قسم الكيمياء الحيوية
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BCH 445
Biochemistry of nutrition

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Vitamins

Vitamins:

- **Organic, essential nutrients required in small amounts by the body for health.**
- **Vitamins regulate body processes that support growth, maintain life and prevent diseases.**
- **vita = life**
- **amine = containing nitrogen (the first vitamins discovered contained nitrogen)**
- **Vitamins must be supplied by the food.**

Water-Soluble and Fat-Soluble Vitamins

Water-soluble vitamins	Fat-Soluble Vitamins
B vitamins:	**Vitamin A**
Thiamin (B1)	**Vitamin D**
Riboflavin (B2)	**Vitamin E**
Niacin (B3)	**Vitamin K**
Pantothenic acid (B5)	
pyridoxine, pyridoxal, pyridoxamine (B6)	
Biotin (B7)	
Folate (B9)	
Cobalamins (B12)	
Vitamin C	

Water-Soluble and Fat-Soluble Vitamins Compared

	Water-Soluble Vitamins: B Vitamins and Vitamin C	Fat-Soluble Vitamins: Vitamins A, D, E, and K
Absorption	Directly into the blood	First into the lymph, then the blood
Transport	Travel freely	Many require transport proteins
Storage	Circulate freely in water-filled parts of the body	Stored in the cells associated with fat
Excretion	Kidneys detect and remove excess in urine	Less readily excreted; tend to remain in fat-storage sites
Toxicity	Possible to reach toxic levels when consumed from supplements	Likely to reach toxic levels when consumed from supplements
Requirements	Needed in frequent doses (perhaps 1 to 3 days)	Needed in periodic doses (perhaps weeks or even months)

Water-Soluble vitamins

B vitamins: Thiamin

Other Names

Vitamin B_1

RDA

Men: 1.2 mg/day

Women: 1.1 mg/day

Chief Functions in the Body

Part of coenzyme TPP (thiamin pyrophosphate) used in energy metabolism

Significant Sources

Whole-grain, fortified, or enriched grain products; moderate amounts in all nutritious food; pork

Easily destroyed by heat

Deficiency Disease

Beriberi (wet, with edema; dry, with muscle wasting)

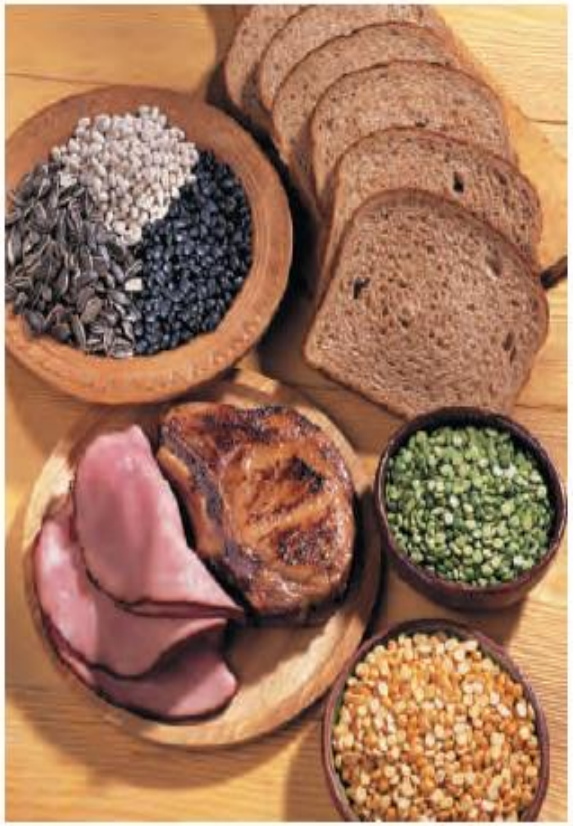
Deficiency Symptoms[a]

Enlarged heart, cardiac failure; muscular weakness; apathy, poor short-term memory, confusion, irritability; anorexia, weight loss

Toxicity Symptoms

None reported

[a]Severe thiamin deficiency is often related to heavy alcohol consumption with limited food consumption (Wernicke-Korsakoff syndrome).



