MINERAL DEFICIENCY IN MAN

INTRODUCTION

Dietary minerals are chemical elements required by living organisms. They can be either bulk minerals (required in relatively large amounts) or trace minerals (required only in very small amounts).

Appropriate intake levels of each dietary mineral must be sustained to maintain physical health. Excessive intake of a dietary mineral may either lead to illness directly or indirectly because of the competitive nature between mineral levels in the body. For example, large doses of zinc are not really harmful unto them, but will lead to a harmful copper deficiency (unless compensated for, as in the Age-Related Eye Disease Study).

The body needs various minerals for health. Inadequate diet can lead to mineral deficiency, or at least to insufficient minerals. Some of the more common deficiencies are iron deficiency, iodine deficiency, and calcium deficiency. Iron is needed by the blood and iron deficiency leads to anemia and various other symptoms. Iodine deficiency leads to goitre, but is less common in industrialized nations due to the addition of iodine to table salt. The body needs calcium for bones and other purposes. Calcium deficiency or at least an inadequate intake of calcium can be implicated in osteoporosis and other diseases.

Soils in different geographic areas contain varying quantities of minerals.

ESSENTIAL MINERALS FOR MAN

Some sources state that sixteen chemical elements are *required* to support human biochemical processes by serving structural and functional roles as well as electrolytes: However, as many as 26 elements in total (including the common hydrogen, carbon, nitrogen and oxygen) are suggested to be used by mammals, as a result of studies of biochemical, special uptake, and metabolic handling studies. However, many of these additional elements have no well-defined biochemical function known at present. Most of the known and suggested dietary elements are of relatively low atomic weight, and are reasonably common on land, or at least, common in the ocean (iodine, sodium).

In humans the most important dietary minerals are:

- Chromium
- Copper
- Fluorine
- Iodine
- Iron
- Magnesium
- Manganese
- Molybdenum
- Potassium
- Selenium
- Zinc

Secondary dietary minerals are defined below. Not all have been definitively established as essential to human nutrition:

- Arsenic
- Bismuth
- Boron
- Nickel
- Rubidium
- Silicon
- Strontium
- Tellurium
- Titanium
- Tungsten
- Vanadium

PERIODIC TABLE HIGHLIGHTING DIETARY ELEMENTS

H																		**He**
Li	**Be**												**B**	**C**	**N**	**O**	**F**	**Ne**
Na	**Mg**												**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
K	**Ca**		**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Ge**	**As**	**Se**	**Br**	**Kr**
Rb	**Sr**		**Y**	**Zr**	**Nb**	**Mo**	**Tc**	**Ru**	**Rh**	**Pd**	**Ag**	**Cd**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
Cs	**Ba**	*****	**Lu**	**Hf**	**Ta**	**W**	**Re**	**Os**	**Ir**	**Pt**	**Au**	**Hg**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
Fr	**Ra**	******	**Lr**	**Rf**	**Db**	**Sg**	**Bh**	**Hs**	**Mt**	**Ds**	**Rg**	**Cn**	**Uut**	**Fl**	**Uup**	**Lv**	**Uus**	**Uuo**
			*****	**La**	**Ce**	**Pr**	**Nd**	**Pm**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	
			******	**Ac**	**Th**	**Pa**	**U**	**Np**	**Pu**	**Am**	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	

The four organic basic elements	Quantity elements	Essential trace elements	Suggested function from biochemistry and handling but no identified biological function in humans

ROLE OF MINERALS IN HUMAN BODY

The following minerals play important roles in biological processes:

