JOST CHEMICAL CO.

The Importance of Minerals in the Long Term Health of Humans

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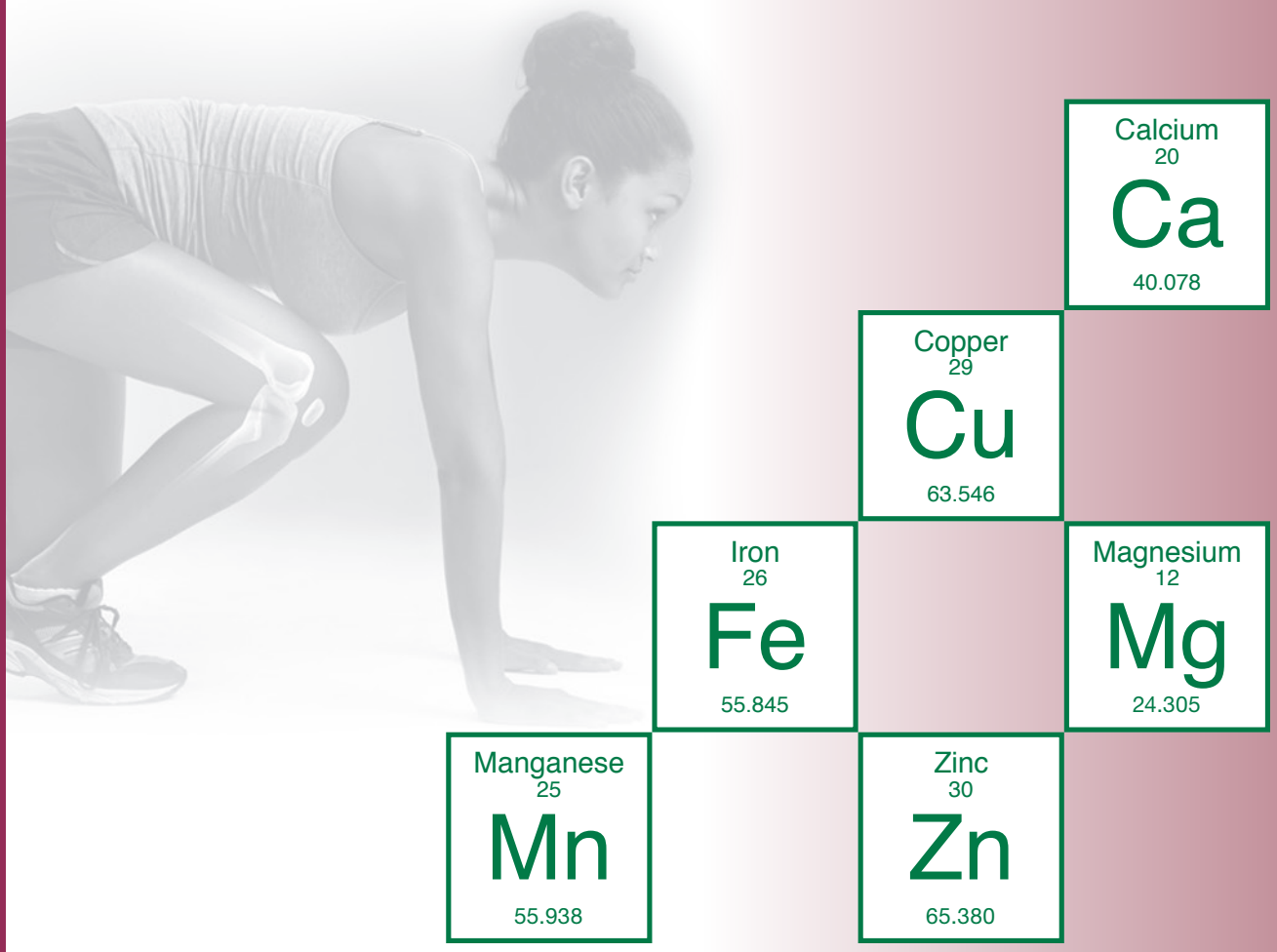

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Introduction

Daily intakes of several minerals are necessary for the continued basic functioning of the human body. The minerals, Calcium (Ca), Iron (Fe), Copper (Cu), Magnesium (Mg), Manganese (Mn), and Zinc (Zn) are known to be necessary for proper function and growth of the many systems in the human body and thus contribute to the overall health of the individual. There are several other trace minerals requirements. Minimum (and in some cases maximum) daily amounts for each of these minerals have been established by the Institute of Medicine (IOM) from the National Academy of Science (NAS). As can be seen from these tables, the IOM has extensive data that gives the general Daily Reference Intake (DRI) for every human age group and gender. The upper limit is the amount above which the mineral does harm to the individual.

Discussion

In this section each individual mineral is discussed with its functions in the human body. Why this mineral is required? What biological systems does it support? Also which Jost Chemical Co. products can be considered to supplement these minerals?

General

In general for a mineral salt to be most bioavailable it must not be a simple salt of the mineral acids. For example, ferrous sulfate is a simple salt of iron and sulfuric acid. It is very soluble and the small ions flush through the digestive system without much bioavailability. On the other hand, ferrous fumarate is a chelated product that is not very soluble and the large moiety goes through the stomach into the intestine and adheres to the intestinal lining where the iron transfers through the lining into the blood system (see Jost's Chelated Minerals, Published 2010). This makes the Fe in ferrous fumarate much more bioavailable than the sulfate.

It is generally true that large complexes of the mineral are more bioavailable than smaller molecules.

