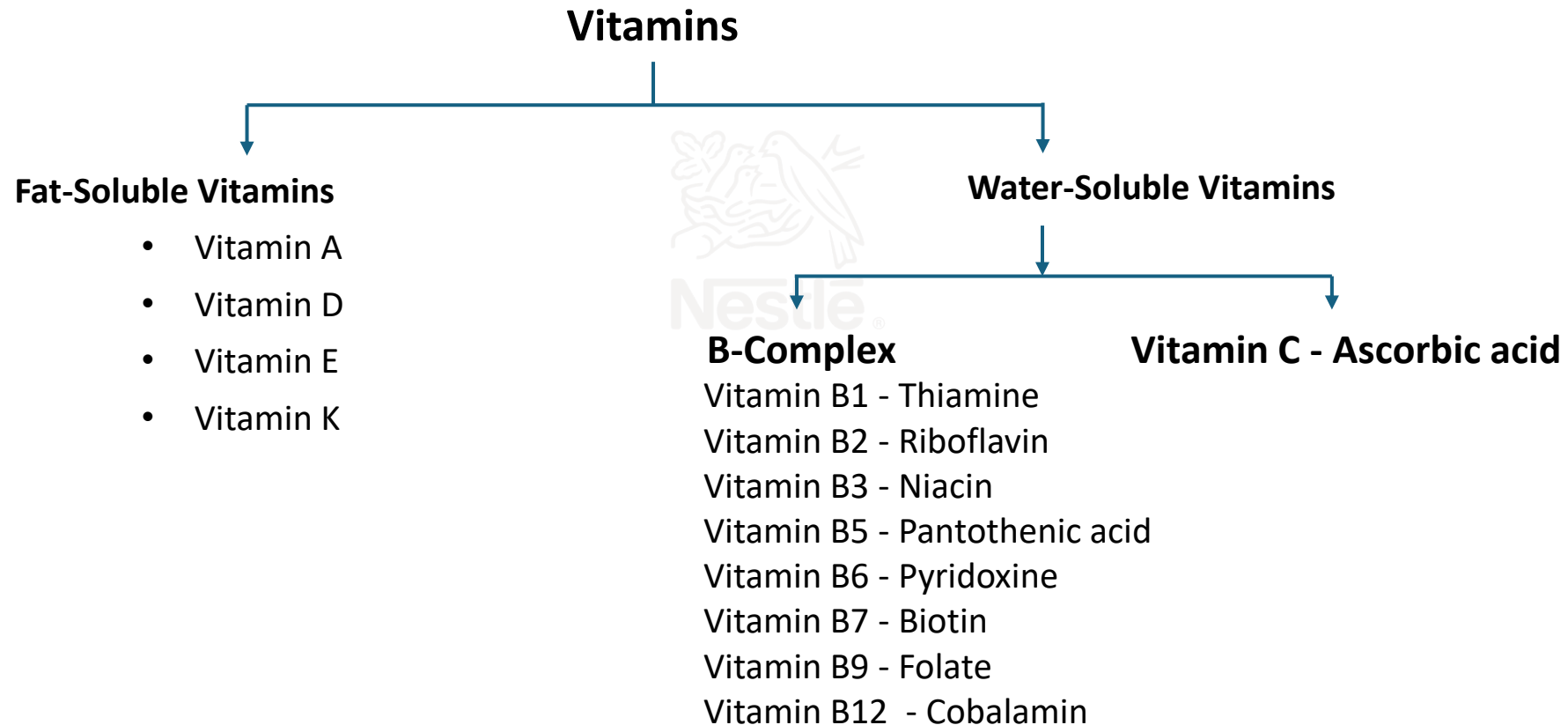
Topic	Sub-topics covered	Learning objectives
Micronutrients: Vitamins and minerals.	• Vitamins: Types, function, sources, and deficiency. • Minerals: Types, function, sources, and deficiency.	✓ Clarity regarding the role of specific nutrients in the body, their food sources and effect of deficiency.

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Vitamins

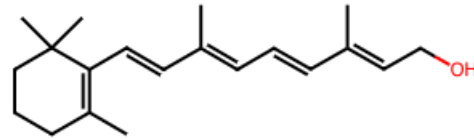
Types

Vitamins are defined as a group of complex organic micronutrients present in small amounts in food or nutritional supplements that the body requires for its normal metabolism and function.



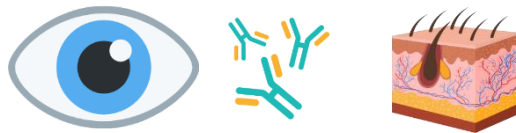
Fat-soluble vitamins: Vitamin A

Vitamin A plays a critical role in vision in dim light, in the retina of the eye. [33]



Vitamin A - Retinol

Functions:



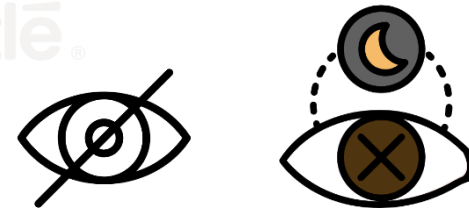
Vision, immunity and skin maintenance

Sources:



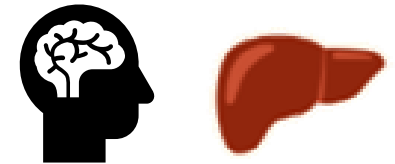
Carrots, papaya, mangoes, spinach, drumstick leaves, liver

Deficiency:



Night blindness;
Xerophthalmia

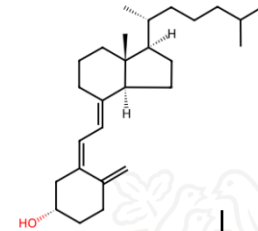
Excess Intake:



Hypervitaminosis A
(headache, liver damage)

Fat-soluble vitamins: Vitamin D

In humans, the ultraviolet rays of sunlight, with a wavelength of 290-315nm, initiate the photoconversion of provitamin D3, 7-dehydrocholesterol, to pre vitamin D3 in the skin. [33]



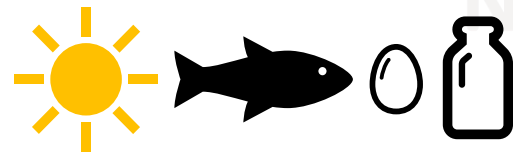
Vitamin D

Functions:



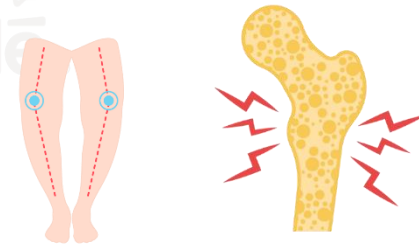
Bone health, and calcium absorption.

Sources:



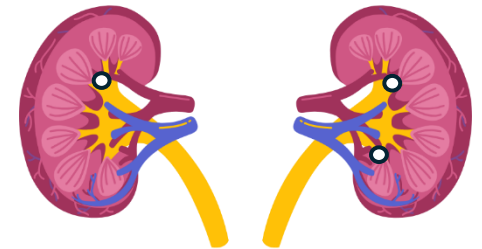
Sunlight, fish (rohu, sardines), egg yolk, and fortified milk

Deficiency:



Rickets and osteomalacia

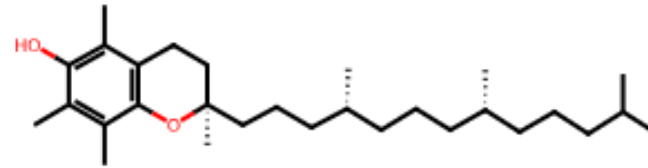
Excess Intake:



Hypercalcemia (kidney stones)

Fat-soluble vitamins: Vitamin E

Vitamin E is a fat-soluble vitamin. Hence, it is able to mix and protect lipids from oxidation. [33]



Vitamin E - Tocopherol

Functions:



Antioxidant, supports immune function and maintains healthy skin and hair.

Sources:



Vegetable oils (sunflower, safflower, soybean), nuts, seeds (sunflower, sesame) and leafy green vegetables (spinach, kale).

Deficiency:



Nerve damage, muscle weakness and vision problems.

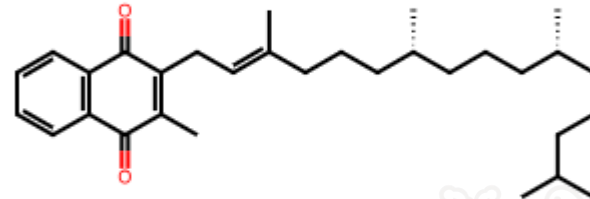
Excess Intake:



Fatigue, headache, muscle weakness; Bleeding occurs only when there is an excess intake of anticoagulant combinations.

Fat-soluble vitamins: Vitamin K

A well-known function of Vitamin K is its use by the liver in the synthesis of various substances needed for blood clotting. [33]



Vitamin K - Phylloquinone

Functions:



Blood clotting (coagulation), bone health (calcium regulation and bone mineralization), and cardiovascular health.

Sources:



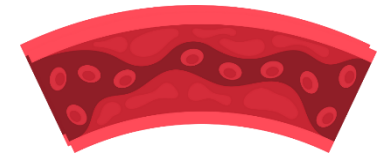
Leafy green vegetables, vegetable oils (soybean oil, canola oil), dairy products and fermented foods.

Deficiency:



Excessive bleeding or bruising.
Weak bones (osteoporosis);
Risk of haemorrhage.

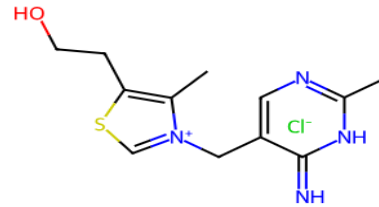
Excess Intake:



Can promote thrombogenesis and hemolysis.

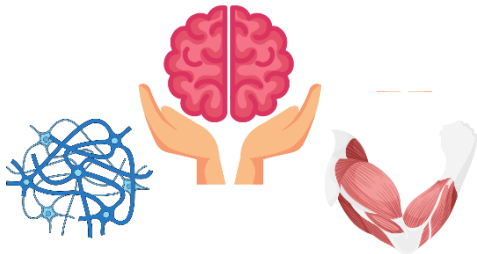
Water-soluble vitamins: Vitamin B1 (Thiamine)

Thiamine is involved in the transmission of high frequency impulses across nerve synapses. [33]



Vitamin B1 - Thiamine

Functions:



Energy production, supporting nerve function, brain health and muscle function.