Minerals	RDA/ AI (mg)	Description	Category	High nutrient density dietary sources	Deficiency diseases	When Excess
Potassium	4700 mg	Quantity	Is a systemic electrolyte and is essential in coregulating ATP with sodium.	Legumes, potato skin, tomatoes, bananas, papayas, lentils, dry beans, whole grains, avocados, yams, soybeans, spinach, chard, sweet potato, turmeric.	Hypokalemia	Hyperkalemia
Chlorine	2300 mg	Quantity	is needed for production of hydrochloric acid in the stomach and in cellular pump functions.	Table salt (sodium chloride) is the main dietary source.	Hypochloremia	Hyperchloremia
Sodium	1500 mg	Quantity	is a systemic electrolyte and is essential in coregulating ATP with potassium.	Table salt (sodium chloride, the main source), sea vegetables, milk, and spinach.	Hyponatremia	Hypernatremia
Calcium	1300 mg	Quantity	is needed for muscle, heart and digestive system health, builds bone, supports synthesis and function of blood cells.	Dairy products, eggs, canned fish with bones (salmon, sardines), green leafy vegetables, nuts, seeds, tofu, thyme, oregano, dill, cinnamon.	Hypocalcaemia	Hypercalcaemia
Phosphorus	700 mg	Quantity	is a component of bones (see apatite), cells, in energy processing and many other functions.	Red meat, dairy foods, fish, poultry, bread, rice, oats. In biological contexts, usually seen as phosphate.	Hypophosphatemia	Hyperphosphatemia
Magnesium	420 mg	Quantity	is required for processing ATP and for bones.	Raw nuts, soy beans, cocoa mass, spinach, chard, sea vegetables, tomatoes, halibut, beans, ginger,	Hypomagnesemia, magnesium deficiency	Hypermagnesemia

				cumin, cloves.		
Zinc	11 mg	Trace	is pervasive and required for several enzymes such as carboxypeptidase, liver alcohol dehydrogenase, and carbonic anhydrase.	Calf liver, eggs, dry beans, mushrooms, spinach, asparagus, scallops, red meat, green peas, yogurt, oats, seeds, miso.	Zinc deficiency	Zinc toxicity
Iron	18 mg	Trace	is required for many proteins and enzymes, notably hemoglobin to prevent anemia.	Red meat, fish (tuna, salmon), grains, dry beans, eggs, spinach, chard, turmeric, cumin, parsley, lentils, tofu, asparagus, leafy green vegetables, soybeans, shrimp, beans, tomatoes, olives, and dried fruit.	Anemia	Iron overload disorder
Mangan ese	2.3 mg	Trace	is a cofactor in enzyme functions.	Spelt grain, brown rice, beans, spinach, pineapple, tempeh, rye, soybeans, thyme, raspberries, strawberries, garlic, squash, eggplant, cloves, cinnamon, turmeric.	Manganese deficiency	Manganism
Copper Main article: Copper in health	0.900 mg	Trace	is required component of many redox enzymes, including cytochrome c oxidase.	Mushrooms, spinach, greens, seeds, raw cashews, raw walnuts, tempeh, barley.	Copper deficiency	Copper toxicity
Iodine	0.150 mg	Trace	is required not only for the synthesis of thyroid hormones, thyroxine and triiodothyronine and to prevent goiter, but also, probably as an	Sea vegetables, iodized salt, eggs. Alternate but inconsistent sources of iodine: strawberries, mozzarella cheese, yogurt, milk, fish, shellfish.	Iodine deficiency	Iodism

			antioxidant, for extrathyroidal organs as mammary and salivary glands and for gastric mucosa and immune system (thymus): Iodine in biology			
Selenium	0.055 mg	Trace	a cofactor essential to activity of antioxidant enzymes like glutathione peroxidase.	Brazil nuts, cold water wild fish (cod, halibut, salmon), tuna, lamb, turkey, calf liver, mustard, mushrooms, barley, cheese, garlic, tofu, seeds.	Selenium deficiency	Selenosis
Molybdenum	0.045 mg	Trace	the oxidases xanthine oxidase, aldehyde oxidase, and sulfite oxidase.	Tomatoes, onions, carrots.	Molybdenum deficiency	

DIETARY NUTRITION

Dietitians may recommend that dietary elements are best supplied by ingesting specific foods rich with the chemical element(s) of interest. The elements may be naturally present in the food (e.g., calcium in dairy milk) or added to the food (e.g., orange juice fortified with calcium; iodized salt, salt fortified with iodine). Dietary supplements can be formulated to contain several different chemical elements (as compounds), a combination of vitamins and/or other chemical compounds, or a single element (as a compound or mixture of compounds), such as calcium (as carbonate, citrate, etc.) or magnesium (as oxide, etc.), chromium (usually as picolinate) or iron (as bis-glycinate).

