# The Trace Minerals

**“Of special interest to...” symbol key:** HotTopicLogo = Hot Topic AppleLogo = Personal Health   
HealthCareLogo = Health Care Professionals ScienceLogo = Science Majors

1. The **Trace Minerals**—An Overview

Trace minerals are needed in very small quantities in the human body. They perform many essential functions important to health. Toxic levels can easily be reached with the use of supplements. Humans can get the amounts of trace minerals needed by consuming a wide variety of foods.

AppleLogo A. Food Sources

* + 1. Depends on soil and water composition
    2. Depends on processing
    3. Bioavailability
    4. Wide variety of foods

HealthCareLogo B. Deficiencies

* + 1. Mild deficiencies are easily overlooked.
    2. Severe deficiencies are easy to recognize.
    3. Deficiencies have wide-reaching effects.
    4. Affects all ages

HealthCareLogo C. Toxicities

* + 1. A person should not exceed Upper Level Recommended Intakes.
    2. A person should not exceed 100% Daily Values.
    3. FDA does not limit amounts in supplements.
  1. Interactions
     1. Common and coordinated to meet body needs
     2. Can lead to nutrient imbalances

1. Iron

Iron is found in the body as part of the oxygen-binding proteins hemoglobin and myoglobin. Iron is used for energy metabolism and enzyme activity. Special proteins assist with iron absorption, transport, and storage. Both iron deficiency and iron toxicity cause damage so balance is important. Heme iron is better absorbed but nonheme iron absorption can be enhanced.

ScienceLogo A. Iron Roles in the Body

* + 1. Ferrous iron is reduced and has a net positive charge of two.
    2. Ferric iron is oxidized and has a net positive charge of three.
    3. Cofactor in oxidation-reduction reactions
    4. Part of the protein hemoglobin which carries oxygen in the blood
    5. Part of the protein **myoglobin** in the muscles which makes oxygen available for muscle contractions
    6. Utilization of energy in cell metabolism

ScienceLogo B. Iron Absorption and Metabolism

* + 1. Iron Absorption
       1. The protein **ferritin** stores iron in the **mucosal** cells. The **mucosa** is the lining of the digestive tract.
       2. Transfers iron to mucosal **transferrin.**
       3. Transfers iron to blood transferrin
       4. Transports iron to the cells
       5. Excreted and replaced as needed
    2. **Heme** and **Nonheme** Iron
       1. **Heme** iron
          1. Foods that are flesh of animals
          2. 10% of days consumption
          3. Absorption rate of 25%
       2. **Nonheme** iron
          1. Plant-derived and animal-derived foods
          2. Absorption rate of 17%
    3. Absorption-Enhancing Factors
       1. **MFP factor**
       2. Vitamin C
       3. Citric acid and lactic acid from foods
       4. HCl from stomach
       5. Sugars
    4. Absorption-Inhibiting Factors
       1. Phytates and fibers from grains and vegetables
       2. Oxalates from spinach, beets and rhubarb
       3. Calcium and phosphorus from milk
       4. EDTA (food additive)
       5. Tannic acid and other polyphenols in tea and coffee
    5. Dietary Factors Combined
       1. Difficult to assess with meal consumption
       2. Most relevant factors are MFP factor, Vitamin C and phytates
    6. Individual Variation
       1. Dietary factors
       2. Health status
       3. Stage in life cycle
       4. Iron status
    7. Iron Transport and Storage
       1. Surplus is stored in bone marrow, spleen, and liver
       2. **Hemosiderin** is a storage protein used when concentrations of iron are extremely high.
       3. Storing excess iron is a protective measure because iron can act as a free radical.
    8. Iron Recycling
       1. Liver and spleen dismantle red blood cells and package iron into transferrin.
       2. Transferrin carries iron in the blood.
       3. Bone marrow incorporates iron into hemoglobin and stores iron as ferritin.
       4. Iron-containing hemoglobin carries oxygen in the blood.
       5. Iron is lost with bleeding and through the GI tract.

