# FDSN 201: Notes

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# Chapter 1

# Nutrition: Linking Food and Health

## 1.1 What is Nutrition?

- **Nutrition** – the study of food, including
  - How food nourished our bodies
  - How food influences our health
- Nutrition is a relatively new discipline of science.
- Nutrition research focuses on supporting health and preventing and/or treating chronic diseases.
- Nutrition involves study of the following:
  - Food consumption
  - Food digestion
  - Food absorption
  - Food storage
  - Factors that influence eating patterns
  - Recommended amounts of types of food
  - Food safety
  - The global food supply

## 1.2 How Does Nutrition Support Health?

- Nutrition supports health and wellness
- **Wellness** – A multidimensional, active process by which people make choices to enhance their lives
  - Includes: physical, emotional, social, occupational, and spiritual health

- Critical components of wellness
  - Nutrition
  - Physical activity

## 1.3 Wellness

### 1.3.1 Physical Health

Includes nutrition and physical activity.

### 1.3.2 Spiritual Health

Includes spiritual values and beliefs.

### 1.3.3 Emotional Health

Includes positive feelings about one's self and life.

### 1.3.4 Social Health

Includes family, community, and social environment.

### 1.3.5 Occupational Health

Includes meaningful work or vocation.

## 1.4 Nutrition and Chronic Disease Prevention

- Nutrition can prevent disease
  - Nutrient-deficiency diseases:
    * scurvy (Vitamin-C deficiency)
    * pellagra
  - Three chronic diseases strongly associated with poor nutrition:
    * Heart disease
    * Stroke
    * Diabetes
  - Diseases in which nutrition plays a role:
    * Osteoarthritis

    * Osteoporosis

- Obesity is the primary link between poor nutrition and mortality

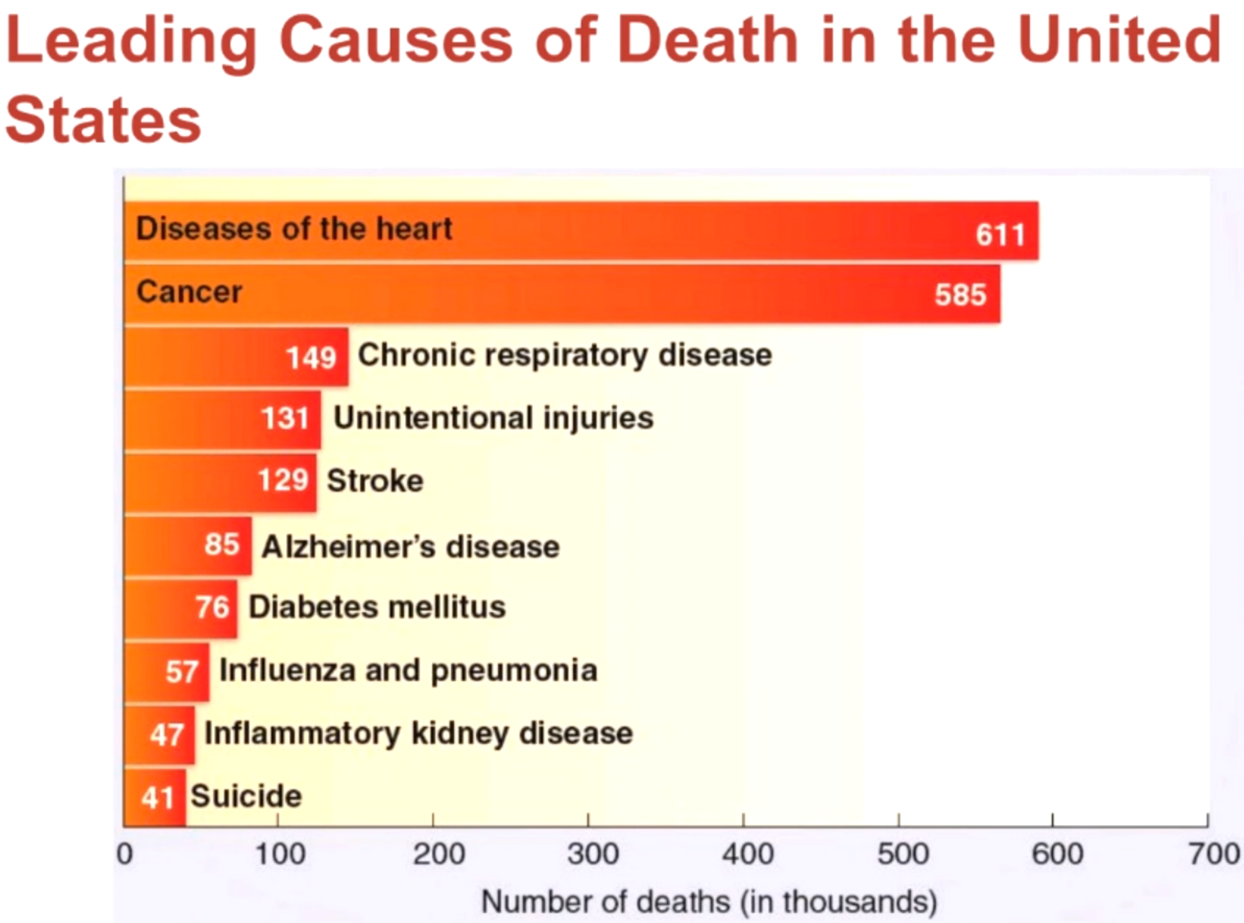
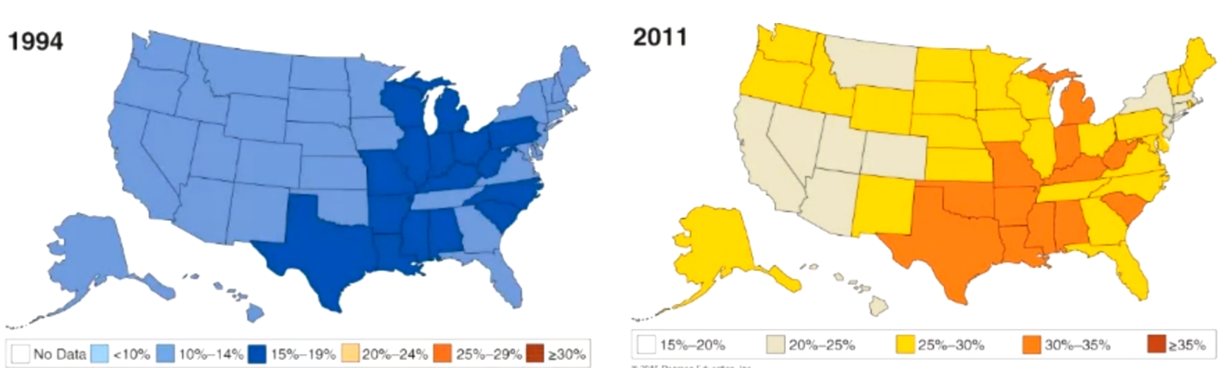



Figure 1.1: Leading Causes of Death in the United States




(a) Obesity rates per U.S. state in 1994. (b) Obesity rates per U.S. state in 2011.

Figure 1.2: A 15-year difference between obesity rates in the United States.

## 1.5 Healthy People 2020

- Nutrition is so important that it has become a national goal
- The Healthy People plan, revised every decade, identifies goals and objectives to reach by 2020.

### 1.5.1 Goals of Healthy People 2020

- Attain high-quality, longer lives free of preventable disease, disability, injury, and premature death
- Achieve health equity, eliminate disparities, and improve the health of all groups
- Create social and physical environments that promote good health for all
- Promote quality of life, healthy development, and healthy behaviors across all life stages

Table 1.1: Weight, Nutrition, and Physical Activity Objecives from Healthy People 2020

| Topic | Objective Number and Description |
|---|---|
| Weight status | NWS-8. Increase the proportion of adults who are at a healthy weight from 30.8% to 33.9%.<br>NWS-9. Reduce the proportion of adults who are obese from 34.0% to 30.6%.<br>NWS-10.2. Reduce the proportion of children aged 6 to 11 years who are considered obese from 17.4% to 15.7%. |
| Food and nutrient composition | NWS-14. Increase the contribution of fruits to the diets of the population aged 2 years and older.<br>NWS-15. Increase the variety and contribution of vegetables to the diets of the population aged 2 years and older. |
| Physical activity | PA–1. Reduce the proportion of adults who engage in no leisure-time physical activity from 36.2% to 32.6%.<br>PA–2.1. Increase the proportion of adults who engage in aerobic physical activity of at least moderate intensity for at least 150 minutes per week, or 75 minutes per week of vigorous intensity, or an equivalent combination from 43.5% to 47.9%.<br>PA–2.3. Increase the proportion of adults who perform muscle-strengthening activities on 2 or more days of the week from 21.9% to 24.1%. |

Data adapted from: Healthy People 2020 (U.S. Department of Health and Human Services).

## 1.6 What Are Nutrients?

- **Nutrients** – chemicals in foods that are critical to human growth and function
- There are six groups of essential nutrients found in foods:
  - Carbohydrates
  - Vitamins
  - Fats and oils
  - Minerals
  - Proteins
  - Water
- **Macronutrients** – nutrients required in relatively large amounts (grams)
  - Provide energy
  - Carbohydrates, fats and oils, proteins
- **Micronutrients** – nutrients required in smaller amounts

## 1.7 Macronutrients Provide Energy

- We measure energy in kilocalories (kcal)
- **Kilocalorie** – amount of energy required to raise the temperature of 1 kg of water by 1°C
- On food labels, "Calorie" actually refers to kilocalories.

### 1.7.1 Carbohydrates

- Provide 4 kcal per gram.

**Functions**

Primary energy source of fuel for the body, especially for the brain

**Composed of**

Chains of carbon, hydrogen, and oxygen

**Best Sources**

Whole grains, vegetables, fruits

### 1.7.2 Vitamins

**Functions**

Important source of energy at rest during low-intensity exercise

**Composed of**

Carbon, hydrogen, and oxygen

**Best Sources**

Vegetable oils, butter and dairy products

### 1.7.3 Fats and oils

- Fats are composed of lipids, molecules that are insoluble in water
- Provide 9 kcal per gram.
- Fats are an important source of fuel for our bodies during times of rest or low-intensity exercise
- Our bodies can store fat which can be used for energy while we are not eating
- Source of fat-soluble vitamins and essential fatty acids

**Functions**

Support tissue growth, repair and maintenance

**Composed of**

Amino acids made up of carbon, hydrogen, oxygen and nitrogen

**Best Sources**

Meats, dairy products, seeds, nuts, legumes

### 1.7.4 Minerals

**Functions**

Assist with release of macronutrients; critical to building and maintaining bone, muscle, and blood; support immune function and vision

**Composed of**

fat-soluble and water-soluble compounds

**Best Sources**

fruits, vegetables, dairy products, meats

### 1.7.5 Proteins

- Proteins are chains of amino acids
- Can supply 4 kcal of energy per gram, but are not usually a primary energy source
- Important for:
  - Building cells and tissues

**Functions**

Assist with fluid regulation and energy production; maintain health of blood and bones; rid body of harmful by-products of metabolism

**Composed of**

Carbon,

**Best Sources**

Fruits, vegetables, dairy products, meats

### 1.7.6 Water

**Functions**

Ensures proper fluid balance; assists in regulation of nerve impulses, body temperature, and muscle contractions

**Composed of**

Hydrogen and oxygen

**Best Sources**

Water, juices, soups, fruits, vegetables

## 1.8 Micronutrients

- Vitamins and minerals (and phytochemicals/phytonutrients) are known as micronutrients
- **Micronutrients** – Nutrients needed in relatively small amounts to support normal health and body functions
- Neither vitamins not minerals provide kilocalories

### 1.8.1 Vitamins

- **Vitamins** – organic molecules that assist in regulating body processes
- Vitamins are classified by the way they are absorbed, transported, and stored in the body
  - Fat-soluble vitamins
  - Water-soluble vitamins

Table 1.2: Overview of Vitamins

| Type | Names | Distinguishing Features |
|---|---|---|
| Fat soluble | A, D, E, K | Soluble in fat<br>Stored in the human body<br>Toxicity can occur from consuming excess amounts, which accumulate in the body |
| Water soluble | C, B-vitamins (thiamin, riboflavin, niacin, vitamin $B_6$, vitamin $B_{12}$, pantothenic acid, biotin, folate) | Soluble in water<br>Note stored to any extent in the human body<br>Excess excreted in urine<br>Toxicity generally only occurs as a result of vitamin supplementation |

### 1.8.2 Minerals

- **Minerals** – inorganic (cannot be broken down) substances required for body processes
  - Minerals include sodium, calcium, iron, potassium, and magnesium
  - Minerals have many different functions, such as fluid regulation and energy production; are essential to bones and blood; and help eliminate harmful by-products of metabolism

Table 1.3: Overview of Minerals

| Type | Names | Distinguishing Features |
|---|---|---|
| Major Minerals | Calcium, phosphorus, sodium, potassium, chloride, magnesium, sulfur | Needed in amounts greater than 100 mg/day in our diet<br>Amount present in the human body is greater than 5 g (5,000 mg) |
| Trace minerals | Iron, zinc, copper, manganese, fluoride, chromium, molybdenum, selenium, iodine | Needed in amounts less than 100 mg/day in our diet<br>Amount present in the human body is less than 5 g (5,000 mg) |

### 1.8.3 Water Supports All Body Functions

- Water is an inorganic nutrient that is vital for health and survival
- Water is involved in many bodily processes:
  - fluid balance
  - nutrient transport
  - nerve impulses
  - removal of wastes
  - muscle contractions
  - body temperature

## 1.9 Determining Nutrient Needs

- Dietary Reference Intakes (DRIs) identify the
  - Amount of a nutrient needed to prevent deficiency disease in healthy people
  - Amount of a nutrient that may reduce the risk of chronic disease
  - Upper level of safety for nutrient intake
- DRIs consist of four values
  - Estimated Average Requirement (EAR)
  - Recommended Dietary Allowance (RDA)
  - Adequate Intake (AI)
  - Tolerable Upper Intake Level (UL)

### 1.9.1 Estimated Average Requirement (EAR)

- The average daily intake level of a nutrient that will meet the needs of half of the healthy people in a particular life stage and gender group
- Used to determine the Recommended Dietary Allowance (RDA) of a nutrient

### 1.9.2 Recommended Dietary Allowance (RDA)

- The average daily intake level required to meet the needs of 97–98% of health people in a particular life stage and gender group

### 1.9.3 Adequate Intake (AI)

- Recommended average daily intake level for a nutrient that is assumed to be adequate
- Based on observations and estimates from experiments
- Used when the RDA is not yet established: vitamin D, vitamin K, fluoride, and chromium

### 1.9.4 Tolerable Upper Intake Level (UL)

- Highest average daily intake level that is not likely to have adverse effects on the health of most people
- Consumption of a nutrient at levels above the UL is not considered safe

## 1.10 DRIs and Energy

- Two DRIs apply to energy specifically
  - Estimated Energy Requirement (EER)
  - Acceptable Macronutrient Distribution Range

### 1.10.1 Estimated Energy Requirement (EER)

- Average dietary energy intake to maintain energy balance
- Based on age, gender, weight, height, and level of physical activity

### 1.10.2 Acceptable Macronutrient Distribution Range (AMDR)

- The range of energy intake from carbohydrate, fat and protein associated with reduced risk of chronic disease
- The range of macronutrient intake that provides adequate levels of essential nutrients

## 1.11 Interpreting Nutrition Research

- Research involves applying the scientific method
  - Observation and description of a phenomenon
  - Creation of a hypothesis
  - Design of a repeatable experiment
  - Collection, analysis, and interpretation of data
    * Formation of a conclusion, or proposal of an alternative hypothesis
  - Development of a theory based on repeated experiments

## 1.12 Types of Research Studies

- Animal versus human studies
  - Drawbacks: ethical concerns, and results may not apply to humans
- Epidemiological studies
- Observational studies
  - Can only indicate relationships between factors
- Case control studies
- Clinical trials

### 1.12.1 Clinical Trials

- In clinical trials, an intervention's effect on a certain disease or health condition is tested using two groups: the experimental group and the control group
- Randomized trials
- Single- and double-blind experiments
  - Placebo: an imitation treatment that has no effect, given to the control group in placebo-controlled double-blind randomized clinical trials

## 1.13 Evaluating Nutrition-Related Claims

- Ask these questions to determine scientific validity:
  - Who is reporting the information?
    * What are their credentials?

  - Who conducted the research and who paid for it?
    * Is there a conflict of interest?

- Is the report based on reputable research studies?
  - Was there a control and an experimental group?
  - Was the sample size large enough to rule out chance variation?
  - Was a placebo effectively administered?
  - Was it a double-blind study?

- Is the report based on testimonials?

- Are the claims too good to be true?

## 1.14 Determining a Website's Reliability

Look at:

- The website sponsors' credentials

- Whether the date of the website is recent

- The Internet address: ".gov", ".edu" and ".org" are generally considered reliable

## 1.15 Whom Can You Trust?

- Trustworthy experts are educated and credentialed
  - Registered dietitian (RD)
  - Licensed dietitian
  - Nutritionist with credentials and experience
  - Professional with advanced degree(s) in nutrition (MS, MA, or PhD in nutrition)
  - Physician with appropriate expertise in nutrition

- Government agencies are usually trustworthy
  - The Centers for Disease Control and Prevention (CDC) supports two large national surveys
    * National Health and Nutrition Examination Survey (NHANES)
    * Behavioral Risk Factor Surveillance System Survey (BRFSS)

- National Institutes of Health (NIH) focuses on specific areas of research, including cancer; heart, lung, and blood diseases; diabetes; and alternative medicine

- Professional organizations publish cutting-edge nutrition research and information
- These include
  - Academy of Nutrition and Dietetics (AND)
  - American Society for Nutrition (ASN)
  - American College of Sports Medicine (ACSM)
  - The Obesity Society (TOS)

## 1.16 In Depth: New Frontiers

- **Nutrigenomics** – studies the interactions among genes, the environment, and nutrition
  - Key theory: foods and environmental factors can "switch" some genes on while turning off others
  - Could help in reducing risk of diet-related disease, treating existing conditions through diet, and making personalized nutrition possible
- The human genome is the set of genes making up the DNA in the nucleus of a human cell
- The human microbiome is the set of genes belonging to microorganisms that inhabit the human body
  - Our health is affected by the way they interact with our human cells and genes that are required for digestion
  - GI flora: helpful bacteria in our gastrointestinal (GI) tract
- Functional foods have biologically active ingredients that provide health benefits beyond basic nutrition
  - **Probiotics** – contain live microorganisms that improve the intestinal microbial balance
  - **Prebiotics** – nondigestible food ingredients that stimulate the growth and/or activity of probiotic bacteria
  - **Phytochemicals** – naturally occuring plant compounds believed to have health-promoting effects in humans

# Chapter 2

# Designing a Healthful Diet

## 2.1 What Is a Healthful Diet?

- A healthful diet is
  - Adequate
  - Moderate
  - Balanced
  - Nutrient-dense
  - Varied

## 2.2 A Healthful Diet is...

### 2.2.1 Adequate

- An adequate diet provides enough energy, nutrients, and fiber to support a person's health
- A diet adequate in one area can still be inadequate in another
- A diet adequate for one person may not be adequate for another

### 2.2.2 Moderate

- Another key to a healthful diet is moderation
- A healthful diet contains the right amounts of foods for maintaining proper weight and nutrition

### 2.2.3 Nutrient-Dense

- A nutrient dense diet is made up of foods and beverages that supply the highest level of nutrients for the lowest number of calories
- Examples of nutrient dense foods are fruits, vegetables and whole grain

### 2.2.4 Balanced

- A balanced diet contains the right combinations of foods to provide the proper proportions of nutrients

### 2.2.5 Varied

- **Variety** – eating many different foods from the different food groups on a regular basis
- A healthful diet is not based on only one or a few types of foods

## 2.3 What's Behind Our Food Choices?

- Hunger is a basic biological urge, while appetite is a psychological desire influenced by
  - Sensory data
    - Social and cultural cues
    - Sight
    - Smell
    - Taste
    - Texture
    - Sound
  - Social, cultural, and emotional cues
    - Craving "comfort foods"
    - Associating food with a location
      - Popcorn at the movies, or hot dogs at a baseball game
  - Learned factors (family, community, religion)
    - Conditioned taste aversion: avoidance of a food as a result of a negative experience such as an illness

## 2.4 Designing a Healthful Diet

- Tools for designing a healthful diet include:
  - Food labels

- 2010 Dietary Guidelines for Americans
- The USDA Food Patterns and MyPlate graphic
- Other eating plans

## 2.5 Food Labels

- Five components of food labels:
  - Statement of identity
  - Net contents of the package
  - Ingredient list
  - Name and address of the food manufacturer, packer, or distributor
  - Nutrition information

### 2.5.1 Nutrition Facts Panel

- The Nutrition Facts Panel contains the nutrition information required by the FDA
  - Label regulations began in 1973
  - The U.S. Food and Drug Administration (FDA) has made changes to the 20-year old nutrition labels on packaged foods. The changes to the nutrition label provide information to help compare products and make healthy food choices.
- This information can be used in planning a healthful diet
- Serving size and servings per container
  - Serving sizes can be used to plan appropriate amounts of food
  - Standardized serving sizes allow for comparisons among similar products
- Calories and Calories from fat per serving
  - This information can be used to determine if a product is relatively high in fat
- List of nutrients
  - Fat (total, saturated, and trans)
  - Cholesterol
  - Sodium
  - Carbohydrates
  - Protein
  - Some vitamins and minerals

- Percent Daily Values (%DV)
  - Describe how much a serving of food contributes to your total intake of a nutrient
  - Based on a diet of 2,000 Calories per day
  - Can be used to determine if a product is low or high in a particular nutrient
  - Based on:
    * Reference Daily Intakes (RDIs) for foods with a Recommended Dietary Allowance (RDA) value
    * Daily Reference Values (DRVs) for foods without an RDA value
- Footnote
  - Contains general dietary advice for all people of all health
  - Must be present on all food labels
  - Also compares a 2,000-Calorie diet with a 2,500-Calorie diet

### 2.5.2 Nutrient Claims on Food Labels

- The FDA has approved several claims related to health and disease
- If current scientific evidence about a health claim is not convincing, the label may have to include a disclaimer
- **Structure** – function claims such as "Builds stronger bones" can be made with no proof and therefore no actual benefits may be seen

Table 2.1: FDA-Approved Terms and Definitions

| Nutrient | Claim | Meaning |
|---|---|---|
| Energy | Calorie free | Less than 5 kcal per serving |
| | Low Calorie | 40 kcal or less per serving |
| | Reduced Calorie | At least 25% fewer kcal than reference (or regular) food |
| Fat and Cholesterol | Fat free | Less than 0.5 g of fat per serving |
| | Low fat | 3 g or less fat per serving |
| | Reduced fat | At least 25% less fat per serving than reference food |
| | Saturated fat free | Less than 0.5 g of saturated fat and less than 0.5 g of trans fat per serving |
| | Low saturated fat | 1 g or less saturated fat and less than 0.5 g trans fat per serving and 15% or less of total kcal from saturated fat |
| | Reduced saturated fat | At least 25% less saturated fat and reduced by more than 1 g saturated fat per serving as compared to reference food |
| | Cholesterol free | Less than 2 mg of cholesterol per serving and 2 g or less saturated fat and trans fat combined per serving |
| | Low cholesterol | 20 mg or less cholesterol and 2 g or less saturated fat per serving |
| | Reduced cholesterol | At least 25% less cholesterol than reference food and 2 g or less saturated fat per serving |
| Fiber and Sugar | High fiber | 5 g or more fiber per serving* |
| | Good source of fiber | 2.5 g to o4.9 g fiber per serving |
| | More or added fiber | At least 2.5 to 4.9 g fiber per serving |
| | Sugar free | Less than 0.5 g sugars per serving |
| | Low sugar | Not defined; no basis for recommended intake |
| | Reduced/less sugar | At least 25% less sugars per serving than reference food |
| | No added sugars or without added sugars | No sugar or sugar-containing ingredient added during processing |

