

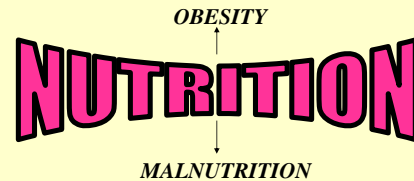
Chapter 18

Human Anatomy & Physiology

NUTRITION & METABOLISM

Karen Webb Smith

A matter of BALANCE!



“Why We Eat”

nutrients – chemical substances supplied from environment

macronutrients – carbohydrates, proteins, & fats

micronutrients – vitamins & minerals (needed daily in small amounts)

nutrition – (nutrients) foods needed for health that cannot be synthesized by body cells

metabolism – ways nutrients are used to support life processes

essential nutrients – cannot be synthesized by cells & needed by body (amino acids)

water – essential & must be added to diet

Various factors acting on cells of the hypothalamus control body weight.

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| TABLE 18.1 Types of Vegetarian Diets | |
|--------------------------------------|---|
| Type | Food Restrictions |
| Vegan | No animal foods |
| Ovo-vegetarian | Eggs allowed; no dairy or meat |
| Lacto-vegetarian | Dairy allowed; no eggs or meat |
| Lacto-ovo-vegetarian | Dairy and eggs allowed; no meat |
| Pesco-vegetarian | Dairy, eggs, and fish allowed; no other meat |
| Semivegetarian | Dairy, eggs, chicken, and fish allowed; no other meat |

carbohydrates - Organic compounds that include sugars & starches. The energy in chemical bonds is the power that drives cellular processes.

Carbohydrate Sources

complex carbs – polysaccharides, starch from grains, vegetables, & glycogen from meat

simple carbs – disaccharides from milk sugar, cane sugar, beet sugar, molasses, & monosaccharides from honey & fruits

digestion breaks complex carbs down to monosaccharides which are small enough to be absorbed. (glucose)

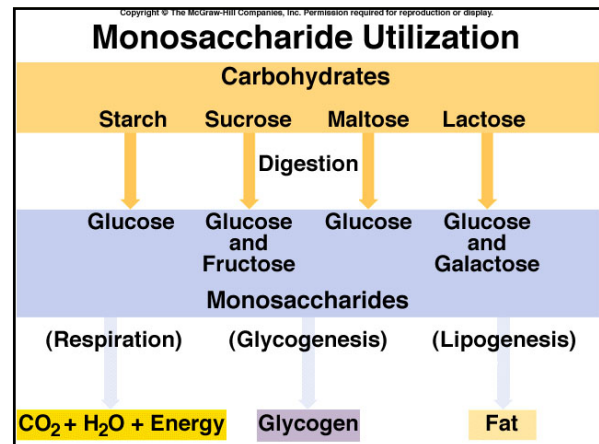
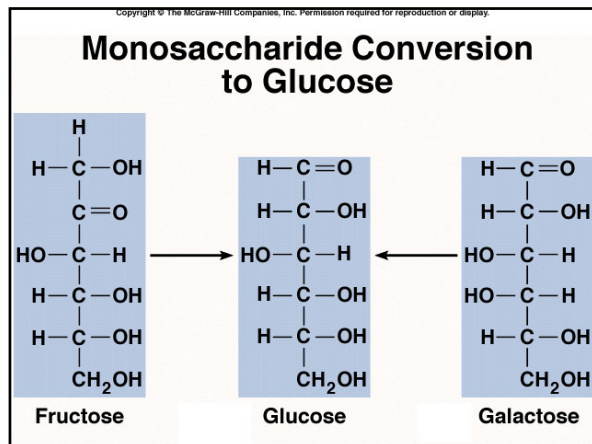
cellulose – complex carb human enzymes cannot digest; it provides bulk or roughage against which the muscular wall of the intestines can push

Carbohydrate Utilization

- * Carbohydrates are absorbed as monosaccharides.
- * The liver converts fructose & galactose to glucose.
- * Oxidation releases energy from glucose.
- * Excess glucose is stored as glycogen or converted to fat.

