TOXIC & NUTRIENT elements chart

Great Smokies Diagnostic Lab

Toxic Elements

Elements	Sources	Synergistic for Uptake/Retention	Antagonistic for Uptake/Retention	Physiological Interactions	Symptoms of Excessive Exposure
ALUMINUM (Al)	Processed foods; cheeses, non-dairy creamers, infant milk formulas, acidic foods (eg tomatoes) when cooked in Al pots. Fruit juices and soft drinks. Water, soil (varies from 700-100,000 ppm). Air - dust and other particles from weathering of rock, mining and agricultural processes, metal working fluids. Antacids, antiperspirants, aluminum cookware. Renal dialysis solutions.	Iron or calcium deficiency.	Adequate iron and calcium. Vitamin C (for all toxins).	Accumulates in bone, liver, kidney and brain. Follows phosphate. Inhibits isocitrate dehydrogenase in mitochondria, thus decreases alpha-keto-glutarate. Interferes with bone mineralization, binds to brain calmodulin, may enhance acetylcholine turnover. Associated with neuronal plaques.	Headache, fatigue, bone pain, dementia. Low hemoglobin, hypophosphatemia, hyperammonemia.
ANTIMONY (Sb)	Meats, vegetables, and seafood (0.2 to 1.1 ppb), tobacco. Flame retardants in textiles, mordant in dyeing processes. Metal work factories, rubber processing, mining, smelting and hazardous waste sites.	Magnesium or selenium deficiency.	Adequate magnesium, selenium, and methionine.	Accumulates in adrenals, thyroid, kidney, liver, spleen, and bone. Clears rapidly from blood. Inhibits various enzyme systems (PFK, MAO). Binds to sulfhydryl groups.	Antimony spots (from vapor), ocular conjunctivitis. Chronic exposure can lead to; antimony pneumoconiosis, alterations in pulmonary function, chronic bronchitis, chronic emphysema, inactive tuberculosis, pleural adhesions, and irritation. HBP, myopathy, angina, altered EKG readings. GI disorders, metallic taste, gout-like symptoms, anorexia and fatigue.
ARSENIC (As)	Fish and shellfish, air and drinking water. Arsenic treated wood, pesticides, fungicides, rat poison. Hazardous waste environments, smelting processes (eg copper, zinc, and lead), chemical and glass manufacturing, paints. Chemical, electronic & photoelectric processes, specialty glass.	Selenium or iodine deficiency.	Adequate selenium and iodine.	Organic forms readily absorbed; inorganic forms in water are also easily absorbed. Deposits in liver, kidney, skin and spleen. Disables alpha-lipoic acid. Potential carcinogen. Binds to sulfhydryl and phosphatide groups.	Hair loss, white-streaked nails, myalgia, garlic odor, anorexia, hypopigmentation, hypotension, chest pain, nausea, diarrhea.
BARIUM (Ba)	Contaminated water, air or soil. Fish and aquatic organisms. Rat poisons and insecticides. Medical tests (barium enemas), barium salts. Drilling equipment used by oil and gas industries. Mining and refining, coal and oil burning emissions, processing plants (eg paint, brick, tile, glass, and rubber). Arc-welding, metal fabrication work, fireworks, pigments and cathode ray tubes.	Potassium or sulfate deficiency.	Calcium, potassium, vitamin C.	Displaces potassium and increases stress hormone (catecholamines). High levels may trigger ventricular fibrillation, bronchoconstriction, and brain swelling.	Difficulties in breathing, increased blood pressure, changes in heart rhythm, stomach irritation, brain swelling, muscle tingling/weakness. May damage heart, liver, kidneys and spleen.