*High-fiber claims must also meet the definition of low fat; if not, then the level of total fat must appear next to the high-fiber claim. Data adapted from: “Food Labeling Guide” (U.S. Food and Drug Administration)

# Chapter 3

# The Human Body: Are We Really What We Eat?

## 3.1 Organization of the Body

**Atoms** – the smallest units of matter

- Atoms bond to each other to form molecules

**Molecules** – groups of atoms bonded in specific configurations

- Examples
  - Water is $H_2O$
  - Carbon dioxide is $CO_2$
- Carbohydrates, proteins, fats, and vitamins are usually very large molecules
- The goal of digestion:
  - Break these large molecules down into smaller molecules
  - Absorb the smaller molecules into the cells of the body

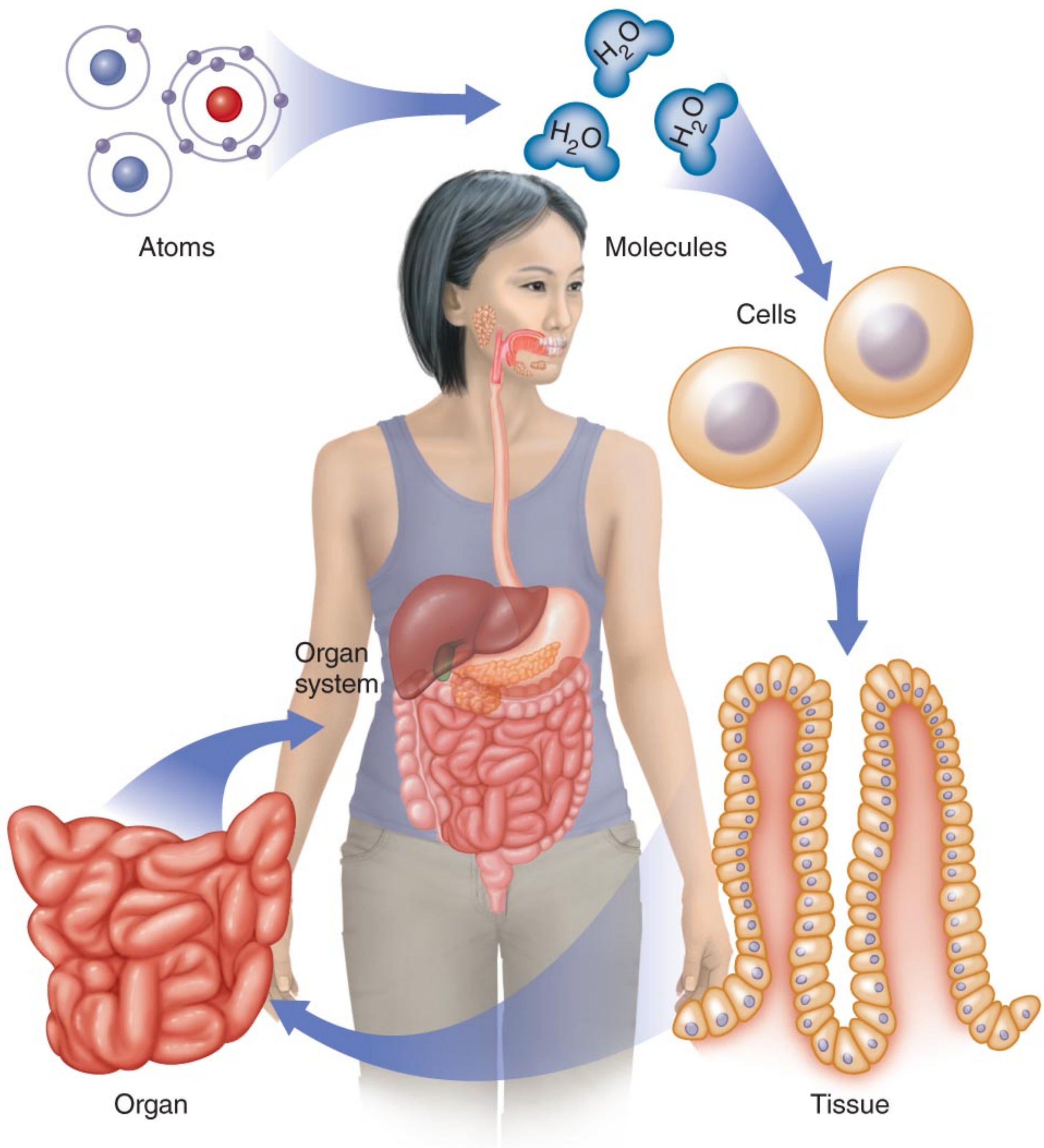



Figure 3.1: Organization of the Body

- Molecules are the building blocks of cells
- **Cells** – the smallest unit of life
- Molecules that result from the digestion of food are used to build the cells of the body
- **Cell membrane** – outer layer enclosing each cell of the body

- Composed of two layers of phospholipids
- Long lipid "tails" face each other toward the interior of the membrane
- Phosphate "heads" line the interior and exterior surfaces of the membrane
- Cholesterol and proteins are embedded in the membrane

- The cell membrane is selectively permeable, allowing it to control the passage of materials into and out of the cell

- The cell membrane encloses the
  - **Cytoplasm** – the liquid within the cell
  - **Organelles** – tiny structures that perform many different cellular functions
  - Examples
    - Nucleus
    - Mitochondria

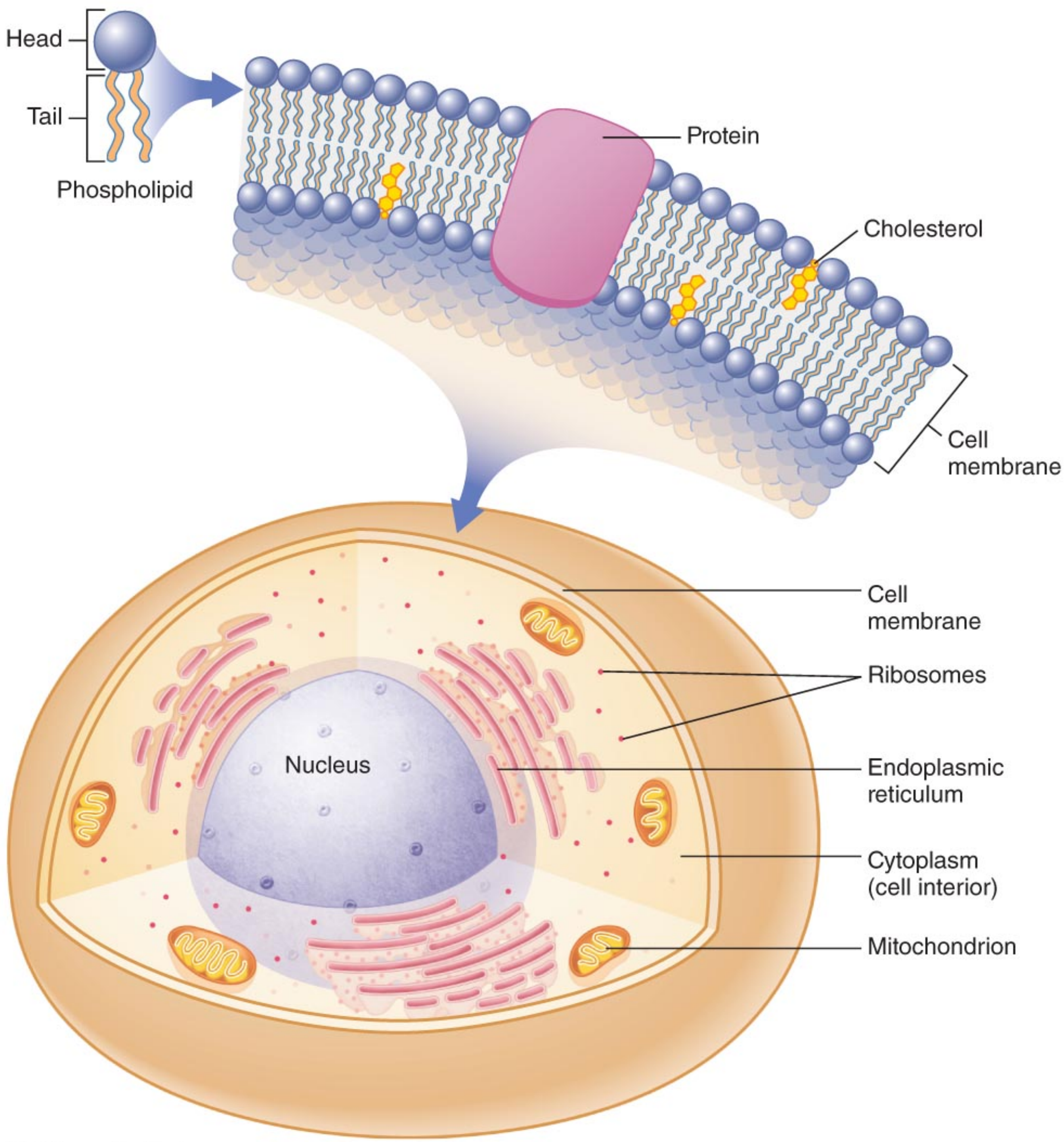



Figure 3.2: Representative Enterocyte

- Cells join together to form tissues
- **Tissue** – group of cells acting together to perform a common function
  - Examples
    - Muscle tissue
    - Nervous tissue

- Different tissues combine to form organs
- **Organ** – a sophisticated organization of tissues that performs a specific function
  - Examples
    - Stomach
    - Heart
    - Brain
- **Organ systems** – groups of organs working together for a particular function
  - Example
    - Gastrointestinal system

## 3.2 Types of Organ Systems (11)

- Nervous
- Cardiovascular (circulatory)
- Respiratory
- Renal
- Digestive
- Endocrine
- Integumentary & Exocrine
- Immune & Lymphatic
- Muscular
- Skeletal
- Reproductive

## 3.3 Why Do We Want to Eat?

**Appetite** – a desire to eat that is stimulated by

- Sight
- Smell
- Thought of food

**Hunger** – a physiologic drive to eat that occurs when our body senses that we need food

- The hypothalamus region of the brain contains a cluster of nerve cells known as the feeding center and another cluster of cells known as the satiety center
  - Nerve cells in the stomach and small intestine sense food and send message to hypothalamus
  - Hormones relay messages to the hypothalamus
  - Amount and type of food consumed influence satiety

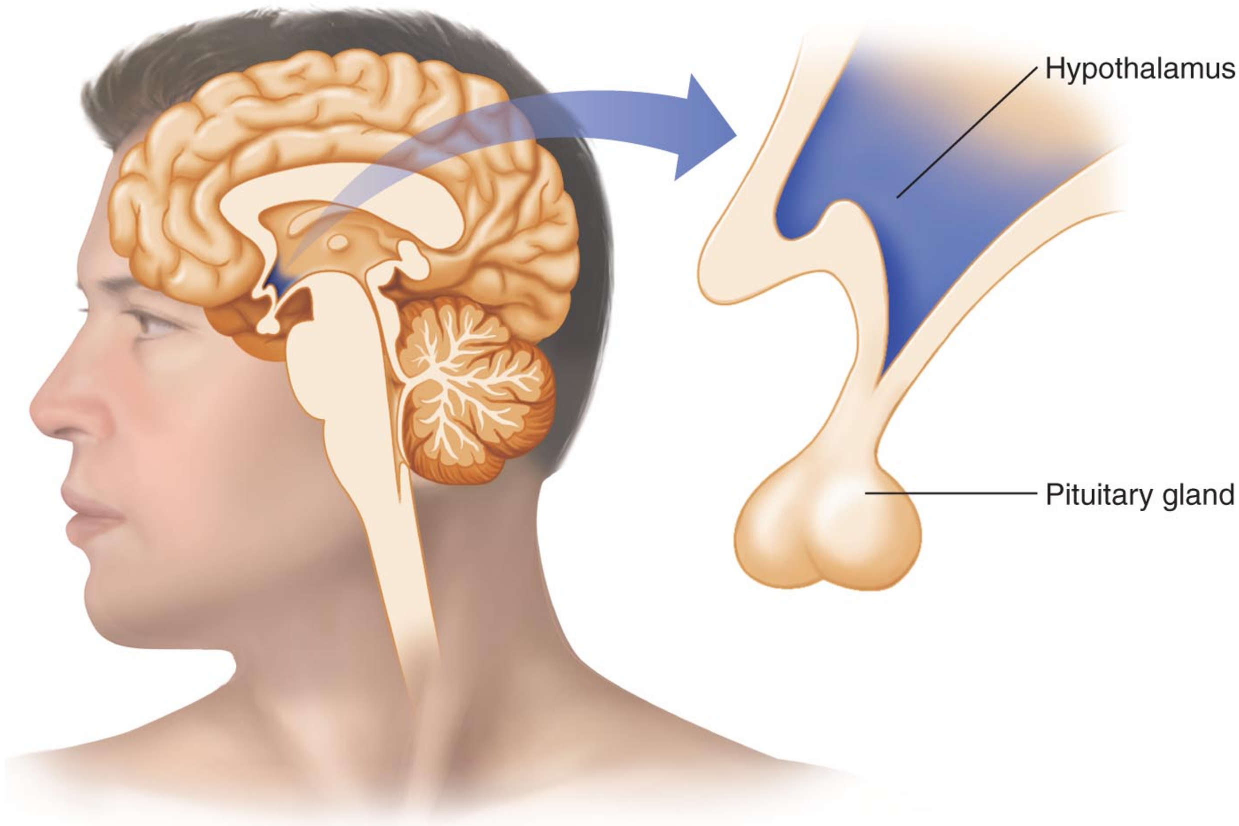



Figure 3.3: The Hypothalamus Triggers Hunger

- The signals that prompt us to eat include
  - Nerve receptors in the stomach, which send signals to the hypothalamus to indicate if the stomach is full ot empty
  - Blood fuel (glucose, ketones) levels, which trigger the release of hormones
    - insulin and glucagon
- **Hormones** – chemicals produced in specialized glands that travel in the bloodstream to target organs in other parts of the body
  - Some hormones stimulate hunger

    * Ghrelin
  - Some hormones produce a feeling of satiety
    * Cholecystokinin (CCK)
    * Leptin

- Foods have different effects on our feelings of hunger and satiety
  - Proteins have the highest satiety value
  - Carbohydrates have a lower satiety value than fats
  - Bulky foods provided a sense of satiety
  - Solid foods are more filling than semisolid foods or liquids

## 3.4 What Happens to the Food We Eat?

- **Gastrointestinal (GI) tract** – series of organs arranged as a long tube through which the food passes
- The GI tract includes
  - Organs such as the stomach and intestines
  - **Sphincters** – muscles that control the passage of material from one organ to the next

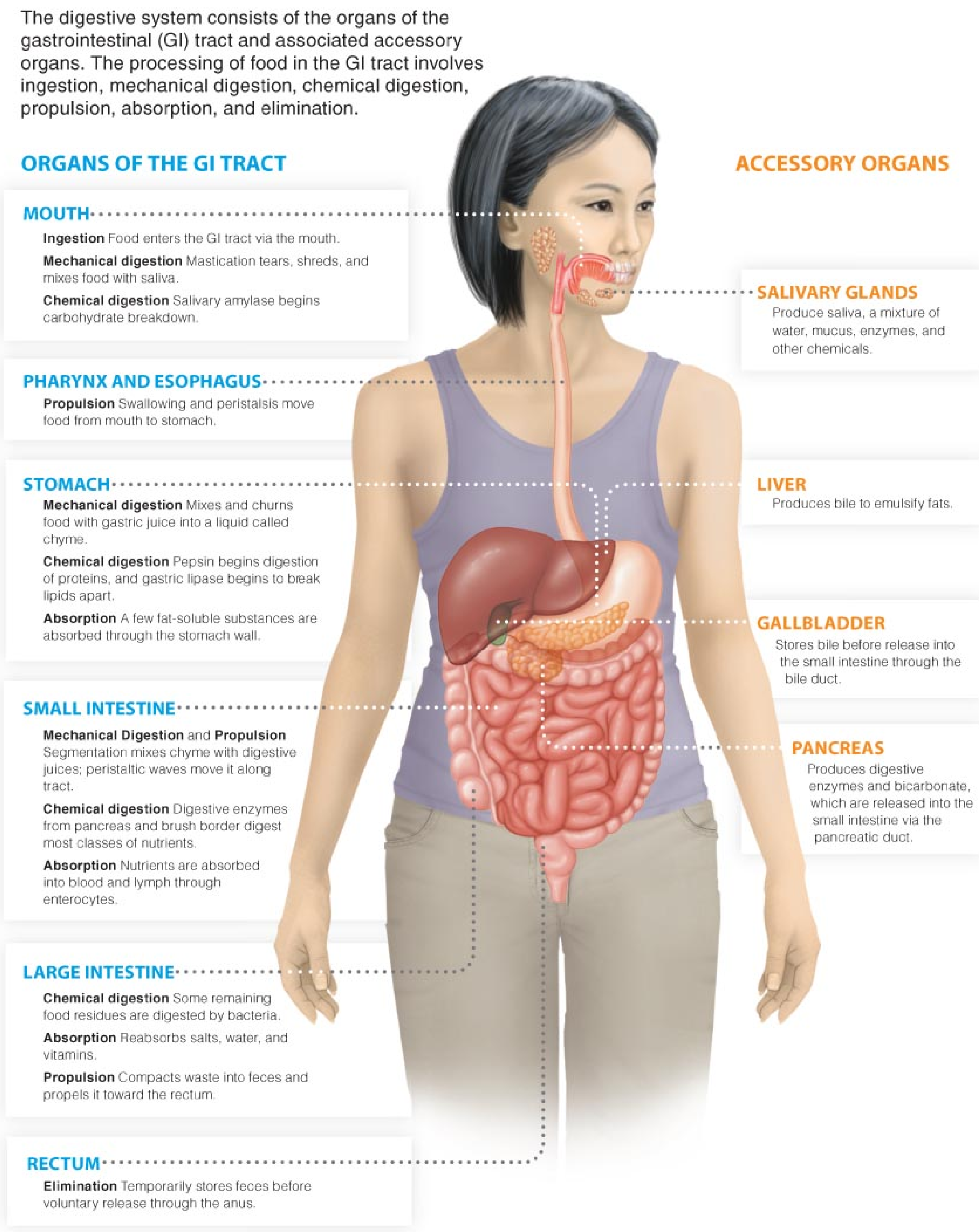



Figure 3.4: Digestive System

## 3.5 Digestion

### 3.5.1 The Mouth

- Digestion begins in the mouth
  - Chewing is the mechanical digestion that breaks food into smaller pieces
  - Some chemical digestion takes place in the mouth
    - **Salivary amylase** – an enzyme produced by the salivary glands that begins the chemical digestion of carbohydrates

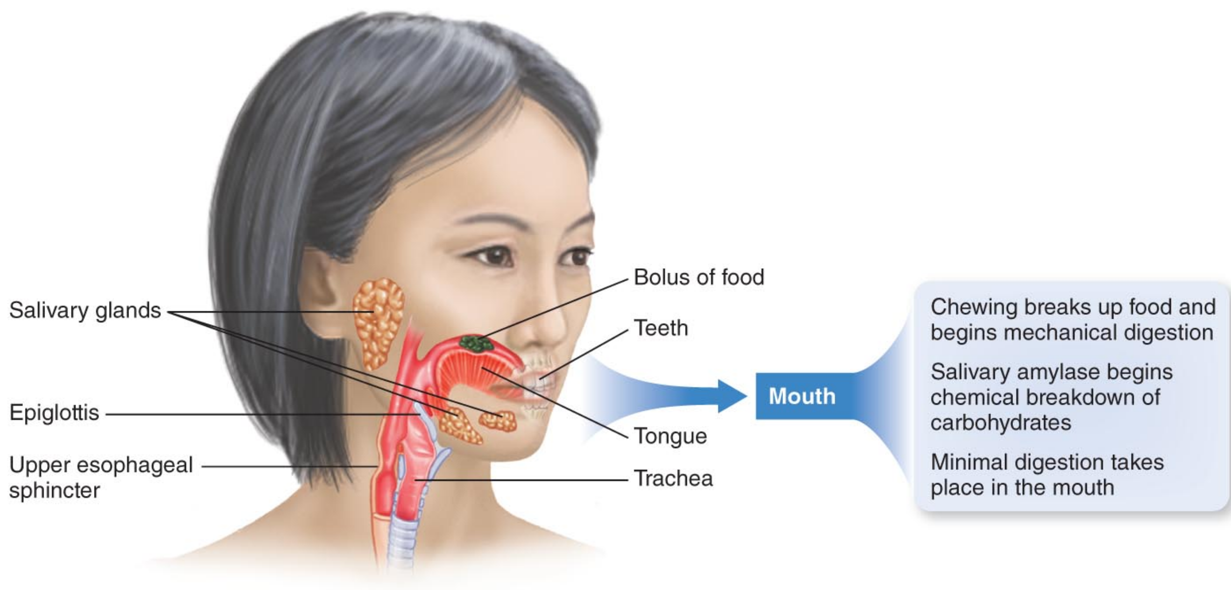



Figure 3.5: Digestion: The Mouth

- The esophagus propels food into the stomach
  - The epiglottis covers the opening to the trachea during swallowing
  - Food travels from the mouth to the stomach through the esophagus
  - Peristalsis is the muscular contractions moving food through the GI tract
  - The gastroesophogeal sphincter separates the esophagus from the stomach

### 3.5.2 Stomach

- The stomach mixes, digests, and stores food
- Digestion in the stomach includes
  - Extensive mechanical digestion to mix food with gastric juice
  - Chemical digestion of proteins and fats

- Gastric juice contains
  - **Hydrochloric acid (HCl)** – to denature proteins and activate pepsin
  - **Intrinsic factor** – a protein critical to the absorption of vitamin $B_{12}$
  - **Pepsin** – an enzyme to digest protein
  - **Gastric lipase** – an enzyme to digest fat
- **Chyme** – semisolid product of mechanical and chemical digestion in the stomach

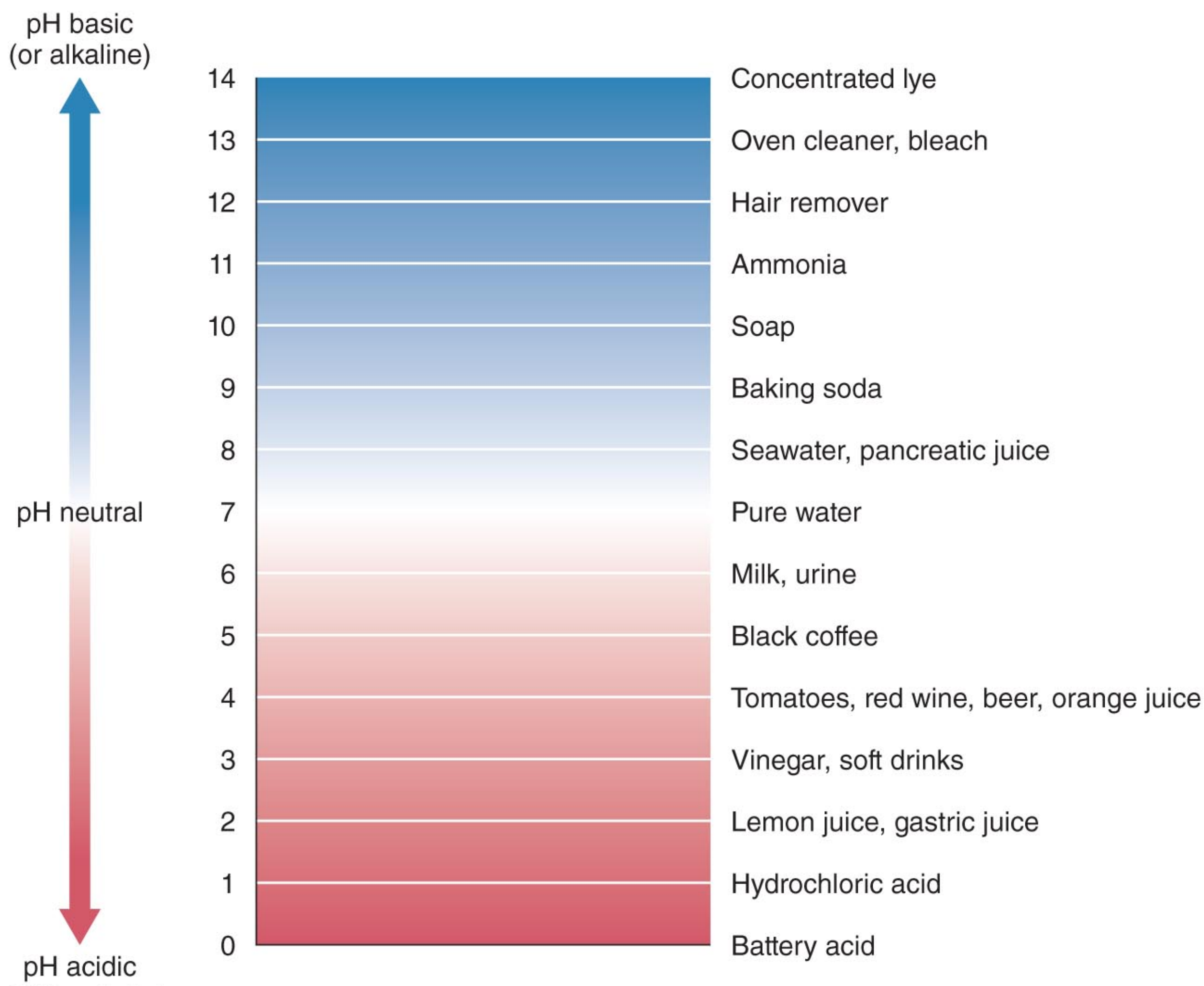



Figure 3.6: Hydrochloric Acid (HCl) on the pH Scale

### 3.5.3 Small Intestine

- From the stomach, chyme is slowly released through the pyloric sphincter to the small intestine
- Chemical digestion continues in the small intestine using pancreatic enzymes and bile