HealthCareLogoHotTopicLogo C. Iron Deficiency

* + 1. Vulnerable Stages of Life
       1. Women in reproductive years
       2. Pregnant women
       3. Infants and young children
       4. Teenagers
    2. Blood Losses
       1. Giving a pint of blood loses about 2.5 mg iron
       2. Menstruation
       3. Bleeding ulcers
       4. Malaria and parasites
    3. Assessment of Iron Deficiency
       1. Stage 1 - Iron stores diminish; measure serum ferritin
       2. Stage 2 – Transport iron decreases; measure transferrin saturation
       3. Stage 3 – Hemoglobin production declines; **erythrocyte protoporphyrin** accumulates and **hematocrit** declines
    4. **Iron Deficiency** and Anemia
       1. **Iron deficiency** is depleted iron stores.
       2. **Iron-deficiency anemia** is the severe depletion of iron stores. Also called **microcytic hypochromic anemia**.
       3. Symptomsinclude fatigue, weakness, headaches, apathy, pallor and poor resistance to cold temperatures.
    5. **Iron Deficiency** and Behavior
       1. Energy metabolism is impaired.
       2. Neurotransmitter synthesis is reduced.
       3. Physical work capacity is reduced.
       4. Mental productivity is reduced.
    6. Iron Deficiency and **Pica**
       1. Habit of eating ice, clay, paste, and other nonfood substances
       2. Generally in women and children from low-income groups

HealthCareLogo D. Iron Toxicity

* + 1. **Iron Overload**
       1. **Hemochromatosis** is generally a genetic disorder that enhances iron absorption.
       2. Repeated blood transfusions
       3. Massive doses of supplemental iron
       4. May cause **hemosiderosis**
       5. Symptoms include apathy, lethargy, and fatigue
       6. Problems include liver tissue damage and infections
       7. Higher risk of diabetes, liver cancer, heart disease, and arthritis
    2. Iron and Heart Disease – may be a link to high iron stores
    3. Iron and Cancer – may be a link with free radical activity
    4. Iron Poisoning
       1. Upper level for adults: 45 mg/day
       2. Accidental supplement poisoning in children
       3. Symptoms include nausea, vomiting, diarrhea, constipation, rapid heartbeat, weak pulse, dizziness, shock, and confusion

HealthCareLogoAppleLogo E. Iron Recommendations and Sources

* + 1. Recommended Intakes (2001 RDA)
       1. RDA Men: 8 mg/day for adults 19-50 years of age
       2. RDA Women: 18 mg/day for adults 19-50 years of age
       3. RDA Women: 8 mg/day for adults over 51 years of age
       4. Vegetarians needs 1.8 times as much iron because of low bioavailability.
    2. Iron in Foods
       1. Red meats, fish, poultry, and shellfish
       2. Eggs
       3. Legumes
       4. Dried fruits
    3. Iron-Enriched Foods
       1. Often added to grain foods
       2. Not absorbed as well
    4. Maximizing Iron Absorption
       1. Bioavailability is high in meats, fish, and poultry.
       2. Bioavailability is medium in grains and legumes.
       3. Bioavailability is low in vegetables.
       4. Combined effect of enhancing and inhibiting factors
  1. Iron Contamination and Supplementation
     1. **Contamination Iron**
        1. Iron cookware takes up iron salts
        2. Acidic foods and long time cooking increase uptake of iron salts
     2. Iron Supplements
        1. Best absorbable form is ferrous sulfate or an iron **chelate**
        2. Take on empty stomach and with liquids other than milk, tea, or coffee
        3. Vitamin C enhances food iron absorption not supplement absorption
        4. Side effect of constipation

1. Zinc

Zinc is important in a multitude of chemical reactions in the body. The best sources of dietary zinc are protein-rich foods. Zinc from pancreatic secretions is also available for absorption. Phytates and fiber can bind zinc, therefore limiting absorption. A special binding protein monitors the absorption of zinc. Zinc deficiency symptoms include growth retardation and sexual immaturity.