Carbohydrate Requirements

- * Carbs are primary source of energy for the body.
- * Some cells need a constant supply of glucose.
- * Amino acids will be converted to glucose if glucose is scarce.
- * 125-175 grams of carbs daily is necessary to spare protein breakdown & excess fat utilization
- * 200-300 grams of carbs in average daily diet



lipids - Organic compounds that supply energy & are used to build cell structures ; include fats, cholesterol, & phospholipids

Lipid Sources

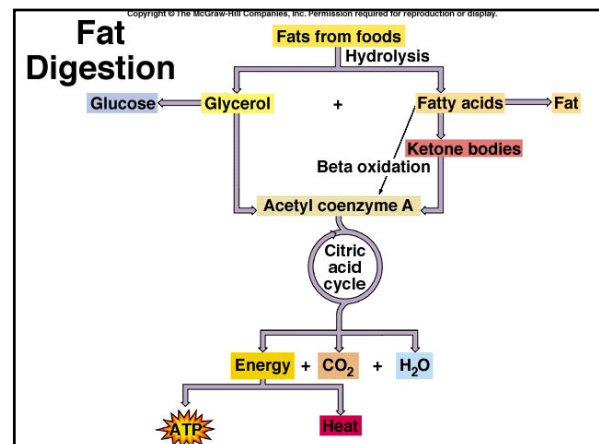
- *triglycerides are found in plant & animal-based foods
- *saturated fats should only be 10% of diet; found in meat, eggs, milk, lard, palm oil & coconut oil
- *unsaturated fats are found in seeds, nuts, & plant oils
- *cholesterol – found in liver & egg yolk; small amounts in whole milk, butter, cheese, & meats (plants do not contain cholesterol)

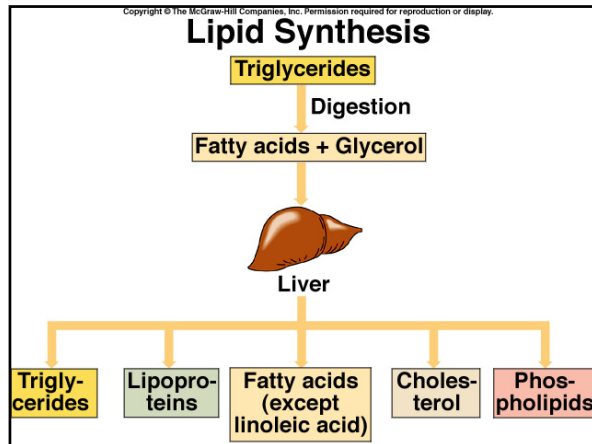
Lipid Utilization

- *triglycerides = glycerol + 3 fatty acids
- *fats contain more than twice as much chemical energy as carbs; before a triglyceride molecule can release energy it must undergo hydrolysis & be broken down into glycerol + 3 fatty acids; beta oxidation occurs & acetyl CoA is produced in the mitochondria; acetyl CoA is then oxidized in the citric acid cycle
- *the liver and adipose tissue tightly control triglyceride metabolism (read in text); the liver can alter the molecular structures of fatty acids however there are some that is cannot Ex. linoleic acid – necessary for synthesis of phospholipids for cell membranes & myelin sheaths; sources for linoleic acid include corn oil, cottonseed oil, & soy oil
- *the liver regulates the amount of cholesterol by synthesizing or excreting it (read in text)

Lipid Requirements

- *no more than 30% of total daily calories should be from fat
- *amounts & types of lipids needed for health are unknown
- *dietary fats must also supply the required amounts of fat-soluble vitamins





proteins - polymers of amino acids with many functions; amino acids are absorbed & transported by the blood to cells; they form other new proteins as DNA directs; they become enzymes, structural materials, & energy sources

*deamination – occurs in the liver when amino acids lose their NH₂ groups which later become urea

*using structural proteins to generate energy causes the Tissue-wasting characteristic of starvation

Protein Sources - meats, dairy products, cereals, & legumes

*digestion of proteins provides amino acids for formation of enzymes & energy sources (after deamination); deaminated portions of amino acids can be broken down into CO₂ & H₂O to produce glucose or fat

*8 amino acids are essential for adults & must be provided by diet (10 required for children) *look at table*

*all 20 types of amino acids must be in the body at the same time for growth & tissue repair to occur

*complete proteins – in milk, meats, & eggs have essential amino acids

*incomplete proteins – in corn, lack adequate amounts of one or more essential amino acids