Pork is the richest source of thiamin, but enriched or whole-grain products typically make the greatest contribution to a day's intake because of the quantities eaten. Legumes such as split peas are also valuable sources of thiamin.

Riboflavin

Other Names

Vitamin B_2

RDA

Men: 1.3 mg/day

Women: 1.1 mg/day

Chief Functions in the Body

Part of coenzymes FMN (flavin mononucleotide) and FAD (flavin adenine dinucleotide) used in energy metabolism

Significant Sources

Milk products (yogurt, cheese); whole-grain, fortified, or enriched grain products; liver

Easily destroyed by ultraviolet light and irradiation

Deficiency Disease

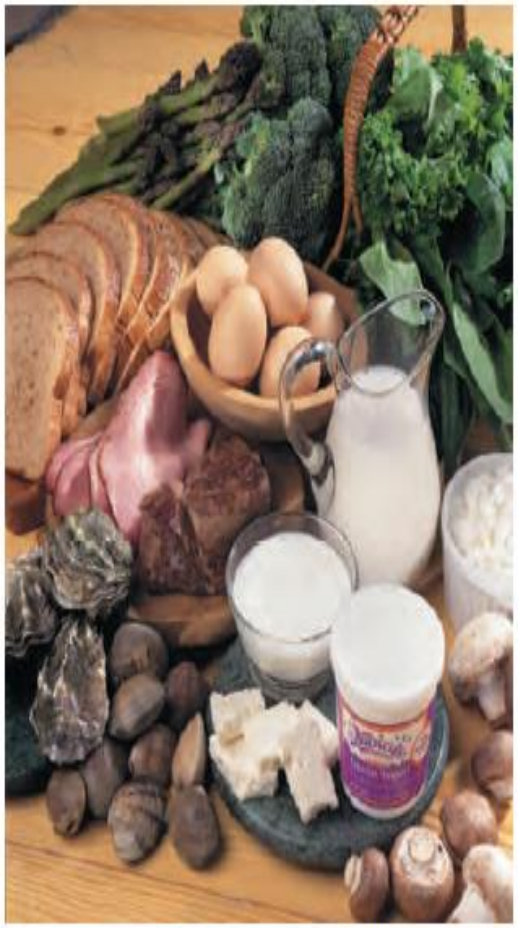
Ariboflavinosis (ay-RYE-boh-FLAY-vin-oh-sis)

Deficiency Symptoms

Sore throat; cracks and redness at corners of mouth;[a] painful, smooth, purplish red tongue;[b] inflammation characterized by skin lesions covered with greasy scales

Toxicity Symptoms

None reported



All of these foods are rich in riboflavin, but milk and milk products provide much of the riboflavin in the diets of most people.

Niacin

Other Names

Nicotinic acid, nicotinamide, niacinamide, vitamin B_3; precursor is dietary tryptophan (an amino acid)

RDA

Men: 16 mg NE/day

Women: 14 mg NE/day

UL[a]

Adults: 35 mg/day

Chief Functions in the Body

Part of coenzymes NAD (nicotinamide adenine dinucleotide) and NADP (its phosphate form) used in energy metabolism

Significant Sources

Milk, eggs, meat, poultry, fish; whole-grain, fortified, and enriched grain products; nuts and all protein-containing foods