There have been many studies that demonstrate that Calcium Citrate is much more bioavailable than Calcium Carbonate. (see: *J Clin Pharmacol.* 2000;40:1237-12). Calcium Citrate is a complex molecule in which the Ca is chelated into the molecule matrix thus causing the whole molecule to pass into the intestine as one moiety. Another example is a study for Mg bioavailability showed that magnesium in the aspartate, citrate, and lactate forms is absorbed more completely and is more bioavailable than magnesium oxide and magnesium sulfate [Ranade VV, Somberg JC. Bioavailability and pharmacokinetics of magnesium after administration of magnesium salts to humans. Am J Ther 2001;8:345-57. [PubMed abstract]; Firoz M, Graber M. Bioavailability of US commercial magnesium preparations. Magnes Res 2001;14:257-62. [PubMed abstract] and many more studies.]


Calcium
20
Ca
40.078

Calcium

Calcium is the most abundant mineral in the human body. Calcium is important for optimal bone health throughout your life. Your body needs calcium to build and maintain strong bones. Your heart, muscles and nerves also need calcium to function properly. If you don't get enough calcium, you could face health problems related to weak bones and muscles:

- Children may not reach their full potential adult height.
- Adults may have low bone mass, which is a risk factor for osteoporosis.

Although diet is the best way to get calcium, calcium supplements may be an option if your diet falls short. Below is a chart that shows how much Ca is required depending on your age and sex. Adults generally require a minimum of 1000 mg/day of Ca. Calcium sources can be found in various forms. There are many who take ground oyster shell or Calcium Carbonate, neither of which is very bioavailable. The complex organic acid salts are much more bioavailable such as the citrate, lactate, gluconate, fumarate, malate, or the citrate malate. These are much more bioavailable than the simple salts of the mineral acids or the oxides or carbonate.

Some studies suggest that calcium, along with vitamin D, may have benefits beyond bone health, perhaps protecting against cancer, diabetes and high blood pressure. But currently evidence about such health benefits is not definitive (Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium and Vitamin D. Washington, DC: National Academy Press, 2010). Many Americans don't get enough calcium in their diets. Children and adolescent girls are at particular risk, but so are adults age 50 and older.

Recommended Dietary Allowances (RDAs) for Calcium[1]

Age	*Male*	*Female*	*Pregnant*	*Lactating*
0–6 months*	200 mg	200 mg		
7–12 months*	260 mg	260 mg		
1–3 years	700 mg	700 mg		
4–8 years	1,000 mg	1,000 mg		
9–13 years	1,300 mg	1,300 mg		
14–18 years	1,300 mg	1,300 mg	1,300 mg	1,300 mg
19–50 years	1,000 mg	1,000 mg	1,000 mg	1,000 mg
51–70 years	1,000 mg	1,200 mg		
71+ years	1,200 mg	1,200 mg		

* Adequate Intake (AI)
[1] Source: National Institutes of Health; Office of Dietary Supplements

There is also data that indicates that Ca plays a role in preventing colorectal cancer suggesting that there may be a protective effect (Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium and Vitamin D. Washington, DC: National Academy Press, 2010.) Several studies have found that higher intakes of calcium from foods (low-fat dairy sources) and/or supplements are associated with a decreased risk of colon cancer (Slattery M, Edwards S, Boucher K, Anderson K, Caan B. Lifestyle and colon cancer: an assessment of factors associated with risk. Am J Epidemiol 1999;150:869-77). In a follow-up study to the

Calcium Polyp Prevention Study, supplementation with calcium carbonate led to reductions in the risk of adenoma (a nonmalignant tumor) in the colon, a precursor to cancer (Baron JA, Beach M, Mandel JS, van Stolk RU, Haile RW, Sandler RS, et. al. Calcium supplements for the prevention of colorectal adenomas. N Engl J Med 1999: 340:101-7) even as long as 5 years after the subjects stopped taking the supplement. In two large prospective epidemiological trials, men and women who consumed 700–800 mg per day of calcium had a 40%–50% lower risk of developing left-side colon cancer Wu K, Willett WC, Fuchs CS, Colditz GA, Giovannucci EL, Calcium intake and risk of colon cancer in women and men. J Natl Cancer Inst 2002, 94:437-46). But other observational studies have found the associations to be inconclusive.

In the Women's Health Initiative, a clinical trial involving 36,282 postmenopausal women, daily supplementation with 1,000 mg of calcium and 400 International Units (IU) of vitamin D3 for 7 years produced no significant differences in the risk of invasive colorectal cancer compared to placebo (Wactawski-Wende J, Kotchen JM, Anderson GL, Assaf AR, Brunner RL, O'Sullivan MJ, et al. Calcium plus vitamin D supplementation and the risk of colorectal cancer. N Engl J Med 2006; 354:684-96). The authors of a Cochrane systematic review concluded that calcium supplementation might moderately help prevent colorectal adenomas, but there is not enough evidence to recommend routine use of calcium supplements to prevent colorectal cancer. Given the long latency period for colon cancer development, long-term studies are needed to fully understand whether calcium intakes affect colorectal cancer risk.

Not all calcium consumed is actually absorbed in the gut. Humans absorb about 30% of the calcium in foods, but this varies depending upon the type of food consumed (Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium and Vitamin D. Washington, DC: National Academy Press, 2010).

Other factors also affect calcium absorption including the following:

Amount consumed: The efficiency of absorption decreases as calcium intake increases (Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium and Vitamin D. Washington, DC: National Academy Press, 2010).