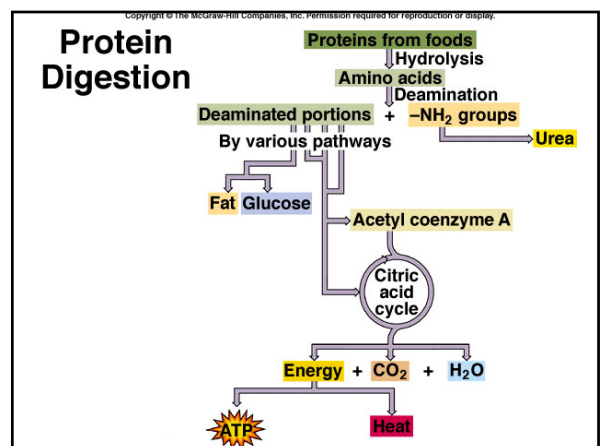
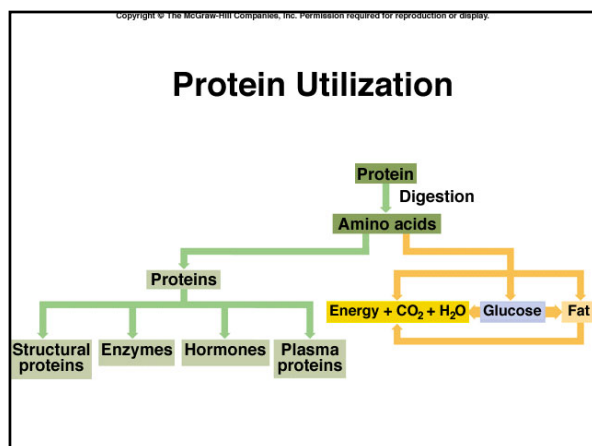
Nitrogen Balance – in a healthy adult proteins are continuously built up & broken down; gain of body proteins equals the loss = dynamic equilibrium > nitrogen balance

*starving person has a negative nitrogen balance

*growing child, pregnant woman, or an athlete in training has a positive nitrogen balance

Protein Requirements – amount of protein needed varies according to body size, metabolic rate, & nitrogen balance condition

*children who are growing face severe consequences if proteins are not in the diet



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| TABLE | 18.2 | Amino Acids in Foods |
|-------|----------------|----------------------|
| | | |
| | Alanine | Leucine (e) |
| | Arginine (ch) | Lysine (e) |
| | Asparagine | Methionine (e) |
| | Aspartic Acid | Phenylalanine (e) |
| | Cysteine | Proline |
| | Glutamic acid | Serine |
| | Glutamine | Threonine (e) |
| | Glycine | Tryptophan (e) |
| | Histidine (ch) | Tyrosine |
| | Isoleucine (e) | Valine (e) |

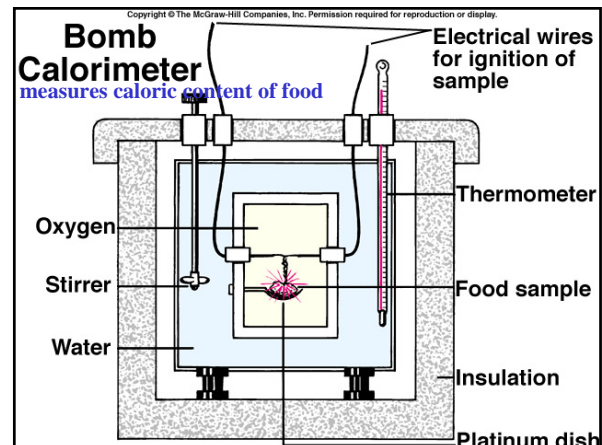
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| 18.3 | Carbohydrate, Lipid, and Protein Nutrients | | | | |
|-------------------|--|-------------------|---|---|--|
| Nutrient | Sources and RDA* for Adults | Calories per Gram | Utilization | Conditions Associated with | |
| Carbo- hydrate | Primarily from starch and sugars in food of plant origin and from glycogen in meats 0.8/kg body weight | 4.1 | Oxidized for energy; used in production of ribose, deoxyribose, and lactose; stored in liver and muscles as glycogen; converted to fats and stored in adipose tissue | Excesses Obesity, dental caries, nutritional deficits | Deficiencies Metabolic acidosis |
| Lipid | Meats, eggs, milk, lard, plant oils 80-100 g | 9.5 | Oxidized for energy; production of triglycerides, phospholipids, lipoproteins, and cholesterol; stored in adipose tissue; glycerol portions of fat molecules may be used to synthesize glucose | Obesity, increased serum cholesterol, increased risk of heart disease | Weight loss, skin lesions |
| Protein | Meats, cheese, nuts, milk, eggs, cereals, legumes 125-175 g | 4.1 | Production of protein molecules used to build cell structure and to function as enzymes or hormones; used in the transport of oxygen, regulation of water balance, control of pH, formation of antibodies; amino acids may be broken down and oxidized for energy or converted to carbohydrates or fats for storage | Obesity | Extreme weight loss, wasting, anemia, growth retardation |

Energy Expenditures - required for all metabolic processes to ensure cell survival

Energy Values of Foods

- *expressed in calories – units of heat
- *food Calorie – equals the amount of heat required to raise the temperature of a kilogram of water 1 degree C
- *When energy losses due to incomplete absorption & incomplete oxidation are taken into account, 1 gram of carbohydrate or 1 gram of protein yields about 4 calories, whereas 1 gram of fat yields about 9 calories



Energy requirements - amount of energy required varies from person to person.