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BISMUTH (Bi)	Drinking water, fruits, vegetables (small amounts), pharmaceuticals, antacids, anti-diarrheal and ulcer medications. Cosmetics, automatic sprinklers, fuse alloys, solders, pigments and paints, semiconductors, electronic components, batteries, metal mining and refining.	Methionine deficiency.	Lipoic acid, methionine as "SAM".	Binds to sulfhydryl sites, inactivates enzymes, affects methylation. Distributes to liver, kidney, soft tissues, and bones. Also affects central nervous system and mucous membranes. Excess may cause nephrotoxicity with renal tubular lesions.	Confusion, decreased appetite, weight loss, weakness, joint pain, skin rash, tremors, diarrhea, staining on gums.
CADMIUM (Cd)	Shellfish, liver and kidney meats, soft water, tobacco. Mining and smelting processes (eg lead and zinc). Nickel-cadmium batteries, PVC plastics, paint pigments. Insecticides, fungicides, sludge, and commercial fertilizers. Other sources include; dental alloys, electroplating, motor oil, and exhaust.	Iron deficiency. Lead and mercury accentuate toxicity.	Adequate zinc, calcium, magnesium, and copper.	Kidney proximal tubule is main site of accumulation. May modify catecholamine metabolism. Decreases CYP-450. Inhibits antitrypsin. Changes in arterial endothelium seen.	Hypotension, hypertension, fatigue, anemia, proteinuria, osteomalacia, nausea, vomiting, diarrhea, emphysema. Target organs are the liver, placenta, kidneys, lungs, brain, and bones .
CESIUM (Cs)	Food and drinking water from contaminated soil, alcoholism. Radioactive sites, nuclear explosions or the breakdown of uranium in fuel elements. Electronic, photoelectric, and medical applications, atomic clocks and fountains.	Potassium deficiency.	Potassium.	Inhibits potassium current in myocardial cells, increases intracellular pH. May affect erythrocytes, liver, and central nervous system.	Fatigue, muscle weakness, palpitations and arrhythmia.
GALLIUM (Ga)	Analogue integrated circuits and optoelectronic devices (light-emitting diodes, laser diodes, photodetectors and solar cells) are the most common sources. Wets glass or porcelain to create mirrors. Dental materials, microwave components, high-temp thermometers. Semiconductors, transistors, telecommunications materials, fluorescent lamps.	Intestinal absorption increased by carboxylc acids (e.g., citric acid), iron deficiency.	Absorption from intestines is inhibited by phosphate; citric acid may help detoxify.	May deposit in liver, spleen, brain, renal cortex and bone. Urine is major route of excretion. May irritate mucosal membranes, decrease gastric function, and trigger kidney tubular damage. Can bind to hydroxyapatite in bone.	Hyperexcitability, photophobia, rapid weight loss (anorexia), mucosal irritation, gastrointestinal distress.
GADOLINIUM (Gd)	Gadolinium is a member of a group of rare earth metals known as lanthanides. It has been used for superconductors, magnets, fluorescent materials, and as a nuclear MRI contrast agent.	Zinc deficiency	Zinc excess	Metabolism appears similar to nickel and copper. Physiologic changes are consistent with Zinc deficiency and are correlated with increased urinary zinc concentrations.	Toxicity appears similar to nickel and copper, and has been associated with hair loss and skin lesions.