Age and life stage: Net calcium absorption is as high as 60% in infants and young children, who need substantial amounts of the mineral to build bone (National Institutes of Health. Optimal calcium intake. NIH Consensus Statement: 1994;12:1-31. PubMed abstract). Absorption decreases to 15%–20% in adulthood (though it increases during pregnancy) and continues to decrease as people age; compared with younger adults, recommended calcium intakes are higher for females older than 50 years and for both males and females older than 70 years.

Vitamin D intake: This nutrient, obtained from food and produced by skin when exposed to sunlight of sufficient intensity, improves calcium absorption.

Other components in food: Phytic acid and oxalic acid, found naturally in some plants, bind to calcium and can inhibit its absorption. Foods with high levels of oxalic acid include spinach, collard greens, sweet potatoes, rhubarb, and beans. Among the foods high in phytic acid are fiber-containing whole-grain products and wheat bran, beans, seeds, nuts, and soy isolates. The extent to which these compounds affect calcium absorption varies. Research shows, for example,

that eating spinach and milk at the same time reduces absorption of the calcium in milk. In contrast, wheat products (with the exception of wheat bran) do not appear to lower calcium absorption. For people who eat a variety of foods, these interactions probably have little or no nutritional consequence and, furthermore, are accounted for in the overall calcium DRIs, which factor in differences in absorption of calcium in mixed diets.

The Danger of Too Much Ca

Excessively high levels of calcium in the blood known as hypercalcemia can cause renal insufficiency, vascular and soft tissue calcification, hypercalciuria (high levels of calcium in the urine) and kidney stones. High calcium intake can cause constipation. It might also interfere with the absorption of iron and zinc, though this effect is not well established (Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium and Vitamin D. Washington, DC: National Academy Press, 2010).

In adults, too much Calcium (from dietary supplements but not food) might increase the risk of kidney stones. Some studies show that people who consume high amounts of Calcium might have increased risks of prostate cancer and heart disease, but more research is needed to clarify these possible links. (National Institute of Health, Office of Dietary Supplements)

The upper limits for Calcium are listed below. Most people do not get amounts above the upper levels from food alone; excess intakes usually come from supplements. Surveys show that some older women in the US probably get amounts above the upper limit since the use of supplements is common among these women.

Life Stage	*Upper Limit*
Birth to 6 months	1,000 mg
Infants 7–12 months	1,500 mg
Children 1–8 years	2,500 mg
Children 9–18 years	3,000 mg
Adults 19–50 years	2,500 mg
Adults 51 years and older	2,000 mg
Pregnant and breastfeeding teens	3,000 mg
Pregnant and breastfeeding adults	2,500 mg

The Tolerable Upper Intake Levels (ULs) for calcium established by the Food and Nutrition Board are listed in the table above in milligrams (mg) per day. Getting too much calcium from foods is rare; excess intakes are more likely to be caused by the use of calcium supplements. Recently there have been several negative stories of overuse of Ca. There was an article of the overuse being linked to CVD (cardiovascular disease) in older women in the British Medical Journal in 2013. There was another article in JAMA that linked overuse to CVD in men but not in women (JAMA, Osteoporosis International, February 2013, Volume 24, Issue 2, Pages 567-580).

Cardiovascular disease

Calcium has been proposed to help reduce cardiovascular disease (CVD) risk by decreasing intestinal absorption of lipids, increasing lipid excretion, lowering cholesterol levels in the blood, and promoting calcium influx into cells. However, data from prospective studies of calcium's effects on CVD risk are inconsistent,

and whether dietary calcium has different effects on the cardiovascular system than supplemental calcium is not clear. In the Iowa Women's Health Study, higher calcium intake from diet and/or supplements was associated with reduced ischemic heart disease mortality in postmenopausal women (Bostick RM, Kushi LH, Wu Y, Meyer KA, Sellers TA, Folsom AR. Relation of calcium, vitamin D, and dairy food intake to ischemic heart disease mortality among postmenopausal women. Am J Epidemiol. 1999 Jan 15;149(2):151-61). Overall, it is still not clear that Ca supplementation will lower cardiovascular disease occurrence.

Jost Chemical Calcium Supplements

Jost Chemical Co. has a variety of organic calcium salts that are bioavailable and have been successfully used for Ca supplementation. These products are produced under Q7 GMP regulations and are fit for food, dietary supplement, and pharmaceutical uses. Included are the citrate, lactate, fumarate, malate, and succinate. Jost also produces the phosphates (MCP, DCP, TCP), carbonate, and hydroxide. Another Ca salt produced is the citrate malate which has shown high bioavailability.

The most water soluble Ca salts are lactate (3.1 gm in 100 ml at RT), fumarate (2gm in 100ml at RT), and malate (0.8gm in 100ml at RT). The other salts are practically insoluble with much less than 1gm solubility. These somewhat soluble salts are useful for liquid products in which solubility is important. The insoluble salts can still be used in liquids where a suspension is expected.

Jost has many different particle sizes of these products for a variety of uses. Particle sizes of as fine as 1.7 um are produced for suspension in liquid medium.