- ***basal metabolic rate** – rate at which the body expends energy under **basal conditions** – when a person is awake & at rest, after an overnight fast, & is in a comfortable, controlled environment. (thyroid test)
- *Factors that influence energy requirements include basal metabolic rate, muscular activity, body temperature, & nitrogen balance

Energy balance – exists when caloric intake = caloric output

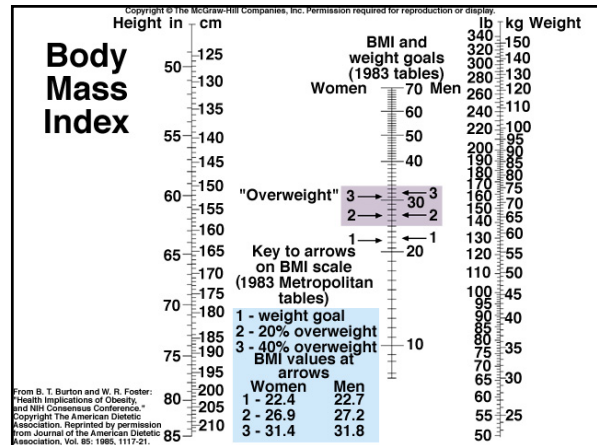
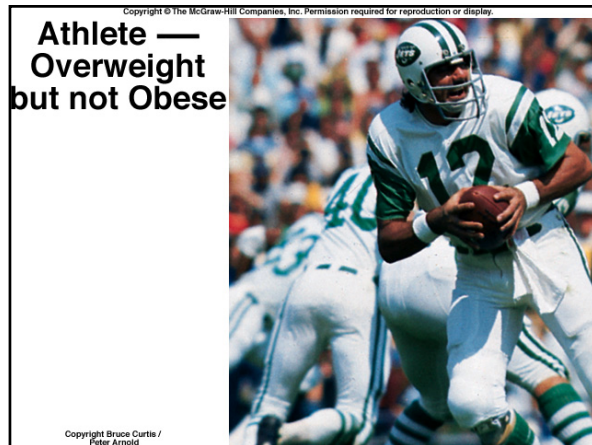
- *When caloric intake in the form of foods = output from the basal metabolic rate & muscular activities
- *If energy balance is positive, body weight increases; if energy balance is negative, body weight decreases

Desirable weight – nutritional disorders reflect caloric imbalances

- *adults of all ages should have similar weights based on height-weight guidelines
- *person who exceeds desirable weight by 10% – 20 % is called overweight
- *person whose body contains excess fatty tissue is obese

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| 18.4 Activities — Calories Used | |
|---------------------------------|---------------------|
| Activity | Calories (per Hour) |
| Walking up stairs | 1,100 |
| Running (jogging) | 570 |
| Swimming | 500 |
| Vigorous exercise | 450 |
| Slow walking | 200 |
| Dressing and undressing | 118 |
| Sitting at rest | 100 |



Vitamins Organic compounds (not carbs, proteins, or fats) that are essential for normal metabolic processes & cannot be synthesized by body cells in adequate amounts.

Fat – soluble vitamins – carried in lipids & are influenced by the same factors that affect lipid absorption; fairly resistant to the effects of heat; they are not destroyed by cooking or food processing (Vitamins A, D, E, & K)

Water – soluble vitamins – B vitamins & vitamin C; B vitamins make up a group called the vitamin B complex & oxidize carbs, lipids, & proteins

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| 18.5 Vitamin Fallacies and Facts | |
|--|--|
| Fallacy | Fact |
| The more vitamins, the better | Too much of a water-soluble vitamin results in excretion of the vitamin through urination; too much of a fat-soluble vitamin can harm health |
| A varied diet provides all needed vitamins | Many people do need vitamin supplements, particularly pregnant and breast-feeding women |
| Vitamins provide energy | Vitamins do not directly supply energy; they aid in the release of energy from carbohydrates, fats, and proteins |