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GERMANIUM (Ge)	Seafood, dietary supplements (Panax Ginseng, Garlic, Comfrey, Aloe). Chemotherapeutic agent. Smelting processes, metal residue processing, coal combustion. Used as an alloying agent, a phosphor in fluorescent lamps, and as a catalyst. Optical equipment, wide angle camera lenses and microscope objectives. Semiconductor electronics, and gray spectroscopy detectors.	NA	NA	High doses may impair liver, lung, and kidney function, or trigger myopathy, peripheral neuropathy, and reduced skeletal muscle and bone mineralisation.	Wheezing, anemia, skin or eye irritation (from airborne exposure).
LEAD (Pb)	Dolomite, soil, pewter ware, pesticides, make up and hair coloring. Paint pigments, ceramics, stained glass and crystal glass production. Pipes, drains, and soldering materials. Batteries, cable coverings, plumbing, ammunition, and fuel additives. Other sources include; PVC plastics, x-ray shielding, newsprint and pencils.	Calcium, iron, zinc, and phosphate deficiencies increase absorption. Children and infants have 40% higher absorption.	Calcium, zinc, and phytate decrease absorption. Adequate selenium.	Lead binds to hemoglobin, deposits in bone, aorta, kidney tubules, brain, adrenal, thyroid, liver. Inhibits heme synthesis, may depress mitochondrial respiratory chain. ATP-ases also affected.	Microcytic anemia, glycosuria, cognitive dysfunction, anorexia, metallic taste, insomnia, reticulocytosis. Target organs include the brain, bone, blood, kidneys, and thyroid gland.
MERCURY (Hg)	Aquatic food chains, fungicides, thermometers, thermostats, and dental amalgams. Algaecides, childhood vaccines, medicines (mercurochrome and merthiolate). Paints, batteries, electrical relays, coal-burning emissions, mining and explosives.	Selenium deficiency.	Adequate manganese, zinc, and copper.	The organic form is readily absorbed in the gastrointestinal tract (90-100%); lesser but still significant amounts of inorganic mercury are absorbed in the gastrointestinal tract (7-15%). Organic mercury has a half-life of 2 months & binds to enzymes, proteins, and glutathione. MAO, catalase, P-450, and mitochondrial functions are affected. Accumulates also in the liver and kidneys.	Headache, fine tremor, increased salivation, excitability, hypertension, skin rash, poor mental concentration, metallic taste. Target organs are the brain and kidneys.
NICKEL (Ni)	Cocoa, plant foods (nuts), hydrogenated oils, water, tobacco. Soil and sediment (attaches to particles that contain Fe and Mn), sewage slude. Dental crowns and bridges, jewelry. Stainless steel manufacturing, electroplating, coal and oil combustion. Electrical equipment and household appliances. Catalysts, pigments, batteries (Ni-Cd), metal and coins containing Ni.	Iron, copper, or zinc deficiencies.	Riboflavin, antioxidants.	Controversial nutrient role in humans, accumulates in kidney, liver, skin, brain. Hypersensitizes skin for inflammatory responses in allergic patients.	Dermatitis, allergies, increased inflammation.
NIOBIUM (Nb)	Tea, coffee, jewelry. Metal alloys, electronic devices and superconductive magnets. Used with titanium to make artificial joints, plates, pacemakers and dental implants. Stainless steel manufacturing, component of nuclear reactor cores.	Copper or zinc deficiency.	Aspartic acid, vitamin C, lipoic acid.	May affect cell mitochondria, liver, heart and kidneys.	Lethargy, muscle weakness, glycosuria.