Jost Chemical Products — Calcium

Salt	*Solubility %*[1]	*Metal Content %*	*Taste*
Calcium Lactate Anhydrous	3.1^{0}-7.9^{30}	18.0-18.6	Exothermic, sharp
Calcium Fumarate Anhydrous	2	23.0-29.9	Neutral
Calcium Malate Anhydrous	0.8^{0}-$1.2^{37.5}$	20.0-23.5	Slightly salty
Calcium Hydroxide	0.185^{0}-0.077^{100}	51.6-54.7	Biting
Calcium Citrate Tetrahydrate	0.10	20.5-21.2	Neutral
Calcium Phosphate Dibasic (DCP)	0.02	27.8-29.7	Neutral
Calcium Phosphate Tribasic Anhydrous (TCP)	0.002	34.0-40.0	Neutral
Calcium Succinate Monohydrate	0.004	22.0-25.0	Salty, strong aftertaste
Calcium Carbonate Anhydrous	0.0014	39.4-40.5	Neutral

[1] Superscript is test temperature; if no superscript, 25°C.

Calcium Magnesium Citrate

There is a need to have products that contain the correct ratio of Ca: Mg of 2:1 as the daily requirement is in this ratio. There is a strong tendency for mixtures of Ca- and Mg- Citrates to set up hard in solution. They become cement-like. This is a natural reaction that occurs often in water suspensions. Jost Chemical Co. became aware of this phenomenon in discussions with Jost customers who were trying to produce a solution that contained both Ca and Mg. Jost R&D developed a product Ca_2MgCitrate which will not harden in water solution and gives the correct ratio of Ca: Mg of 2:1 in one product.

Copper (Cu)

Copper is a trace element also essential for the human body to function properly. Copper is present in all body tissues and plays a role in the formation of connective tissue, and in the normal functioning of muscles and the immune and nervous systems.

The human body requires copper for normal growth and health. Copper, along with iron, is a critical component in the formation of red blood cells. Copper also influences the functioning of the heart and arteries, helps prevent bone defects such as osteoporosis and osteoarthritis, and promotes healthy connective tissues (hair, skin, nails, tendons, ligaments and blood vessels). (Source: Dr. Andrew Weil, Internet)

Recommended Dietary Allowances (RDAs) for Copper

Age	*Male*	*Female*	*Pregnancy*	*Lactation*
Birth to 6 months*	200mcg			
7–12 months*	220	220		
1–3 years	340	340		
4–8 years	440	440		
9–13 years	700	700		
14–18 years	890	890	1000	1300
19–30 years	900	900	1000	1300
31–50 years	900	900	1000	1300
51+ years	900	900		

* Adequate Intake (AI). Source: National Institutes of Health; Office of Dietary Supplements

Copper plays many important roles in maintaining a healthy body and some of its benefits include (Source: Organic Facts on Internet):

Arthritis: The health benefits of copper relate to its anti-inflammatory actions that assist in reducing the symptoms of arthritis. The consumer market is also flooded with copper bracelets as well as other accessories for curing this condition. Copper can also work as a home remedy for arthritis; store water in a copper container overnight to accumulate copper traces. These are beneficial in strengthening the muscular system, so drink the water when you wake in the morning. You will feel energized and active for the day, because your metabolism will have a good source of copper for its daily processes.

Proper Growth: Copper is essential for normal growth and health. Thus, it is very important to include this mineral in balanced levels in your regular diets. It is also helpful in the protection of the skeletal, nervous and cardiovascular systems. If you suffer from a copper deficiency, the normal and healthy growth of organs and tissues, as well as their proper oxygenation from an ample red blood cell concentration, would be impossible. Copper deficiencies are seen in many third world countries and are reflected in the number of birth and growth defects in children of those nations.

Pigmentation of Hair and Eyes: Copper is a vital component of the natural dark pigment, melanin, which imparts coloration to the skin, hair, and eyes. Melanin can be produced by melanocytes only in the presence of the cuproenzyme called tyrosinase, which is derived from copper. Intake of copper supplements also helps in protecting against graying of the hair. So while it is often overlooked as an antioxidant mineral, it does protect the integrity of those cells and keeps you looking young! It also maintains the color of your eyes and is essential, along with zinc, to keep your eyes beautifully colored into your old age.

Copper deficiency is rare, but can occur in people who are severely undernourished or who have chronic diarrhea. Disorders that impair nutrient absorption, such as Crohn's disease, can also lead to copper deficiency, as can high dietary intakes of iron or zinc. Signs of deficiency include bleeding under the skin, damaged blood vessels, hair loss, pale skin, and an enlarged heart. Symptoms include fatigue and, because copper plays a role in immunity, imbalances can make you more susceptible to infections.

Good food sources include vegetables, legumes, beans, nuts and seeds, mushrooms, shellfish (especially cooked oysters), avocado and whole grains.

Copper is toxic in large amounts, and acute poisoning can lead to nausea, vomiting, diarrhea and even kidney damage, anemia and death. The toxic amount for adults is 10000 micrograms. One should not take more than that amount daily. For younger people smaller amounts become toxic.

Wilson's disease is a rare (affecting about one in 30,000 people) inherited disorder in which excessive amounts of copper accumulate in the liver or brain. If a person has Wilson's disease or a family history of it, they should not take supplements containing copper and get regular testing to monitor the copper levels; for more information, see www.wilsonsdisease.org.

Boron, vitamin C, selenium, manganese and molybdenum can affect levels of copper in the body. Zinc can lower copper stores, so it is often recommended to take supplemental copper (at a ratio of 1 to 10) if you take supplemental zinc.

Jost Chemical Co. manufactures several Cu compounds including sulfate, gluconate, citrate, and oxide. Jost also manufactures encapsulated versions of the sulfate and the gluconate to inhibit interactions between the Cu and

other ions in a normal multivitamin. The encapsulated products also inhibit the bitter flavor from interfering with the taste of the other components in the finished product.