Rickets — Vitamin D Deficiency



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| 18.7 Water Soluble Vitamins | | | | |
|---|---|---|--|--|
| Vitamin | Characteristics | Functions | Source and RDA* for Adults | Conditions Associated with |
| Thiamine (Vitamin B₁) | Destroyed by heat and oxygen, especially in alkaline environment | Part of coenzyme needed for oxidation of carbohydrates; coenzyme needed in synthesis of ribose | Lean meats, liver, eggs, whole-grain cereals, leafy green vegetables, legumes 1.5 mg | Excesses None known Deficiencies Beriberi, muscular weakness, heart enlarges |
| Riboflavin (Vitamin B₂) | Stable to heat, acids, and oxidation; destroyed by bases and ultra-violet light | Part of enzymes and coenzymes, such as FAD, needed for oxidation of glucose and fatty acids and for cellular growth | Meats, dairy products, leafy green vegetables, whole-grain cereals 1.7 mg | Excesses None known Deficiencies Dermatitis, blurred vision |
| Niacin (Nicotinic acid) | Stable to heat, acids, and bases; converted to niacinamide by cells; synthesized from tryptophan | Part of coenzymes NAD and NADP needed for oxidation of glucose and synthesis of proteins, fats and nucleic acids | Liver, lean meats, peanuts, legumes 20 mg | Excesses Hyperglycemia, vasodilation, gout Deficiencies Pellagra, photosensitive dermatitis, diarrhea, mental disorders |
| Pantothenic acid | Destroyed by heat, acids, and bases | Part of coenzyme A needed for oxidation of carbohydrates and fats | Meats, whole-grain cereals, legumes, milk, fruits, vegetables 10 mg | Excesses None known Deficiencies Rare, loss of appetite, mental depression, muscle spasms |
| Vitamin B₆ | Group of three compounds; stable to heat and acids; destroyed by oxidation, bases, and ultra-violet light | Coenzyme needed for synthesis of proteins and various amino acids, for conversion of tryptophan to niacin, for production of antibodies, and for synthesis of nucleic acids | Liver, meats, bananas, avocados, beans, peanuts, whole-grain cereals, egg yolk 2 mg | Excesses Numbness Deficiencies Rare, convulsions, vomiting, seborrhea lesions |

RDA = recommended dietary allowance

| 18.6 Fat Soluble Vitamins | | | | |
|---------------------------|--|--|---|--|
| Vitamin | Characteristics | Functions | Sources and RDA* for Adults | Conditions Associated with |
| Vitamin A | Occurs in several forms; synthesized from carotenes; stored in liver; stable in heat, acids, and bases; unstable in light | An antioxidant necessary for synthesis of visual pigments, mucoproteins, and mucopolysaccharides; for normal development of bones and teeth; and for maintenance of epithelial cells | Liver, fish, whole milk, butter, eggs, leafy green vegetables, yellow and orange vegetables and fruits 4,000-5,000 IU** | Excesses Nausea, headache, dizziness, hair loss, birth defects Deficiencies Night blindness, degeneration of epithelial tissues |
| Vitamin D | A group of steroids; resistant to heat, oxidation, acids, and bases; stored in liver, skin, brain, spleen, and bones | Promotes absorption of calcium and phosphorus; promotes development of teeth and bones | Produced in skin exposed to ultraviolet light; in milk, egg yolk, fish liver oils, fortified foods 400 IU | Excesses Diarrhea, calcification of soft tissues, renal damage Deficiencies Rickets, bone decalcification and weakening |
| Vitamin E | A group of compounds; resistant to heat and visible light; unstable in presence of oxygen and ultra-violet light; stored in muscles and adipose tissue | An antioxidant; prevents oxidation of vitamin A and polyunsaturated fatty acids; may help maintain stability of cell membranes | Oils from cereal seeds, salad oils, margarine, shortenings, fruits, nuts and vegetables 30 IU | Excesses Hypertension Deficiencies Rare, uncertain effects |
| Vitamin K | Occurs in several forms; resistant to heat, but destroyed by acids, bases, and light; stored in liver | Needed for synthesis of prothrombin, which functions in blood clotting | Leafy green vegetables, egg yolk, pork liver, soy oil, tomatoes, cauliflower 55-70 µg | Excesses None known Deficiencies Easy bruising and bleeding |