The dietary focus on chemical elements derives from an interest in supporting the biochemical reactions of metabolism with the required elemental components. Appropriate intake levels of certain chemical elements have been demonstrated to be required to maintain optimal health. Diet can meet all the body's chemical element requirements, although supplements can be used when some requirements (e.g., calcium, which is found mainly in dairy products) are not adequately met by the diet, or when chronic or acute deficiencies arise from pathology, injury, etc.

OTHER ELEMENTS

Many elements have been suggested as essential, but such claims have usually not been confirmed. Definitive evidence for efficacy comes from the characterization of a biomolecule containing the element with an identifiable and testable function. One problem with identifying efficacy is that some elements are innocuous at low concentrations and are pervasive (examples: silicon and nickel in solid and dust), so proof of efficacy is lacking because deficiencies are difficult to reproduce.

Element	Description	Excess
Sulfur	Relatively large quantities of sulfur are required, but there is no RDA, as the sulfur is obtained from and used for amino acids, and therefore should be adequate in any diet containing enough protein.	(primarily associated with compounds)
Cobalt	Cobalt is required in the synthesis of vitamin B_{12}, but because bacteria are required to synthesize the vitamin, it is usually considered part of vitamin B_{12} deficiency rather than its own dietary element deficiency.	Cobalt poisoning
Nickel	There have been occasional studies asserting the essentiality of nickel, but it currently has no RDA.	Nickel toxicity
Chromium	Chromium has been described as nonessential to mammals. Some role in sugar metabolism in humans has been invoked, but evidence is lacking, despite a market for the supplement chromium picolinate.	Chromium toxicity
Fluorine	Fluorine (as Fluoride) is not generally considered an essential mineral element because humans do not require it for growth or to sustain life. However, if one considers the prevention of dental cavities an important criterion in determining essentiality, then fluoride might well be considered an essential trace element. However, recent research indicates that the primary action of fluoride occurs topically (at the surface).	Fluoride poisoning
Boron	Boron has been found to be essential for the utilization of vitamin D and calcium in the body.	
Strontium	Strontium has been found to be involved in the utilization of	Rachitogenic

	calcium in the body. It has promoting action on calcium uptake into bone at moderate dietary strontium levels, but a rachitogenic (rickets-producing) action at higher dietary levels.	
Other	Arsenic, silicon, and vanadium have established, albeit specialized, biochemical roles as structural or functional cofactors in other organisms, and are possibly, even probably, used by mammals (including humans). By contrast, tungsten, bromine, and cadmium have specialized biochemical uses in certain lower organisms, but these elements appear not to be utilized by humans.	Multiple

MINERAL DEFICIENCY DISEASES

GOITER

A goitre or goiter is a swelling of the thyroid gland, which can lead to a swelling of the neck or larynx (voice box). Goitre is a term that refers to an enlargement of the thyroid (thyromegaly) and can be associated with a thyroid gland that is functioning properly or not.

Worldwide, over 90.54% cases of goitre are caused by iodine deficiency.

Causes

There are different kinds of goiters.

- A simple goiter can occur for no known reason, or when the thyroid gland is not able to produce enough thyroid hormone to meet the body's needs. The thyroid gland makes up for this by becoming larger.
- Toxic nodular goiter involves an enlarged thyroid gland that contains a small, rounded growth or growths called nodules. These nodules produce too much thyroid hormone.

Iodine is needed to produce thyroid hormone.

- Simple goiters may occur in people who live in areas with iodine-poor soil. People in these areas might not get enough iodine in their diet.
- The use of iodized table salt in the United States today prevents a lack of iodine in the diet.

In most cases of simple goiter the cause is unknown. Sometimes, certain medications such as lithium or aminoglutethimide can cause a simple goiter.

Simple goiters are also more common in:

- Anyone over age 40
- People with a family history of goiter
- Females

Symptoms

The main symptom is a swollen thyroid gland. The size may range from a single small nodule to a large neck lump.

Some people with a simple goiter may have symptoms of an underactive thyroid gland.