Jost Chemical Products — Copper

Salt	*Solubility %[1]*	*Metal Content %*	*Taste*
Copper Sulfate Pentahydrate	31.6^{0}-203.3^{100}	24.9-26.8	Sharp, bitter
Copper Gluconate Anhydrous	30	13.7-14.3	Mild, sweet
Copper Sulfate Anhydrous	14.3-75.4^{100}	39.2-40.0	Sharp, bitter
Copper Citrate Hemi-Trihydrate	Insoluble	36.0-37.8	Mild
Copper Oxide Anhydrous	Insoluble	78.7-80.7	Mild

[1] Superscript is test temperature; if no superscript, 25°C.

Iron (Fe)

Iron is a mineral that is naturally present in many foods, added to some food products, and available as a dietary supplement. Iron is an essential component of hemoglobin, an erythrocyte protein that transfers oxygen from the lungs to the tissues. As a component of myoglobin, a protein that provides oxygen to muscles, iron supports metabolism. Iron is also necessary for growth, development, normal cellular functioning, and synthesis of some hormones and connective tissue. (Internet Source: National Institutes of Health; Office of Dietary Supplements)

Most of the 3 to 4 grams of elemental iron in adults is in hemoglobin which is the compound that transmits oxygen in the blood to the cells. Much of the remaining iron is stored in the form of ferritin or hemosiderin (a degradation product of ferritin) in the liver, spleen, and bone marrow or is located in myoglobin in muscle tissue. Humans typically lose only small amounts of iron in urine, feces, the gastrointestinal tract, and skin. Losses are greater in menstruating women because of blood loss.

Hemoglobin concentrations are routinely measured to determine if the person has enough iron. The last stage of iron deficiency, characterized by iron-deficiency anemia (IDA), occurs when blood hemoglobin concentrations are low. Hemoglobin and hematocrit tests are the most commonly used measures to screen patients for iron deficiency, even though they are neither sensitive nor specific. Hemoglobin concentrations lower than 13 g/dL in men and 12 g/dL in women indicate the presence of IDA. Normal hematocrit values, which are generally three times higher than hemoglobin levels, are approximately 41% to 50% in males and 36% to 44% in females.

Recommended Intakes

Intake recommendations for iron and other nutrients are provided in the Dietary Reference Intakes (DRIs) developed by the Food and Nutrition Board (FNB) at the Institute of Medicine (IOM) of the National Academies (formerly National Academy of Sciences). DRI is the general term for a set of reference values used for planning and assessing nutrient intakes of healthy people. These values, which vary by age and gender, include:

- Recommended Dietary Allowance (RDA): average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%–98%) healthy individuals.
- Adequate Intake (AI): established when evidence is insufficient to develop an RDA; intake at this level is assumed to ensure nutritional adequacy.
- Estimated Average Requirement (EAR): average daily level of intake estimated to meet the requirements of 50% of healthy individuals. It is usually used to assess the adequacy of nutrient intakes in population groups but not individuals.
- Tolerable Upper Intake Level (UL): maximum daily intake unlikely to cause adverse health effects.

Table 1 lists the current iron RDAs for nonvegetarians. The RDAs for vegetarians are 1.8 times higher than for people who eat meat. This is because heme iron from meat is more bioavailable than nonheme iron from plant-based foods, and meat, poultry, and seafood increase the absorption of nonheme iron.

For infants from birth to 6 months, the FNB established an AI for iron that is equivalent to the mean intake of iron in healthy, breastfed infants.

Table 1: Recommended Dietary Allowances (RDAs) for Iron

Age	*Male*	*Female*	*Pregnancy*	*Lactation*
Birth to 6 months	0.27 mg*	0.27 mg*		
7–12 months	11 mg	11 mg		
1–3 years	7 mg	7 mg		
4–8 years	10 mg	10 mg		
9–13 years	8 mg	8 mg		
14–18 years	11 mg	15 mg	27 mg	10 mg
19–50 years	8 mg	18 mg	27 mg	9 mg
51+ years	8 mg	8 mg		

* Adequate Intake (AI). Source: National Institutes of Health; Office of Dietary Supplements

Jost Chemical Co. manufactures several compendial grades of Fe suitable for foods or dietary supplements such as Ferric Ammonium Citrate, Ferric Ammonium Sulfate, Ferric Phosphate, Ferrous Gluconate Dihydrate, Ferrous Lactate Dihydrate, Ferrous Fumarate Anhydrous, Ferrous Citrate Dibasic Monohydrate, and the Ferric Citrate x-Hydrate.

Jost Chemical Co. also manufactures encapsulated products of Ferrous Sulfate, Ferrous Fumarate and Reduced Iron.

Jost Chemical Products — Iron

Salt	*Solubility %*[1]	*Metal Content %*	*Taste*
Ferric Ammonium Citrate Brown	Very soluble	16.5-18.5	Strong
Ferrous Ammonium Sulfate Hexahydrate	20-34.2[70]	13.5-14.2	Strong
Ferrous Gluconate Dihydrate	9[28]-60[80]	USP 10.9-11.9 EP 11.8-12.5	Salty, bitter
Ferrous Lactate Dihydrate	2-8.5[100]	20.1-20.8	Mild
Ferrous Fumarate Anhydrous	0.14	30.3-33.2	Neutral
Ferrous Citrate Dibasic Monohydrate	Insoluble	20.0-22.0	Mild
Ferric Citrate x-Hydrate	Insoluble	16.5-20.0	Mild
Ferric Phosphate Hydrate	Insoluble	26.0-32.0	Slightly sour, stings

[1] Superscript is test temperature; if no superscript, 25°C.