Toxic Elements

Elements	Sources	Synergistic for Uptake/Retention	Antagonistic for Uptake/Retention	Physiological Interactions	Symptoms of Excessive Exposure
PLATINUM (Pt)	Soil and river sediments, air (automobile catalysts), jewelry. Catalytic converters (gas, engines), petroleum refining. Electroplating, catalyst production and equipment. Chemical processing, smelting, nickel/copper refining, electronic parts, aerospace applications.	Zinc deficiency.	Methionione, lipoic acid, N-acetylcysteine, cystine, vitamins C and E.	Complexes with other metals can irritate tissues, disrupt immune function, and interfere with heme synthesis in the liver. May decomplex and bind to sulfhydryl sites. Inhibits DNA synthesis. May affect liver, kidney, testes and lungs.	Rhinorrhea, wheezing, dermatitis, dyspnea.
RHODIUM (Rh)	Rhodium is a member of the platinum group elements (PGEs) and is commonly found in automotive catalytic converters.		Bismuth sub-nitrate, a potent inducer of metallothionein, reduces nephrotoxicity of platinum analogues.	Bio-accumulation has been noted and there is known allergic potential.	Long-term and low level rhodium exposure has raised questions about potential carcinogenicity and nephrotoxicity; both of which have been noted in related platinum compounds.
TELLURIUM (Te)	Plants/vegetables (via soil content). Chemical processing, metal alloys, rubber vulcanization, ceramic/glass pigments and glazes, thermoelectric and semiconductor materials.	Vitamin C or vitamin E deficiency.	Methionione, lipoic acid, N-acetylcysteine, cystine, vitamins C and E.	Interferes with cholesterol synthesis, inhibits glutathione peroxidase. Bonds to sulfhydryl groups. May damage nerves, liver, gastrointestinal tract.	Garlic-odor breath, inflammation, peripheral neuropathy, metallic taste, nausea, insomnia, decreased perspiration.
THALLIUM (Tl)	Fish and shellfish, enters food chain via plant absorption. Tobacco, rodent poisons. Coal burning and smelting. Electronic manufacturing, semiconductors, switches and closures, photocell batteries (Ni-Cd). Glass manufacturing and medical procedures.	Zinc, iron, or copper deficiency	Adequate zinc, iron, and copper.	Absorbed through skin, lungs, and via ingestion. Inhibits RNA and DNA synthesis. Inactivates riboflavin. Inhibits cholinesterase and phosphatase. Accumulates in kidney, heart, muscle, brain.	Anorexia, alopecia, ataxia, mental confusion, tremor, hypertension, polyneuropathy, immune changes.
THORIUM (Th)	Rocks, soil, water, plants and animals. Mining and smelting (thorium, uranium, tin, phosphate), radioactive waste dumps. Ceramics, gas lantern mantles, aerospace metals, fuel for nuclear reactions.	Zinc or calcium deficiency.	Adequate potassium and selenium.	Inhalation of contaminated dust main route for entering body. May also penetrate skin. Affects leukocytes, liver, lungs, lymph nodes. Can lead to genetic mutations. Binds to aspartic and glutamic acids and to bone glucoprotein. Inhibits certain digestive enzymes.	Thorium is odorless and tasteless. Excessive exposure has been linked to diseases of the lung, liver, bone, kidney, pancreas, and blood.

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TIN (Sn)	Seafood, plants, used to line cans for food, beverages and aerosols. Found in soil, water and air when naturally present in rocks. Mining and manufacturing processes, coal and oil combustion. Brass, bronze, ceramics, pewter, gas lantern mantles and soldering materials. Inorganic tin compounds are found in toothpaste, perfumes, soaps, food additives and dyes. Organotin compounds inlcude; plastics, food packages, plastic pipes, pesticides, paints, and pest repellents. Photoconductive film, aerospace industry products, nuclear reactions, nuclear energy fuel, radioactive waste disposal sites.	Acidosis decreases excretion.	Alkaline diet (high vegetable intake) enhances excretion.	Accumulates in liver, brain, and lymphatic. Half-life is 5-100 days. Decreases P-450 and oxidative phosphorylation.	Hyperglycemia, ataxia, headache, vision changes, liver pain.
TITANIUM (Ti)	Soil, air, water, tin coated cans. Aerospace and chemical industries. Titanium dioxide is used as a white pigment in paints.	NA	Antioxidants.	May accumulate in lungs, liver, and kidney.	Lung fibrosis, inflammation.
TUNGSTEN (W)	Tap water, plants, vegetables. Disposal of coal ash, incinerator ash, and industrial waste increase soil content. Prostheses, dental implants, pigment, shampoos, cosmetics, art supplies and sports equipment. Lighting filaments, electrical and electronic contacts, wire and rods. Television sets, high speed power tools, magnetrons in microwaves, aerospace applications. Used as a hardmetal and chemically as a catalyst.	Molybdenum deficiency.	Lipoic acid.	May disrupt glutamine synthesis. Can displace molybdate, and inhibit molybdate-dependent enzymes. May generate oxidative stress, lung fibrosis, and DNA damage.	Dyspnea, coughing, headache, dizziness, nausea, impaired sense of smell, asthma.
URANIUM (U)	Food, air and water (naturally occurring in rocks and soil). Processing plants, coal mines, phosphate fertilizers, chemical processing, pigments. Metallurgical industry, inert-gas welding, metal cutting tools, defense weapons, metal alloys, light bulbs, cathode ray tubes and electric heaters/furnaces.	Calcium deficiency.	Adequate calcium and iron.	Accumulates in liver, kidney (proximal tubule, glomerulus), spleen, and bone.	Chronic fatigue, glycosuria, hyperaminoaciduria.