Sources:



Whole grains, fortified cereals, legumes (beans, lentils), nuts, seeds, fortified cereals, meat.

Deficiency:



Beriberi (weakness, fatigue, heart problems) and Wernicke-Korsakoff syndrome (confusion, memory loss).

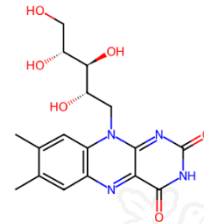
Excess Intake:



Generally considered safe, but high doses may cause allergic reactions.

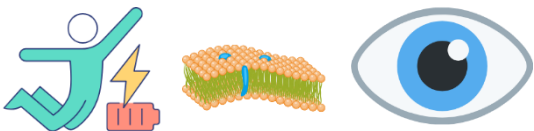
Water-soluble vitamins: Vitamin B2 (Riboflavin)

Riboflavin occurs in food in three forms: Riboflavin itself, Flavin Mononucleotide (FMN), and Flavin Adenine Dinucleotide (FAD), the coenzyme forms of the vitamin. All three forms can help meet the body's requirements. [33]



Vitamin B2 - Riboflavin

Functions:



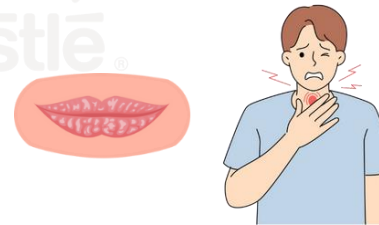
Energy production, maintaining health of skin/mucous membranes and eyes

Sources:



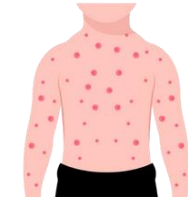
Dairy products, leafy green vegetables (spinach, kale), whole grains, eggs and organ meat

Deficiency:



Ariboflavinosis (cracks in the corners of the mouth, sore throat, skin rash).

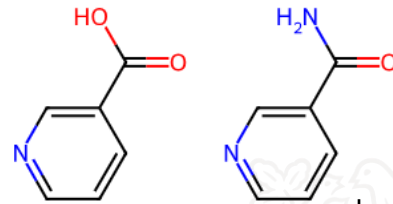
Excess Intake:



Generally considered safe, but high doses may cause urine to become yellow.

Water-soluble vitamins: Vitamin B3 (Niacin)

Niacin partners with riboflavin in the cellular coenzyme systems that convert protein and glycerol from fats to glucose and that oxidize glucose to release controlled energy. [33]



Vitamin B3 - Niacin

Functions:



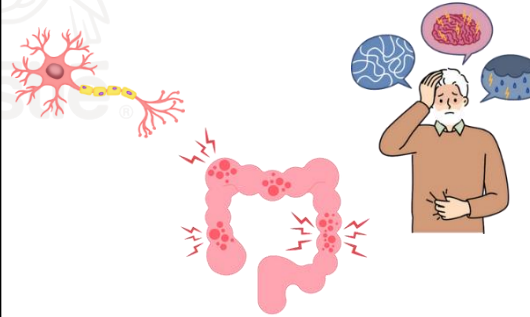
Energy production, healthy skin and nerves and cholesterol reduction (high doses).

Sources:



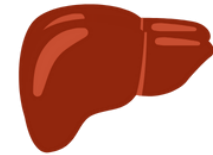
Meat (chicken, beef, pork), fish, legumes, peanuts and enriched bread/cereals.

Deficiency:



Pellagra - rough skin, diarrhoea, dementia.

Excess Intake:

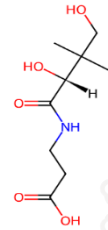


Flushing (redness and warmth of the skin) and Liver damage.

Water-soluble vitamins: Vitamin B5 (Pantothenic acid)

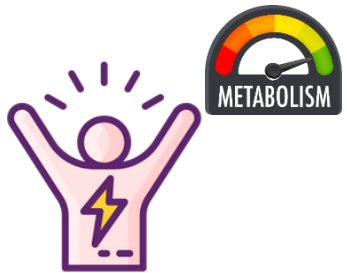


The coenzyme form of pantothenic acid is required for the synthesis of cholesterol, steroid hormones, Vitamin A , Vitamin D and all compounds formed from isoprenoid units. [33]



Vitamin B5 – D-Pantothenic acid

Functions:



Energy production, metabolism, and synthesis of coenzyme A (CoA).

Sources:



Broccoli, sweet potatoes, egg yolk, and milk.

Deficiency:



Decreased metabolism, muscle cramp, and sleep disturbance.

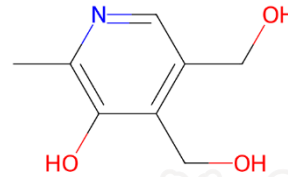
Excess Intake:



Overdosage might cause diarrhea, stomach trouble, headache, excessive stress.