Deficiency Disease

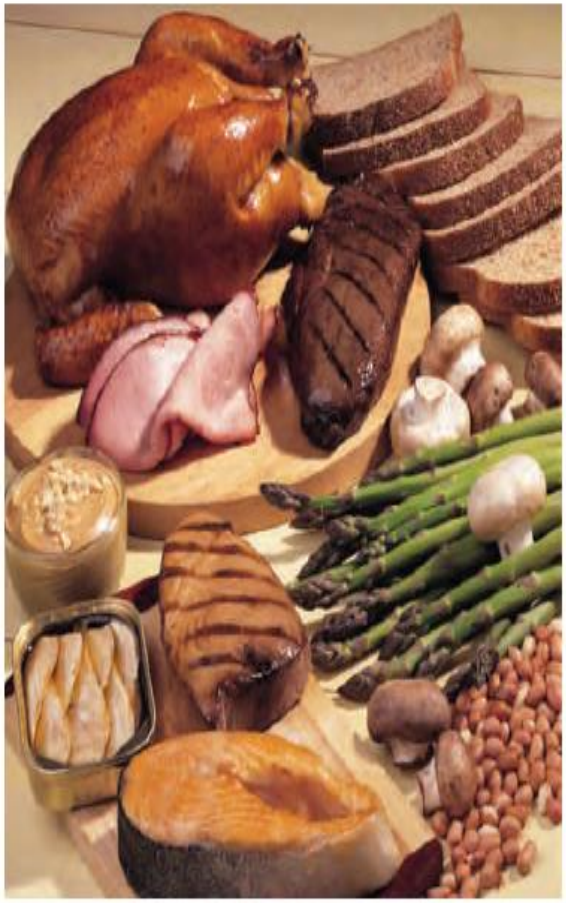
Pellagra

Deficiency Symptoms

Diarrhea, abdominal pain, vomiting; inflamed, swollen, smooth, bright red tongue;[b] depression, apathy, fatigue, loss of memory, headache; bilateral symmetrical rash on areas exposed to sunlight

Toxicity Symptoms

Painful flush, hives, and rash ("niacin flush"); nausea and vomiting; liver damage, impaired glucose tolerance



Protein-rich foods such as meat, fish, poultry, and peanut butter contribute much of the niacin in people's diets. Enriched breads and cereals and a few vegetables are also rich in niacin.

Biotin

Adequate Intake (AI)

Adults: 30 µg/day

Chief Functions in the Body

Part of a coenzyme used in energy metabolism, fat synthesis, amino acid metabolism, and glycogen synthesis

Significant Sources

Widespread in foods; liver, egg yolks, soybeans, fish, whole grains; also produced by GI bacteria

Deficiency Symptoms

Depression, lethargy, hallucinations, numb or tingling sensation in the arms and legs; red, scaly rash around the eyes, nose, and mouth; hair loss

Toxicity Symptoms

None reported

Pantothenic acid

Adequate Intake (AI)
Adults: 5 mg/day
Chief Functions in the Body
Part of coenzyme A, used in energy metabolism
Significant Sources
Widespread in foods; chicken, beef, potatoes, oats, tomatoes, liver, egg yolk, broccoli, whole grains
Easily destroyed by food processing

Deficiency Symptoms
Vomiting, nausea, stomach cramps; insomnia, fatigue, depression, irritability, restlessness, apathy; hypoglycemia, increased sensitivity to insulin; numbness, muscle cramps, inability to walk
Toxicity Symptoms
None reported

Vitamin B6

Other Names

Pyridoxine, pyridoxal, pyridoxamine

RDA

Adults (19–50 yr): 1.3 mg/day

UL

Adults: 100 mg/day

Chief Functions in the Body

Part of coenzymes PLP (pyridoxal phosphate) and PMP (pyridoxamine phosphate) used in amino acid and fatty acid metabolism; helps to convert tryptophan to niacin and to serotonin; helps to make red blood cells

Significant Sources

Meats, fish, poultry, potatoes and other starchy vegetables, legumes, noncitrus fruits, fortified cereals, liver, soy products

Easily destroyed by heat

Deficiency Symptoms

Scaly dermatitis; anemia (small-cell type);[a] depression, confusion, convulsions

Toxicity Symptoms

Depression, fatigue, irritability, headaches, nerve damage causing numbness and muscle weakness leading to an inability to walk and convulsions; skin lesions

[a]Small-cell-type anemia is called *microcytic anemia.*

Most protein-rich foods such as meat, fish, and poultry provide ample vitamin B_6; some vegetables and fruits are good sources too.