| 18.7 Water Soluble Vitamins (Continued) | | | | |
|--|--|--|--|--|
| Vitamin | Characteristics | Functions | Sources and RDA* for Adults | Conditions Associated with |
| Cyanocobalamin (Vitamin B₁₂) | Complex, cobalt-containing compound; stable to heat; inactivated by light, strong acids, and strong bases; absorption regulated by intrinsic factor from gastric glands; stored in liver | Part of coenzyme needed for synthesis of nucleic acids and for metabolism of carbohydrates; plays role in synthesis of myelin; needed for normal red blood cell production | Liver, meats, milk, cheese, eggs 3-6 µg | Excesses None known Deficiencies Pernicious anemia |
| Folic acid (Folic acid) | Occurs in several forms; destroyed by oxidation in acid environment or by heat in alkaline environment; stored in liver where it is converted into folic acid | Coenzyme needed for metabolism of certain amino acids and for synthesis of DNA; promotes production of normal red blood cell | Liver, leafy green vegetables, whole-grain cereals, legumes 0.4 mg | Excesses None known Deficiencies Megaloblastic anemia |
| Biotin | Stable to heat, acids, and light; destroyed by oxidation and bases | Coenzyme needed for metabolism of amino acids and fatty acids; and for synthesis of nucleic acids | Liver, egg yolk, nuts, legumes, mushrooms 0.3 mg | Excesses None known Deficiencies Rare, elevated blood cholesterol, nausea, fatigue, anorexia |
| Ascorbic acid (Vitamin C) | Chemically similar to monosaccharides; stable in acids but destroyed by oxidation, heat, light, and bases | Needed for production of collagen, conversion of folic acid to folic acid, and metabolism of certain green amino acids; promotes absorption of iron and synthesis of hormones from cholesterol | Citrus fruits, tomatoes, potatoes, leafy greens, vegetables 60 mg | Excesses Exacerbates gout and kidney stone formation Deficiencies Scurvy, lowered resistance to infection, wounds heal slowly |

RDA = recommended dietary allowance

Minerals

- responsible for about 4% of body weight; 75% by weight of minerals are found in bones & teeth as Ca & P; are usually incorporated into organic molecules, although some exist in inorganic compounds; they comprise structural materials, function in enzymes, & play vital roles in various metabolic processes; mineral concentrations are generally regulated by homeostatic mechanisms; ionized forms are the physiologically active forms

Major minerals – Ca, P, K, S, Na, Cl, Mg

Trace elements – Fe, Mn, Cu, I, Co, Zn, Fl, Se, Cr

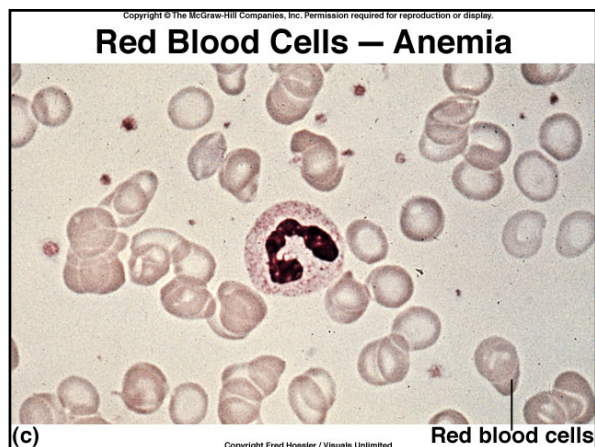
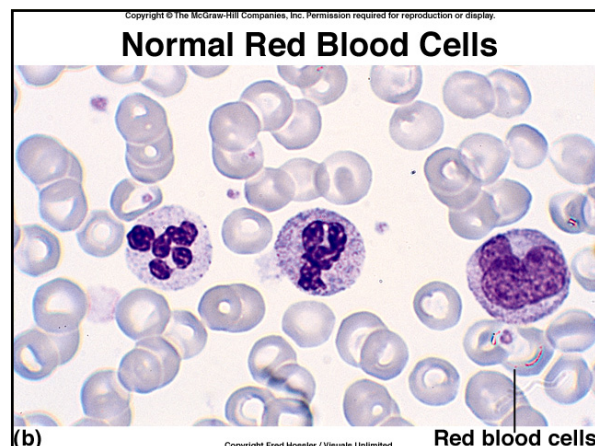
| 18.8 Major Minerals | | | | |
|-----------------------|---|--|---|---|
| Mineral | Distribution | Functions | Sources of RDA* for Adults | Conditions Associated with |
| Calcium (Ca) | Mostly in the inorganic salts of bones and teeth | Structure of bones and teeth; essential for nerve impulse conduction, muscle fiber contraction, and blood coagulation; increases permeability of cell membranes; activates certain enzymes | Milk, milk products, leafy green vegetables 800 mg | Excesses Kidney stones Deficiencies Stunted growth, misshapen bones, fragile bones |
| Phosphorus (P) | Mostly in the inorganic salts of bones and teeth | Structure of bones and teeth; component in nearly all metabolic reactions; constituent of nucleic acids, many proteins, some enzymes, and some vitamins; occurs in cell membrane, ATP, and phosphates of body fluids | Meats, cheese, nuts, whole-grain cereals, milk, legumes 800 mg | Excesses None known Deficiencies Stunted growth |
| Potassium (K) | Widely distributed; tends to be concentrated inside cells | Helps maintain intracellular osmotic pressure and regulate pH; promotes metabolism; needed for nerve impulse conduction and muscle fiber contraction | Avocados, dried apricots, meats, nuts, potatoes, bananas 2,500 mg | Excesses None known Deficiencies Muscular weakness, cardiac abnormalities, edema |
| Sulfur (S) | Widely distributed; abundant in skin, hair, and nails | Essential part of various amino acids, thiamine, insulin, biotin, and mucopolysaccharides | Meats, milk, eggs, legumes None established | Excesses None known Deficiencies None known |

*RDA = recommended daily allowance.