Rarely, the swollen thyroid can put pressure on the windpipe and food pipe (esophagus), which can lead to:

- Breathing difficulties (may rarely occur with very large goiters)
- Cough
- Hoarseness
- Swallowing difficulties

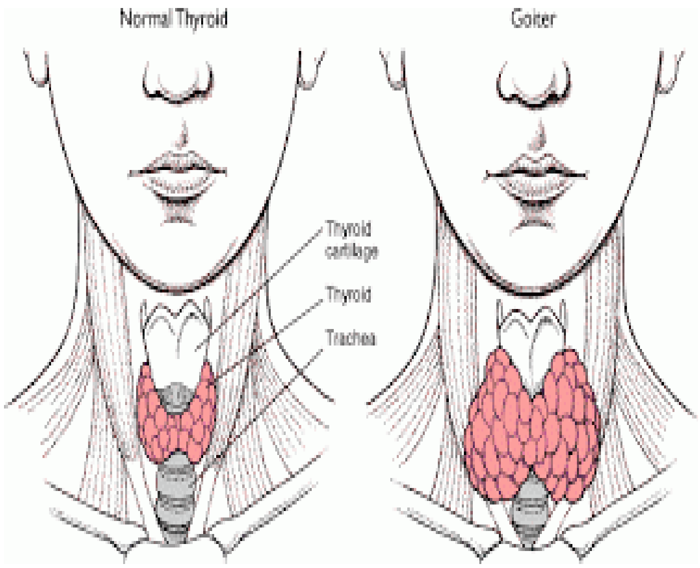


Fig. Goiter

Diagnosis

The doctor will feel your neck as you swallow. The doctor may be able to feel swelling in the area.

With very large goiters, there may be swelling in the neck vein, and you may feel dizzy when you raise your arms above your head.

You may have the following blood tests to measure thyroid function:

- Free thyroxine (T4)
- Thyroid stimulating hormone (TSH)

Tests to look for abnormal and possibly cancerous areas in the thyroid gland include:

- Thyroid scan and uptake
- Ultrasound of the thyroid

If nodules are found on an ultrasound, a biopsy should be done to check for thyroid cance

RICKETS

Rickets is a softening of bones in immature mammals due to deficiency or impaired metabolism of vitamin D,phosphorus or calcium, potentially leading to fractures and deformity. Rickets is among the most frequent childhood diseases in many developing countries. The predominant cause is a vitamin D deficiency, but lack of adequate calcium in the diet may also lead to rickets (cases of severe diarrhea and vomiting may be the cause of the deficiency). Although it can occur in adults, the majority of cases occur in children suffering from severe malnutrition, usually resulting from famine or starvation during the early stages of childhood.

Cause

The primary cause of rickets is a vitamin D deficiency. Vitamin D is required for proper calcium absorption from the gut. Sunlight, especially ultraviolet light, lets human skin cells convert Vitamin D from an inactive to active state. In the absence of vitamin D, dietary calcium is not properly absorbed, resulting in hypocalcaemia, leading to skeletal and dental deformities and neuromuscular symptoms, e.g. hyperexcitability. Foods that contain vitamin D include butter, eggs, fish liver oils, margarine, fortified milk and juice, portabella & shiitake mushrooms, and oily fishes such as tuna, herring, and salmon. A rare X-linked dominant form exists called Vitamin D resistant rickets.

Epidemiology

In developed countries, rickets is a rare disease
Those at higher risk for developing rickets include:

- Breast-fed infants whose mothers are not exposed to sunlight
- Breast-fed infants who are not exposed to sunlight
- Breast-fed babies who are exposed to little sunlight
- Any child whose diet does not contain enough vitamin D or calcium

Types

- Nutritional Rickets
- Vitamin D Resistant Rickets
- Vitamin D Dependent Rickets
    - Type I
    - Type II
- Congenital Rickets
- Newborn Rickets

Symptoms of rickets

The symptoms of rickets can include:

- Soft skull bones or skull deformities
- Delayed development
- A protruding abdomen (tummy)
- Poor growth (children may be short for their age)
- scoliosis
- Floppy limbs and body because of muscle weakness
- Teeth taking longer than usual to come through
- Weak tooth enamel that may lead to tooth decay
- Painful bones – particularly those in the arms, legs, spine and pelvis (although this is rare)
- Fractures, as the result of a fall

Children with severe rickets may also have low levels of calcium. This can cause muscle spasms.