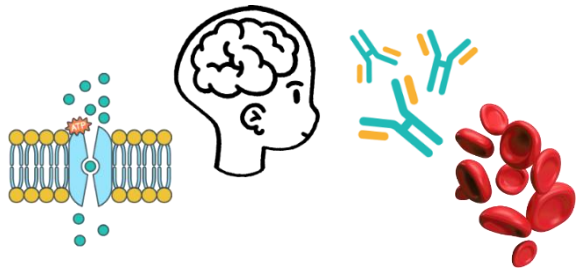
Water-soluble vitamins: Vitamin B6 (Pyridoxine)

Pyridoxine is the predominant form of vitamin present in plant foods, whereas in animal foods the major form is pyridoxal and pyridoxal phosphate. [33]



Vitamin B6 – Pyridoxine

Functions:



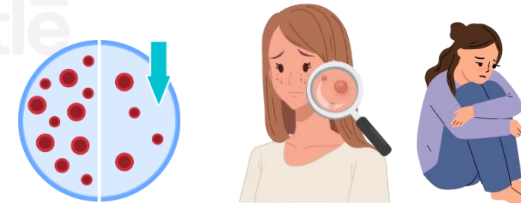
Protein metabolism, brain development, immune function and red blood cell production.

Sources:



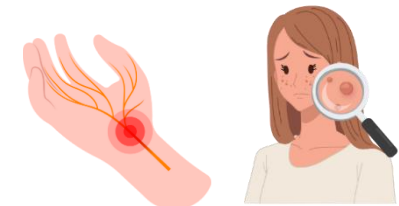
Meat, potatoes, bananas, legumes and fortified cereals.

Deficiency:



Anaemia, skin problems, nerve damage and depression.

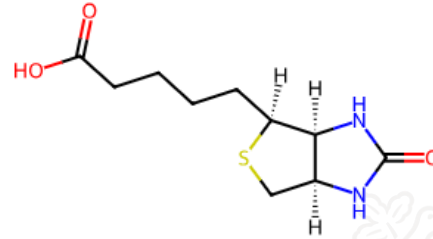
Excess Intake:



Nerve damage and skin problems.

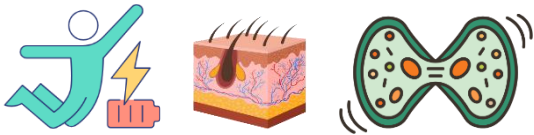
Water-soluble vitamins: Vitamin B7 (Biotin)

Biotin deficiency does not occur in human except under extraordinary circumstances. [33]



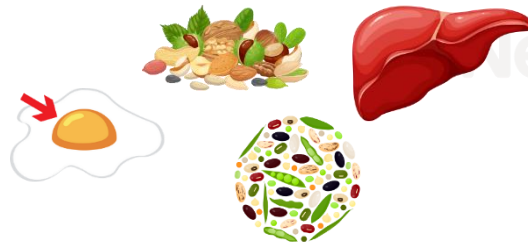
Vitamin B7 - Biotin

Functions:



Energy production, healthy hair, skin and cell growth.

Sources:



Egg yolks, nuts, legumes, whole grains and liver.

Deficiency:



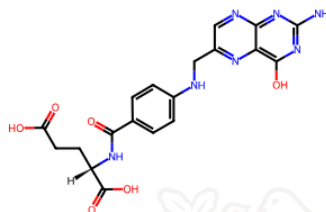
Skin rash, hair loss, fatigue and muscle aches.

Excess Intake:

No adverse effect was identified for excess intake

Water-soluble vitamins: Vitamin B9 (Folate)

Folic acid is required for the normal growth and division of all cells.^[33]



Vitamin B9 – Folic acid

Functions:



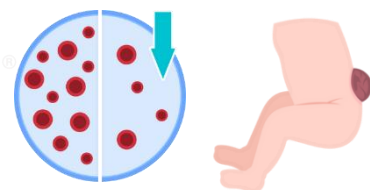
Cell growth and development, red blood cell production, and prevents neural tube defects in developing fetuses.

Sources:



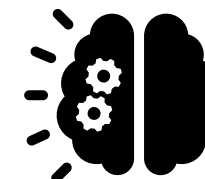
Leafy green vegetables (spinach, kale), legumes, citrus fruits and fortified cereals.

Deficiency:



Anemia, and neural tube defects (in developing fetuses).

Excess Intake:



May mask a Vitamin B12 deficiency. Could have adverse health outcomes in the elderly concerning anemia and cognitive health.

Vitamin B12, like folate, is involved in biochemical processes essential for DNA synthesis and, therefore, for the growth and division of cells.^[33]

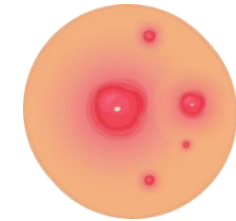


Sources:



Animal products (meat, poultry, fish, eggs, dairy), fortified plant-based milk and cereals.

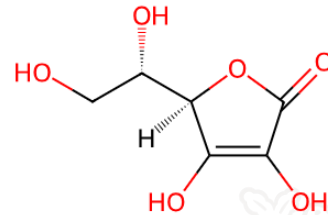
Excess Intake:



Generally considered safe, but high doses may cause acne.