ScienceLogo A. Zinc Roles in the Body

* + 1. Supports the work of **metalloenzymes**
       1. Helps to make parts of DNA and RNA
       2. Manufactures heme for hemoglobin
       3. Assists in essential fatty acid metabolism
       4. Releases Vitamin A from liver stores
       5. Metabolizes carbohydrates
       6. Synthesizes proteins
       7. Metabolizes alcohol
       8. Disposes damaging free radicals
    2. Affects platelets in blood clotting and wound healing
    3. Affects thyroid hormone function
    4. Influences behavior and learning performance
    5. Taste perception
    6. Sperm development
    7. Fetal development

ScienceLogo B. Zinc Absorption and Metabolism

* + 1. Zinc Absorption
       1. Rate of absorption depends on zinc status
       2. Phytates and fiber bind zinc and reduce absorption.
       3. **Metallothionein** is a special protein that holds zinc in storage.
    2. Zinc Recycling
       1. **Enteropancreatic circulation**
       2. Losses occur in the feces.
    3. Zinc Transport
       1. Transported by the protein albumin
       2. Binds to transferrin

HealthCareLogo C. Zinc Deficiency

* + 1. Not widespread
    2. Occurs in pregnant women, young children, the elderly, and the poor
    3. Symptoms of deficiency
       1. Growth retardation
       2. Delayed sexual maturation
       3. Impaired immune function
       4. Hair loss, eye and skin lesions
       5. Loss of appetite

HealthCareLogo D. Zinc Toxicity

* + 1. Upper Level for Adults: 40 mg/day
    2. Symptoms
       1. Loss of appetite
       2. Impaired immunity
       3. Low HDL
       4. Copper and iron deficiencies
       5. Vomiting and diarrhea
       6. Exhaustion
       7. Headaches

HealthCareLogoAppleLogo E. Zinc Recommendations and Sources

* + 1. Recommended Intakes (2001 RDA)
       1. RDA Men: 11 mg/day
       2. RDA Women: 8 mg/day
    2. Zinc in Foods
       1. Red meats and shellfish
       2. Whole grains
  1. Zinc Supplementation
     1. Developing countries use zinc to reduce incidence of disease and diarrhea.
     2. Zinc lozenges for the common cold are controversial and inconclusive.

1. Iodine

Iodide is an essential component of the thyroid hormone that helps to regulate metabolism. Iodine deficiency can cause simple goiter and cretinism. The iodization of salt has eliminated iodine deficiency in the United States and Canada.

* 1. Iodide Roles in the Body
     1. Component of two thyroid hormones
     2. Regulates growth, development, and metabolic rate
  2. Iodine Deficiency
     1. **Simple goiter** is the enlargement of the thyroid gland caused by iodine deficiency. **Goiter** is enlargement of the thyroid gland due to malfunction of the gland, iodine deficiency or overconsumption of goitrogens.
     2. **Cretinism** is a congenital disease characterized by mental and physical retardation and commonly caused by maternal iodine deficiency during pregnancy.
     3. **Goitrogen** overconsumption– naturally occurring in cabbage, kale, brussels sprouts, cauliflower, broccoli, and kohlrabi
  3. Iodine Toxicity
     1. Upper level 1000 μg/day
     2. Symptoms include underactive thyroid gland, elevated TSH, and goiter
     3. Supplement use, medications, and excessive iodine from foods
  4. Iodine Recommendations and Sources
     1. Recommendations (2001 RDA) Adults: 150 μg/day
     2. Sources
        1. Iodized salt
        2. Seafood
        3. Bread and dairy products
        4. Plants grown in iodine-rich soils
        5. Animals that feed on plants grown in iodine-rich soils

1. **Selenium**

Selenium is an antioxidant nutrient associated with protein foods. It may provide some protection against certain types of cancer.

* 1. Selenium Roles in the Body
     1. Defends against oxidation
     2. Regulates thyroid hormone
  2. Selenium Deficiency
     1. **Keshan disease** – a pre-disposition to heart disease where cardiac tissue becomes fibrous
     2. Prevalent in regions of China
  3. Selenium and Cancer
     1. May protect against certain forms of cancer
     2. Inconclusive evidence and more research is needed
     3. Food sources are better than supplements
  4. Selenium Recommendations and Sources
     1. Recommendations (2000 RDA) Adults: 55 μg/day
     2. Sources include seafood, meat, whole grains, and vegetables (depends on soil content)
  5. Selenium Toxicity
     1. Upper Level for Adults: 400 μg/day
     2. Symptoms
        1. Loss and brittleness of hair and nails
        2. Skin rash, fatigue, irritability, and nervous system disorders
        3. Garlic breath odor

1. Copper

Copper is a component of several enzymes associated with oxygen or oxidation. Copper deficiency is rare. There are some diseases associated with excessive intakes. Food sources of copper include legumes, whole grains, and seafood.