* For further information on toxic elements, refer to the Agency for Toxic Substances and Disease Registry website: **http://www.atsdr.cdc.gov/**

Nutrient Elements

Elements	Sources	Recommended Daily Intake	Absorption/ Utilization Factors	Biochemical Actions	Symptoms of Imbalance
BORON (B)	Dark green leafy vegetables (kale, spinach, mustard greens, etc.), potatoes, fruit, and fruit based beverages, legumes, avocados and nuts. Plant content depends on soil levels.	Not determined. Total daily intake estimated at 17-20 mg/d.*	Very well absorbed from diet, rapidly excreted.	Functions in bone structure & strength. Interacts with calcium, magnesium and vitamin D. May increase estrogen levels in post-menopausal women.	DEFICIENCY: Growth retardation, osteoporosis, higher calcium, magnesium excretion in urine. EXCESS: Higher B2 excretion, impaired chymotrypsin function.
CALCIUM (Ca)	Dark green leafy vegetables, Chinese cabbage, broccoli, kale. Corn tortillas, dairy products, tofu, canned salmon and sardines.	Between 1,000-1,300 mg/d.*	Vitamin D deficiency increases need. Best absorbed in acidic medium. Potassium and phosphorus decrease urinary losses. Vitamin D enhances absorption from gastrointestinal tract. Parathyroid hormone helps with calcium reabsorption in kidneys.	Bone mineralization, blood clotting, muscle contraction nerve conduction, enzyme regulation, membrane permeability.	Rickets, tetany, and osteoporosis can result from deficient intake. Hypertension, and colon cancer may relate to chronic low intake.
CHROMIUM (Cr)	Organ meats poultry, fish. Brewer's yeast, whole grains, cheese, mushrooms, prunes, nuts, asparagus, beer.	Between 24-35 mcg/d.*	Jejunum is site of absorption, which is some 2% of dietary intake. The glucose tolerance factor form may be better absorbed. Amino acids, oxalate and nicotinic acid act to improve absorption. Chromium lowers insulin need.	Potentiates normal insulin response via GTF form. Has an influence on lipoprotein lipase. Therefore, it can raise HDL cholesterol.	Hypoglycemia and hyperglycemia improve with chromium supplementation. May be deficient in cardiovascular disease and prolonged stress.
COBALT (Co)	Vegetables, whole grains. Vitamin B12 contains cobalt and may be a source of the inorganic form.	Estimated at 10-20 mcg/d.	Inorganic cobalt is absorbed similar to iron. Iron deficiency enhances cobalt absorption. Cobalt is also absorbed as vitamin B12.	Participates in erythropoesis via different mechanism than B12.	Anemias may respond to administration of cobalt chloride. Heart, thyroid, and pancreatic damage result from toxic levels of cobalt. High alcohol use worsens toxicity.
COPPER (Cu)	Organ meats, shellfish, cocoa based products, whole grain products, seeds, nuts, especially pecans.	890-900 mcg/d.*	Duodenum is main site of absorption. Two systems of absorption are evident: active transport & passive diffusion. Citrate, gluconate, histidine enhance absorption as do acid conditions. Alkalinity impairs absorption as does high intake of antacid preparations.	Copper is a key component of ceruloplasmin, important for iron and manganese oxidation. Copper is part of the cytosol form of SOD, a key antioxidant enzyme. Interacts with selenium and sulphur. Competes with zinc and molybdenum.	Hypochromic, normocytic anemia, neutropenia. Depigmentation of hair and skin can occur with deficiency. Toxic levels cause nausea, behavior problems, vomiting and diarrhea.
IODINE (I)	Seafood, iodized salt, sea vegetables such as dulse, nori, wakame and kelp. Processed foods.	150 mcg/d.*	Absorption is very efficient via the stomach and gastrointestinal tract. Bromide, lithium, and other halides can compete with I-transport into thyroid cells. Cabbage family vegetables contain goitrogens which impede normal thyroid function.	Crucial for thyroid hormone synthesis. Also concentrated in the cerebrospinal fluid and salivary glands.	Goiter is found with frank deficiency or high intake of goitrogenic foods. High intake over time can also impair thyroid function.

