Appendix C: Nutrient Chart - Function, Deficiency and Toxicity Symptoms, and Major Food Sources

Nutrient	Function	Deficiency Symptoms	Toxicity Symptoms	Major Food Sources
Protein	Anabolism of tissue proteins; helps maintain fluid balance; energy source; formation of immunoglobulins; maintenance of acid-base balance; important part of enzymes and hormones	Kwashiorkor-edema; reddish pigmentation of hair and skin; fatty liver; retardation of growth in children; diarrhea; dermatosis; decreased T-cell lymphocytes with increased secondary infections;	Azotemia; acidosis; hyperammonemia	Breast milk, infant formula, meat, fish, poultry, egg yolk, cheese, yogurt, legumes
Carbohydrate	Major energy source; protein sparing; necessary for normal fat metabolism; glucose is the sole source of energy for the brain; many sources also provide dietary fiber	Ketosis		Breast milk; infant formula; whole-grain breads, cereals, and other fortified or enriched grain products; potatoes; corn; legumes; fruits; vegetables
Fat	Concentrated energy source; protein sparing; insulation for temperature maintenance; supplies essential fatty acids; carries fat-soluble vitamins A, D, E, K	Eczema; low growth rate in infants; lowered resistance in infection; hair loss		Breast milk, infant formula, protein-rich foods (meats, dairy products, egg yolk, nuts), butter, margarine, cream, salad oils and dressings, cooking and meat fats
Vitamin D	Necessary for the formation of normal bone; promotes the absorption of calcium and phosphorus in the intestines	Rickets (symptoms: costochondral beading, epiphyseal enlargement, cranial bossing, bowed legs, persistently open anterior fontanelle)	Abnormally high blood calcium (hypercalcemia), retarded growth, vomiting, nephrocalcinosis	Infant formula, egg yolk, liver, fatty fish, sunlight (activation of 7-dehydrocholesterol in the skin)
Vitamin A	Preserves integrity of epithelial cells; formation of rhodopsin for vision in dim light; necessary for wound healing, growth, and normal immune function	Night blindness, dry eyes, poor bone growth, impaired resistance to infection, papillary hyperkeratosis of the skin	Fatigue; night sweats; vertigo; headache; dry and fissured skin; lips; hyperpigmentation; retarded growth; bone pain; abdominal pain; vomiting; jaundice; hypercalcemia	Breast milk, infant formula, liver, egg yolk, dark green and deep yellow vegetables and fruits
Vitamin E	May function as an antioxidant in the tissues; may also have a role as a coenzyme; neuromuscular function	Hemolytic anemia in the premature and newborn; hyporeflexia, and spinocerebellar and retinal degeneration	May interfere with vitamin K activity leading to prolonged clotting and bleeding time; in anemia, suppresses the normal hematologic response to iron	Breast milk; infant formula; vegetable oils; liver; egg yolk; butter; green leafy vegetables; whole-grain breads, cereals, and other fortified or enriched grain products; wheat germ