Magnesium

The Recommended Daily Intake (RDI) for magnesium (Mg) is 400 mg/day for adult males with slightly lower amounts for women and children. Mg is a vital nutrient and is the active mineral in at least 300 known enzymes in the human body[1,2,3] (see chart on following page). It is required to help the body produce energy, including protein synthesis, muscle and nerve function, blood glucose control, and blood pressure regulation. Maintaining these functions is vital to several systems in the human body. Deficiencies lead to serious health issues.

Mg is very important for heart function. It has been shown to be required for the electrical functions of the heart to keep a regular beat. It also is important for maintaining healthy blood pressures. It has also been shown that diabetics do not have enough of this vital mineral[4]. Mg actually helps control blood glucose[5,6]. Heart patients and diabetics require supplementation with Mg. There is a vast amount of research on these topics.[1, 2, 3, 4, 5, 6]

Magnesium has been found to regulate and improve blood sugar control. It plays a vital role in the secretion and function of insulin and is necessary for insulin to open cell membranes for glucose and helps the body digest, absorb, and utilize proteins, fats, and carbohydrates. Those who are low on this mineral (a survey conducted by The Gallup Organization found that 72 percent of adult Americans fall short of the Recommended Dietary Allowance of magnesium), increases their risk of developing diabetes.

Recommended Dietary Allowances (RDAs) for Magnesium[1]

Age	*Male*	*Female*	*Pregnancy*	*Lactation*
Birth to 6 months	30 mg*	30 mg*		
7–12 months	75 mg*	75 mg*		
1–3 years	80 mg	80 mg		
4–8 years	*130 mg*	*130 mg*		
9–13 years	240 mg	240 mg		
14–18 years	410 mg	360 mg	400 mg	360 mg
19–30 years	400 mg	310 mg	350 mg	310 mg
31–50 years	420 mg	320 mg	360 mg	320 mg
51+ years	420 mg	320 mg		

* Adequate Intake (AI).
[1] Source: National Institutes of Health; Office of Dietary Supplements

Researchers have shown that because magnesium is so vital to energy supply and utilization in the body, they have determined that lower levels of magnesium in the blood lead to metabolic malfunctions such as diabetes. Researchers also have shown that the impaired kidney function connected with diabetes might explain the higher levels of magnesium in the urine, which combined with insufficient magnesium intake, causes the high blood sugar levels.

Mg is the metal responsible for the activity in chlorophyll, acting as the catalyst that turns CO_2 and H_2O into sugar. Thus plants are a good source of Mg. The green leafy vegetables are particularly good. They lose much of their Mg when they are processed.

Studies show that the soil has been depleted of Mg from constant farming and the amount of Mg in our foods has diminished. It is difficult to get the required amount of Mg from foods alone. Supplements have become important for people to attain the proper amount of this vital mineral.

Studies have shown that the average American male gets about three fourths of the RDI. Supplementation with dietary supplements seems crucial to maintaining good health.[7]

Jost Chemical Co. produces several Mg compounds for supplementation. As all of Jost manufactured products, the Mg compounds are all pure products that follow the appropriate USP, NF and FCC monographs. These products include Mg citrate, lactate, gluconate, phosphate di- and tribasic, aspartate, malate, and ascorbate, which are all chelated and offer high bioavailability[8, 9, 10, 11, 12]. Jost also produces Mg sulfate which is ionic and soluble and may not be as bioavailable. It is used more as a laxative.

Jost Chemical Products — Magnesium

Salt	*Solubility %*[1]	*Metal Content %*	*Taste*
Magnesium Ascorbate x-Hydrate	72	6.1-6.6	Neutral, slightly tart
Magnesium Citrate Tribasic Anhydrous	15	14.5-16.4	Neutral
Magnesium Aspartate Dibasic Anhydrous	14.5	14.2-15.7	Strong
Magnesium Gluconate Hydrate	8	5.7-6.0	Slightly tart
Magnesium Lactate Anhydrous	3.5	11.8-12.2	Mild, sweet, slightly spicy
Magnesium Lactate Dihydrate	$3.3\text{-}16.7^{100}$	10.0-10.4	Mild, sweet, slightly spicy
Magnesium Malate Trihydrate	2	11.3-11.8	Neutral
Magnesium Citrate Tribasic x-hydrate	$0.4\text{-}2.8^{95}$	11.2-12.0	Neutral
Magnesium Phosphate Dibasic Trihydrate	Slightly soluble	13.4-14.0	Neutral
Magnesium Phosphate Tribasic Pentahydrate	Insoluble	20.2-20.9	Neutral

[1] Superscript is test temperature; if no superscript, 25°C.

Several of these salts are water soluble (aspartate, citrate, gluconate, lactate, ascorbate, and malate). These can be used where the end product is a liquid and needs solubility. The hydrated citrate and phosphates are insoluble and used more in dry powder or tabletted products. When mixed with Ca Citrate salts, they tend to solidify in water solutions.

1. Institute of Medicine (IOM). Food and Nutrition Board. Dietary Reference Intakes: Calcium, Phosphorus, Magnesium, Vitamin D and Fluoride. Washington, DC: National Academy Press, 1997.

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3. Rude RK. Magnesium. In: Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, eds. Modern Nutrition in Health and Disease. 11th ed. Baltimore, Mass: Lippincott Williams & Wilkins; 2012:159-75.

4. Sales CH, Pedrosa LF, Lima JG, Lemos TM, Colli C. Influence of magnesium status and magnesium intake on the blood glucose control in patients with type 2 diabetes. Clin Nutr. 2011 Jan 31.