### 3.5.4 Large Intestine

- Undigested food components move through a sphincter called the ileocecal valve to the large intestine
- In the large intestine
  - Very little digestion takes place
  - Material is stored 12–24 hours prior to elimination
  - Water and some nutrients are absorbed

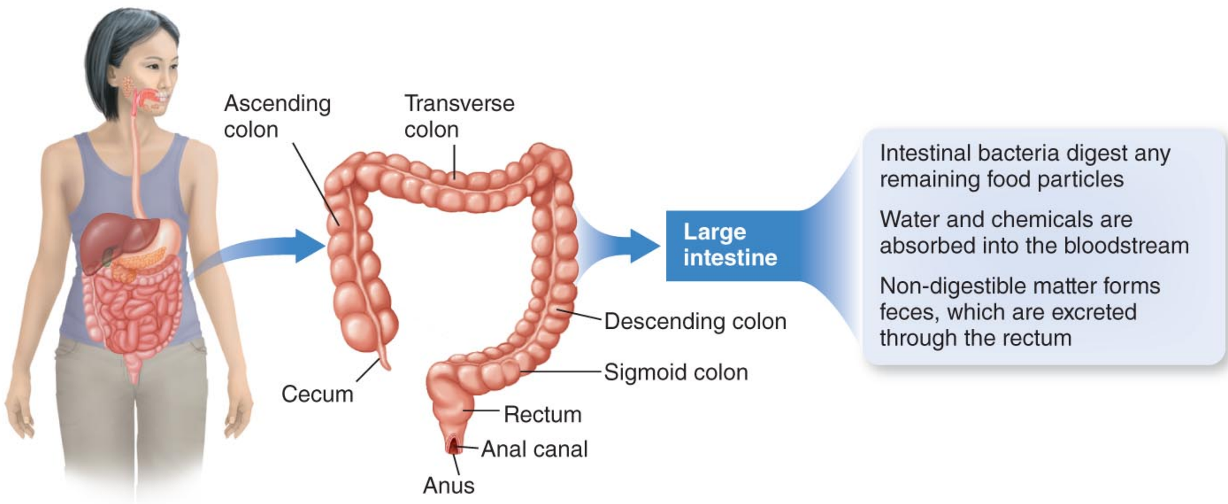



Figure 3.7: Elimination

### 3.5.5 Accessory Organs

- Surrounding the GI tract are several accessory organs
  - Salivary glands
  - **Liver** – produces bile, which emulsifies fats
  - Pancreas
    - Produces many digestive enzymes
    - Produces bicarbonate to neutralize chyme
  - **Gallbladder** – stores bile

## 3.6 Absorption

- **Absorption** – the process of taking molecules across a cell membrane and into cells of the body

- A small amount of absorption occurs in the stomach
- Most absorption of nutrients occurs in the three sections of the small intestine
  - Duodenum
  - Jejunum
  - Ileum
- The lining of the GI tract has special structures to facilitate absorption
  - **Villi** – folds in the lining that are in close contact with nutrient molecules
  - **Brush border** – composed of microvilli that greatly increase the surface area
- Water-soluble nutrients (carbohydrates, protein, minerals, and some vitamins) enter the portal vein
  - The portal vein transports these nutrients to the liver
- Fat-soluble nutrients (lipids and some vitamins) enter the lymphatic vessels
  - Lymphatic vessels transport these nutrients directly to the bloodstream
- Nutrients are absorbed across the mucosal membrane and into the blood stream or lymph by:
  - Passive diffusion
  - Facilitated diffusion
  - Active transport
  - Endocytosis

## 3.7 The Role of the Neuromuscular System

- Two components of the neuromuscular system regulate the activities of the GI tract
  - The muscles of the GI tract mix and move food
    - Both voluntary and involuntary muscles
  - Nerves control the contractions and secretions of the GI tract
    - The enteric nervous system (ENS)
    - Other branches of the autonomic nervous system
    - The central nervous system (CNS)

## 3.8 GI Tract Disorders

- The lining of the stomach is designed to cope with hydrochloric acid, but other regions of the GI tract are not
- **Heartburn** – caused by hydrochloric acid in the esophagus
- **Gastroesophageal reflux disease (GERD)** – a chronic disease for which painful, persistent heartbutn is the most common symptom
- **Peptic ulcers** – regions of the GI tract that have been eroded by HCl and pepsin
- The bacterium Helicobacter pylori contributes to the production of both gastric and duodenal ulcers
- Vomiting often accompanies a gastrointestinal infection such as the norovirus
- **Cyclic vomiting syndrome (CVS)** – a chronic condition involving severe nausea and vomiting that can lasy for hours or days
- Diarrhea can be caused by
    * Food intolerances
    * Infection of the GI tract
    * Stress
    * Bowel disorders
  - Can lead to severe dehydration
  - Is more dangerous for children and the elderly
- **Constipation** – no stool passed for two or more days

Table 3.1: Signs and Symptoms of Dehydration

| **Symptoms in Adults** | **Symptoms in Children** |
|---|---|
| Thirst | Dry mouth and tongue |
| Light-headedness | No tears when crying |
| Less frequent urination | No wet diapers for 3 hours or more |
| Dark-colored urine | High fever |
| Fatigue | Sunken abdomen, eyes, or cheeks |
| Dry skin | Irritable or listless |
| | Skin does not rebound when pinches or released |

Data adapted from: Diarrhea, National Digestive Diseases Information Clearinghouse, www.niddk.nih.gov.

- **Irritable Bowel Syndrome (IBS)** – a disorder that interferes with normal colon function

- Symptoms of IBS include
  - Abdominal cramps and bloating
  - Either diarrhea or constipation
- IBS is more common in women than in men
- Cancer can develop in any region of the GI tract
- The most common forms are
  - Oral cancer
  - Pancreatic cancer
  - Colorectal cancer

## 3.9 In Depth: Disorders Related to Foods

- **Food intolerance** – a particular good causes numerous unpleasant symptoms, including
  - Gas
  - Pain
  - Diarrhea
  - The immune system is not involved
- **Food allergy** – hypersensitivity reaction of the immune system to a component in a food
- **Celiac disease** – an autoimmune disease that is also considered a genetic disorder
  - Complete intolerance for gluten, a protein found in wheat, rye, barley, and triticale
  - Can damage the small intestine, leading to poor absorption of nutrients
  - Requires a diet lacking wheat, rye, barley, and triticale

## 3.10 Non-Celiac Gluten Sensitivity

- Some individuals may have a negative GI reaction when consuming gluten, but do not have Celiac Disease
  - Bloating
  - Abdominal pain
  - Diarrhea
  - Possible joint pain
- Symptoms improve by following a gluten free diet

# Chapter 4

# Carbohydrates: Plant-Derived Energy Nutrients

## 4.1 What Are Carbohydrates?

Carbohydrates

- One of the three macronutrients
- An important energy source, especially for nerve cells
- Composed of the atoms: Carbon, Hydrogen, and Oxygen
- Good sources include fruits, vegetables, and grains

Glucose

- The most abundant carbohydrate
- Produced by plants through photosynthesis
- The preferred source of energy for the brain
- An important source of energy for all cells

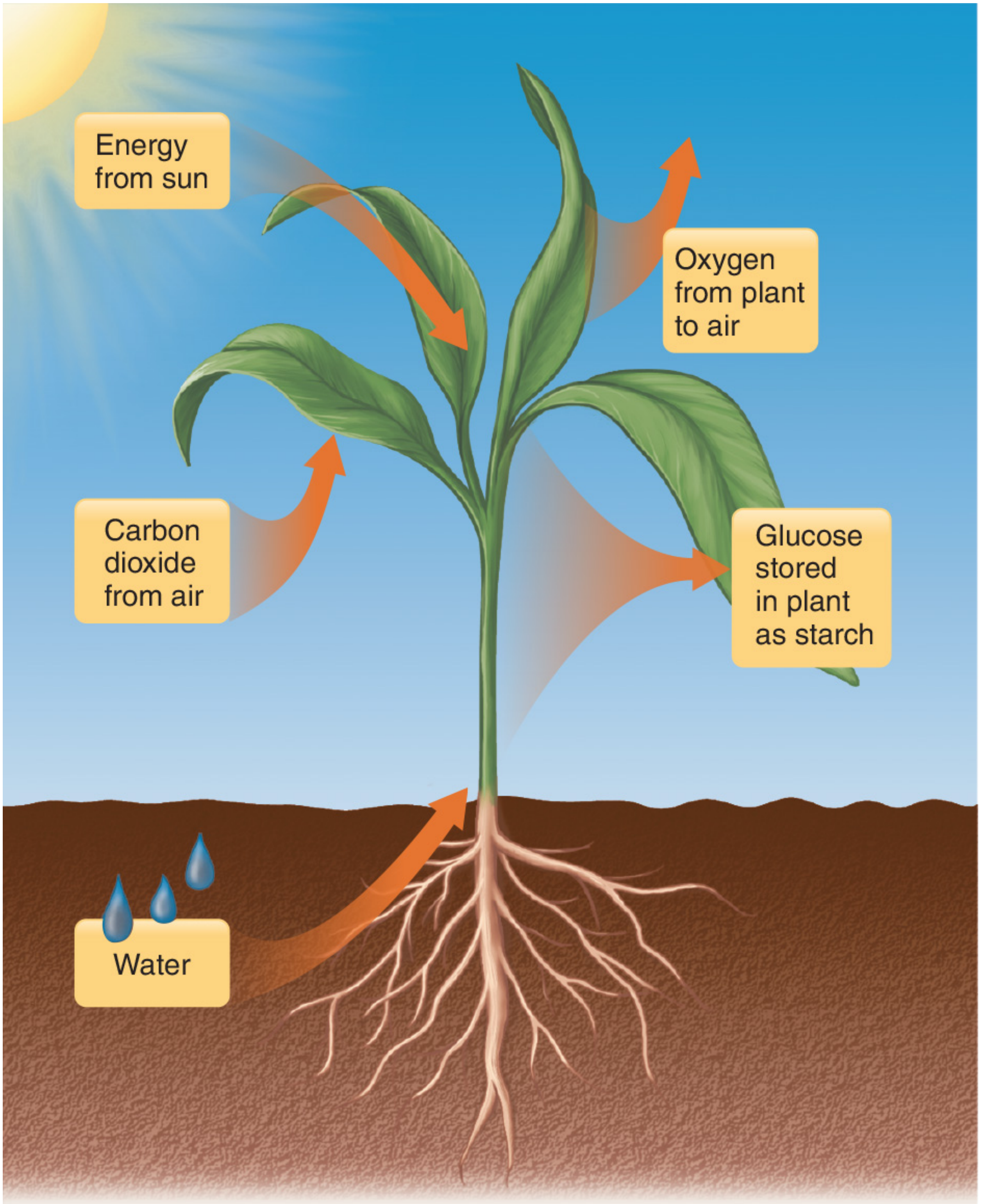



Figure 4.1: Photosynthesis

Simple carbohydrates contain one or two molecules

**Monosaccharides** contain only one molecule

- Glucose, fructose, galactose, ribose

**Disaccharides** contain two molecules

- Lactose, maltose, sucrose

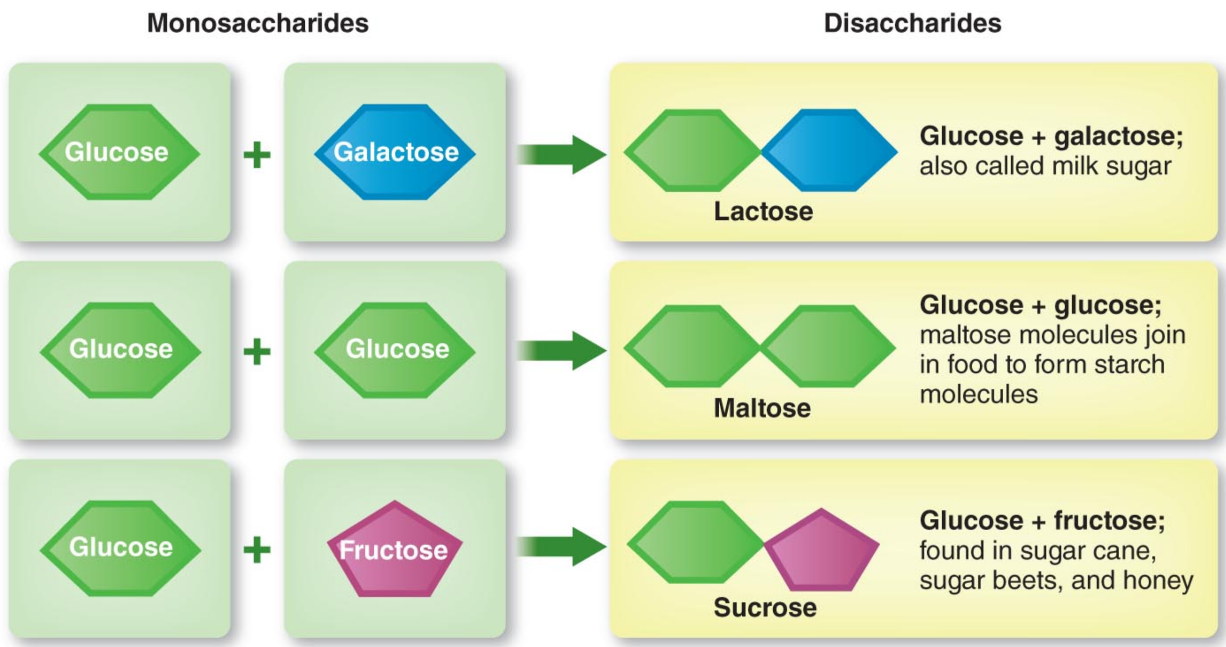
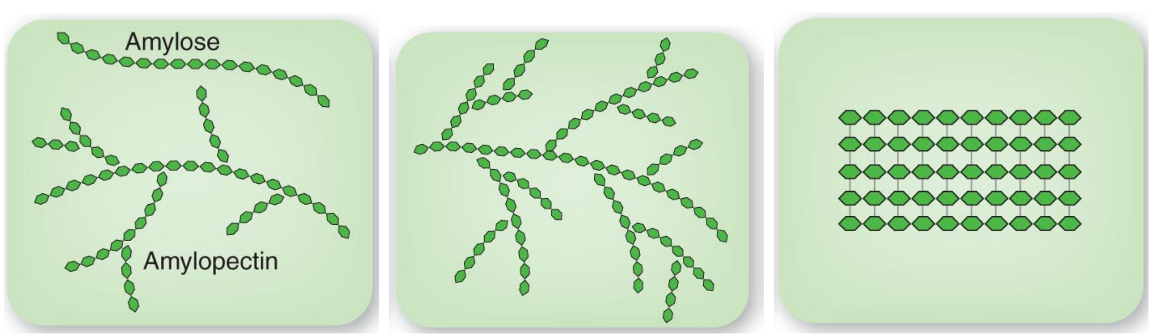



Figure 4.2: Disaccharides




(a) **Starch** – Storage form of glucose in plants; found in grains, legumes, and tubers

(b) **Glycogen** – Storage form of glucose in animals; stored in liver and muscles

(c) **Fiber** – Forms the support structures of leaves, stems, and plants

Figure 4.3: Complex Carbohydrates

### 4.1.1 Starch

- Plants store glucose as polysaccharides in the form of starch

- Our cells cannot use complex starch molecules exactly as they occur in plants
- We digest (break down) starch into glucose
- Grains, legumes, and tubers are good sources of dietary starch

### 4.1.2 Glycogen

- Animals store glucose as glycogen
- Stored in our bodies in the liver and muscles
- Not found in food and therefore not a dietary source of carbohydrate

### 4.1.3 Fiber

**Dietary fiber** the non-digestible part of plants

- Also classified by solubility

**Functional fiber** the non-digestible form of carbohydrate with known health benefits, which is extracted from plants and added to foods

- Cellulose, guar gun, pectin, psyllium

**Total fiber** dietary + function fiber

#### Soluble fiber

- Dissolves in water
- Viscous and fermentable
- Easily digested by bacteria in the colon
- Found in citrus fruits, berries, oats and beans
- Reduce risk of cardiovascular disease and type 2 diabetes by lowering blood cholesterol and glucose levels

#### Insoluble fiber

- Generally do not dissolve in water
- Found in whole grains (e.g., wheat, rye, brown rice) and many vegetables
- Promote regular bowel movements, alleviate constipation, and reduce risk of diverticulosis

## 4.2 Why Do We Need Carbohydrates

### 4.2.1 Energy

- Fuel daily activity
- Fuel exercise
- Help preserve protein for other uses
  - When the diet does not provide enough carbohydrates, the process of gluconeogenesis converts proteins in blood and tissue into glucose
- Each gram of carbohydrate = 4 kcal
- Red blood cells rely only on glucose for their energy supply
- Both carbohydrates and fats supply energy for daily activities
- Glucose is especially important for energy during exercise
- Sufficient energy intake from carbohydrates prevents production of ketones as an alternative energy source
- Excessive ketones can result in high blood acidity and ketoacidosis
- High blood acidity damages body tissues

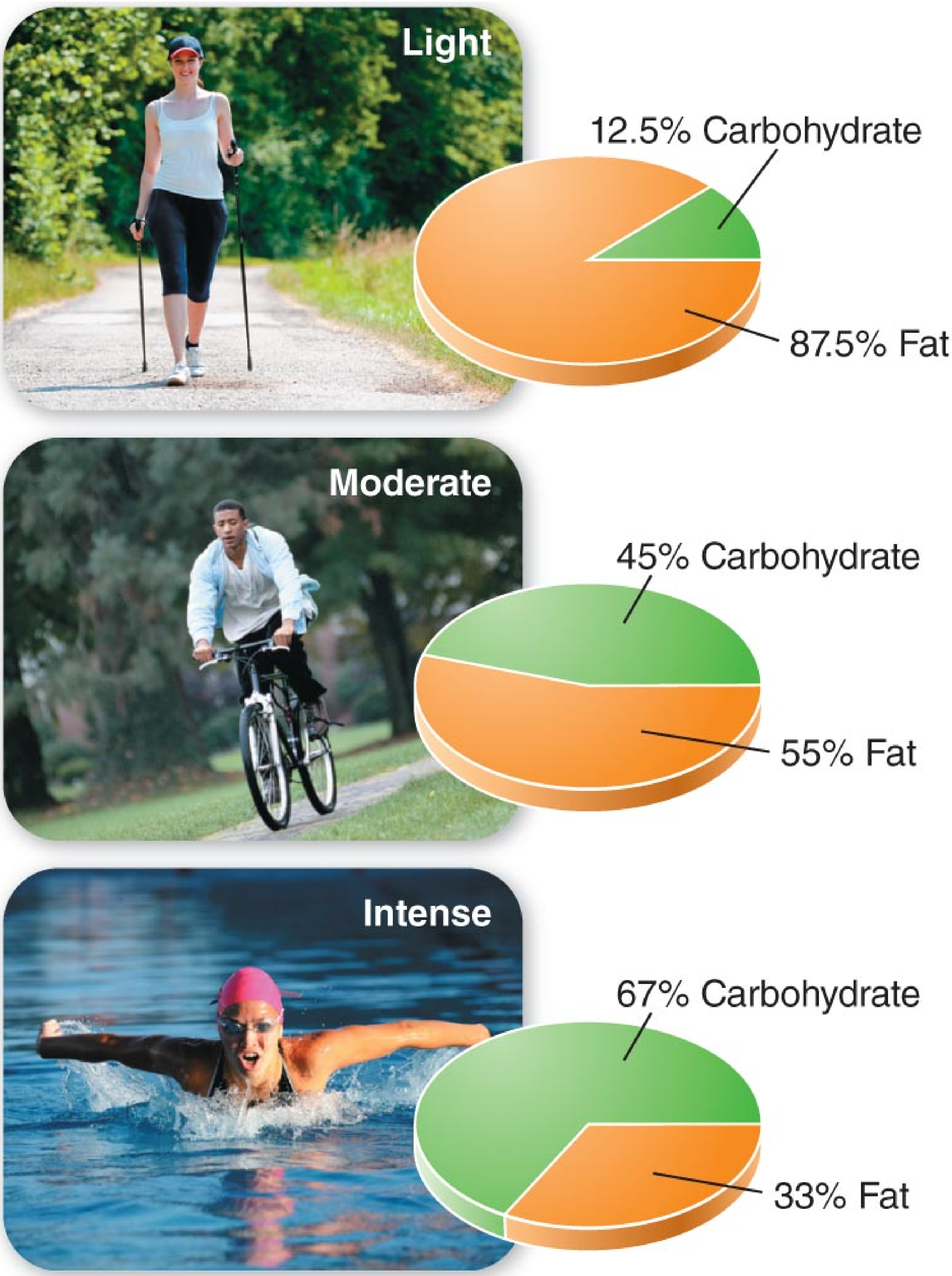



Figure 4.4: Carbohydrate Use by Exercise Intensity

### 4.2.2 Fiber

- May reduce the risk of colon cancer
- Promotes bowel health by helping to prevent hemorrhoids and constipation
- May reduce the risk of heart disease
- May enhance weight loss
- May lower the risk of type 2 diabetes
- Reduces risk of diverticulosis