Folate

Other Names

Folic acid, folacin, pteroylglutamic acid (PGA)

RDA

Adults: 400 µg/day

UL[a]

Adults: 1000 µg/day

Chief Functions in the Body

Part of coenzymes THF (tetrahydrofolate) and DHF (dihydrofolate) used in DNA synthesis and therefore important in new cell formation

Significant Sources

Fortified grains, leafy green vegetables, legumes, seeds, liver

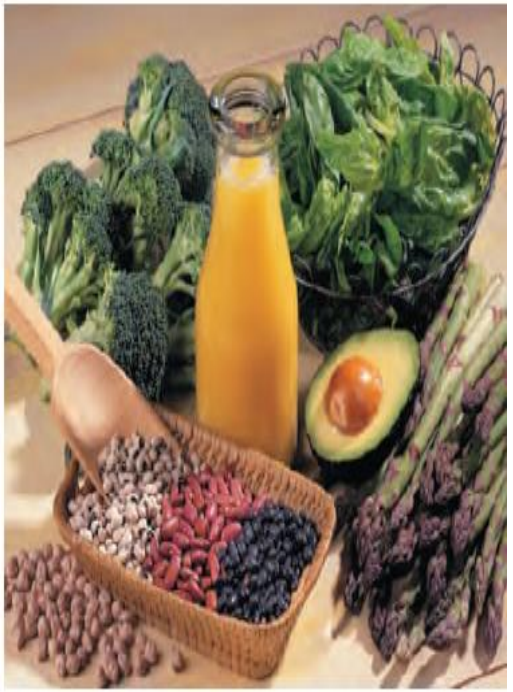
Easily destroyed by heat and oxygen

Deficiency Symptoms

Anemia (large-cell type);[b] smooth, red tongue;[c] mental confusion, weakness, fatigue, irritability, headache; shortness of breath; elevated homocysteine

Toxicity Symptoms

Masks vitamin B_{12}–deficiency symptoms



Dark green and leafy vegetables (such as spinach and broccoli), legumes (such as black beans, kidney beans, and black-eyed peas), liver, and some fruits (notably citrus fruits and juices) are naturally rich in folate.

Vitamin B12

Other Names

Cobalamin (and related forms)

RDA

Adults: 2.4 µg/day

Chief Functions in the Body

Part of coenzymes methylcobalamin and deoxyadenosylcobalamin used in new cell synthesis; helps to maintain nerve cells; reforms folate coenzyme; helps to break down some fatty acids and amino acids

Significant Sources

Foods of animal origin (meat, fish, poultry, shellfish, milk, cheese, eggs), fortified cereals

Easily destroyed by microwave cooking

Deficiency Disease

Pernicious anemia[a]

Deficiency Symptoms

Anemia (large-cell type);[b] fatigue, degeneration of peripheral nerves progressing to paralysis; sore tongue, loss of appetite, constipation

Toxicity Symptoms

None reported

Vitamin C

Other Names

Ascorbic acid

RDA

Men: 90 mg/day

Women: 75 mg/day

Smokers: +35 mg/day

UL

Adults: 2000 mg/day

Chief Functions in the Body

Collagen synthesis (strengthens blood vessel walls, forms scar tissue, provides matrix for bone growth), antioxidant, thyroxin synthesis, amino acid metabolism, strengthens resistance to infection, helps in absorption of iron

Significant Sources

Citrus fruits, cabbage-type vegetables (such as brussels sprouts and cauliflower), dark green vegetables (such as bell peppers and broccoli), cantaloupe, strawberries, lettuce, tomatoes, potatoes, papayas, mangoes

Easily destroyed by heat and oxygen

Deficiency Disease

Scurvy

Deficiency Symptoms

Anemia (small-cell type),[a] atherosclerotic plaques, pinpoint hemorrhages; bone fragility, joint pain; poor wound healing, frequent infections; bleeding gums, loosened teeth; muscle degeneration, pain, hysteria, depression; rough skin, blotchy bruises

Toxicity Symptoms

Nausea, abdominal cramps, diarrhea; headache, fatigue, insomnia; hot flashes; rashes; interference with medical tests, aggravation of gout symptoms, urinary tract problems, kidney stones[b]

[a]Small-cell type anemia is microcytic anemia.