* 1. Copper Roles in the Body
     1. Absorption and use of iron in the formation of hemoglobin
     2. Part of several enzymes
     3. Some copper containing enzymes are antioxidants.
  2. Copper Deficiency and Toxicity
     1. Deficiency symptoms include anemia and bone abnormalities.
     2. Menkes disease
     3. Toxicity
        1. Upper Level for Adults: 10,000 μg/day (10 mg/day)
        2. Wilson’s disease
  3. Copper Recommendations and Sources
     1. Recommendations (2001 RDA) Adults: 900 μg/day
     2. Sources
        1. Seafood, nuts, seeds and legumes
        2. Whole grains

1. Manganese

Manganese is a cofactor for several enzymes involved in bone formation and various metabolic processes. Deficiencies are rare and toxicities are associated with environmental contamination. Manganese is found widespread in foods.

* 1. Manganese Roles in the Body
     1. Cofactor for several enzymes
     2. Assists in bone formation
     3. Pyruvate conversion
  2. Manganese Deficiency and Toxicity
     1. Deficiency symptoms are rare
     2. Phytates, calcium and iron limit absorption.
     3. Toxicity occurs with environmental contamination.
     4. Upper Level for Adults: 11 mg/day
     5. Toxicity symptoms include nervous system disorders.
  3. Manganese Recommendations and Sources
     1. Recommendations (2001 AI)
        1. AI Men: 2.3 mg/day
        2. AI Women: 1.8 mg/day
     2. Sources
        1. Nuts
        2. Whole grains
        3. Leafy vegetables
        4. Tea

1. Fluoride

Fluoride makes bones stronger and teeth more resistant to decay. The use of fluoridated water can reduce dental caries. Excess fluoride causes fluorosis—the pitting and discoloration of teeth.

* 1. Fluoride Roles in the Body
     1. Formation of teeth and bones
     2. Helps to make teeth resistant to decay
     3. **Fluorapatite** is the stabilized form of bone and tooth crystals

AppleLogo B. Fluoride and Dental Caries

* + 1. Widespread health problem
    2. Leads to nutritional problems

HealthCareLogo C. Fluoride and Toxicity

* + 1. Tooth damage called **fluorosis**
    2. Upper Level for Adults: 10 mg/day
    3. Prevention of **fluorosis**
       1. Monitor fluoride content of local water supply.
       2. Supervise toddlers during tooth brushing.
       3. Watch quantity of toothpaste used (pea size) for toddlers.
       4. Use fluoride supplements only if prescribed by a physician.
  1. Fluoride Recommendations and Sources
     1. Recommendations (1997 AI)
        1. AI Men: 3.8 mg/day
        2. AI Women: 3.1 mg/day
     2. Sources
        1. Fluoridated drinking water
        2. Seafood and tea

1. Chromium

Chromium enhances insulin’s action. It is widely available in unrefined foods.

* 1. Chromium Roles in the Body
     1. Enhances insulin action
     2. **Glucose tolerance factors (GTF)** are small organic compounds that enhance insulin’s action
  2. Chromium Recommendations and Sources
     1. Recommendations (2001 AI)
        1. AI Men: 35 μg/day
        2. AI Women: 25 μg/day
     2. Sources
        1. Meat, especially liver
        2. Whole grains
        3. Brewer’s yeast
  3. Chromium Supplements
     1. Do not effectively improve glucose or insulin response in diabetics
     2. Claims about reducing body fat and improving muscle strength remain controversial.

1. **Molybdenum**

Molybdenum is a cofactor in several enzymes. It is needed in minuscule amounts. It is available in legumes, grains, and organ meats.