Children with rickets may also have problems such as:

- Thick ankles, wrists or knees (‘knock-knees’)
- Legs that curve outwards (‘bow legs’)
- A breastbone that sticks out (‘pigeon chest’)
- Ribs that stick out
- A protruding forehead
- Spinal deformities (for example, a hunched back)
- Pelvic deformities

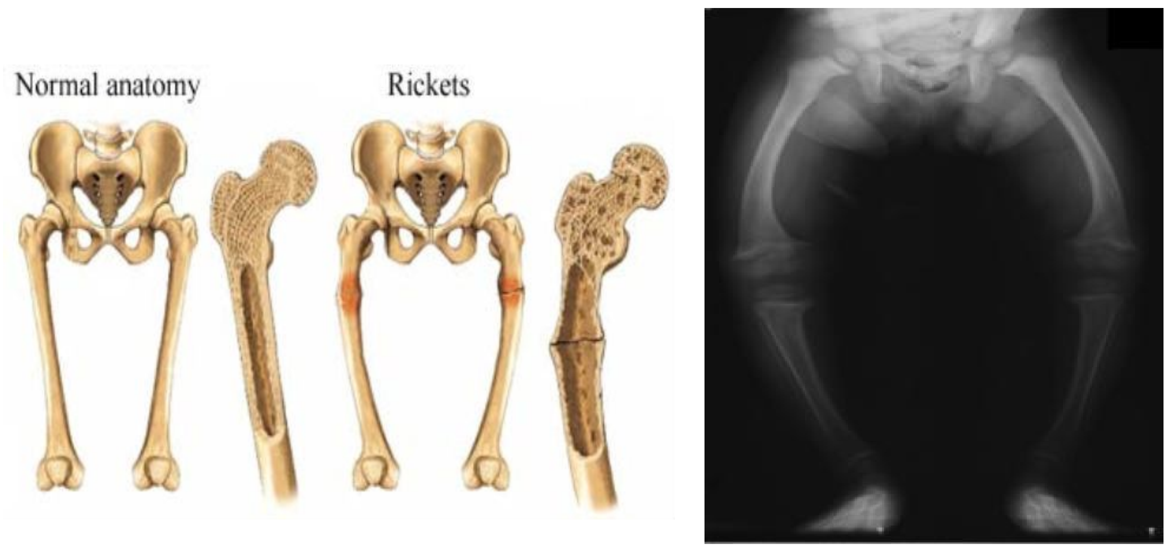


Fig. Femur in Rickets

Diagnosis

Rickets may be diagnosed with the help of:

- **Blood tests:**
  - Serum calcium may show low levels of calcium, serum phosphorus may be low, and serum alkaline phosphatase may be high.
- Arterial blood gases may reveal metabolic acidosis
- X-rays of affected bones may show loss of calcium from bones or changes in the shape or structure of the bones.
- Bone biopsy is rarely performed but will confirm rickets

IRON DEFICIENCY ANEMIA

Causes

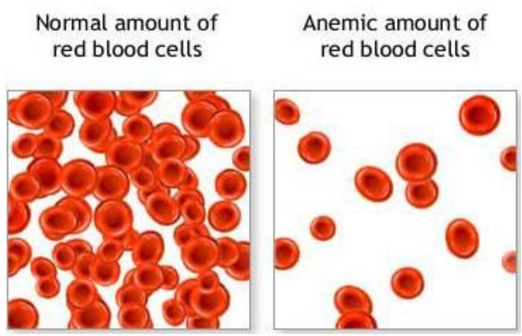
A diagnosis of iron-deficiency anemia then requires further investigation as to its cause. It can be caused by increased iron demand or decreased iron intake, and can occur in both children and adults.