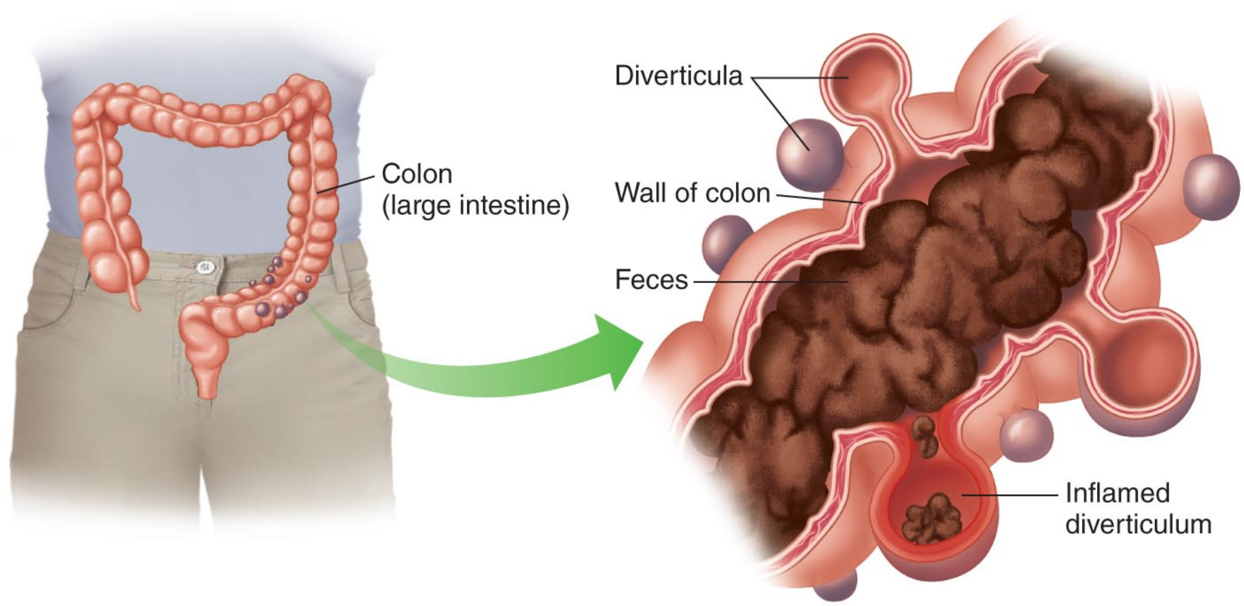



Figure 4.5: Diverticulosis

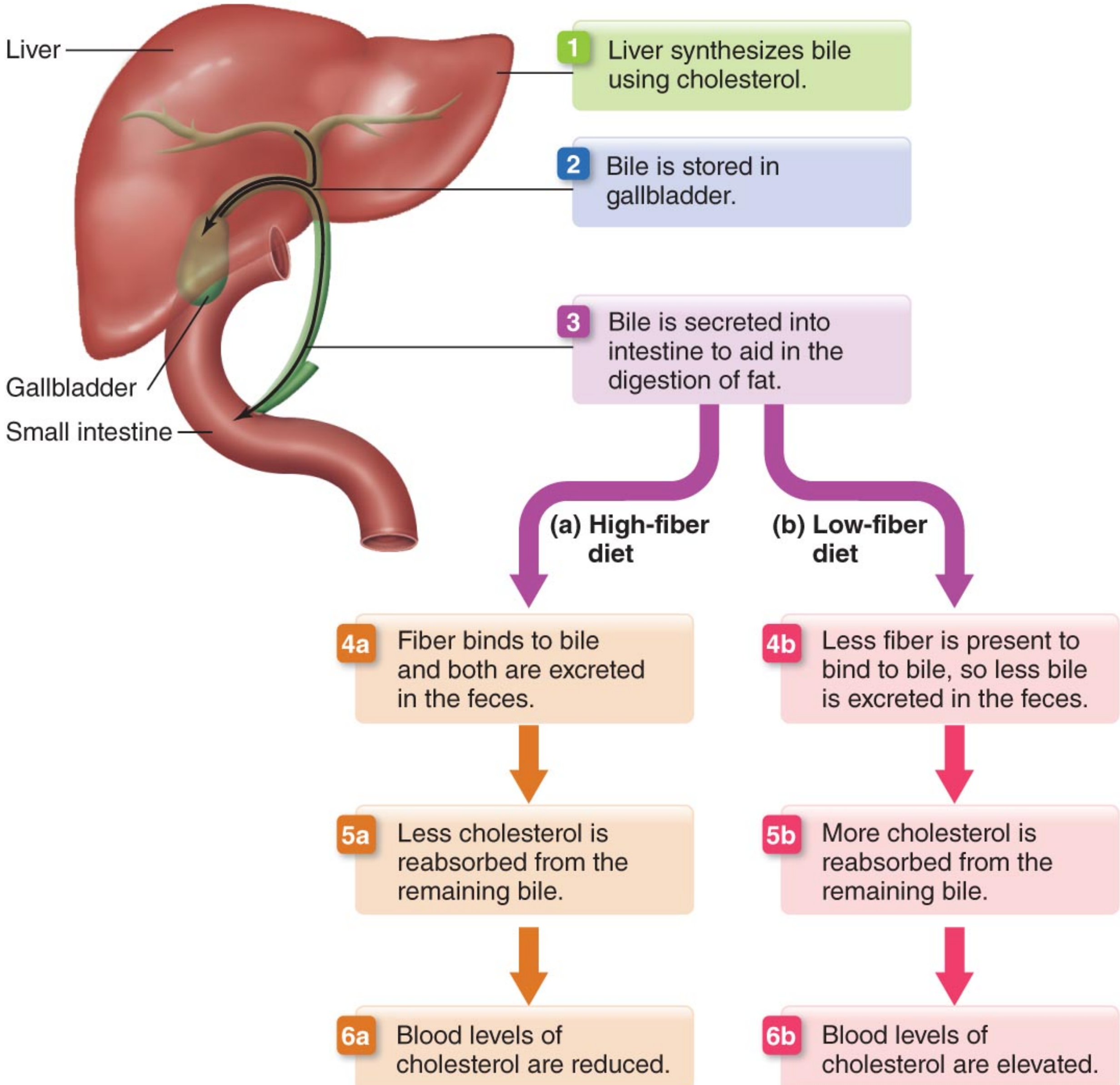



Figure 4.6: Fiber May Help Decrease Blood Cholesterol

## 4.3 Digestion of Carbohydrates

- Most chemical digestion of carbohydrates occurs in the small intestine

### 4.3.1 Pancreatic amylase

- Enzyme produced in the pancreas and secreted into the small intestine
- Enzymatically digests starch to maltose

- Additional enzymes secreted by cells that line the small intestine (mucosal cells) digest disaccharides to monosaccharides
- These enzymes include maltase, sucrase, and lactase
- Monosaccharides are absorbed into the cells lining the small intestine and then enter the bloodstream
- Most monosaccharides are converted to glucose by the liver
  - Glucose is released into the bloodstream to provide immediate energy
  - Excess glucose is converted to glycogen and stored in the liver and muscles

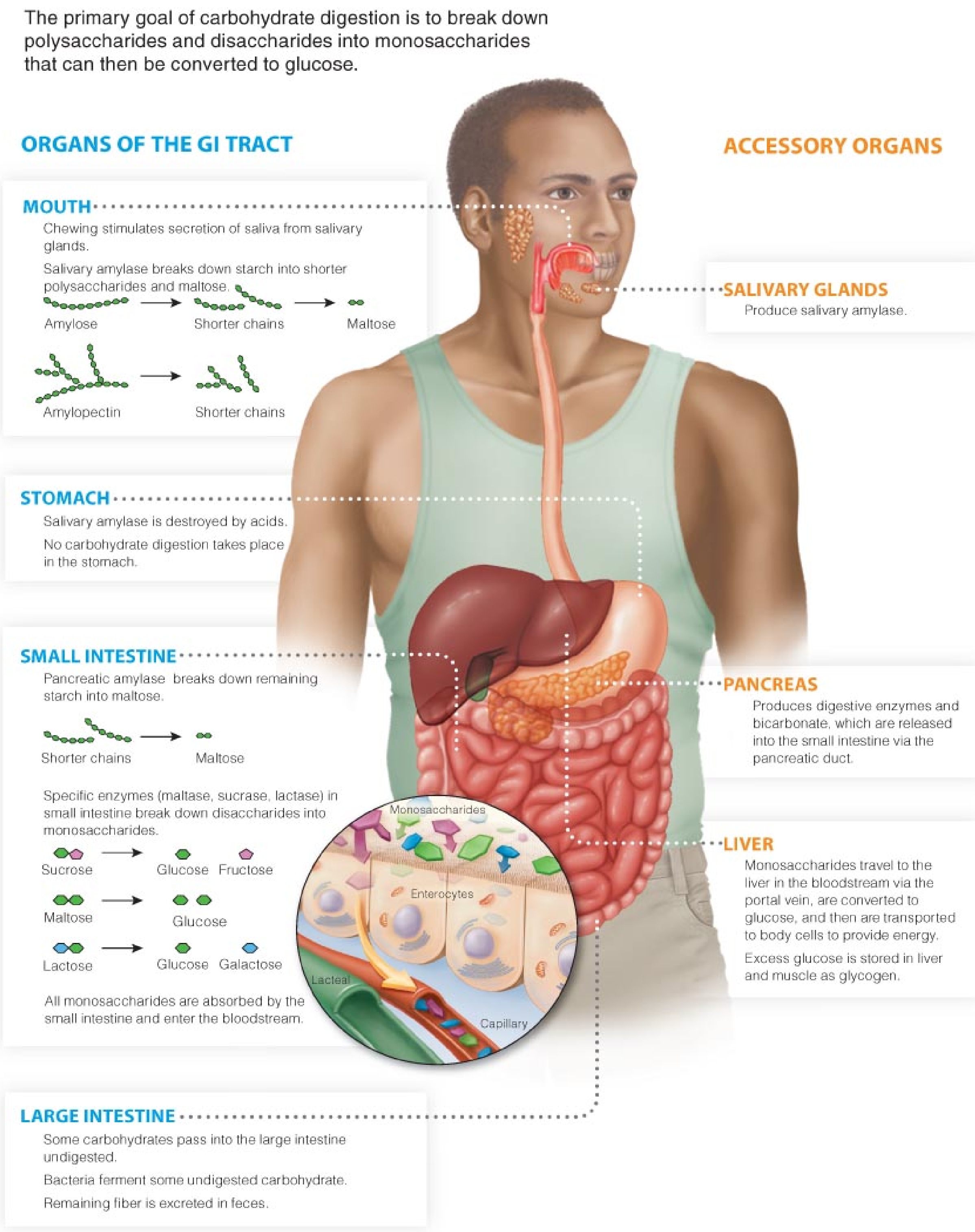



Figure 4.7: Digestion of Carbohydrates

## 4.4 Regulation of Blood Glucose

### 4.4.1 Insulin

- A hormone secreted by the pancreas
- Transported in our blood throughout the body
- Helps transport glucose from the blood into cells
- Stimulates the liver and muscles to take up glucose and convert it to glycogen

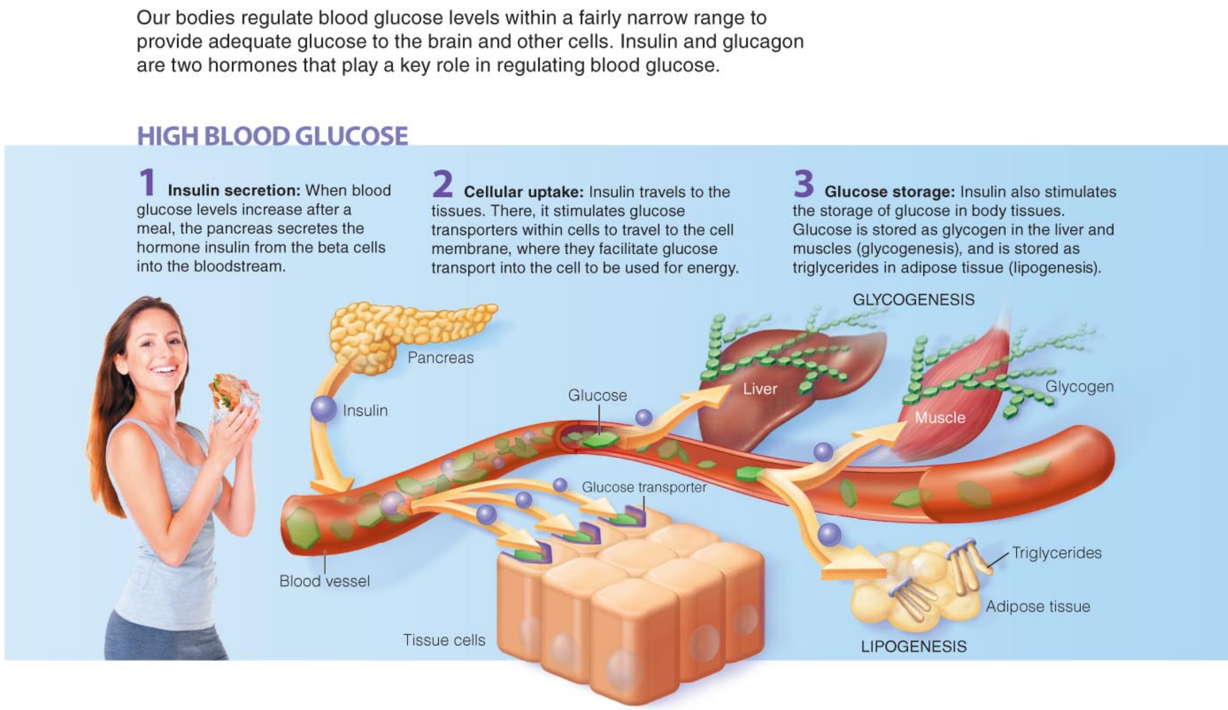



Figure 4.8: Regulation of Blood Glucose: Insulin

### 4.4.2 Glucagon

- Another hormone secreted by the pancreas
- Stimulates the breakdown of glycogen to glucose to make glucose available to cells of the body
- Stimulates gluconeogensis–the production of “new” glucose from amino acids

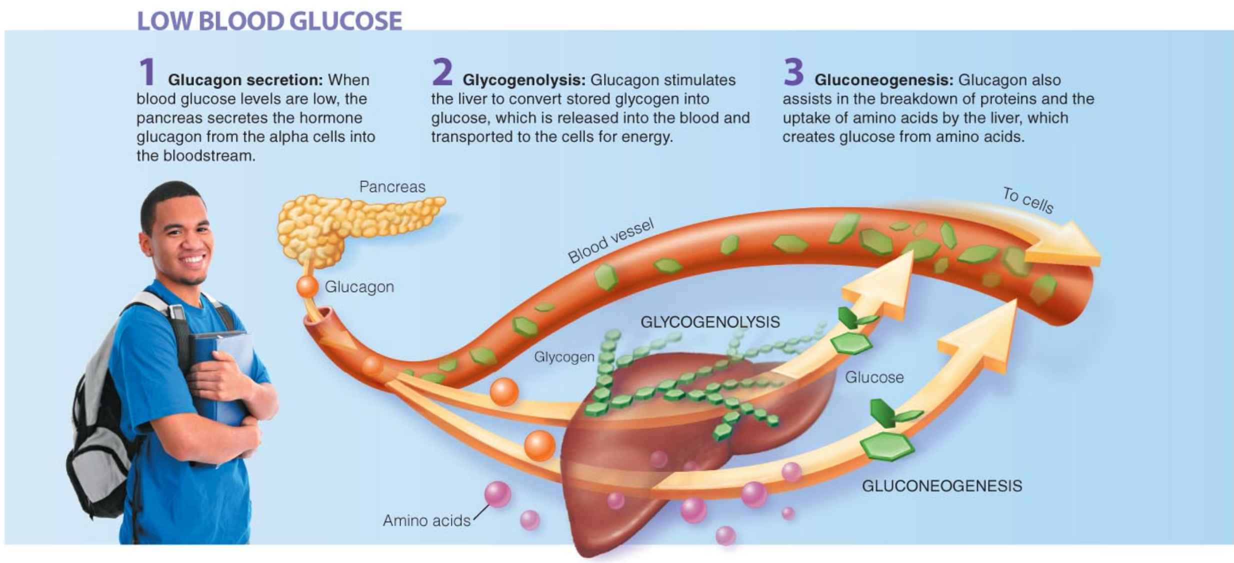



Figure 4.9: Regulation of Blood Glucose: Glucagon

- Fructose does not stimulate the release of insulin
  - Fructose is metabolized differently then glucose
  - Absorbed further down in the small intestine

**Glycemic index** a measure of a food's ability to raise blood glucose levels

- Foods wih a low glycemic index cause low to moderate fluctuations in blood glucose

**Glycemic load** amount fo carbohydrate in a food multiplied by its glycemic index

- Considered a more useful tool than glycemic index

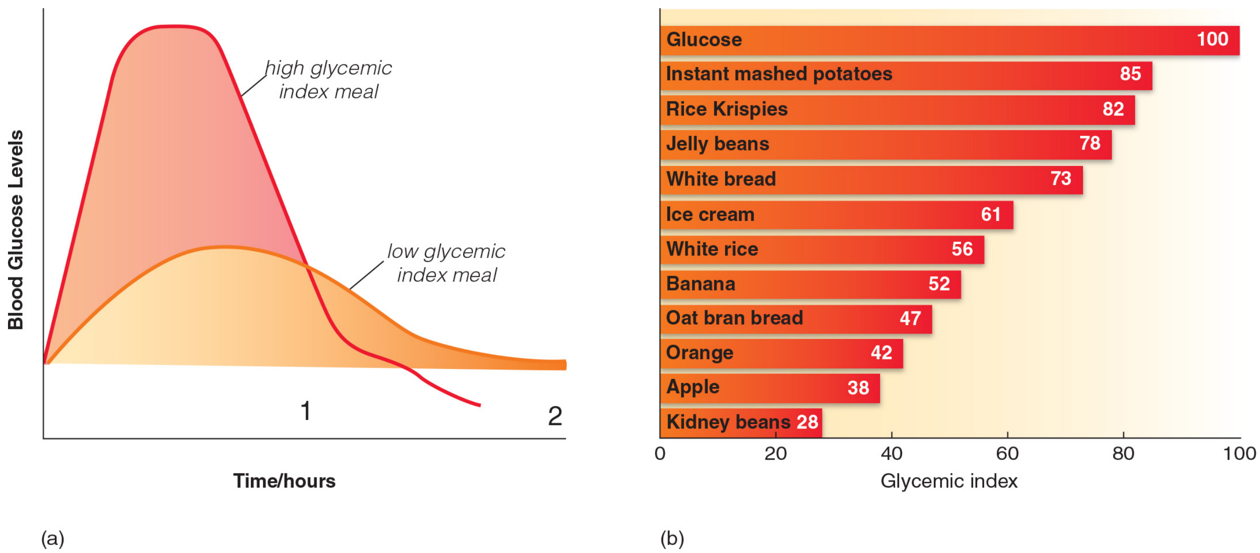



Figure 4.10: Regulation of Blood Glucose

- Foods and meals with a lower glycemic load
  - Are better for people with diabetes
  - Are generally higher in fiber
  - May reduce the risk of heart disease and colon cancer
  - Are associated with a reduced risk of prostate cancer

## 4.5 How Much Carbohydrate Should We Eat?

- The Recommended Dietary Allowance (RDA) for carbohydrate is 130 g per day just to supply the brain with glucose
  - 45–65% of daily Calorie intake should be in the form of carbohydrates
  - Focus on foods high in fiber and low in added sugars
- Most Americans eat too much added sugar
  - Sugars are added to foods during processing or preparation
  - Most common source is soft drinks
  - Typical sources are cookies, candy, fruit drinks
  - Unexpected sources include peanut butter, flavored rice mixes, salad dressing
  - Added sugars are not chemically different from naturally occurring sugars, but have fewer vitamins
- Sugars are blamed for many health problems
  - Can cause dental problems and tooth decay
  - No proven association with childhood hyperactivity; long-term effects not known
  - Associated with increased “bad cholesterol” and decreased “good cholesterol”
  - Associated with a higher risk of diabetes
  - Associated with obesity
- Most Americans eat too little fiber-rich carbohydrates
- The Adequate Intake (AI) of fiber is 14 grams per 1,000 kcal in the diet daily (or 25 g for women; 38 g for men)
- Whole-grain foods (grains, vegetables, fruits, nuts, legumes) are much more healthful sources than foods with added sugar or fiber
  - Whole grains are kernels that retain the bran, endosperm, and germ

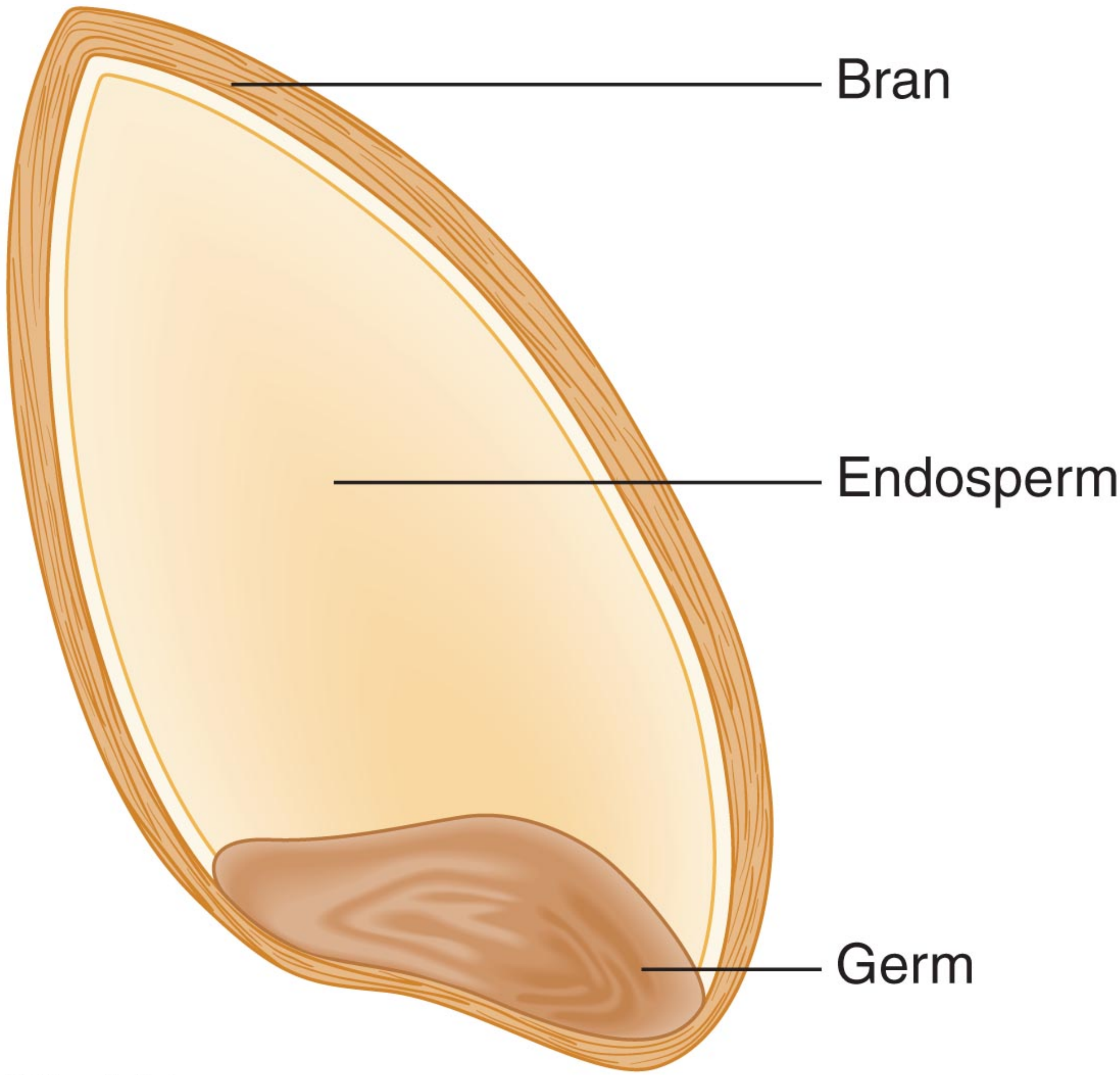



Figure 4.11: Whole Grain

Table 4.1: Dietary Recommendations for Carbohydrates

| **Health and Medicine Division of the National Academies of Science Recommendations*** | **2015–2020 Dietary Guidelines for Americans†** |
|---|---|
| Recommended Dietary Allowance (RDA) for adults 19 years of age and older is 130 g of carbohydrate per day.<br>The Acceptable Macronutrient Distribution Range (AMDR) for carbohydrate is 45–65% of total daily energy intake.<br>Added sugar intake should be 25% of less of total energy intake each day. | Consume a healthful eating pattern that accounts for all foods and beverages within an appropriate Calorie level. A healthful eating pattern includes: a variety of vegetables from all subgroups (dark green, red and orange, legumes, starch and other); fruits (especially whole fruits); grains (at least half of which are whole grains); fat-free or low-fat dairy; a variety of protein foods; and oils. |

*Data from:

Table 4.2: Forms of Sugar Commonly Added to Foods

| **Name of Sugar** | **Definition** |
|---|---|
| Brown sugar | A highly refined sweetener made up approximately 99% sucrose and produced by adding to white table sugar either molasses or burnt table sugar for clothing and flavor. |
| Cane sugar | Sucrose that has been extracted from sugarcane, a tropical plant naturally rich in sugar. |
| Concentrated fruit juice sweetener | A form of sweetener made with concentrated fruit juice, commonly pear juice. |
| Confectioner's sugar | A highly refined, finely ground white sugar; also referred to as powdered sugar. |
| Corn sweeteners | A general term for any sweetener made with corn starch |
| Corn syrup | A syrup produced by the partial hydrolysis of corn starch. |
| Dextrose | An alternative term for glucose. |
| Fructose | A monosaccharide that occurs in fruits and vegetables; also called levulose, or fruit sugar. |
| Galactose | A monosaccharide that joins with glucose to create lactose. |
| Granulated sugar | Another term for white sugar, or table sugar. |
| High-fructose corn syrup | A type of corn in which part of the sucrose is converted to fructose, making it sweeter than sucrose or regular corn syrup; most high-fructose corn syrup contains 42% to 55% fructose. |
| Honey | A sweet, sticky liquid sweetener made by bees from the nectar of flowers; contains glucose and fructose. |
| Invert sugar | A sugar created by heating a sucrose syrup with a small amount of acid; inverting sucrose results in its breakdown into glucose and fructose, which reduces the size of the sugar crystals; because of its smooth texture, it is used in making candies and some syrups. |
| Levulose | Another term for fructose, or fruit sugar. |
| Mannitol | A type of sugar alcohol |
| Maple sugar | A sugar made by boiling maple syrup |
| Molasses | A thick, brown syrup that results from the processing of sugar beets or sugarcane; it is approximately 96% to 98% sucrose; true raw sugar contains impurities and is not stable in storage; the raw sugar available to consumers has been purified to yield an edible sugar. |
| Natural sweeteners | A general term used for any naturally occurring sweeteners, such as fructose, honer, and raw sugar. |
| Raw sugar | The sugar that results from the processing of sugar beets or sugarcane; it is approximately 96% to 98% sucrose; true raw sugar contains impurities and is not stable in storage; the raw sugar available to consumers has been purified to yield an edible sugar. |
| Sorbitol | A type of sugar alcohol |
| Turbinado sugar | The form of raw sugar that is purified and safe for human consumption; sold as "Sugar in the Raw" in the United States. |
| White sugar | Another name for sucrose, or table sugar. |
| Xylitol | A type of sugar alcohol |

## 4.6 Alternative Sweeteners

### 4.6.1 Nutritive sweeteners

- Contain 4 kcal energy per gram
- Sucrose, fructose, honey, brown sugar

### 4.6.2 Sugar alcohols

- Contain 2–3 kcal energy per gram
- Have the benefit of a decreased glycemic response and decreased risk of dental caries

### 4.6.3 Non-nutritive (alternative) sweeteners

- Provide little or no energy
- Developed to sweeten foods without the usual risks
- No Acceptable Daily Intake (ADI) has been set for saccharin (e.g., "Sweet n' Low"), but it has been removed from the list of cancer-causing agents
- ADIs have been established for

  **Acesulfame-K** "Sweet One", "Sunette"

  **Aspartame** "Equal"

  **Sucralose** "Splenda"

## 4.7 Diabetes

- Inability to regulate blood glucose levels
- **Hyperglycemia** – in which glucose levels are higher than normal–becomes chronic
- Three types
  - Type 1 diabetes
  - Type 2 diabetes
  - Gestational diabetes
- Uncontrolled diabetes can cause infections, nerve damage, kidney damage, blindness, seizures, stroke, and cardiovascular disease; and can be fatal

### 4.7.1 Type 1 Diabetes

- Accounts for about 5% of all cases
- Body does not produce enough insulin
- Creates high blood sugar (glucose) levels
- Key warning sign is frequent urination
- May lead to ketoacidosis, coma and death
- Classified as an autoimmune disease
- Most frequently diagnosed in adolescents
- Has a genetic link

### 4.7.2 Type 2 Diabetes

- Accounts for 90–95% of cases
- Develops progressively over time
- Body cells become insensitive or unresponsive to insulin
- Obesity is most common trigger
- Variations include insulin resistance, impaired fasting glucose, and pre-diabetes
- Eventually the pancreas may become unable to produce any insulin

## 4.8 Diabetes Testing and Diagnosis

- Three blood tests can be used to diagnose diabetes
  - Fasting plasma glucose (FPG)
  - Oral glucose tolerance (OGT)
  - Glycosylated hemoglobin test (HbA1c)

| Diagnosis | Fasting Plasma Glucose (mg/dL) | Oral Glucose Tolerance Test (mg/dL) | A1C (percent) |
|---|---|---|---|
| Diabetes | 126 or above | 200 or above | 6.5 or above |
| Prediabetes | 100 to 125 | 140 to 199 | 5.7 to 6.4 |
| Normal | 99 or below | 139 or below | About 5 |

Figure 4.12: Diabetes Testing and Diagnosis

### 4.8.1 Who is at risk?

- Obesity, genetics, physical inactivity, and poor diet increase overall risk
- Metabolic syndrome (high waist circumference, high blood pressure, high blood lipids and glucose) increases risk of type 2 diabetes
- Increased age increases risk, but younger people and children are now commonly diagnosed

### 4.8.2 Prevention and control

- Eat a healthful diet, get daily exercise, keep a healthful body weight
- Limit intake of added sugars
- Choose fiber-rich foods like whole grains
- Limit consumption of red meat and processed meat
- Avoid alcoholic beverages, which can cause hypoglycemia
- Healthful lifestyle choices can prevent or delay onset of type 2 diabetes
- Oral medications and/or insulin injections may be required once diabetes has been diagnosed

# Chapter 5

# Fats: Essential Energy-Supplying Nutrients

## 5.1 What are Fats?

- Fats are one type of lipid
- **Lipid** – diverse class of organic substances that are insoluble in water
  - Lipids (fats) do not dissolve in water

### 5.1.1 Triglycerides

- Most of the fat we eat is in the form of triglycerides
  - About 95% of the fats we consume
- Triglycerides are composed of
  - Three fatty acid molecules
    - **Fatty acids** – long chains of carbon atoms surrounded by hydrogen atoms
  - One glycerol molecule
    - **Glycerol** – a three-carbon alcohol that is the backbone of a triglyceride

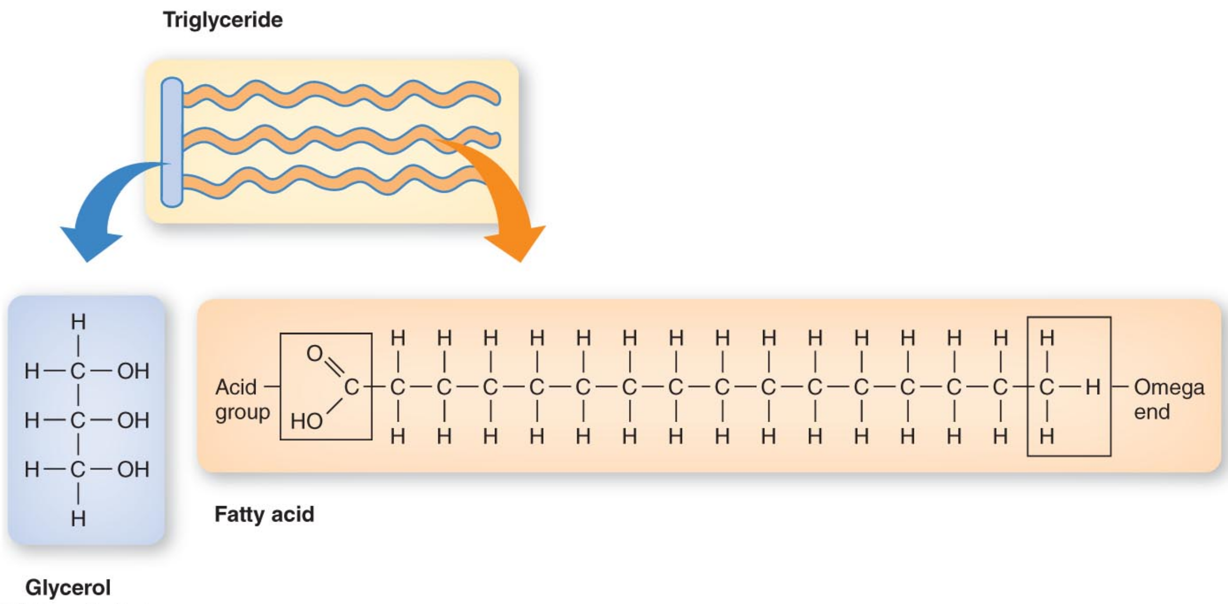



Figure 5.1: Triglyceride molecule

### 5.1.2 Phospholipids

- Composed of
  - Glycerol backbone
  - Two fatty acids
  - Phosphate
- Soluble in water
- Manufactured in our bodies so they are not required in our diet
- Important components of cell membranes

### 5.1.3 Sterols

Sterols – Lipids containing multiple rings of Carbon atoms

- Essential components of cell membranes and many hormones
- Manufactured in our bodies and therefore not an essential component of our body
- Cholesterool is the major sterol found in the body

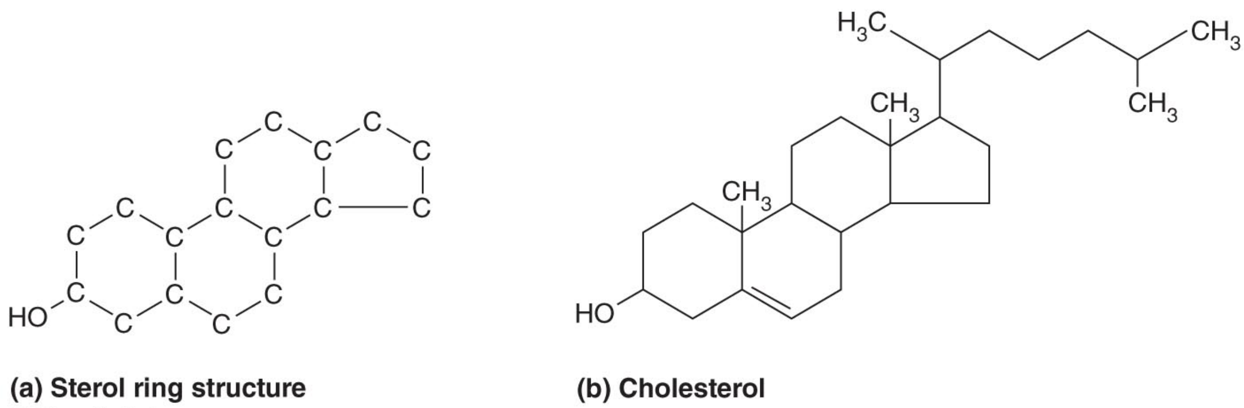



Figure 5.2: Sterol diagram

- Fatty acids can differ in
  - Length of their carbon chain
    - Short (< 6 Carbons)
    - Medium (6 – –12 Carbons)
    - Long (> 13 Carbons)
  - Level of saturation
    - Saturation refers to how many hydrogen atoms surround each carbon
  - Shape
- **Saturated fatty acids** – have strong hydrogen atoms surrounding every Carbon in the chain; they have no double bonds
- **Monosaturated fatty acids** – lack hydrogen atoms in one region; they have one double bond
- **Polysaturated fatty acids** – lack hydrogen atoms in multiple locationsl they have two or more double bonds
- Note: Each double bond causes the loss of two hydrogen atoms

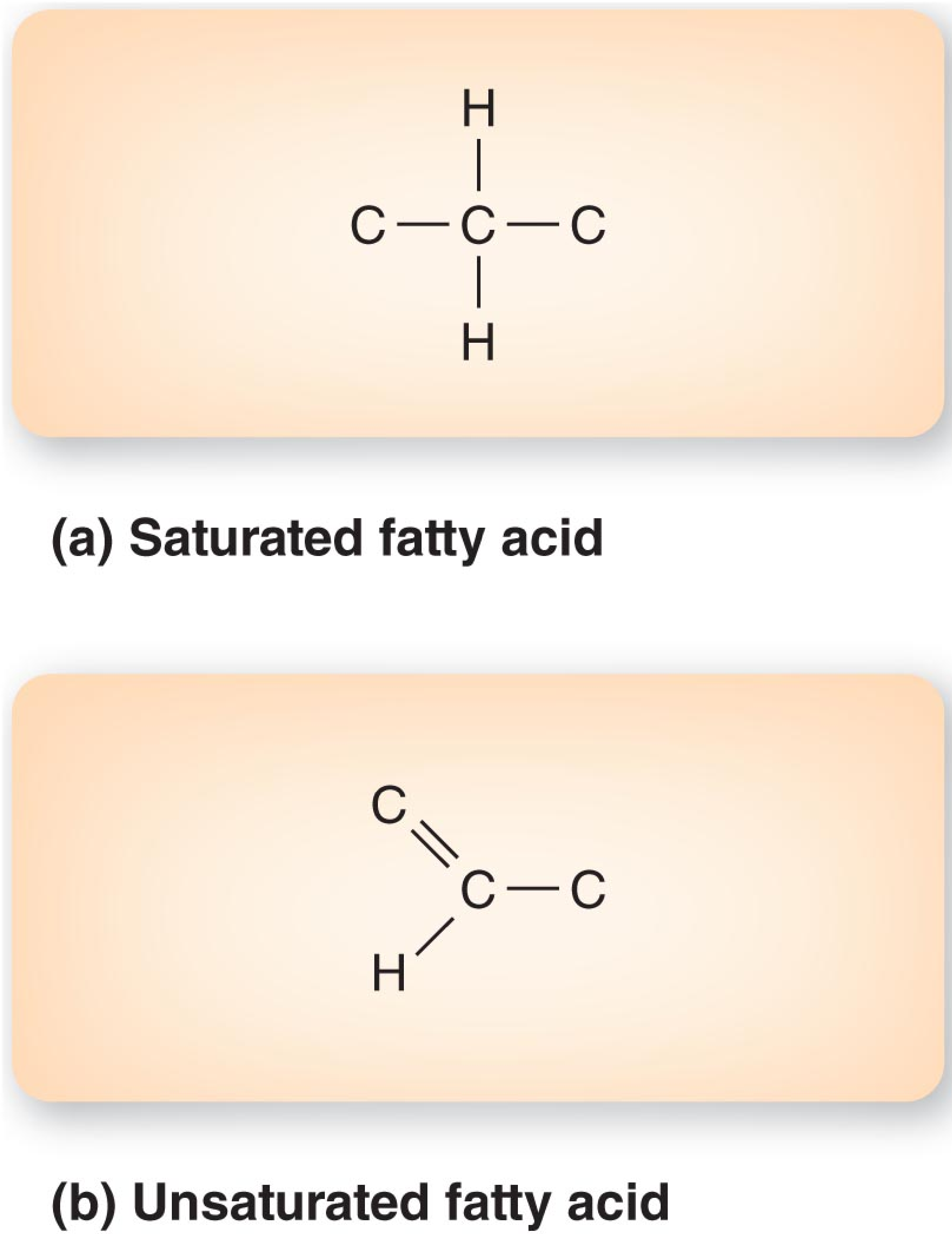



Figure 5.3: Saturated and Unsaturated Fatty Acids

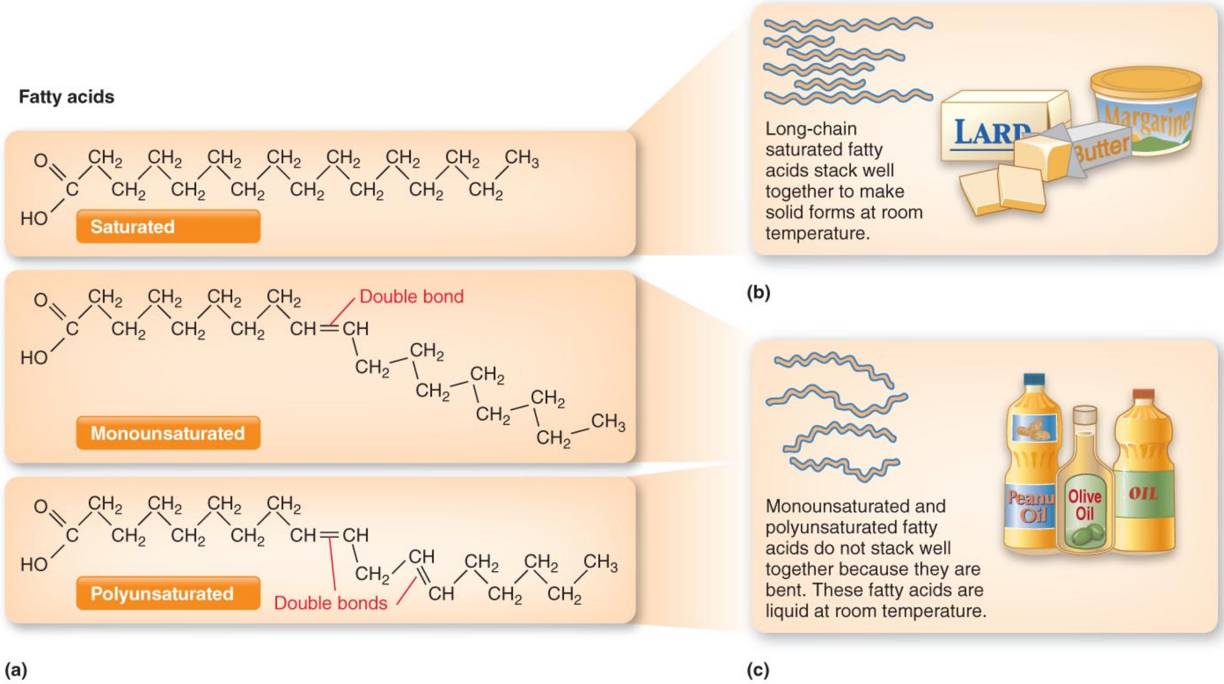



Figure 5.4: Levels of Saturation Among Fatty Acids

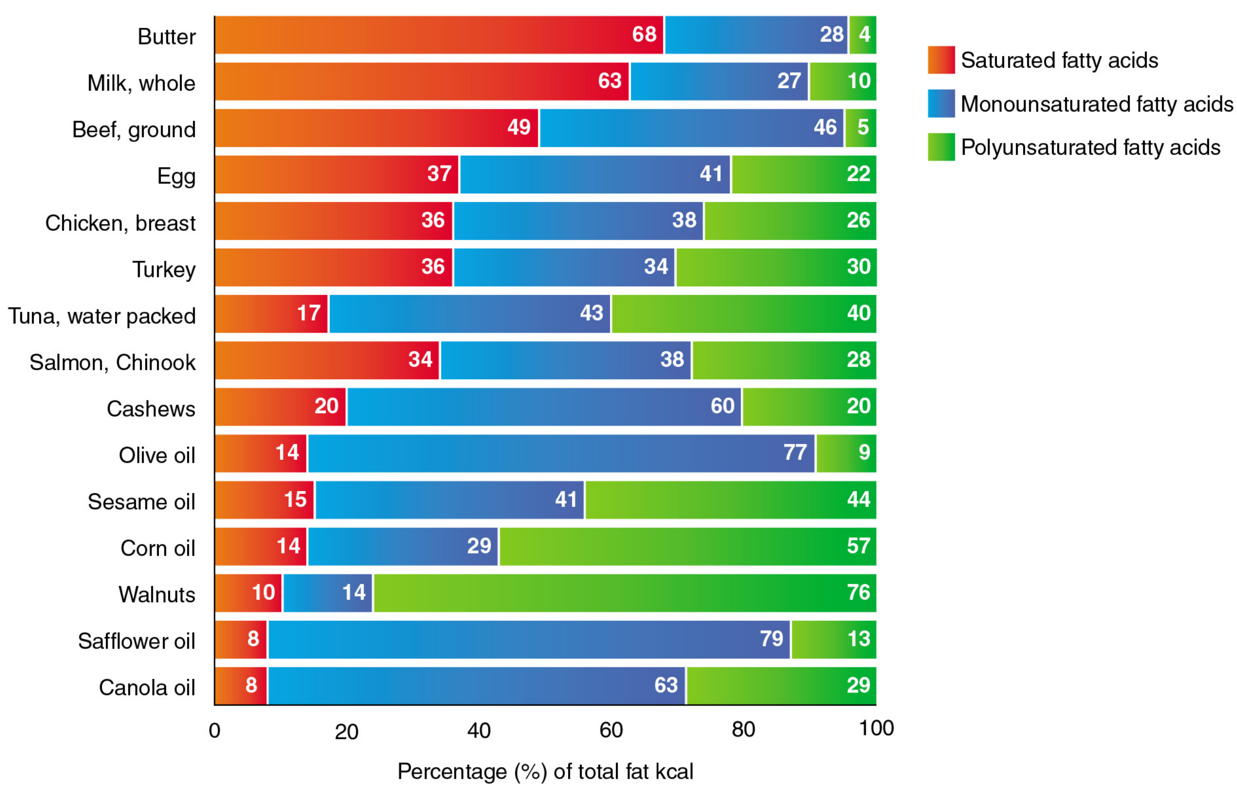



Figure 5.5: Major Sources of Dietary Fat

- The shape of a triglyceride is determined by the saturation of the carbon chains
- Saturated fatty acids can pack tightly together and are solid at room temperature
  - For example, coconut oil, animal fats, butter, and lard are high in saturated fatty acids
- Unsaturated fatty acids do not stack together well and are liquid at room temperature
  - Unsaturated fatty acids are the predominant type in plants
  - Two exceptions are coconut and palm kernel oil
- The hydrogen atoms at the unsaturated region can be arranged in different positions

  **Cis** same side of the carbon chain

  **Trans** opposite sides of the carbon chain

- **Hydrogenation** – the addition of hydrogen atoms to unsaturated fatty acids
  - Converts liquid fats (oils) into a semisolid (spreadable) or solid form
  - Used to create margarine from plant oil
  - Often creates trans fatty acids
  - Listed on food labels as partially hydrogenated oil

## 5.2 Essential Fatty Acids

**Essential Fatty Acids** – cannot be synthesized in the body and must be obtained in the diet

- Omega-6 and omega-3 fatty acids
- There are precursors to biological compounds called *eicosanoids*, which regulate cellular function
- Linoleic acid is found in vegetable and nut oils
- Alpha-linolenic acid (ALA) is derived from dark-green leafy vegetables, flaxseeds and flaxseed oil, soybeans and soybean oil, walnuts and walnut oil, and canola oil
- Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) have important health benefits and are found in fish, shellfish, and fish oils

## 5.3 Why Do We Need Fats?

### 5.3.1 Energy

- Fat is very energy dense, providing 9 kcal/gram
- Much of the energy used during rest comes from fat
- Fat is used for energy during exercise, especially after glycogen is depleted
- Fat is also used for energy storage

### 5.3.2 Fat-soluble vitamins

- Vitamins A, D, E, and K are soluble in fat; fat is required for their transport
- Fat is essential to many body functions
  - Cell membrane structure
  - Nerve cell transmissions
  - Protection of internal organs
  - Insulation to retain body heat
- Fat provides flavor and texture to foods
- Fat contributes to making us feel satiated
  - Fats are more energy dense than carbohydrates or protein
  - Fats take longer to digest

## 5.4 How Does Our Body Process Fats?

- As fat enters the small intestine:
  - Bile is secreted from the gallbladder into the small intestine
    * Bile is produced by the liver and stored in the gallbladder
  - Bile disperses dat into smaller fat droplets
  - Pancreatic enzymes break triglycerides into two separate fatty acids and a monoglyceride
  - Fat enters the mucosal cell as a micelle (fatty acids, monoglycerides), phospholipids, and sterols)
- In the intestinal mucosal cell:
  - Fatty acids are reattached to the monoglyceride to re-form triglycerides

  - A small amount of protein is added to lipids, forming a chylomicron
  - **Chylomicron** – a lipoprotein produced by cells lining the small intestine
    * Composed of triglycerides surrounded by phospholipids and proteins
    * Soluble in water