Nutrient Elements

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IRON (Fe)	Organ meats (liver), poultry, shellfish, dark green leafy vegetables, molasses, dried fruit. Legumes, nuts and seeds, fortified bread and grain products.	8-18 mcg/d.*	Iron absorption is enhanced by hydrochloric acid and protease action on heme iron from meats. Vitamin C and acids assist non-meat absorption. High pH, phytates, oxylates and tannins impair absorption.	Heme systems, cytochrome systems, and electron transport. Catalase requires iron and macrophage killing of bacteria via myeloperoxidase, also has heme iron requirements.	Microcytic anemia occurs late in deficiency. Plasma ferritin a good early indicator. Hemochromatosis and liver damage with toxic levels.
LITHIUM (Li)	Hard water, foods according to soil content.	Estimated at 30-100+ mcg/d.*	Easily absorbed and excreted. May be retained in endocrine tissues: ovary, thyroid, adrenal and pituitary.	Participates in exchange with sodium in red blood cells. Stimulates white blood cell and platelet formation. Therapeutic levels may impact cAMP, as well as glucocorticoid receptor or cholinergic activity.	Low levels associated with Gastrointestinal disorders, low stomach acid, heartburn, bloating, Bipolar/manic-depressive disorder. Excessive doses can cause nausea, vomiting, diarrhea, weight gain, staggering gait, hypothyroidism/goiter, tremors, renal and liver disease."
MAGNESIUM (Mg)	Oatmeal, buckwheat, unpolished grains, nuts, dark green leafy vegetables, chocolate, starches, milk.	360-420 mg/d.*	30%-60% of dietary forms are absorbed via small intestine. Stool fats decrease absorption as do phytate and fiber. Vitamin D mildly increases absorption. Taurine deficiency causes urinary wasting.	Bone formation, ATP formation via both glycolysis and Krebs cycle. Muscle contractility and nerve conduction are influenced by magnesium, cAMP production.	Deficiency results in muscle weakness/spasm. May be related to depression, hypertension, and heart attack risk.
MANGANESE (Mn)	Whole grains, legumes, nuts, dark green leafy vegetables, liver, kidney, tea.	1.6-2.3 mg/d.*	Iron competes with manganese for absorption. Variable absorption rates, participation in urea formation with phytate, oxalate, calcium, and phosphorus perhaps complexing and impairing absorption. Citrate and histidine enhance the absorption of manganese.	Key in mitochondrial superoxide dismutase. cAMP and intracellular calcium levels are modified with manganese. Deficiency results in abnormal arginase and Krebs cycle conversion of pyruvate to oxaloacetate. Also crucial for bone and connective tissue.	Toxicity: Rare, by inhalation or mining activities. Poor bone/connective tissue growth. Impaired glucose tolerance and lipid metabolism, skin dryness, hair changes, allergies, behavioral problems.
MOLYBDENUM (Mo)	Buckwheat, beans, grains, nuts, legumes, meats, vegetables.	43-45 mcg/d.*	Absorbed moderately well from the diet in many forms. Competes with inorganic sulfate for sites of absorption in the proximal small intestine. Tungsten interferes with molybdenum function/retention.	Functions in redox enzymes. Xanthine oxidase, aldehyde oxidase, xanthine dehydrogenase and sulfite oxidase all require the cofactor molybdopterin. The production of uric acid and of inorganic sulfate therefore hinges on Mo availability.	High molybdenum along with low copper intake may cause copper deficits and resultant anemias. Low molybdenum may impair sulfation detoxification pathways.
PHOSPHORUS (P)	Meat, fish, poultry, eggs, dairy products, peas, some cereals and breads.	800-1,200 mg/d.*	Readily absorbed in inorganic state from food. Phytate form largely unavailable. Iron, magnesium, calcium, aluminum-containing antacids, and unsaturated fatty acids can form insoluble salts with phosphorus.	85% of phosphorus is found in bone, as part of calcium phosphate and hydroxyapatite laid down onto collagen during bone formation. Also part of nucleic acids and cell membrane phospholipids. Participates in pH-buffering processes.	Phosphorus is adequately controlled by renal resorptive mechanisms so that deficiencies or toxicities are rare. Malabsorptive diseases may cause low levels leading to weakness, myopathy, and neurologic changes. Excesses affect calcium and magnesium.