* 1. Molybdenum functions as a cofactor for several enzymes.
  2. No deficiency symptoms
  3. No reported toxicity symptoms
  4. Recommendations (2001 RDA)
     1. Adults: 45 μg/day
     2. Upper Level Adults: 2 mg/day
  5. Food sources include legumes, grains, and organ meats.

1. Other Trace Minerals

Much of the research on other trace minerals is from animal studies. Humans need very small amounts. Determining exact needs, functions, deficiencies, and toxicities is difficult. Some key roles of these other trace minerals have been identified.

* 1. Nickel is a cofactor for certain enzymes.
  2. Silicon is used in bone and collagen formation.
  3. Vanadium is for growth, development, and normal reproduction.
  4. Cobalt is a key component of Vitamin B12.
  5. Boron may be key in brain activities.
  6. Arsenic is useful in some types of leukemia.

1. Contaminant Minerals

Contaminate minerals are also called **heavy metals**. These include mercury, lead, and cadmium. These minerals enter the food supply through soil, water, and air pollution. They disrupt body processes and impair nutrition status.

HotTopicLogo A. Lead Toxicity Symptoms in Children

* + 1. Learning disabilities in children
    2. Low IQ
    3. Behavior problems
    4. Slow growth
    5. Dental caries
    6. Iron-deficiency anemia
    7. Sleep disturbances like night walking, restlessness, and head banging
    8. Nervous system disorders and seizures
    9. Slow reaction time and poor coordination
    10. Impaired hearing
  1. Lead Toxicity Symptoms in Adults
     1. Hypertension
     2. Reproductive complications
     3. Kidney failure

1. Highlight: Phytochemicals and Functional Foods

Phytochemicals are nonnutrient compounds. Only a few of the thousands of phytochemicals have been researched. There are many questions and few answers about their role in human health. Foods that provide health benefits beyond those of nutrients are now called functional foods. Some have an identified role in disease prevention.

HotTopicLogo A. The Phytochemicals

* + 1. Defending against Cancer
       1. **Phytoestrogens** mimic estrogen
          1. Antioxidant activity
          2. Slow the growth of breast and prostrate cancer
          3. Found in soybeans, **flaxseed** oil, whole grains, fruits and vegetables
       2. **Lycopene**
          1. Powerful antioxidant
          2. Inhibit the growth of cancer cells
          3. Found in tomatoes and cooked tomato products, apricots, guava, papaya, pink grapefruits, and watermelon
       3. Five servings of fruits and vegetables are recommended every day.
    2. Defending against Heart Disease
       1. **Flavonoids** in foods
          1. Powerful antioxidants
          2. Protect against LDL cholesterol oxidation and reduce blood platelet stickiness
          3. Lowers risk of chronic diseases
          4. Found in whole grains, legumes, soy, vegetables, fruits, herbs, spices, teas, chocolate, nuts, olive oil, and red wines
       2. Carotenoids in foods especially **lutein** and lycopene
          1. Lower risk of heart disease
          2. Found in fruits and vegetables
       3. **Phytosterols**
          1. May protect against heart disease
          2. Inhibit cholesterol absorption
          3. Lower blood pressure
          4. Act as antioxidants
          5. Found in soybeans and other vegetables
          6. **Lignans**, found in flax seed, are converted to phytosterols by intestinal bacteria.
    3. The Phytochemicals in Perspective
       1. Difficult to assess one food and its benefits alone
       2. Actions of phytochemicals are complementary and overlapping

HotTopicLogo B. **Functional Foods**

* + 1. Foods as Pharmacy
       1. **Yogurt** and **probiotics**
       2. Margarine enhanced with a phytosterol may lower cholesterol.
       3. May be more useful in prevention and mild cases of disease.
       4. Drugs are used for severe cases of disease.
    2. Unanswered Questions
       1. Research is lagging behind food manufacturers.
       2. Consumer questions to ask
          1. Does it work?
          2. How much does it contain?
          3. Is it safe?
          4. Is it healthy?
  1. Future Foods
     1. Use of gene research
     2. Can we design foods to meet exact health needs of each individual?

3. Can farmers grow the “perfect” foods?