- Chylomicrons are the transport vehicles that remove absorbed fats from the small intestine
  - Travel through the lymphatic system
  - Are transferred to the bloodstream
- Short- and medium-chain fatty acids are absorbed more quickly because they are not arranged into chylomicrons
- Once the chylomicron gets to a cell in the body, the triglycerides in the chylomicrons must be disassembled by lipoprotein lipase into two fatty acids and a monoglyceride before they can pass through the cell membrane
- After entering the cell, the two fatty acids and monoglyceride re-form a triglyceride
- The triglyceride can be
  - Used immediately for energy
  - Used to make lipid-containing compounds
  - Stored in liver and muscle cells

## 5.5 Recognize the Fat in Foods

**Visible fats** those we can see in foods or can easily see have been added to foods, such as dressing or chicken skin

**Hidden fats** those added to processed or prepared foods to improve texture or taste, which we may not be aware of, or that occur naturally

- Read the Nutrition Facts Panel on foods carefully
  - Lower-fat versions of foods may not always be lower in Calories

## 5.6 How Much Fat Should We Eat?

- The Acceptable Macronutrient Distribution Range (AMDR) for fat
  - 20–35% of Calories should be from fat
- Athletes and highly active people may need more energy from carbohydrates and can reduce their fat intake to 20–25% of total Calories

- The type of fat consumed is important
  - Intake of saturated and *trans* fatty acids should be minimized as much as possible
  - We typically set enough linoleic acid in our diets from salad dressings, vegetable oils, margarines, and mayonnaise
  - To ensure an adequate amount of omega-3 fatty acids, we need to consume more dark-green leafy vegetables, walnuts, flaxseeds, and fish or fish oils

## 5.7 Essential Fatty Acids

- Linoleic Acid (omega-6)
  - AI is 14–17 g per day for men and 11–12 g per day for women
- Alpha-linoleic acid (Omega-3)
  - AI is 1.6 g per day for men and 1.1 g per day for women

## 5.8 Limit Saturated and *Trans* Fats

- Reduce your intake of saturated fats
  - Be conscious of the saturated fat content of meats, baked goods and snack goods, and foods including vegetables that are fried, breaded, or drenched in sauce
- Avoids *trans* fatty acids
- Limit your intake of dietary cholesterol, which will also help limit your intake of saturated fats

## 5.9 Select Beneficial Fats

- Consume and cook with leafy green vegetables, avocados, soybeans, soybean oil, and flaxseed oil
- Add walnuts, almonds, flaxseeds, and chia seeds to your diet, and try almond milk in your cereal
- Consider including fish in your diet at least twice a week or consider taking a fish oil supplement
  - Fish can contain mercury, PCBs, and other environmental contaminants, so be selective

## 5.10 Fat Replacers

- Snack foods are frequent targets for fat replacers, substances that can reduce the fat content
- Fat replacers such as olestra have not proved very popular or effective because of potential gastrointestinal side effects
- Our growing obesity problems indicate that fat replacers do not help Americans lose weight

## 5.11 Role of Fats in Chronic Disease

- The chronic disease most closely associated with diets high in saturated fat is cardiovascular disease
- The role of dietary fat in the development of cancer has been extensively researched, but the relationship between some cancer types and dietary fats is controversial (e.g., breast cancer)
- The strongest association between dietary fat and cancer is for prostate cancer

## 5.12 In Depth: Cardiovascular Disease (CVD)

- Dysfunction of the heart or blood vessels
- The most common forms:
  - Coronary heart disease, or coronary artery disease
  - Stroke
  - Hypertension, or high blood pressure
  - Peripheral vascular disease
- **Atherosclerosis** – a disease in which artery walls build up lipid deposits and scar tissue, impairing blood flow
  - The stiffness that results is commonly called "hardening of the arteries"
  - The result is that the heart must work harder to push blood through the vessels
- **Hypertension** – a major chronic disease in the United States
  - It functions as a warning sign for a person's risk for developing heart disease or stroke
  - For many people, hypertension is hereditary; for others, it can be induced through poor nutrition and exercise habits or a combination of poor habits and heredity

- Modifiable risk factors for cardiovascular disease include
  - Being overweight
  - Physical inactivity
  - Smoking
  - Type 2 diabetes mellitus
  - Inflammation in the body
  - Abnormal blood lipids
- The intake of certain types of fats can protect against heart disease
- Diets high in omega-3 fatty acids (along with moderate exercise) can reduce inflammation and increase HDL ("good") cholesterol levels
- Low-density lipoproteins (LDLs) are often called "bad" cholesterol because of their role in transporting cholesterol throughout the body
- Diets high in saturated fats
  - Decrease the removal of LDLs from the blood
  - Contribute to the formation of plaques that can block arteries
  - Increase triglyceride levels (chylomicrons and very-low-density lipoproteins, or VLDLs)
- Recommendations to improve blood lipid levels
  - Keep total fat intake level to within 20–35% of your daily energy intake
  - Decrease your dietary saturated fat to less than 7% of total energy intake
  - Increase your consumption of dietary omega-3 fatty acids from foods (e.g., green vegetables, fish)
  - Consume 400 $\mu$g/day of folate
  - Increase dietary intakes of whole grains, fruits and vegetables
  - Maintain blood glucose within normal ranges
  - Eat meals throughout the day rather than eating most of your Calories in the evening before bed
  - Limit alcohol consumption
  - Don't smoke
  - Maintain an active lifestyle
  - Maintain a healthful body weight
- Recommendations to reduce blood pressure
  - Limit dietary sodium
  - Follow the DASH diet "Dietary Approaches to Stop Hypertension"
  - If need, use doctor-prescribed medications

# Chapter 6

# Proteins: Crucial Components of All Body Tissues

## 6.1 What Are Proteins?

- Large, complex molecules found in the cells of all living things
- Critical components of all the tissues of the human body
- Function in metabolism, immunity, fluid balance, and nutrient transport
- In certain circumstances, provide energy
- Contain a special form of nitrogen our bodies can readily use

## 6.2 Amino Acids

**Amino acids** – the nitrogen-containing molecules that combine to form proteins

### 6.2.1 Essential amino acids

- Cannot be produced by our bodies
- Must be obtained from food
- Nine of 20 amino acids in our bodies are essential

### 6.2.2 Nonessential amino acids

- Can be made by our bodies

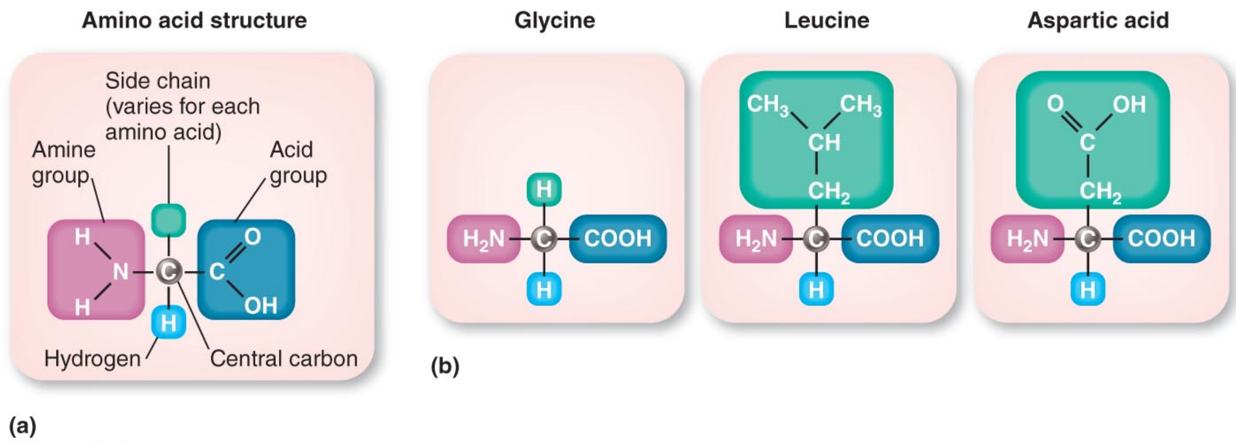



Figure 6.1: Structure of an Amino Acid

Table 6.1: Amino Acids of the Human Body

| **Essential Amino Acids** | **Nonessential Amino Acids** |
|---|---|
| These amino acids must be consumed in the diet. | These amino acids can be manufactured by the body. |
| Histidine | Alanine |
| Isoleucine | Arginine |
| Leucine | Asparagine |
| Lysine | Aspartic acid |
| Methionine | Cysteine |
| Phenylalanine | Glutamic acid |
| Threonine | Glutamine |
| Tryptophan | Glycine |
| Valine | Proline |
| | Serine |
| | Tryosine |

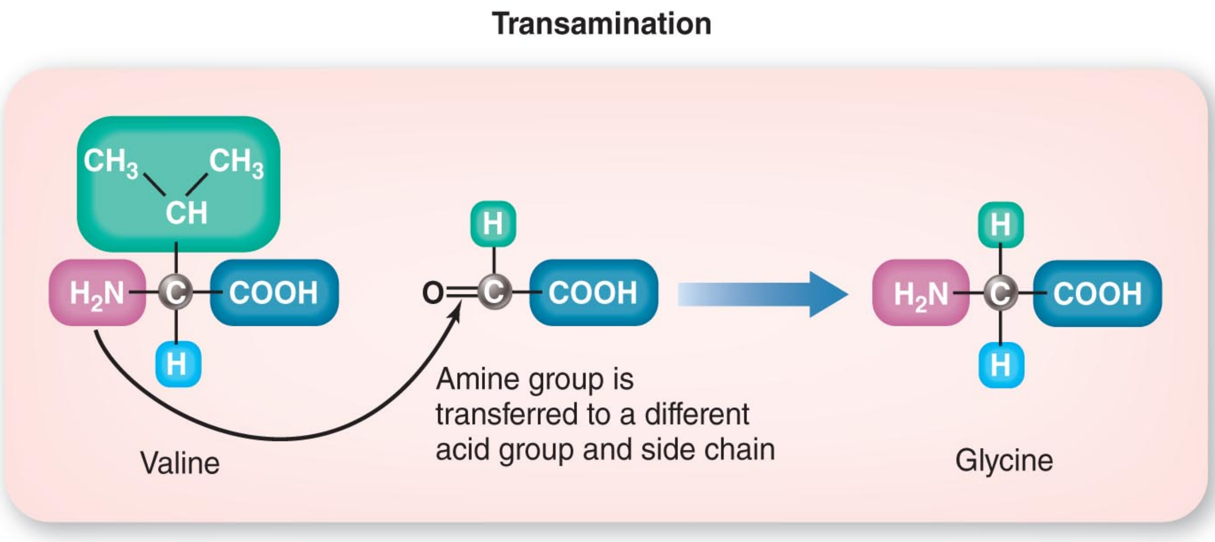



Figure 6.2: Transamination

## 6.3 How Are Proteins Made?

- When two amino acids join together in a peptide bond, they form a dipeptide
- Two or more amino acids bonded together form a polypeptide
- Proteins are made by combining multiple amino acids

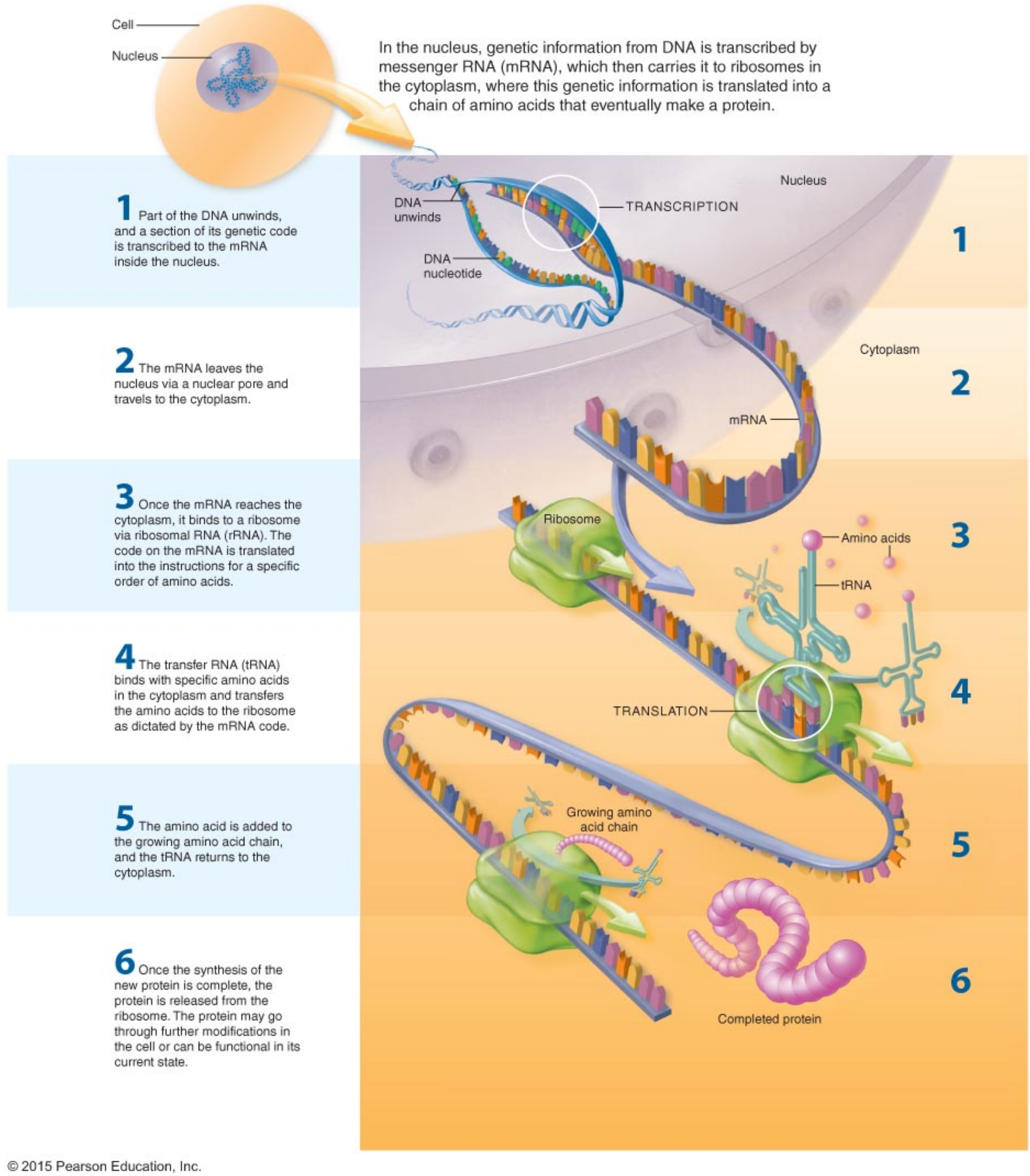



Figure 6.3: Protein Synthesis

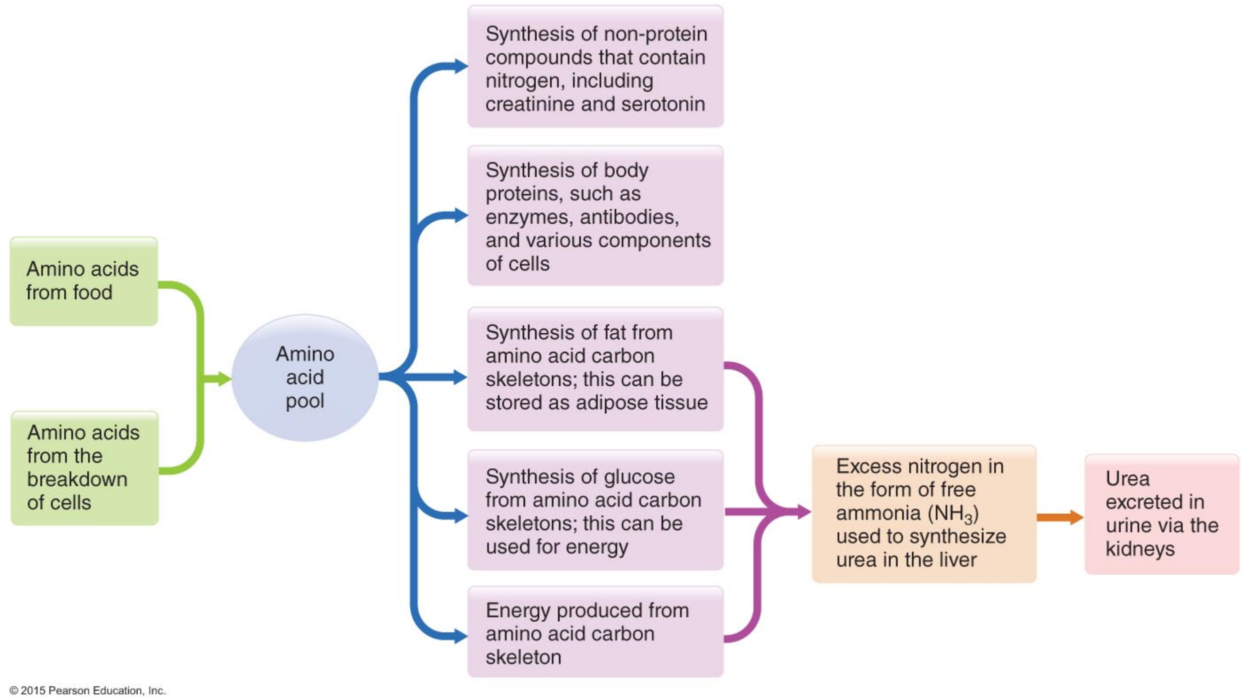



Figure 6.4: Protein Turnover: Synthesis and Breakdown

**Transcription** – use of the genetic information in DNA to make RNA

- mRNA copies the genetic information and carries it to the ribosome

**Translation** – conversion of genetic information in RNA to assemble amino acids in the proper sequence to synthesize a protein on the ribosome

## 6.4 Protein Organization Determines Function

- Protein structure has four levels
  - Primary structure
    - Sequential order of amino acids
  - Secondary structure
    - Spiral shape due to the chemical bonding between the amino acids
  - Tertiary and quaternary structure
    - Further folding into a unique three-dimensional shape that may be globular or fibrous

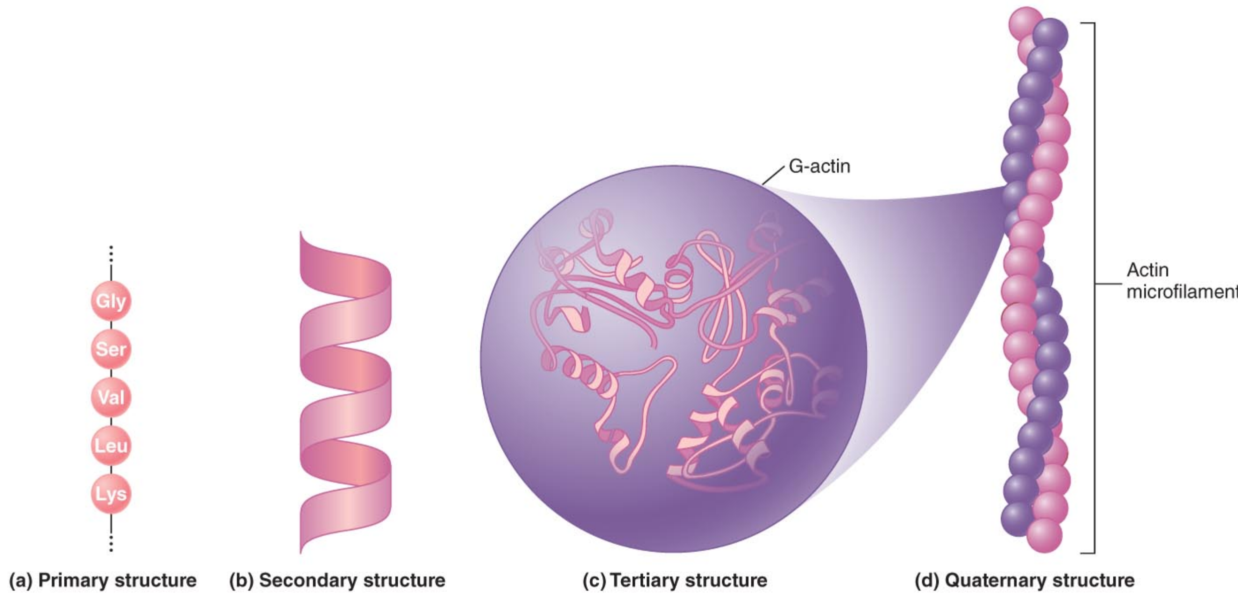



Figure 6.5: Levels of Protein Structure

## 6.5 Protein Function

- Proteins lose shape (denaturation) when subject to
  - Heat
  - Acids and bases
  - Heavy metals
  - Alcohol
- Denaturation results in an irreversible loss in protein function

Figure 6.6: Protein Shape Determines Function

## 6.6 Protein Synthesis Can Be Limited

**Incomplete protein** – does not contain all essential amino acids in sufficient quantites

- Growth and health are compromised
- Considered a "low-quality" protein

**Complete protein** – Contains sufficient amounts of all nine essential amino acids

- Considered a "high-quality" protein

## 6.7 Protein Synthesis Can Be Enhanced

**Mutual supplementation** – combining two incomplete proteins to make a complete protein

**Complementary proteins** – two protein sources that together supply all nine essential amino acids

- Example: beans and rice

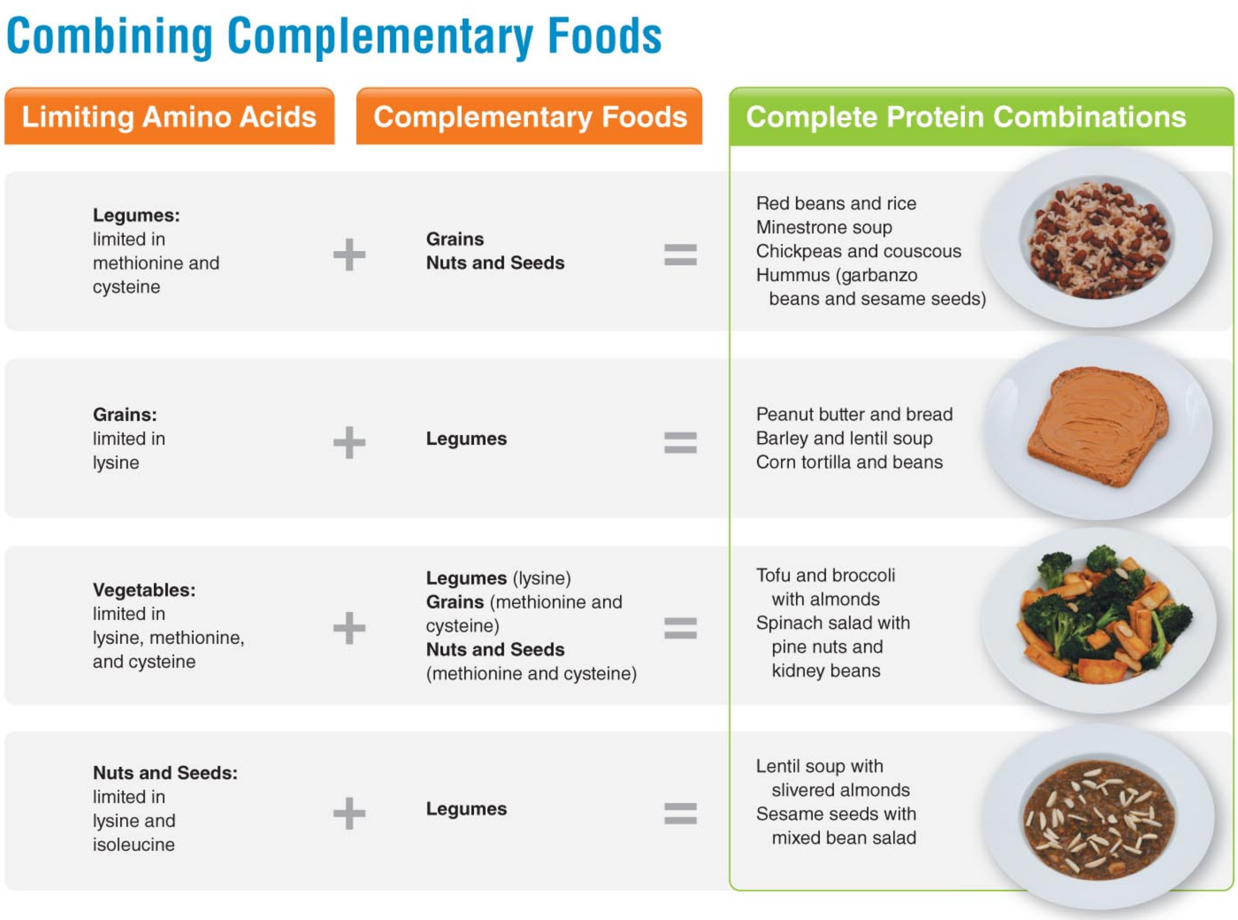



Figure 6.7: Combining Complementary Foods

## 6.8 Why Do We Need Proteins?

- Cell growth, repair, and maintenance
- Enzymes
- Hormones
- Fluid and electrolyte balance
- pH balance
- Antibodies to protect against disease
- Energy source
- Transport and storage of nutrients
- Compounds such as neurotransmitters, fibrin, and collagen