Nutrient Elements

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POTASSIUM (K)	Avocados, almonds, vegetables, fruit/juices, milk, potatoes, lentils, molasses, bananas, beans, spinach, nuts, wheat, beef.	1600-5000 mg/d.*	Highly absorbable (90%+) from the diet. This is thought to occur largely in the colon. Low potassium promotes uptake/retention.	Potassium is the major intracellular ion, intimately related to sodium movement out of the cell via Na/K ATPase. As such, it participates in maintaining normal membrane potential in cells. Potassium is also a major factor in osmotic fluid dynamics in the body. Renal control mechanisms keep blood levels within a narrow range. Normal or increased potassium antagonizes uptake/retention.	Deficiency: Irregular/rapid heart beat, HBP, kidney disease, infrequent menstrual cycles, ovarian cysts, muscle spasms/cramps, joint pains, weakened immune system, hyperglycemia. EXCESS: hypotension, UTI's, reactive hypoglycemia, increased risk for cancer. Toxicity is possible via supplements at doses near 18g or in kidney dysfunction.
RUBIDIUM (Rb)	Soil, seawater, neuropsychiatric medications, vacuum tubes, photocell components, special glasses, atomic clocks/fountains	NA	NA	Absorbed easily from the gut. Only toxic when concentrations reach 30% of potassium levels in blood or muscle cells. Gains entry to cells via K-pumping sites with greater affinity than potassium. May antagonize potassium.	Excessive exposure may trigger weakness, hypotension, muscle twitching and other symptoms of potassium deficiency. May also interfere with thyroid uptake of iodine.
SELENIUM (Se)	Grains (soil dependent), seafood, organ meats, garlic, mushrooms. Vegetable sources may be better absorbed.	55 mcg/d.*	Selenium occurs in a number of forms and is generally well absorbed from the duodenum. Vitamin C, vitamin E, retinol, and reduced glutathione improve absorption. Heavy metals and phytate inhibit absorption.	Integral part of the antioxidant enzyme glutathione peroxidase. Protects against hydrogen peroxides and lipid peroxides in the cytosol and mitochondria. Also involved in deiodination of thyroxine to form T3.	Increased susceptibility to cardiovascular disease and diminished thyroid function are possible results of deficiency. Impaired resistance to oxidative stress also occurs. Extremely low levels are associated with increased cancer risk and cardiomyopathy.
SODIUM (Na)	Ubiquitous in prepared foods, cheeses, canned food.	1000-3500 mg/d.*	95% absorbed from dietary sources with excess excreted from the kidneys. Three separate absorption pathways, two in the small intestine, one in the colon. Co-transport occurs with glucose, B-vitamins, amino acids, and small peptides.	Along with potassium and chloride, sodium participates as an extracellular ion controlling osmolarity, membrane potentials, and adrenal aldosterone output. Calcium excretion is enhanced with high sodium intake.	High levels associated with; edema, hypertension, stroke, dizziness, gout, headaches, kidney damage, kidney stones, stomach problems, nausea, vomiting, coma. Kidneys and sweat losses promote sodium removal when dietary intake is high.
STRONTIUM (Sr)	Most plant foods, dairy, (Brazil) nuts, seawater.	None stated; estimated at 1-5 mg/d.*	Strontium is not well absorbed from the diet. Its concentration in the plasma is quite low (in the 10ng/mL range) where it is partially bound, partially chelated. Calcium appears to compete with strontium for absorption or utilization.	Strontium participates in bone metabolism and may compete with vitamin D. Can diminish vitamin D's anti-rickets activities in animal models.	Dental caries, rickets, abdominal spasms, diarrhea are associated with excessive intake/exposure.
SULFUR (S)	Meats, fish, egg yolk, onions, garlic, dairy, wheat germ, legumes, cabbage, some nuts, certain medications (e.g., magnesium sulfate used in laxatives).	800-1,000 mg/d.*	Sodium, molybdenum, selenium, Vitamin B12 are synergistic for sulfur uptake. Low levels of copper, potassium, calcium, Vitamin B15 and the toxic elements aluminum, mercury, cadmium can impair absorption.	Important for cellular respiration, oxidation-reduction reactions.	DEFICIENCY: Alzheimer's disease, nerve degeneration, memory loss, arthritis/cartilage degeneration, lupus, scleroderma, reduced insulin production collagen diseases affecting hair, skin and nails. EXCESS: Crohn's disease, nerve degeneration, ALS/Lou Gehrig's disease, asthma from sulfites, inflammatory vascular/joint degeneration.