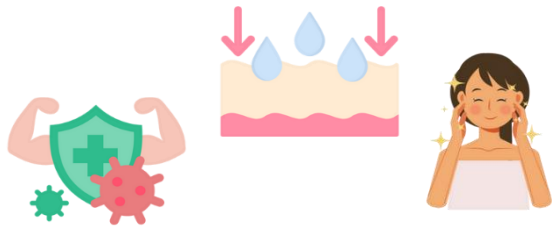
Water-soluble vitamins: Vitamin C

Vitamin C is susceptible to oxidation because it acts as a reducing agent, functioning in the body as an antioxidant.^[33]



Vitamin C – Ascorbic acid

Functions:



Antioxidant function, immune function, absorption of non-heme iron and skin maintenance.

Sources:



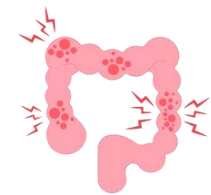
Orange, citrus fruits and tomato.

Deficiency:



Scurvy and petechiae (small, pinpoint bleeding spots under the skin).

Excess Intake:



Diarrhea, nausea, and abdominal cramps.

RDA: Fat soluble vitamins



The NIN expert committee suggests adequate outdoor activity with exposure to sunlight for vitamin D and at least 50% of the vitamin A requirement to be met from animal sources.^[8]

Summary of Recommended Dietary Allowances (RDA) of Nutrients For Indians, 2024

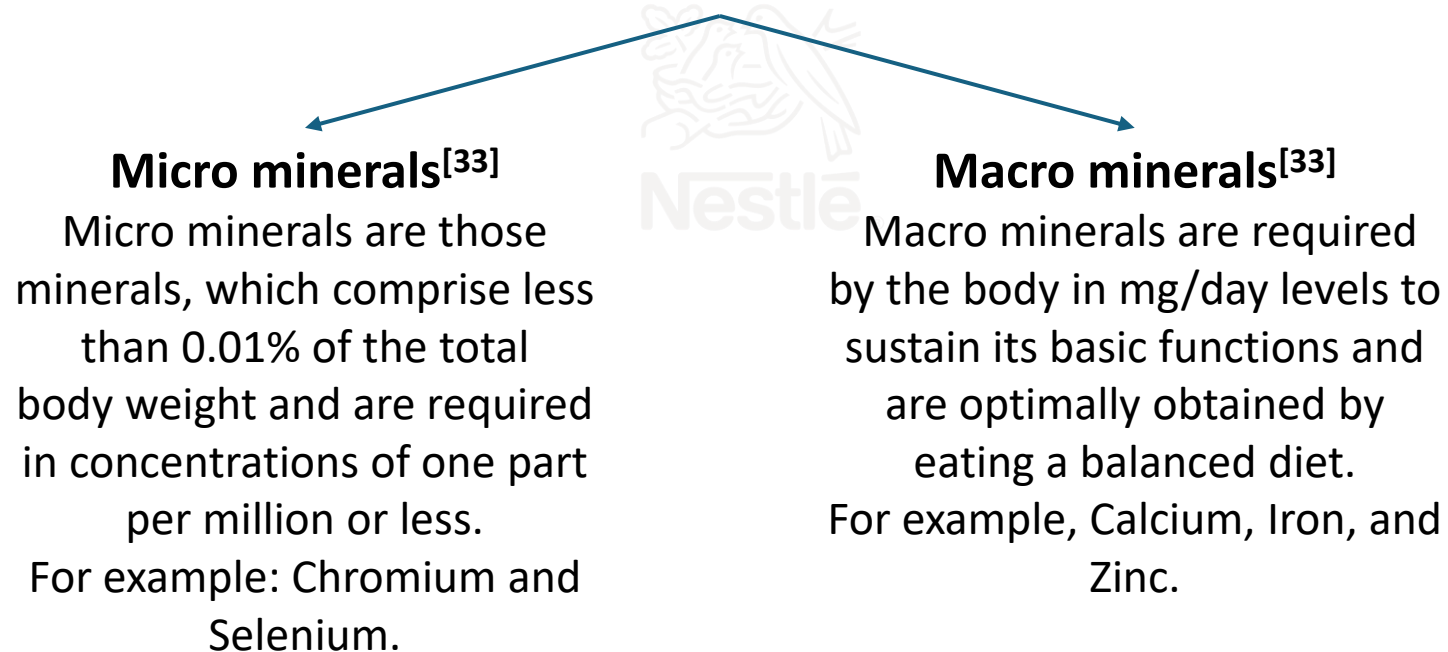
Category/ Age group	Physical activity	Vitamin A	Vitamin D
		(µg/d)	(IU/d)
Adult Men >18y	Sedentary	1000	600
Adult Men >18y	Moderate	1000	600
Adult Men >18y	Heavy	1000	600
Adult Women >18y	Sedentary	840	600
Adult Women >18y	Moderate	840	600
Adult Women >18y	Heavy	840	600
Pregnant women **	-	900	600
Pregnant women **	-	900	600
Lactation 0-6m	-	950	600
Lactation 7-12m	-	950	600

Module 3 Minerals

Minerals and their types

Minerals

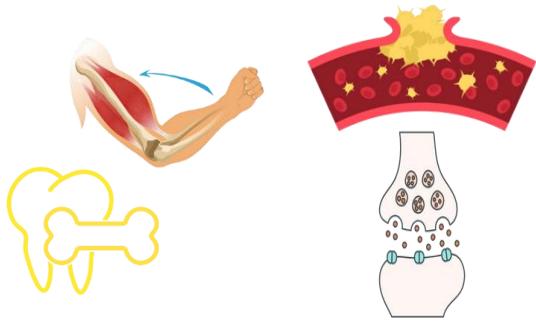
A mineral is a solid, homogeneous, crystalline chemical element or compound that results from an inorganic process of nature.