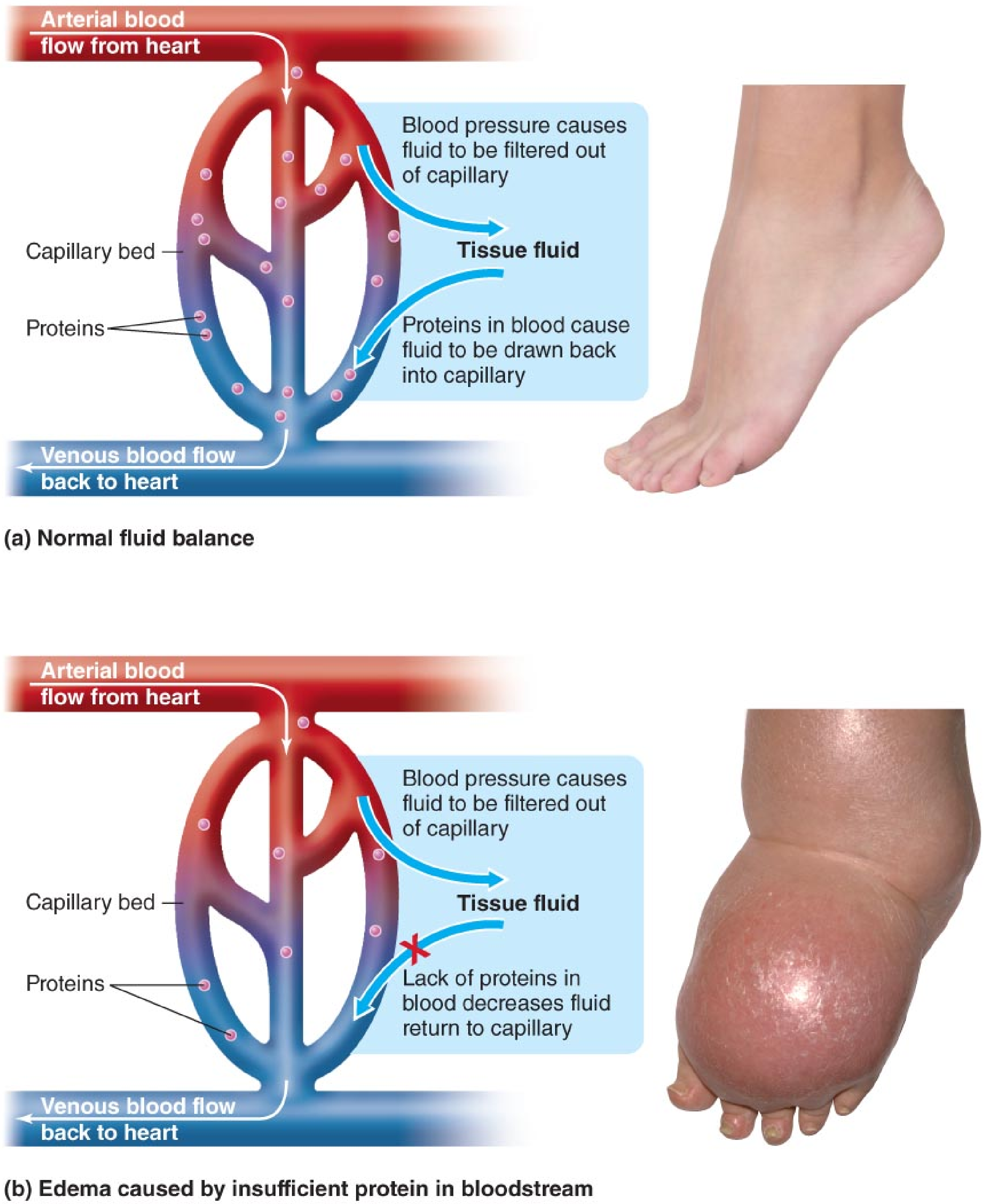





Figure 6.8: Role of Proteins in Fluid Balance

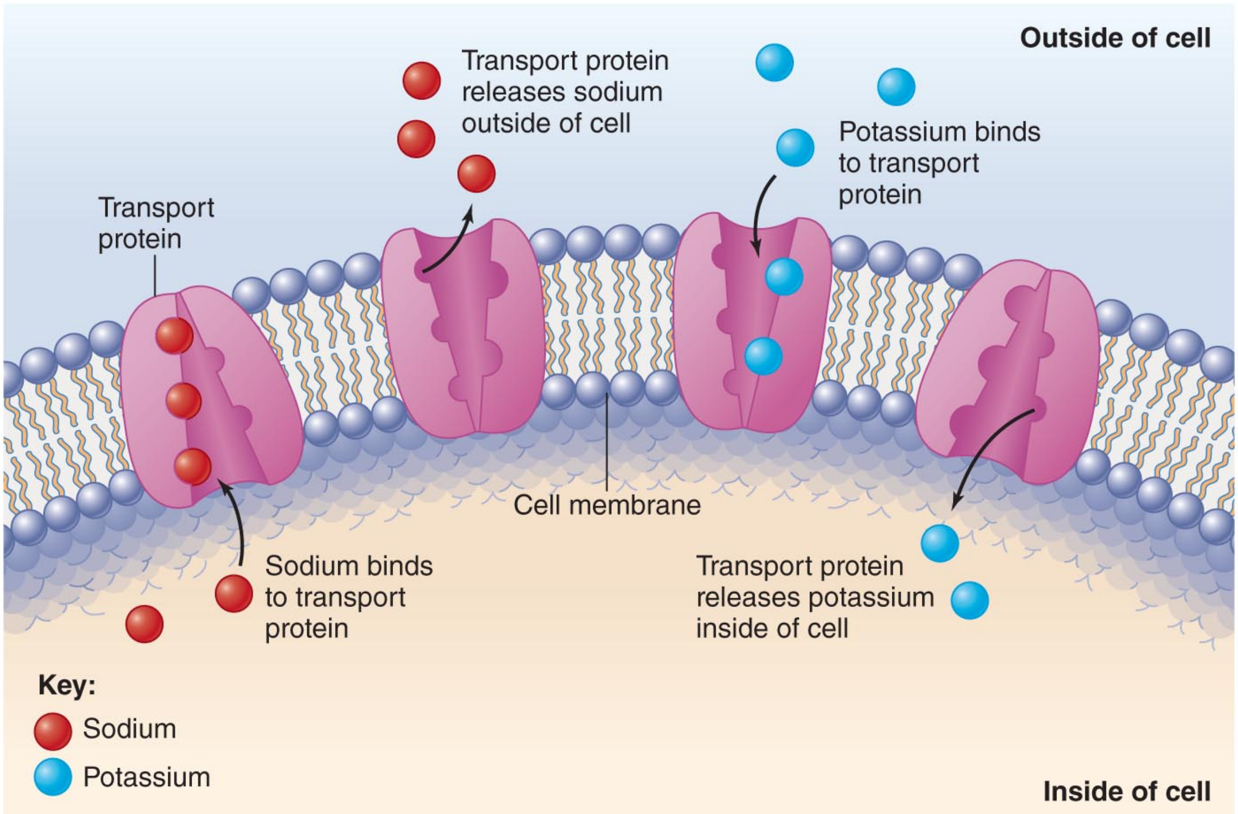



Figure 6.9: Role of Proteins in Electrolyte Balance

## 6.9 How Do We Break Down Proteins?

- Stomach acids and enzymes break proteins into short polypeptides
- Digestion of proteins continues in the small intestine, where the polypeptides are further broken down
  - Pancreatic enzymes called proteases complete the digestion of proteins into single amino acids

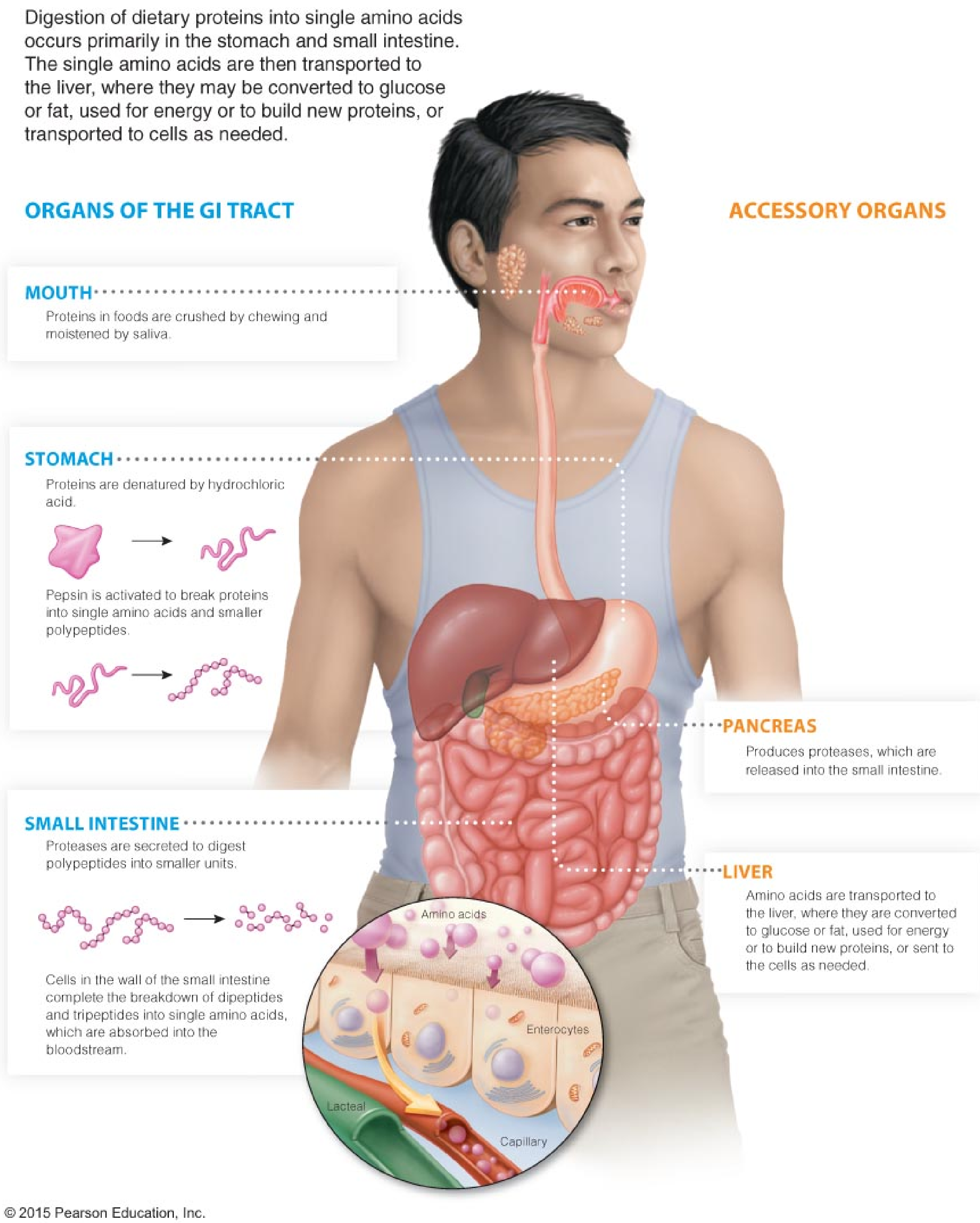



Figure 6.10: Protein Digestion

- Protein digestibility affects protein quality
- Animal protein sources (meat, dairy), soy products, and legumes are highly digestible

- Grains and vegetable proteins are less digestible

## 6.10 How Much Protein Should We Eat?

- People who require more protein include
  - Children
  - Adolescents
  - Pregnant or lactating women
  - Athletes
  - Vegetarians
- Nitrogen balance describes the relationship between how much nitrogen (or protein) we consume and excrete each day

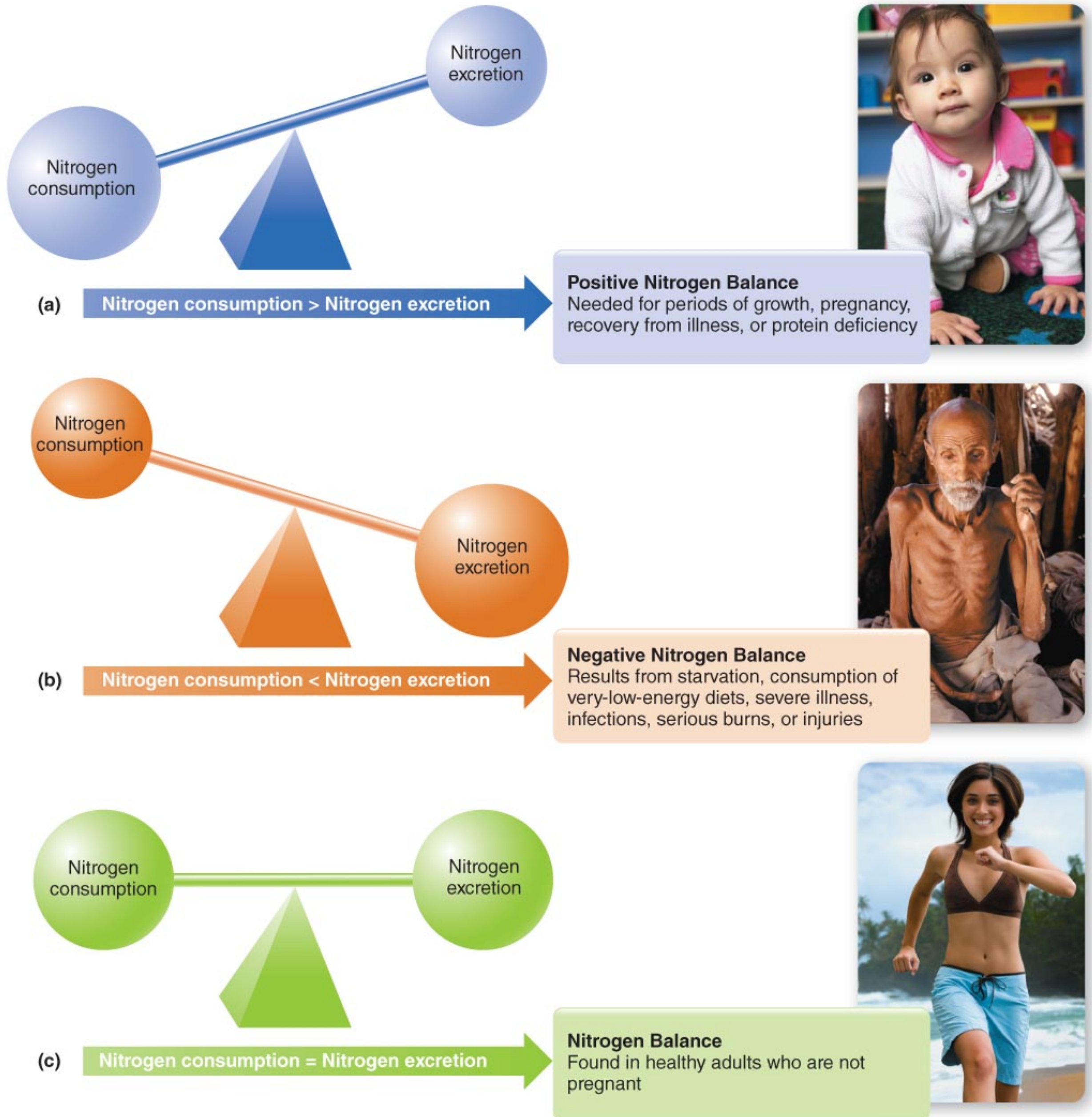



Figure 6.11: Nitrogen Balance

- Recommended Dietary Allowance (RDA)
  - 0.8 grams of protein per kilogram of body weight per day
  - 10–35% of total intake should be from protein
- Most Americans meet or exceed the RDA for dietary protein
- This is true for many athletes as well

- Certain groups of athletes, such as distance runners, figure skaters, female gymnasts, and wrestlers who are dieting, are at risk for low protein intake

## 6.11 Protein Sources

- Protein sources include much more than just mean
  - Legumes
  - Nuts
  - "New" foods
    - quorn
    - quinoa
    - amaranth
    - teff
    - millet
    - sorghum

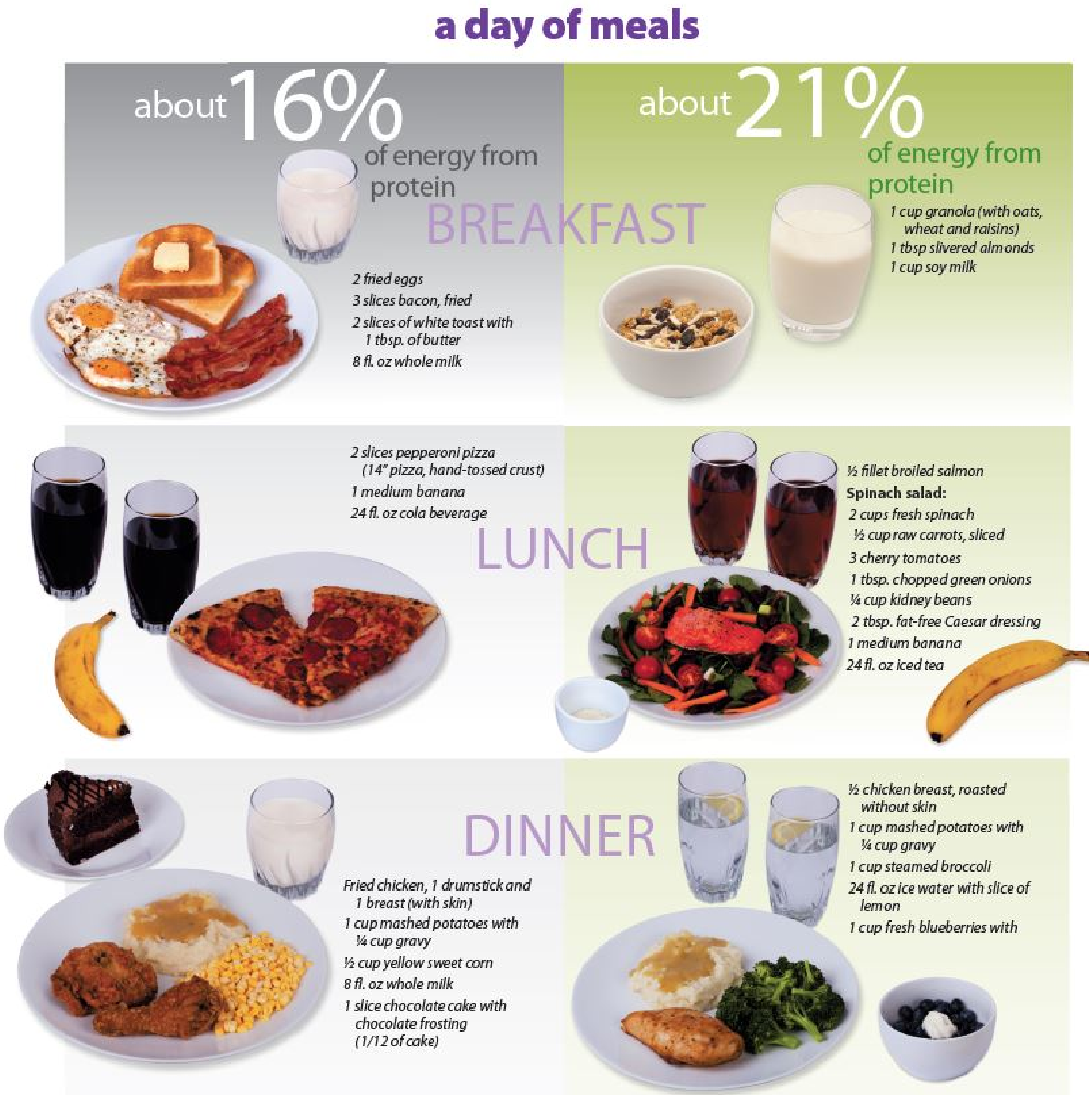



Figure 6.12: Protein Needs

## 6.12 Too Much Dietary Protein Can Be Harmful

- The risks of too much dietary protein include
  - High cholesterol and heart disease
    - Diets high in protein from animal sources are associated with high blood cholesterol
  - Kidney disease

  * High-protein diets are associated with an increased risk of kidney disease in people who are susceptible

- There is no evidence that high-protein diets lead to bone loss, except in people consuming inadequate calcium

**TABLE 6.2** Protein Content of Commonly Consumed Foods

| Food | Serving Amount | Protein (g) |
|---|---|---|
| **Beef** | | |
| Ground, lean, broiled (15% fat) | 3 oz | 22 |
| Beef tenderloin steak, broiled (1/8-in. fat) | 3 oz | 24.7 |
| Top sirloin, broiled (1/8-in. fat) | 3 oz | 23 |
| **Poultry** | | |
| Chicken breast, broiled, no skin (bone removed) | 1/2 breast | 27 |
| Chicken thigh, bone and skin removed | 1 thigh | 28 |
| Turkey breast, roasted, luncheon meat | 3 oz | 18.7 |
| **Seafood** | | |
| Salmon, Chinook, baked | 3 oz | 22 |
| Shrimp, cooked | 3 oz | 20.4 |
| Tuna, in water, drained | 3 oz | 16.5 |
| **Pork** | | |
| Pork loin chop, broiled | 3 oz | 22 |
| Ham, roasted, extra lean (5% fat) | 3 oz | 18.7 |
| **Dairy** | | |
| Whole milk (3.25% fat) | 8 fl. oz | 7.7 |
| Skim milk | 8 fl. oz | 8.8 |
| Low-fat, plain yogurt | 8 fl. oz | 12 |
| Cottage cheese, low-fat (2%) | 1 cup | 23.6 |
| **Soy Products** | | |
| Tofu, firm | 1/2 cup | 10 |
| Tempeh, cooked | 3 oz | 5.5 |
| Soy milk beverage | 1 cup | 8 |
| **Beans** | | |
| Refried | 1/2 cup | 6.4 |
| Kidney, red | 1/2 cup | 6.7 |
| Black | 1/2 cup | 7.2 |
| **Nuts** | | |
| Peanuts, dry roasted | 1 oz | 6.9 |
| Peanut butter, creamy | 2 tbsp. | 7 |
| Almonds, blanched | 1 oz | 6 |

*Source:* Data from U.S. Department of Agriculture, Agricultural Research Service. 2015. USDA National Nutrient Database for Standard Reference, Release 28.