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When dietitians say "vitamin C," people think "citrus fruits" . . .

. . . but these foods are also rich in vitamin C.

Fat-Soluble vitamins

Vitamin A:

Other Names

Retinol, retinal, retinoic acid; precursors are carotenoids such as beta-carotene

2001 RDA

Men: 900 µg RAE/day
Women: 700 µg RAE/day

Upper Level

Adults: 3000 µg/day

Chief Functions in the Body

Vision; maintenance of cornea, epithelial cells, mucous membranes, skin; bone and tooth growth; reproduction; immunity

Significant Sources

Retinol: fortified milk, cheese, cream, butter, fortified margarine, eggs, liver

Beta-carotene: spinach and other dark green, leafy vegetables, broccoli, deep orange fruits (apricots, cantaloupe) and vegetables (squash, carrots, sweet potatoes, pumpkin)

Deficiency Disease

Hypovitaminosis A

Deficiency Symptoms

Night blindness, corneal drying (xerosis), triangular gray spots on eye (Bitot's spots), softening of the cornea (keratomalacia), and corneal degeneration and blindness (xerophthalmia); impaired immunity (infectious diseases); plugging of hair follicles with keratin, forming white lumps (hyperkeratosis)

Toxicity Disease

Hypervitaminosis A[a]

Chronic Toxicity Symptoms

Increased activity of osteoclasts[b] causing reduced bone density; liver abnormalities; birth defects

Acute Toxicity Symptoms

Blurred vision, nausea, vomiting, vertigo; increase of pressure inside skull, mimicking brain tumor; headaches; muscle incoordination

Vitamin D

Other Names

calciferol (vitamin D)

ergocalciferol (vitamin D_2): vitamin D derived from plants in the diet and made from the yeast and plant sterol ergosterol.

cholecalciferol (vitamin D_3 or calciol): vitamin D derived from animals in the diet or made in the skin from 7-dehydrocholesterol, a precursor of cholesterol, with the help of sunlight.

calcidiol (25-hydroxyvitamin D): vitamin D found in the blood that is made from the hydroxylation of calciol in the liver.

calcitriol (1,25-dihydroxyvitamin D): vitamin D that is made from the hydroxylation of calcidiol in the kidneys; the biologically active hormone, sometimes called *active vitamin D*.

2011 RDA

Adults: 15 µg/day or 600 IU/day (19–70 yr)
20 µg/day or 800 IU/day (>70 yr)

Upper Level

Adults: 100 µg/day or 4000 IU/day

Chief Functions in the Body

Mineralization of bones (raises blood calcium and phosphorus by increasing absorption from digestive tract, withdrawing calcium from bones, stimulating retention by kidneys)

Significant Sources

Synthesized in the body with the help of sunlight; fortified milk, margarine, butter, juices, cereals, and chocolate mixes; veal, beef, egg yolks, liver, fatty fish (herring, salmon, sardines) and their oils

Deficiency Diseases

Rickets, osteomalacia

Deficiency Symptoms

Rickets in children:

Inadequate calcification, resulting in misshapen bones (bowing of legs); enlargement of ends of long bones (knees, wrists); deformities of ribs (bowed, with beads or knobs);[a] delayed closing of fontanel, resulting in rapid enlargement of head (see figure below); lax muscles resulting in protrusion of abdomen; muscle spasms

Osteomalacia or osteoporosis in adults:

Loss of calcium, resulting in soft, flexible, brittle, and deformed bones; progressive weakness; pain in pelvis, lower back, and legs

Toxicity Disease

Hypervitaminosis D

Toxicity Symptoms

Elevated blood calcium; calcification of soft tissues (blood vessels, kidneys, heart, lungs, tissues around joints)

Vitamin E

Other Names

Alpha-tocopherol

2000 RDA

Adults: 15 mg/day

Upper Level

Adults: 1000 mg/day

Chief Functions in the Body

Antioxidant (stabilization of cell membranes, regulation of oxidation reactions, protection of polyunsaturated fatty acids [PUFA] and vitamin A)