5. Larsson SC, Wolk A. Magnesium intake and risk of type 2 diabetes: a meta-analysis. J Intern Med 2007;262:208-14. [PubMed abstract]

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Manganese

Manganese is a trace mineral that is vital to life. The human body contains about 15 to 20 milligrams of it. Adults require only about 2 mg Mn per day. Most of it is found in the bones, with the rest distributed throughout the body in tissues like the pancreas, kidneys, liver, adrenal glands and pituitary glands.

Though manganese is needed in only trace amounts, it is estimated that as much as 1/3 of the North American population do not get enough of it. This is mainly due to the highly processed modern diet that we eat.

Recommended Dietary Allowances (RDAs) for Manganese

Age	*Male*	*Female*	*Pregnancy*	*Lactation*
Birth to 6 months	0.003mg			
7–12 months	0.6			
1–3 years	1.2			
4–8 years	1.5			
9–13 years	1.9	1.6		
14–18 years	2.2	1.6	2.0	2.6
19–30 years	2.3	1.8	2.0	2.6
31–50 years	2.3	1.8	2.0	2.6
51+ years	2.3	1.8		

A large proportion of the manganese in food is lost in processing. Whole grains, for instance, are foods high in manganese, but refined grains or flour which are much more widely consumed, provide only half the amount.

Manganese is an essential nutrient in many ways. Its key role is in the activation of enzymes that are needed for the digestion and utilization of foods and nutrients.

It also plays a role in reproduction and bone growth. It is sometimes called the 'brain' mineral, as it is important to mental function.

Manganese deficiency is very rare and hard to determine. However, many people may not be getting the optimal levels needed for health. The most common cause of low manganese is poor dietary intake, either due to a diet lacking in manganese food sources, or because of intestinal tract disorders that hinder the absorption of nutrients from food.

Due to the importance of manganese in enzyme activation, a deficiency can adversely affect many bio-chemical processes in the body but may be difficult to determine. Because it is so necessary for the body's energy and heat, a person with a manganese deficiency will feel tired and weak.

The main ways that manganese benefits the body are summarized here.

Manganese Benefits & Functions

1. Activates enzymes needed to digest and synthesize fatty acids and cholesterol and metabolize carbohydrates and proteins
2. Important for energy production
3. Activates enzymes that enable the utilization of other key nutrients like vitamin B1 (thiamine), biotin, choline, ascorbic acid, and vitamin E
4. Manganese-activated enzymes are also important to normal bone and cartilage growth and keeps bones strong and healthy
5. Needed for collagen formation in skin cells, which is required for healing of wounds
6. Component of metalloenzymes needed for a number of functions that include synthesizing glutamine and glucose metabolism, which helps regulate blood sugar balance
7. Needed to make manganese superoxide dismutase (MnSOD), one of the key antioxidants that protects cells from free radical damage and helps maintain a healthy immune system
8. Required for production of sex hormones, fertility, reproductive health, and lactation
9. Maintains healthy nerves
10. Supports optimal function of the thyroid gland and thyroxine production
11. Essential for proper iron metabolism and helps prevent anemia
12. Works with the B-complex vitamins to generate overall feeling of well-being

Manganese superoxide dismutase (MnSOD) is the principal antioxidant enzyme in the mitochondria. Because mitochondria consumes over 90% of the oxygen used by cells, they are especially vulnerable to oxidative stress. The superoxide radical is one of the reactive oxygen species produced in mitochondria

during ATP synthesis. MnSOD catalyzes the conversion of superoxide radicals to hydrogen peroxide, which can be reduced to water by other antioxidant enzymes (Leach RM, Harris ED. Manganese. In: O'Dell BL, Sunde RA, eds. Handbook of nutritionally essential minerals. New York: Marcel Dekker, Inc; 1997:335-355.)

Jost Chemical Co. sells several Mn products for dietary supplementation and other uses. As always, they are all manufactured under the appropriate GMP's for the type of compendial product (USP, EP, FCC). The Jost Chemical products include sulfate, gluconate, lactate, citrate, and ascorbate salts. Jost also manufactures encapsulated Manganese Sulfate.

Jost Chemical Products — Manganese

Salt	*Solubility %*	*Metal Content %*	*Taste*
Manganese Sulfate Monohydrate	50	31.8-33.2	Mild
Manganese Gluconate Dihydrate	17	11.0-11.9	Mild
Manganese Lactate Dihydrate	10	20.0-20.8	Mild
Manganese Citrate Decahydrate	<1	22.0-23.9	Neutral
Manganese Ascorbate Dihydrate	Insoluble	12.5-14.0	Very bitter

Zinc

Zinc is another mineral that must be absorbed in small amounts to keep humans healthy. The trace mineral zinc is essential for body growth, maturation and development, as well as tissue repair and resistance to disease. Zinc is an important mineral for children and the elderly. It can be found in meats, specifically organ meats, poultry, and seafood. Although rare, trace mineral deficiencies related to zinc can result in reduced growth in children, reduced resistance to infection in adults and delayed wound healing in people of all ages. The body needs 15.0 milligrams of zinc per day.

Zinc is an essential mineral that is naturally present in some foods, added to others, and available as a dietary supplement. Zinc is also found in many cold lozenges and some over-the-counter drugs sold as cold remedies.

Zinc is involved in numerous aspects of cellular metabolism. It is required for the catalytic activity of approximately 100 enzymes and it plays a role in immune function, protein synthesis, wound healing, DNA synthesis, and cell division. Zinc also supports normal growth and development during pregnancy, childhood, and adolescence and is required for proper sense of taste and smell. A daily intake of zinc is required to maintain a steady state because the body has no specialized zinc storage system. (internet source: National Institutes of Health; Office of Dietary Supplements and references there-in).