Minerals: Calcium

Calcium does help in bone growth and bone health. Calcium is not useful in isolation – vitamin D, phosphorus, sodium, magnesium and several trace elements are involved in calcium absorption and resorption^[53].

Functions:



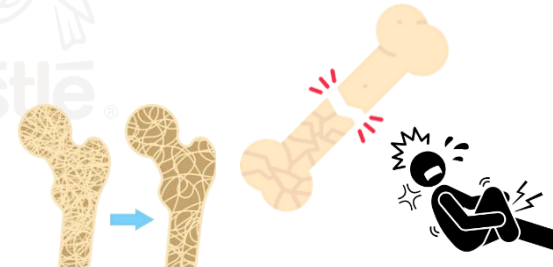
Strong bones and teeth, muscle contraction/relaxation, nerve transmission and blood clotting.

Sources:



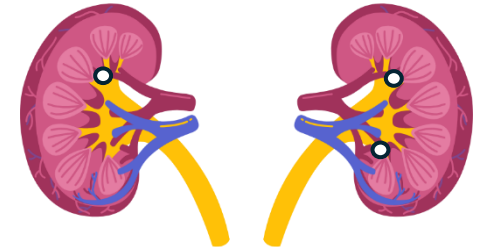
Dairy products (milk, yogurt, cheese), leafy green vegetables (spinach, kale), almonds and sesame seeds, and fortified foods (like plant-based milk).

Deficiency:



Osteoporosis (weak bones), Muscle cramps and irregular heartbeat.

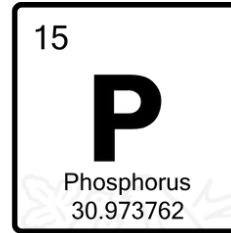
Excess Intake:



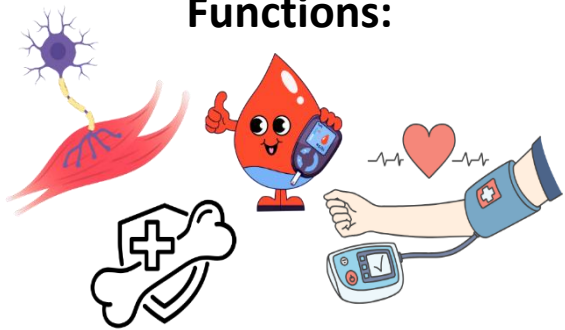
Kidney stones and constipation.

Minerals: Phosphorus

Phosphorus, present in food as inorganic or organic, is 40–60% absorbable from the gut lumen except myo-inositol hexaphosphate (phytate). ^[54]



Functions:



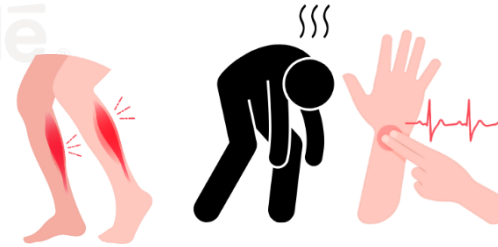
Muscle and nerve function, blood sugar control, blood pressure regulation and strong bones.

Sources:



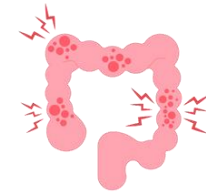
Leafy green vegetables (spinach, kale), nuts (almonds, cashews), seeds (pumpkin, sunflower), whole grains and legumes.

Deficiency:



Muscle cramps, weakness, fatigue and irregular heartbeat.

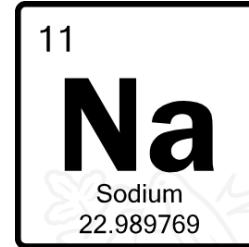
Excess Intake:



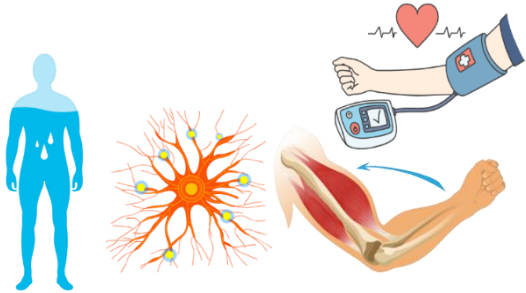
Diarrhea, Muscle weakness and Nausea.

Minerals: Sodium

Sodium is easily absorbed in the gut and helps control body fluid levels and blood pressure through its water-balancing effect.^[55]



Functions:



Fluid balance, nerve impulses and muscle contractions.

Sources:



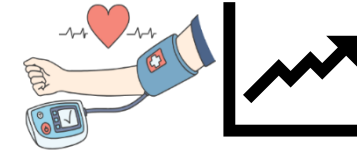
Table salt. Green olive

Deficiency:



Muscle cramps, fatigue and nausea.