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| 18.8 Major Minerals (Continued) | | | | |
|---------------------------------|--|--|--|---|
| Mineral | Distribution | Functions | Sources and RDA* for Adults | Conditions/Associated with |
| Sodium (Na) | Widely distributed; large proportion occurs in extracellular fluids and bound to inorganic salts of bone | Helps maintain osmotic pressure of extracellular fluids and regulate water movement; needed for conduction of nerve impulses and contraction of muscle fibers; aids in regulation of pH and in transport of substances across cell membranes | Table salt, cured ham, saurkraut, cheese, graham crackers 2,500 mg | Excesses: Hypertension, muscle edema Deficiencies: Nausea, cramps, convulsions |
| Chlorine (Cl) | Closely associated with sodium; most highly concentrated in cerebrospinal fluid and gastric juice | Helps maintain osmotic pressure of extracellular fluids, regulate pH, and maintain electrolyte balance; essential in formation of hydrochloric acid; aids in transport of carbon dioxide by red blood cells | Same as for sodium None established | Vomiting Muscle cramps |
| Magnesium (Mg) | Abundant in bones | Needed in metabolic reactions in mitochondria associated with ATP production; helps breakdown of ATP to ADP | Milk, dairy products, legumes, nuts, leafy green vegetables 300-350 mg | Diarrhea Neuromuscular disturbances |

*RDA = recommended dietary allowance



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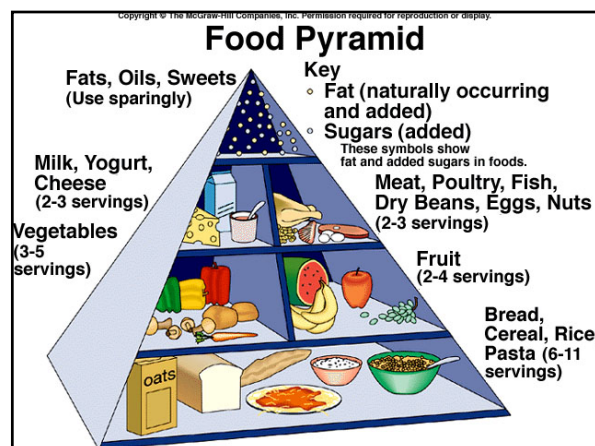
| 18.9 Trace Elements | | | | |
|-----------------------|--|--|--|--|
| Trace Element | Distribution | Functions | Sources of RDA* for Adults | Conditions Associated with |
| Iron (Fe) | Primarily in blood; stored in liver, spleen, and bone marrow | Part of hemoglobin molecule; catalyzes formation of vitamin A; incorporated into a number of enzymes | Liver, lean meats, dried apricots, raisins, enriched whole-grain cereals, legumes, molasses 10-18 mg | Excesses: Liver damage Deficiencies: Anemia |
| Manganese (Mn) | Most concentrated in liver, kidneys, and pancreas | Occurs in enzymes needed for synthesis of fatty acids and cholesterol; formation of urea, and normal functioning of the nervous system | Nuts, legumes, whole-grain cereals, leafy green vegetables, fruits 2.5-5 mg | None known None known |
| Copper (Cu) | Most highly concentrated in liver, heart, and brain | Essential for synthesis of hemoglobin, development of bone, production of melanin, and formation of myelin | Liver, oysters, crabmeat, nuts, whole-grain cereals, legumes 2-3 mg | Rare Rare |
| Iodine (I) | Concentrated in thyroid gland | Essential component for synthesis of thyroid hormones | Food content varies with soil content in different geographic regions; iodized table salt 0.15 mg | Decreased synthesis of thyroid hormones Goiter |
| Cobalt (Co) | Widely distributed | Component of cyanocobalamin; needed for synthesis of several enzymes | Liver, lean meats, milk None established | Heart disease Pernicious anemia |
| Zinc (Zn) | Most concentrated in liver, kidneys, and brain | Constituent of several enzymes involved in digestion, respiration, bone metabolism, liver metabolism; necessary for normal wound healing and maintaining integrity of the skin | Meats, cereals, legumes, nuts, vegetables 15 mg | Stunted speech, problems walking Depressed immunity, loss of taste and smell, learning difficulties |
| Fluorine (F) | Primarily in bones and teeth | Component of tooth structure | Fluoridated water 1.5-4 mg | Mottled teeth None known |
| Selenium (Se) | Concentrated in liver and kidneys | Occurs in enzymes | Lean meats, fish, cereals 0.05-2mg | Vomiting, fatigue None known |
| Chromium (Cr) | Widely distributed | Essential for use of carbohydrates | Liver, lean meats, wine 0.05-2 mg | None known None known |