Nutrient	Function	Deficiency Symptoms	Toxicity Symptoms	Major Food Sources
Vitamin K	Catalyzes prothrombin synthesis; required in the synthesis of other blood clotting factors; synthesis by intestinal bacteria	Prolonged bleeding and prothrombin time; hemorrhagic manifestations (especially in newborns)	Possible hemolytic anemia; hyperbilirubinemia (jaundice)	Infant formula, vegetable oils, green leafy vegetables, pork, liver
Ascorbic Acid (Vitamin C)	Essential in the synthesis of collagen (thus, strengthens tissues and improves wound healing and resistance to infection);iron absorption and transport; water-soluble antioxidant; functions in folacin metabolism	Scurvy, pinpoint peripheral hemorrhages, bleeding gums, osmotic diarrhea	Nausea, abdominal cramps, diarrhea, possible formation of kidney stones	Breast milk, infant formula, fruits (especially citrus fruits, papaya, cantaloupe, strawberries), vegetables (potatoes, cabbage)
Vitamin B12 (Cobalamin, Cyanocobalamin)	Essential for biosynthesis of nucleic acids and nucleoproteins; red blood cell maturation; involved with folate metabolism; central nervous system metabolism	Pernicious anemia; neurologic deterioration		Infant formula, breast milk, meat, fish, poultry, cheese, egg yolk, liver
Folacin (Folate)	Essential in the biosynthesis of nucleic acids; necessary for the normal maturation of red blood cells	Poor growth; megaloblastic anemia (concurrent deficiency of vitamin B12 should be suspected); impaired cellular immunity	Masking of B12 deficiency symptoms in those with pernicious anemia not receiving cyanocobalamin	Breast milk; infant formula; liver; green leafy vegetables; legumes; whole-grain breads, cereals, and fortified or enriched grain products; legumes; oranges; cantaloupe; lean beef
Pyridoxine (Vitamin B6)	Aids in the synthesis and breakdown of amino acids and unsaturated fatty acids from essential fatty acids; essential for conversion of tryptophan to niacin; essential for normal growth	Microcytic anemia; convulsions; irritability	Sensory neuropathy with progressive ataxia; photosensitivity	Breast milk; infant formula; liver; meat; whole-grain breads, cereals, or other grain products; legumes; potatoes
Thiamin (Vitamin B1)	Combines with phosphorus to form thiamin pyrophosphate (TPP) necessary for metabolism of protein, carbohydrate, and fat; essential for growth, normal appetite, digestion, and healthy nerves	Beriberi, neuritis, edema, cardiac failure		Breast milk; infant formula; lean pork; wheat germ; whole-grain and enriched breads, cereals, and other grain products; legumes; potatoes

Nutrient	Function	Deficiency Symptoms	Toxicity Symptoms	Major Food Sources
Riboflavin (Vitamin B2)	Essential for growth; plays enzymatic role in tissue respiration and acts as a transporter of hydrogen ions; synthesis of FMN and FAD	Photophobia, cheilosis, glossitis, corneal vascularization, poor growth		Breast milk; infant formula, meat; dairy products; egg yolk; legumes; green vegetables; whole-grain breads, cereals, and fortified or enriched grain products
Niacin	Part of the enzyme system for oxidation, energy release; necessary for synthesis of glycogen and the synthesis and breakdown of fatty acids	Pellegra: dermatitis, diarrhea, dementia	Transient due to the vasodilating effects of niacin (does not occur with niacinamide)-flushing, tingling, dizziness, nausea; liver abnormalities; hyperuricemia; decreased LDL and increased HDL cholesterol	Breast milk; infant formula; meat; poultry; fish; whole-grain breads, cereals, and fortified or enriched grain products; egg yolk
Calcium	Builds and maintains bones and teeth; essential in clotting of blood; influences transmission of ions across cell membranes; required in nerve transmission	Rickets – abnormal development of bones.	Excessive calcification of bone; calcification of soft tissue; hypercalcemia; vomiting; lethargy	Breast milk, infant formula, yogurt, cheese, fortified or enriched grain products, some green leafy vegetables (such as collards, kale mustard greens, and turnip greens), tofu (if made with calcium sulfate), sardines, salmon
Iron	Essential for the formation of hemoglobin and oxygen transport; increases resistance to infection; functions as part of enzymes involved in tissue respiration.	Hypochromic microcytic anemia; malabsorption; irritability; anorexia; pallor, lethargy	Hemochromatosis; hemosiderosis.	Breast milk; infant formula; meat; liver; legumes; whole-grain breads, cereals, or fortified or enriched grain products; and dark green vegetables
Zinc	Component of many enzyme systems and insulin	Decreased wound healing, hypogonadism, mild anemia, decreased taste acuity, hair loss, diarrhea, growth failure, skin changes	Acute gastrointestinal upset; vomiting; sweating; dizziness; copper deficiency	Breast milk; infant formula; meat; liver; egg yolk; oysters and other seafood; whole-grain breads, cereals, and other fortified or enriched grain products; legumes
Fluoride	Helps protect teeth against tooth decay; may minimize bone loss	Increased dental caries	Mottled, discolored teeth; possible increase in bone density; calcified muscle insertions and exotosis	Fluoridated water
Chloride	Helps regulate acid-base equilibrium and osmotic pressure of body fluids; component of gastric juices	Usually accompanied by sodium depletion; see Sodium		Breast milk, infant formula, sodium chloride (table salt)