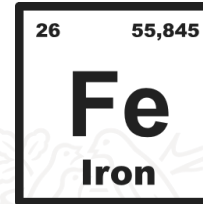
Excess Intake:



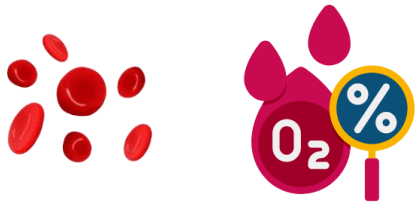
High blood pressure, increased risk of heart disease and stroke.

Minerals: Iron

Iron is an essential component of hemoglobin. Oral absorption of iron occurs in the duodenum and is highly dependent upon its oxidation state, with many absorption influencers possibly interfering with the intestinal uptake.^[56]



Functions:



Red blood cell production, and oxygen transport.

Sources:



Meat (red meat, poultry, fish), leafy green vegetables (spinach, kale), legumes and fortified cereals.

Deficiency:



Anemia (fatigue, weakness, shortness of breath).

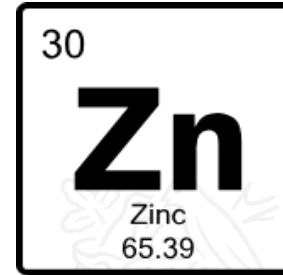
Excess Intake:



Iron overload (liver damage, heart problems) and hemochromatosis.

Minerals: Zinc

Zinc deficiency leads to complications of pregnancy and childbirth, low birth weight and poor growth in childhood, reduced immunocompetence, and increased infectious disease morbidity.^[57]



Functions:



Immune function, wound healing, growth/ development, taste and smell.

Sources:



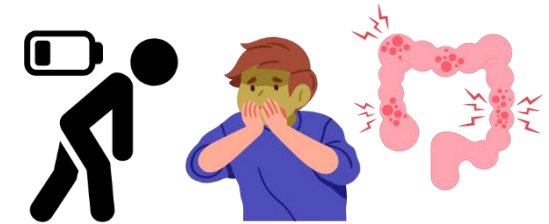
Meat (red meat, poultry, fish), legumes, nuts/seeds, dairy products.

Deficiency:



Growth retardation, delayed wound healing and hair loss and loss of appetite.

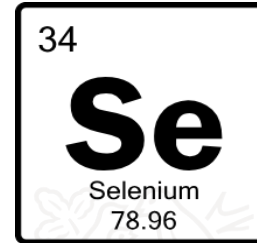
Excess Intake:



Nausea, vomiting and diarrhea.

Minerals: Selenium

Food content of selenium is influenced by geographical location, seasonal changes, protein content and food processing.^[59]



Functions:



Antioxidant protection, thyroid hormone function and immune function.

Sources:



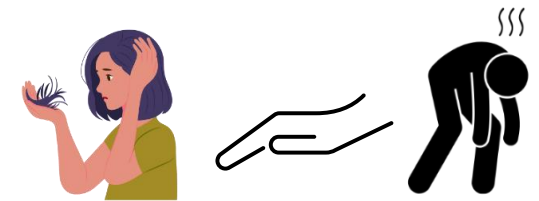
Meat/seafood, mushrooms, whole grains and eggs.

Deficiency:



Thyroid problems: fatigue, weight gain, and muscle weakness.

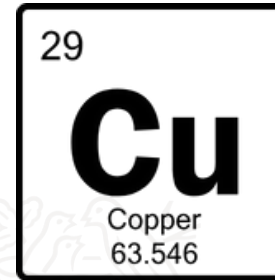
Excess Intake:



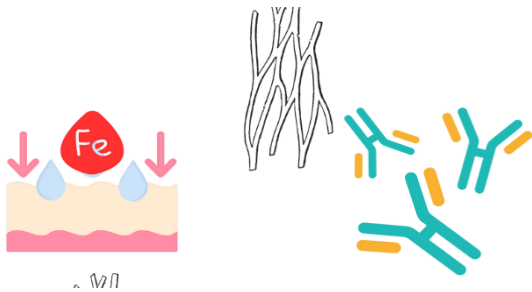
Hair loss, nail changes and fatigue.

Minerals: Copper

The primary physiological function of copper acts as a redox catalyst (a reduction and oxidation reaction involving electron transfer) in various metabolic reactions.^[59]

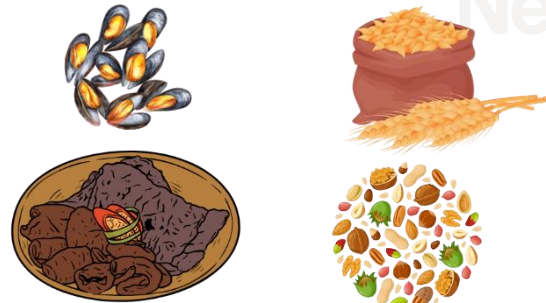


Functions:



Iron absorption, energy production, connective tissue formation, and immune function.

Sources:



Organ meats (liver), shellfish, nuts and seeds and whole grains.

Deficiency:



Anemia, fatigue and weakness.

Excess Intake:



Liver damage, nausea and vomiting.