- Blood loss.
- A lack of iron in the diet.
- An inability to absorb iron.
- Pregnancy

Symptoms

Symptoms and signs of iron-deficiency anemia include:

- Anxiety often resulting in OCD-type compulsions and obsessions
- Irritability or a low feeling
- Angina
- Constipation
- Sleepiness
- Tinnitus
- Mouth ulcers
- Palpitations
- Hair loss
- Fainting or feeling faint
- Depression
- Breathlessness
- Twitching muscles
- Pale yellow skin
- Tingling, numbness, or burning sensations
- Missed menstrual cycle
- Slow social development
- Glossitis (inflammation or infection of the tongue)
- Angular cheilitis (inflammatory lesions at the mouth's corners)
- Koilonychia (spoon-shaped nails) or nails that are weak or brittle
- Poor appetite
- Pruritus (itchiness)
- Dysphagia due to formation of esophageal webs (Plummer-Vinson syndrome)
- Insomnia
- Restless legs syndrome



Diagnosis

Anemia may be diagnosed from symptoms and signs, but when it is mild, it may not be diagnosed from mild nonspecific symptoms. Pica, an abnormal craving for dirt, ice, or other "odd" foods occurs variably in iron and zinc deficiency, but is neither sensitive or specific to the problem, so is of little diagnostic help.

Anemia is often first shown by routine blood tests, which generally include a complete blood count (CBC) which is performed by an instrument which gives an output as a series of index numbers. A sufficiently low hemoglobin (Hb) by definition makes the diagnosis of anemia, and a low hematocrit value is also characteristic of anemia. Further studies will be undertaken to determine the anemia's cause. If the anemia is due to iron deficiency, one of the first abnormal values to be noted on a CBC, as the body's iron stores begin to be depleted, will be a high red blood cell distribution width, reflecting an increased variability in the size of red blood cells (RBCs). In the course of slowly depleted iron status, an increasing RDW normally appears even before anemia appears.

MINERAL ECOLOGY

Recent studies have shown a tight linkage between living organisms and minerals on this planet. This led to the redefinition of minerals as "an element or compound, amorphous or crystalline, formed through 'biogeochemical' processes. The addition of `bio' reflects a greater appreciation, although an incomplete understanding, of the processes of mineral formation by living forms."[:621] Biologists and geologists have only recently started to appreciate the magnitude of mineral biogeoengineering. Bacteria have contributed to the formation of minerals for billions of years and critically define the biogeochemical mineral cycles on this planet. Microorganisms can precipitate metals from solution contributing to the formation of ore deposits in addition to their ability to catalyze mineral dissolution, to respire, precipitate, and form minerals.

Most minerals are inorganic in nature. Mineral nutrients refers to the smaller class of minerals that are metabolized for growth, development, and vitality of living organisms. Mineral nutrients are recycled by bacteria that are freely suspended in the vast water columns of the worlds oceans. They absorb dissolved organic matter containing mineral nutrients as they scavenge through the dying individuals that fall out of large phytoplankton blooms. Flagellates are effective bacteriovores and are also commonly found in the marine water column. The flagellates are preyed upon by zooplankton while the phytoplankton concentrates on the larger particulate matter that is suspended in the water column as they are consumed by larger zooplankton, with fish as the top predator. Mineral nutrients cycle through this marine food chain, from bacteria and phytoplankton to flagellates and zooplankton that are then eaten by fish. The bacteria are important in this chain because only they have the physiological ability to absorb the dissolved mineral nutrients from the sea. These recycling principals from marine environments apply to many soil and freshwater ecosystems as well.

CONCLUSION

Over twenty dietary minerals are necessary for mammals, and several more for various other types of life. The total number of minerals that are absolutely needed is not known for any organism. Ultratrace amounts of some minerals (e.g., boron, chromium) are known to clearly have a role but the exact biochemical nature is unknown, and others (e.g. arsenic, silicon) are suspected to have a role in health, but without proof.

Most minerals that enter into the dietary physiology of organisms consist of simple compounds of chemical elements. Larger aggregates of minerals need to be broken down for absorption. Plants absorb dissolved minerals in soils, which are subsequently picked up by the herbivores that eat them and so on, the minerals move up the food chain. Larger organisms may also consume soil (geophagia) and visit mineral licks to obtain limiting mineral nutrients they are unable to acquire through other components of their diet.

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