Nutrient	Function	Deficiency Symptoms	Toxicity Symptoms	Major Food Sources
Chromium	Required for normal glucose metabolism; insulin cofactor	Glucose intolerance; impaired growth; peripheral neuropathy; negative nitrogen balance; decreased respiratory quotient		Meat; whole-grain breads, cereals, and other fortified or enriched grain products; brewer's yeast; corn oil
Copper	Facilitates the function of many enzymes and iron; may be an integral part of RNA, DNA molecules	Pallor, retarded growth, edema, anorexia	Wilson's disease – copper deposits in the cornea; cirrhosis of liver; deterioration of neurological processes	Liver; kidney; poultry; shellfish; legumes; whole-grain breads, cereals, and other grain products
Iodine	Helps regulate thyroid hormones; important in regulation of cellular oxidation and growth	Endemic goiter; depressed thyroid function; cretinism	Possible thyroid enlargement	Breast milk, infant formula, seafood, iodized salt
Magnesium	Required for many coenzyme oxidation-phosphorylation reactions, nerve impulse transmissions, and for muscle contraction	Muscle tremors; convulsions; irritability; tetany; hyper-or hypoflexia	Diarrhea; transient hypocalcemia	Breast milk; infant formula; whole-grain breads, cereals, and other grain products; tofu; legumes; green vegetables
Manganese	Essential part of several enzyme systems involved in protein and energy metabolism	Impaired growth; skeletal abnormalities; neonatal ataxia	In extremely high exposure from contamination: severe psychiatric and neurologic disorders	Whole-grain breads, cereals, and other grain products; legumes; fruits; vegetables (leafy)
Molybedenum	Part of the enzymes xanthine oxidase and aldehyde oxidase, possibly helps reduce incidence of dental caries		Goutlike syndrome	Organ meats; breads, cereals, and other grain products; dark green leafy vegetables; legumes
Phosphorus	Builds and maintains bones and teeth; component of nucleic acids, phospholipids; as coenzyme functions in energy metabolism; buffers intracellular fluid	Phosphate depletion unusual – effects renal, neuromuscular, skeletal systems as well as blood chemistries	Hypocalcemia (when parathyroid gland not fully functioning)	Breast milk; infant formula; cheese; egg yolk; meat; poultry; fish; whole-grain breads, cereals, and other grain products; legumes
Potassium	Helps regulate acid-base equilibrium and osmotic pressure of body fluids; influences muscle activity, especially cardiac muscle	Muscle weakness; decreased intestinal tone and distension; cardiac arrhythmias; respiratory failure		Breast milk; infant formula; fruits especially orange juice, bananas, and dried fruits; yogurt; potatoes; meat; fish; poultry; soy products; vegetables

Nutrient	Function	Deficiency Symptoms	Toxicity Symptoms	Major Food Sources
Selenium	May be essential to tissue respiration; associated with fat metabolism and vitamin E; acts as an antioxidant	Myalgia; muscle tenderness; cardiac myopathy; increased fragility of red blood cells; degeneration of pancreas		Whole-grain breads, cereals, and other fortified or enriched grain products; onions; meats; seafood; dependent on soil content – vegetables
Sodium	Helps regulate acid-base equilibrium and osmotic pressure of body fluids; plays a role in normal muscle irritability and contractility; influences cell permeability	Nausea; cramps; vomiting; dizziness; apathy; exhaustion; possible respiratory failure		Sodium chloride (table salt), abundant in most foods except fruit
Pantothenic Acid	Functions in the synthesis and breakdown of many vital body compounds; essential in the intermediary metabolism of carbohydrate, fat, and protein	Fatigue; sleep disturbances; nausea; muscle cramps; impaired coordination; loss of antibody production	Diarrhea; water retention	Breast milk; infant formula; meat; fish; poultry; liver; egg yolk; yeast; whole-grain breads, cereals, and other grain products; legumes; vegetables
Biotin	Essential component of enzymes; important in reactions involving the lengthening of carbon chains; coenzyme carrier of carbon dioxide; plays an important role in the metabolism of fatty acids and amino acids	Seborrheic dermatitis; glossitis; nausea; insomnia;		Breast milk, infant formula, liver, meat, egg yolk, yeast, bananas, most vegetables, strawberries, grapefruit, watermelon,

Chart revised from first edition using following references:
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