Significant Sources

Polyunsaturated plant oils (margarine, salad dressings), dark green, leafy vegetables (spinach, turnip greens, collard greens, broccoli), wheat germ, whole grains, liver, egg yolks, nuts, seeds, fatty meats

Easily destroyed by heat and oxygen

Deficiency Symptoms

Red blood cell breakage,[a] nerve damage

Toxicity Symptoms

Augments the effects of anticlotting medication

Vitamin K

Other Names
Phylloquinone, menaquinone, menadione, naphthoquinone
2001 Adequate Intake (AI)
Men: 120 µg/day
Women: 90 µg/day
Chief Functions in the Body
Synthesis of blood-clotting proteins and bone proteins

Significant Sources
Bacterial synthesis in the digestive tract;[a] liver; dark green, leafy vegetables, cabbage-type vegetables; milk
Deficiency Symptoms
Hemorrhaging
Toxicity Symptoms
None known

Vitamin and Chief Functions	Deficiency Symptoms	Toxicity Symptoms	Food Sources
Thiamin Part of coenzyme TPP in energy metabolism	Beriberi (edema or muscle wasting), anorexia and weight loss, neurological disturbances, muscular weakness, heart enlargement and failure	None reported	Enriched, fortified, or whole-grain products; pork
Riboflavin Part of coenzymes FAD and FMN in energy metabolism	Inflammation of the mouth, skin, and eyelids	None reported	Milk products; enriched, fortified, or whole-grain products; liver
Niacin Part of coenzymes NAD and NADP in energy metabolism	Pellagra (diarrhea, dermatitis, and dementia)	Niacin flush, liver damage, impaired glucose tolerance	Protein-rich foods
Biotin Part of coenzyme in energy metabolism	Skin rash, hair loss, neurological disturbances	None reported	Widespread in foods; GI bacteria synthesis
Pantothenic acid Part of coenzyme A in energy metabolism	Digestive and neurological disturbances	None reported	Widespread in foods
Vitamin B_6 Part of coenzymes used in amino acid and fatty acid metabolism	Scaly dermatitis, depression, confusion, convulsions, anemia	Nerve degeneration, skin lesions	Protein-rich foods
Folate Activates vitamin B_{12}; helps synthesize DNA for new cell growth	Anemia, glossitis, neurological disturbances, elevated homocysteine	Masks vitamin B_{12} deficiency	Legumes, vegetables, fortified grain products
Vitamin B_{12} Activates folate; helps synthesize DNA for new cell growth; protects nerve cells	Anemia; nerve damage and paralysis	None reported	Foods derived from animals
Vitamin C Synthesis of collagen, carnitine, hormones, neurotransmitters; antioxidant	Scurvy (bleeding gums, pinpoint hemorrhages, abnormal bone growth, and joint pain)	Diarrhea, GI distress	Fruits and vegetables

Vitamin and Chief Functions	Deficiency Symptoms	Toxicity Symptoms	Significant Sources
Vitamin A			
Vision; maintenance of cornea, epithelial cells, mucous membranes, skin; bone and tooth growth; reproduction; immunity	Infectious diseases, night blindness, blindness (xerophthalmia), keratinization	Reduced bone mineral density, liver abnormalities, birth defects	Retinol: milk and milk products Beta-carotene: dark green, leafy and deep yellow/orange vegetables
Vitamin D			
Mineralization of bones (raises blood calcium and phosphorus by increasing absorption from digestive tract, withdrawing calcium from bones, stimulating retention by kidneys)	Rickets, osteomalacia	Calcium imbalance (calcification of soft tissues and formation of stones)	Synthesized in the body with the help of sunshine; fortified milk
Vitamin E			
Antioxidant (stabilization of cell membranes, regulation of oxidation reactions, protection of polyunsaturated fatty acids [PUFA] and vitamin A)	Erythrocyte hemolysis, nerve damage	Hemorrhagic effects	Vegetable oils
Vitamin K			
Synthesis of blood-clotting proteins and bone proteins	Hemorrhage	None known	Synthesized in the body by GI bacteria; dark green, leafy vegetables