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VANADIUM (V)	Spices (dill seeds, parsley, black pepper), seafood, meat, fish, mushrooms, olives, grains, vegetable oils, fats.	None stated; estimated at 100+ mcg/d.*	Vanadium's absorption rate is unclear. Animal studies show up to 40% absorption while human and other animal studies indicate a rate closer to 5%. In the body vanadium is reduced to the vanadyl form. This form can bind to iron-containing complexes (transferrin, ferritin). Vanadium accumulates in kidney and bone tissue.	Quite active in physiologic systems, with three main types of actions. Competes with phosphate and other metals for binding sites on proteins. Shows insulin-like effects and increases cAMP formation thus accounting for its enhancement of cellular phosphorylation. Studies show high levels associated with bipolar disorder in some cases.	Toxicity at high levels is reported and can occur via inhaled vapors as products of combustion. Symptoms can include; arthritis, aching bones, jaw, teeth, tonsils, ears, weakened immune system, chronic colds, gastrointestinal problems, trabecular bone loss, green tongue coloration.
ZINC (Zn)	Oysters, soybeans, wheat germ, seeds, nuts, lamb, beef, chicken, eggs, herring, milk, yeast, leafy and root vegetables.	9-11 mg/d.*	Zinc is absorbed at about 20%-30% of ingested quantities. There are also significant amounts in the pancreatic and biliary secretions. Absorption is a two-step process which is energy requiring. Competition with calcium, iron and copper can significantly impair absorption, as can high phytate foods and folic acid supplementation.	Involved in over 40 enzyme systems that affect functions of immunity, spermatogenesis, protein synthesis and degradation, heme synthesis, and carbon dioxide transport. Pancreatic proteases require the element as does the cytosol component of superoxide dismutase.	Deficiency may result in decreased growth, loss of taste and smell, sterility, poor wound healing, skin rash, hair loss, heart disease, liver disease, kidney disease, muscle weakness, arthritis, BPH, infertility, impotence, toxemia of pregnancy, hypochlorhydria, diabetes, night blindness, cataracts, and immune dysfunction.

* - RDA sourced from DRI reports (www.nap.edu) and www.acu-cell.com. Doses provided are for adults (14 years and greater) only, and do not represent altered requirements during pregnancy and lactation.

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