Minerals: Iodine

Exposure to environmental pollutants and ingestion of certain dietary substances (goitrogens) can interfere with iodine uptake into the thyroid.^[60]

53



Iodine
126.90447

Functions:



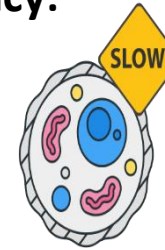
Thyroid hormone production.

Sources:



Iodized salt, seafood, and dairy products

Deficiency:



Goitre (enlarged thyroid gland) and hypothyroidism (slow metabolism).

Excess Intake:



Thyroid dysfunction, both hyperthyroidism (overactive), hypothyroidism and thyrotoxicosis.

RDA: Vitamins & Minerals



Summary of Recommended Dietary Allowances (RDA) of Nutrients For Indians, 2024														
Category/ Age group	Calcium	Magnesium	Iron	Zinc	Iodine	Thiamine	Riboflavin	Niacin	Vitamin B6	Folate	Vitamin B12	Vitamin C	Vitamin A	Vitamin D
	(mg/ d)	(mg/d)	(mg/d)	(mg/d)	(µg/d)	(mg/d)	(mg/d)	(mg/d)	(mg/d)	(µg/d)	(µg/d)	(mg/d)	(µg/d)	(IU/d)
Infants 0-6m	300.0	30.0	-	-	100.0	0.2	0.4	2.0	0.1	25.0	1.2	20	350	400
Infants 6-12m	300.0	75.0	3.0	2.5	130.0	0.4	0.6	5.0	0.6	85.0	1.2	30	350	400
Children 1-3y	500.0	90.0	8.0	3.3	90.0	0.7	1.1	7.0	0.9	120.0	1.2	30	390	600
Children 4-6y	550.0	125.0	11.0	4.5	90.0	0.9	1.3	9.0	1.2	135.0	2.2	35	510	600
Children 7-9y	650.0	175.0	15.0	5.9	90.0	1.1	1.6	11.0	1.5	170.0	2.2	45	630	600
Boys 10-12y	850.0	240.0	16.0	8.5	100.0	1.5	2.1	15.0	2.0	220.0	2.2	55	770	600
Girls 10-12y	850.0	250.0	28.0	8.5	100.0	1.4	1.9	14.0	1.9	225.0	2.2	50	790	600
Boys 13-15y	1000.0	345.0	22.0	14.3	140.0	1.9	2.7	19.0	2.6	285.0	2.2	70	930	600
Girls 13-15y	1000.0	340.0	30.0	12.8	140.0	1.6	2.2	16.0	2.2	245.0	2.2	65	890	600
Boys 16-18y	1050.0	440.0	26.0	17.6	140.0	2.2	3.1	22.0	3.0	340.0	2.2	85	1000	600
Girls 16-18y	1050.0	380.0	32.0	14.2	140.0	1.7	2.3	17.0	2.3	270.0	2.2	70	860	600
Men ≥60y	1200.0	440.0	19.0	17.0	140.0	1.4	2.0	14.0	1.9	300.0	2.2	80.0	1000	800
Women ≥60y	1200.0	370.0	19.0	13.2	140.0	1.4	1.9	11.0	1.9	200.0	2.2	65.0	840	800

Phytonutrients



Phytonutrients are also called phytochemicals, the compounds produced by plants that provide health benefits to the body when consumed. For example: Carotenoids, Flavonoids, Isoflavones.^[62]

Carotenoids

They are yellow, orange, and red pigments synthesized by plants. The most common carotenoids in Indian diets are β -carotene and lycopene.^[63] Lutein and Zeaxanthin are some examples.

Flavonoids

Polyphenolic compounds occur naturally in fruits, vegetables, chocolates, and beverages such as wine and tea. Tea, coffee, apples, guava, fenugreek seeds, mustard seeds, cinnamon, red chilli powder, cloves, and turmeric contain high levels of flavonoids (over 100 mg per 100 g). Moderate amounts (50–100 mg per 100 g) are present in Indian gooseberry, cumin, cardamom, and betel leaf.^[64]

Isoflavones

A type of phytoestrogen, a plant compound that structurally resembles human estrogen, is found in soy (soy isoflavones) and some other foods like Bengal gram. Bengal gram has a high isoflavone content (152 mg/100g).^[65]

Source: 62) <https://www.nal.usda.gov/human-nutrition-and-food-safety/food-composition/phytonutrients>

63) <https://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals/carotenoids#introduction>

64) <https://pmc.ncbi.nlm.nih.gov/articles/PMC7211351/>

65) <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/isoflavone>

Conclusion



- Vitamins are essential micronutrients needed in small amounts for various bodily functions, and they are broadly classified as either fat-soluble (A, D, E, K) or water-soluble (B vitamins, C).
- Most vitamins need to come from food because the body either does not produce them or produces very little. For example, vitamin D synthesized in the body when exposed to sunlight is inadequate and hence needs to be supplemented through the diet.
- Vitamin A, D, E, Iron, Iodine and folic acid are key nutrients in large-scale food fortification programs.
- Maintaining mineral balance in the body is essential since both deficiency and excess may cause health issues.
- The following recommendations are made to maintain vitamin and mineral balance in the body
 - Balanced Diet: Includes fruits and vegetables in the diet.
 - Supplements: Use with caution and only when needed. In addition, consult a health professional before intake.

Module 4 Hydration