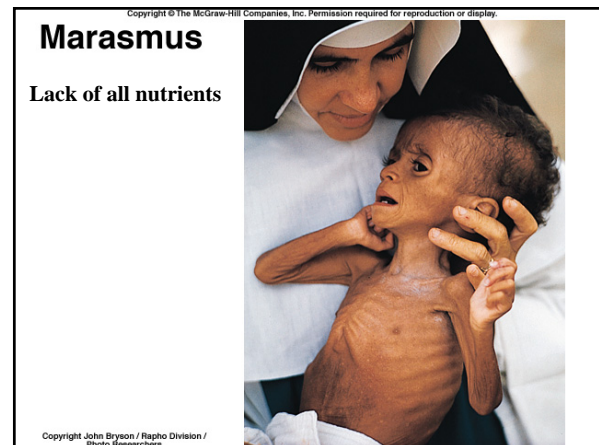
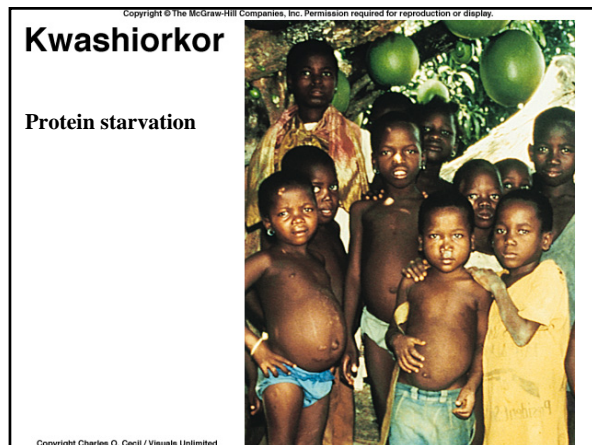
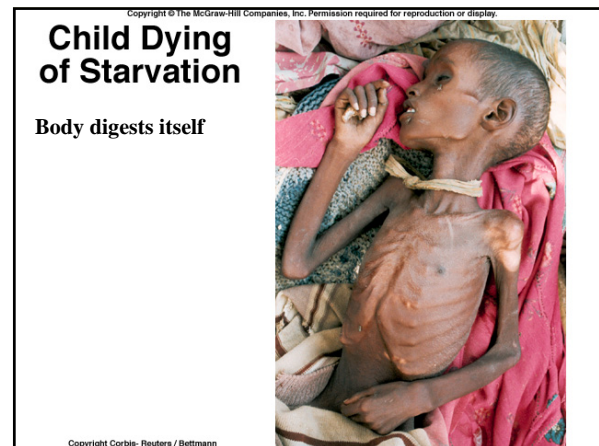
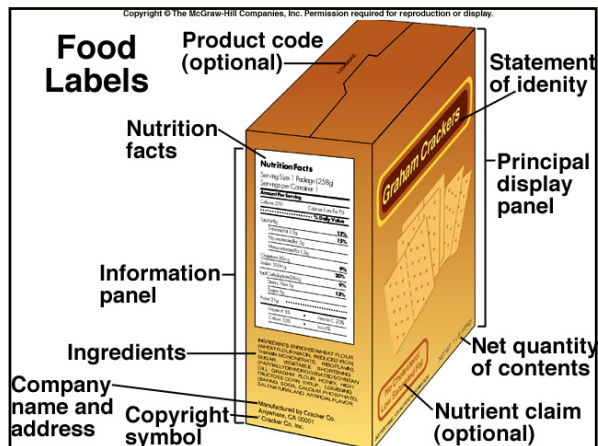
*RDA = recommended dietary allowance

Healthy - Eating

An adequate diet provides sufficient energy & essential nutrients to support optimal growth, as well as maintenance & repair, of tissues.

Individual needs vary.





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| TABLE 18.10 Energy Requirements | | | |
|--|-------|-------|--------|
| Kcal/Day | Age | Male | Female |
| | 23-50 | 2,000 | 2,700 |
| | 51-74 | 1,800 | 2,400 |
| | 75+ | 1,600 | 2,050 |