Intake recommendations for zinc and other nutrients are provided in the Dietary Reference Intakes (DRIs) developed by the Food and Nutrition Board (FNB) at the Institute of Medicine of the National Academies (formerly National Academy of Sciences). DRI is the general term for a set of reference values used for planning and assessing nutrient intakes of healthy people. These values, which vary by age and gender, include the following:

- Recommended Dietary Allowance (RDA): average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%–98%) healthy individuals.
- Adequate Intake (AI): established when evidence is insufficient to develop an RDA and is set at a level assumed to ensure nutritional adequacy.
- Tolerable Upper Intake Level (UL): maximum daily intake unlikely to cause adverse health effects.

The current RDAs for zinc are listed in Table 1. For infants aged 0 to 6 months, the FNB established an AI for zinc that is equivalent to the mean intake of zinc in healthy, breastfed infants.

Table 1: Recommended Dietary Allowances (RDAs) for Zinc

Age	*Male*	*Female*	*Pregnancy*	*Lactation*
0–6 months	2 mg*	2 mg*		
7–12 months	3 mg	3 mg		
1–3 years	3 mg	3 mg		
4–8 years	5 mg	5 mg		
9–13 years	8 mg	8 mg		
14–18 years	11 mg	9 mg	12 mg	13 mg
19+ years	11 mg	8 mg	11 mg	12 mg

* Adequate Intake (AI). Source: National Institutes of Health; Office of Dietary Supplements

Zinc deficiency is characterized by growth retardation, loss of appetite, and impaired immune function. In more severe cases, zinc deficiency causes hair loss, diarrhea, delayed sexual maturation, impotence, hypogonadism in males, and eye and skin lesions. Weight loss, delayed healing of wounds, taste abnormalities, and mental lethargy can also occur. Many of these symptoms are non-specific and often associated with other health conditions; therefore, a medical examination is necessary to ascertain whether a zinc deficiency is present.

Zinc nutritional status is difficult to measure adequately using laboratory tests due to its distribution throughout the body as a component of various proteins and nucleic acids. Plasma or serum zinc levels are the most commonly used indices for evaluating zinc deficiency, but these levels do not necessarily reflect cellular zinc status due to tight homeostatic control mechanisms. Clinical effects of zinc deficiency can be present in the absence of abnormal laboratory indices. Clinicians consider risk factors (such as inadequate caloric intake, alcoholism, and digestive diseases) and symptoms of zinc deficiency (such as impaired growth in infants and children) when determining the need for zinc supplementation.

Zinc toxicity can occur in both acute and chronic forms. Acute adverse effects of high zinc intake include nausea, vomiting, loss of appetite, abdominal cramps, diarrhea, and headaches. One case report cited severe nausea and vomiting within 30 minutes of ingesting 4 g of zinc gluconate (570 mg elemental zinc). Intakes of 150–450 mg of zinc per day have been associated with such chronic effects as low copper

status, altered iron function, reduced immune function, and reduced levels of high-density lipoproteins. Reductions in a copper-containing enzyme, a marker of copper status, have been reported with even moderately high zinc intakes of approximately 60 mg/day for up to 10 weeks. The doses of zinc used in the AREDS study (80 mg per day of zinc in the form of zinc oxide for 6.3 years, on average) have been associated with a significant increase in hospitalizations for genitourinary causes, raising the possibility that chronically high intakes of zinc adversely affect some aspects of urinary physiology.

The FNB has established ULs for zinc (Table 2). Long-term intakes above the UL increase the risk of adverse health effects. The ULs do not apply to individuals receiving zinc for medical treatment, but such individuals should be under the care of a physician who monitors them for adverse health effects.

Table 2: Tolerable Upper Intake Levels (ULs) for Zinc

Age	*Male*	*Female*	*Pregnant*	*Lactating*
7–12 months	5 mg	5 mg		
1–3 years	7 mg	7 mg		
4–8 years	12 mg	12 mg		
9–13 years	23 mg	23 mg		
14–18 years	34 mg	34 mg	34 mg	34 mg
19+ years	40 mg	40 mg	40 mg	40 mg

Jost Chemical Co. produces several products that are used as Zn supplements including gluconates, lactate, citrate, sulfate, ascorbate, phosphate, and oxide. Jost also produces low Pb and heavy metal products for uses that require lower than normally required toxic metals. Jost also manufactures encapsulated zinc oxide and zinc gluconate.

Jost Chemical Products — Zinc

Salt	*Solubility %*[1]	*Metal Content %*	*Taste*
Zinc Ascorbate	Freely Soluble	12.6-13.4	Sharp, biting
Zinc Sulfate Monohydrate	45	36.0-36.8	Cooling (endothermic), faintly salty
Zinc Sulfate Heptahydrate	37	22.3-23.2	Cooling, faintly salty
Zinc Gluconate Hydrate	13	12.3-14.6	Mild, faint taste
Zinc Lactate Dihydrate	$1.7\text{-}17^{100}$	22.0-24.0	Mild, faint taste
Zinc Citrate Dihydrate	Slightly Soluble	31.3-32.1	Neutral
Zinc Phosphate	Insoluble	41.9-43.7	Neutral
Low Pb Zinc Oxide	Insoluble	79.9-80.7	Neutral

[1] Superscript is test temperature; if no superscript, 25°C.

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