Figure 6.13: Protein Content of Common Foods

## 6.13 Disorders Related to Protein Intake

**Protein-energy malnutrition** – a disorder caused by inadequare intake of protein and energy

- There are two common, serious forms
  - Marasmus
  - Kwashiorkor

### 6.13.1 Marasmus

Disease resulting from severely inadequate intakes of protein, energy, and other nutrients

- It is characterized by extreme tissue wasting and stunted growth and development

### 6.13.2 Kwashiorkor

Disease resulting from extremely low protein intake

- Kwashiorkor symptoms include
  - Some weight loss and muscle wasting
  - Edema resulting in distention of the belly
  - Retarded growth and development
- Kwashiorkor is often seen in children in developing countries

## 6.14 Can Vegetarian Diets Provide Protein?

**Vegetarianism** – restricting the diet to foods of plant origin

- There are many versions of vegetarianism
- There are many reasons to adopt a vegetarian diet

Table 6.2: Terms and Definitions of a Vegetarian Diet

| **Type of Diet** | **Foods Consumed** | **Comments** |
|---|---|---|
| Semivegetarian (also called flexitarian or plant-based diet) | Vegetables, grains, nuts, fruits, legumes; sometimes meat, seafood, poultry, eggs and dairy products | Typically excluded or limit red meat; may also avoid other meats |
| Pescovegetarian | Similar to semivegitarian but excludes poultry | *Pesco* means "fish," the only animal source of protein in this diet |
| Lacto-ovovegetarian | Vegetables, grains, nuts, fruits, legumes, dairy products (*lacto*), and eggs *(ovo)* | Excludes animal flesh and seafood |
| Lacto-vegetarian | Similar to lacto-ovovegetarian but excludes eggs | Relies on milk and cheese for animal sources of protein |
| Ovovegetarian | Vegetables, grains, nuts, fruits, legumes and eggs | Excludes dairy, flesh, and seafood products |
| Vegan (also called strict vegetarian) | Only plant-based foods (vegetables, grains, nuts, seeds, fruits, legumes) | May not provide adequate vitamin $B_{12}$, zinc, iron, or calcium |
| Macrobiotic diet | Vegan-type diet; becomes progressively more strict until almost all foods are eliminated; at the extreme, only brown rice and small amounts of water or herbal tea | Taken to the extreme, can cause malnutrition and death |
| Fruitarian | Only raw or dried fruit, seeds, nuts, honey, and vegetable oil | Very restrictive diet; deficient in protein, calcium, zinc, iron, vitamin $B_{12}$, riboflavin, and other nutrients |

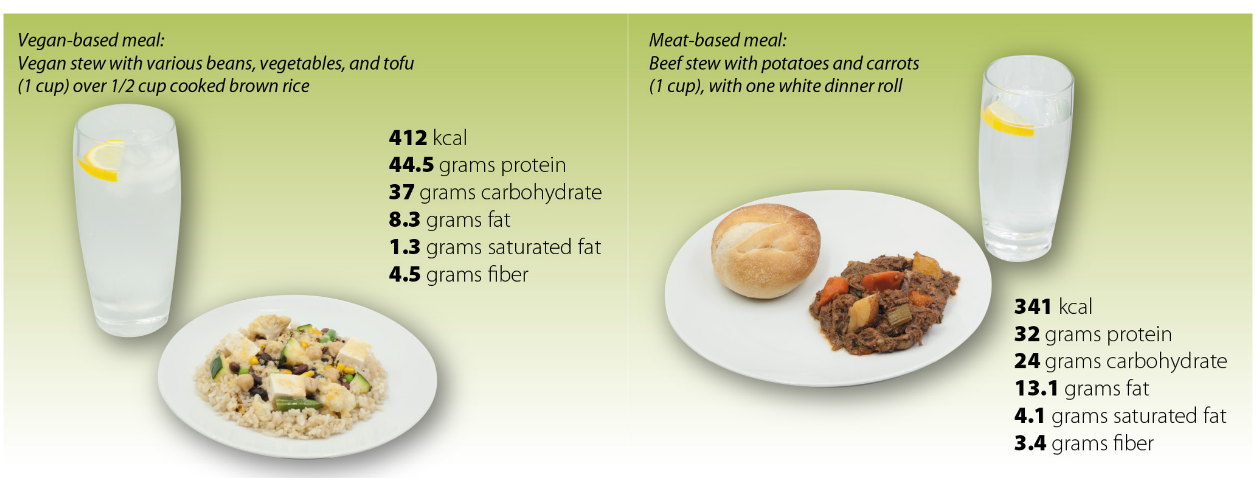



Figure 6.14: Vegetarian Diet

## 6.15 Why Vegetarianism?

- People chose vegetarianism because of
  - Health benefits
  - Ecological reasons
  - Religious reasons
  - Ethical reasons
  - Concerns over food safety

## 6.16 Health Benefits of Vegetarianism

- Lower intake of fat and total energy
- Lower blood pressure
- Reduced risk of heart disease
- Reduced risk of some types of cancer
- Fewer digestive problems
- Reduced risk of kidney disease, kidney stones, and gallstones

## 6.17 Challenges of Vegetarianism

- Vegetarian diets can be low in some vitamins and minerals (iron, calcium, zinc, vitamins D and $B_{12}$)
- Vegetarians must plan a balanced and adequate diet
- Soy products are an excellent protein source
- Vegetarians should include complementary proteins
- Vegetarians can find health eating tips for vegetarians at MyPlate online

Table 6.3: Nutrients of Concern in a Vegan Diet

| Nutrient | Functions | Nonmeat/Nondairy Food Sources |
|---|---|---|
| Vitamin $B_{12}$ | Assists with DNA synthesis; protection and growth of nerve fibers | Vitamin $B_{12}$–fortified cereals, yeast, soy products, and other meat analogs; vitamin $B_{12}$ supplements |
| Vitamin D | Promotes bone growth | Vitamin D–fortified cereals, margarines, and soy products; adequate exposure to sunlight; supplementation may be necessary for those who do not get adequate exposure to sunlight |
| Riboflavin (Vitamin $B_2$) | Promotes release of energy; supports normal vision and skin health | Whole and enriched grains, green leafy vegetables, mushrooms, beans, nuts, and seeds |
| Iron | Assists with oxygen transport; involved in making amino acids and hormones | Whole-grain products, prune juice, dried fruits, beans, nuts, seeds, and leafy vegetables (such as spinach) |
| Calcium | Maintains bone health; assists with muscle contraction, blood pressure, and nerve transmission | Fortified soy milk and tofu, almonds, dry beans, leafy vegetables, calcium-fortified juices, and fortified breakfast cereals |
| Zinc | Assists with DNA and RNA synthesis, immune function, and growth | Whole-grain products, wheat germ, beans, nuts, and seeds |

## 6.18 In Depth: Vitamins and Minerals

### 6.18.1 Macronutrients

- Carbohydrates
- Fats
- Protein
- Provide energy
- Required in relatively large amounts

### 6.18.2 Micronutrients

- Vitamins
- Minerals

- Do not supply energy
- Required in relatively small amounts
- Assist body functions (e.g., energy metabolism, maintenance of healthy cells and tissues)
- Absorption may be very low (3–10%) when compared to macronutrients (85–99%)
- Many micronutrients need to be chemically altered before they are active in the body

### 6.18.3 Vitamins

- Organic compounds
- Thirteen are essential
- Nine are soluble in water
- Four are soluble in fat

### 6.18.4 Characteristics of Fat-Soluble Vitamins

- Large storage capability
- Toxicity is possible
- Deficiency symptoms may take many months to develop
- May occur in numerous chemical forms

Table 6.4: Fat-Soluble Vitamins

| Vitamin Name | Primary Functions | Recommended Intake* | Reliable Food Sources | Toxicity/Deficiency Symptoms |
|---|---|---|---|---|
| A (retinol, retinal, retinoic acid) | Required for ability of eyes to adjust to changes in light<br>Protects color vision<br>Assists cell differentiation Required for sperm production in men and fertilization in women<br>Contributes to healthy bone<br>Contributes to healthy immune system | RDA:<br>Men: 900 $\mu$g/day<br>Women: 700 $\mu$g/day<br>UL: 3,000 $\mu$g/day | Preformed retinol: beef and chicken liver, egg yolks, milk<br>Carotenoid precursors: spinach, carrots, mango, apricots, cantaloupe, pumpkin, yams | *Toxicity*: Fatigue, bone and joint pain, spontaneous abortion and birth defects of fetuses in pregnant women, nausea and diarrhea, liver damage, nervous system damage, blurred vision, hair loss, skin disorders<br>*Deficiency*: Night blindness and xerophthalmia; impaired growth, immunity, and reproductive function |
| D (cholecalciferol) | Regulates blood calcium levels<br>Maintains bone health<br>Assists cell differentiation | RDA:<br>Adults aged 19-70: 15$\mu$g/day<br>Adults aged >70: 20 $\mu$g/day<br>UL 100 $\mu$g/day | Canned salmon and mackerel, milk, fortified cereals | *Toxicity*: Hypercalcemia<br>*Deficiency*: Rickets in children, osteomalacia and/or osteoporosis in adults |
| E (tocopherol) | As a powerful antioxidant, protects cell membranes, polyunsaturated fatty acids, and vitamin A from oxidation<br>Protects white blood cells<br>Enhances immune function<br>Improves absorption of vitamin A | RDA:<br>Men: 15 mg/day<br>Women: 15 mg/day<br>UL: 1,000 mg/day | Sunflower seeds, almonds, vegetable oils, fortified cereals | *Toxicity*: Rare<br>*Deficiency*: Hemolytic anemia; impairment of nerve, muscle, and immune function |
| K (phylloquinone, menaquinone, menadione) | Serves as a coenzyme during production of specific proteins that assist in blood coagulation and bone metabolism | AI:<br>Men: 120 $\mu$g/day<br>Women: 90 $\mu$g/day | Kale, spinach, turnip greens, brussels sprouts | *Toxicity*: None known<br>*Deficiency*: Impaired blood clotting, possible effect on bone health |

*RDA: Recommended Dietary Allowance; UL: upper limit; Al: Adequate Intake.

### 6.18.5 Characteristics of Water-Soluble Vitamins

- Minimal storage capacity
- Toxicity is rare
- Deficiency symptoms occur quickly
- Excreted in urine when tissues are saturated

### 6.18.6 General Properties of Minerals

- Inorganic
- Cannot be synthesized by plants or animals
- Not digested or broken down prior to absorption
- Two classifications based on need

### 6.18.7 Characteristics of Major Minerals

- Required in amounts of at least 100 mg/day
- Body contains 5 g or higher
- Seven major minerals

### 6.18.8 Characteristics of Trace Minerals

- Required in amounts of less than 100 mg/day
- Body contains less than 5 g
- Eight trace minerals are essential for human health
- Absorption of micronutrients depends on numerous factors
  - Chemical form (e.g., absorption of heme iron from meats, fish, poultry is ~25%, whereas non-heme iron from plant products is ~3–5%)
  - Numerous factors in foods bind micronutrients and prevent absorption
  - Other nutrients within a meal alter absorption
- Supplementation of micronutrients is controversial
  - Easier to develop toxicity with supplements
  - Some may be harmful to certain subgroups of consumers
  - Most minerals are better absorbed from animal food sources

  - Eating a variety of foods provides many other nutrients (e.g., phytochemicals)
  - Supplements may alter the balance between nutrients

- Adequate intake of these minerals has been as been associated with lowered disease risk
  - Vitamin D and colon cancer
  - Vitamin E and complications of diabetes
  - Vitamin K and osteoporosis
  - Calcium and hypertension
  - Chromium and type 2 diabetes in older adults
  - Magnesium and muscle wasting in older adults
  - Selenium and certain types of cancer

- Do more essential micronutrients exist?

- Nutrition researchers continue to explore the possibility of other substances being essential

- Vitamin-like factors (e.g., carnitine) and numerous minerals (e.g., boron, nickel, silicon) may prove to be essential in our diet

# Chapter 7

# Nutrients Essential to Fluid and Electrolyte Balance

## 7.1 Fluids

- Substances composed of freely moving molecules
- Have the ability to conform to the shape of the container that holds them
- There are different types of fluids in our bodies
  - $\frac{2}{3}$ of the body's fluid is intracellular fluid
  - The remaining $\frac{1}{3}$ is extracellular fluid

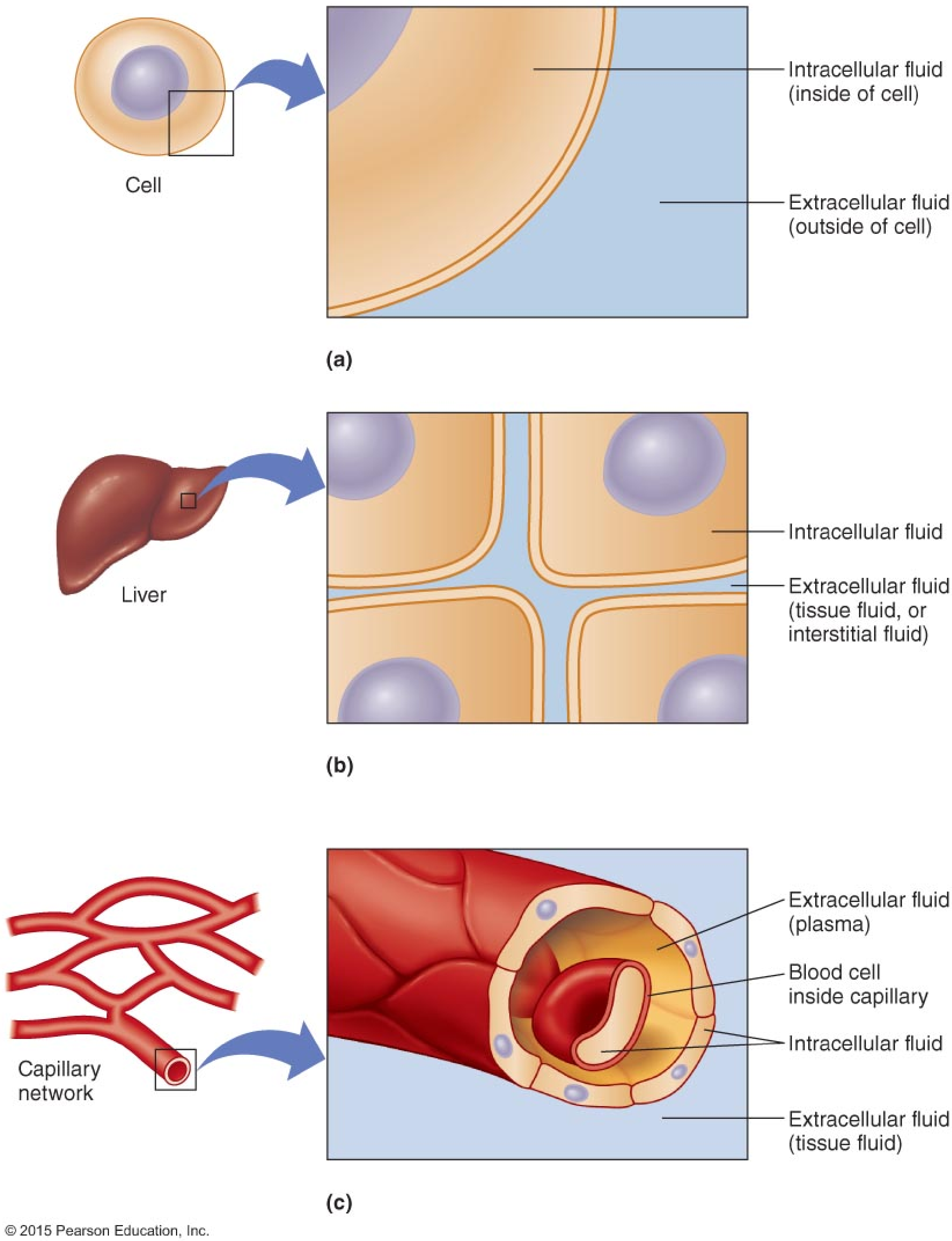



Figure 7.1: Components of Body Fluid

- Extracellular fluids include
  - **Tissue fluid** – found between the cells within tissues and organs of the body
  - **Plasma** – the fluid portion of blood that carries the blood cells
- The body fluid composition of tissue varies by

**Tissue type** lean tissues have higher fluid content than fat tissues

**Gender** males have more lean tissue and therefore more body fluid

**Age** lean tissue is lost with age, and body fluid is lost with it

## 7.2 Electrolytes

- In intracellular fluid, $K^+$ and $HPO_4^{2-}$ are the predominant electrolytes
- In extracellular fluid, $Na^+$ and $Cl^-$ predominate
- There is a slight electrical charge difference on either side of the cell membrane

## 7.3 Functions of Fluids

- Fluids dissolve and transport substances
  - Water is an excellent solvent because it can dissolve many different substances
  - The dissolved materials, or solutes, include ions, carbohydrates, amino acids, vitamins, and minerals
- Fluids account for blood volume
  - **Blood volume** – the amount of fluid in the blood
  - Increased blood volume can cause blood pressure to rise (hypertension)
  - Decreased blood volume can cause low blood pressure
- Fluids help maintain body temperature
  - Because water has a high heat capacity, the temperature of our body fluids remain quite stable
  - Sweating releases heat as the evaporation of water from the skin cools the skin and blood

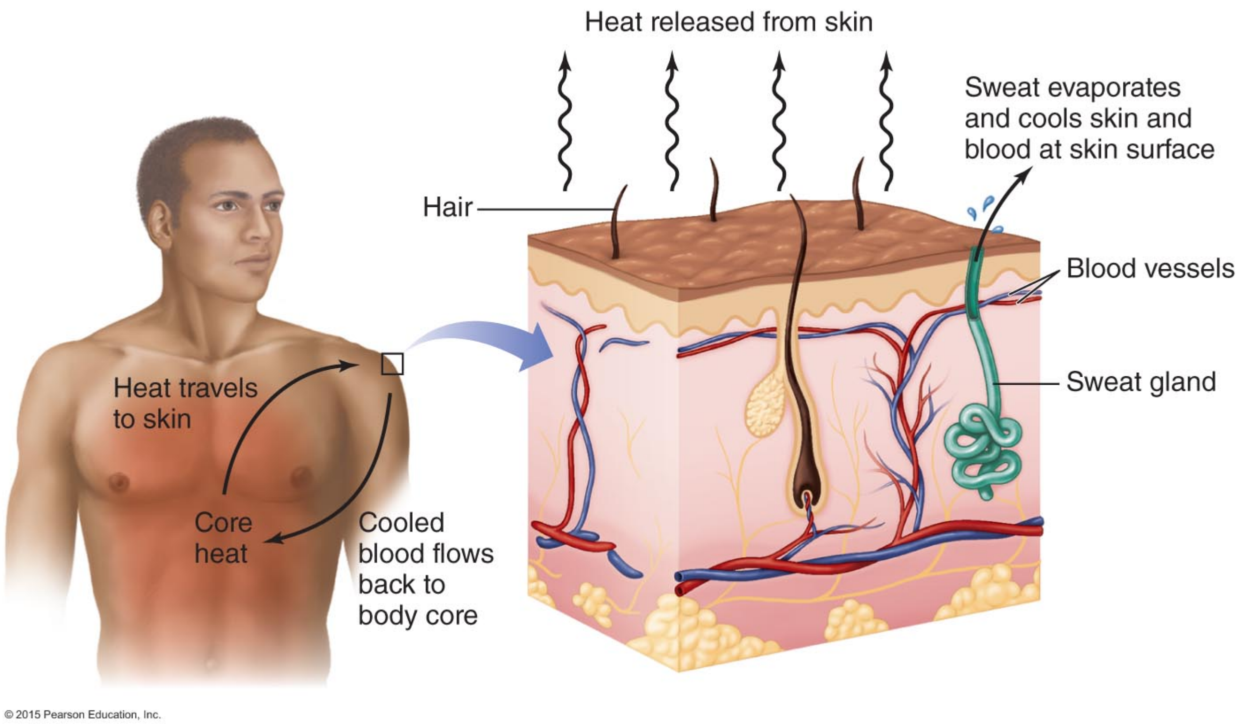



Figure 7.2: Fluids Help Maintain Body Temperature

- Fluids protect and lubricate our tissues
  - Cerebrospinal fluid protects the brain and spinal column
  - Amniotic fluid protects the fetus
  - Synovial fluid is a lubricant around joints
  - Digestive secretions allow for easy passage
  - Pleural fluid covering the lungs allows friction-free expansion and retraction

## 7.4 Functions of Electrolytes

- Electrolytes help regulate fluid balance
  - Water follows the movement of electrolytes, moving by osmosis to areas where the concentration of electrolytes is high
  - This allows for the controlled movement of fluids into and out of cells

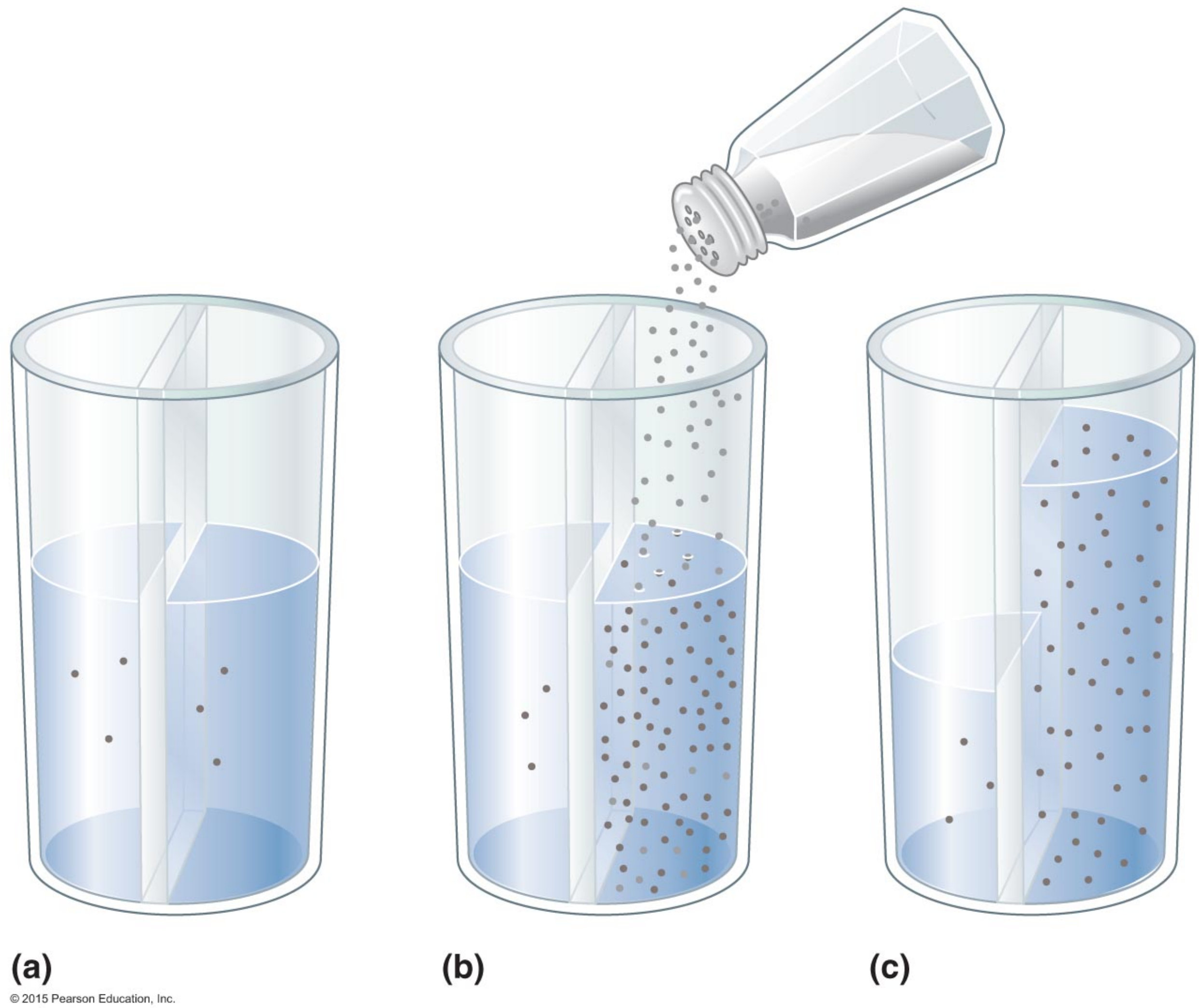



Figure 7.3: Osmosis


Figure 7.4: Fluid and Electrolyte Balance

- Electrolytes enable our nerves to respond to stimuli
  - Movement of sodium ($Na^+$) and potassium ($K^+$) across the membranes of nerve cells changes the electrical charge across the membrane
  - This change in electrical charge carries the nerve impulse along the nerve cell

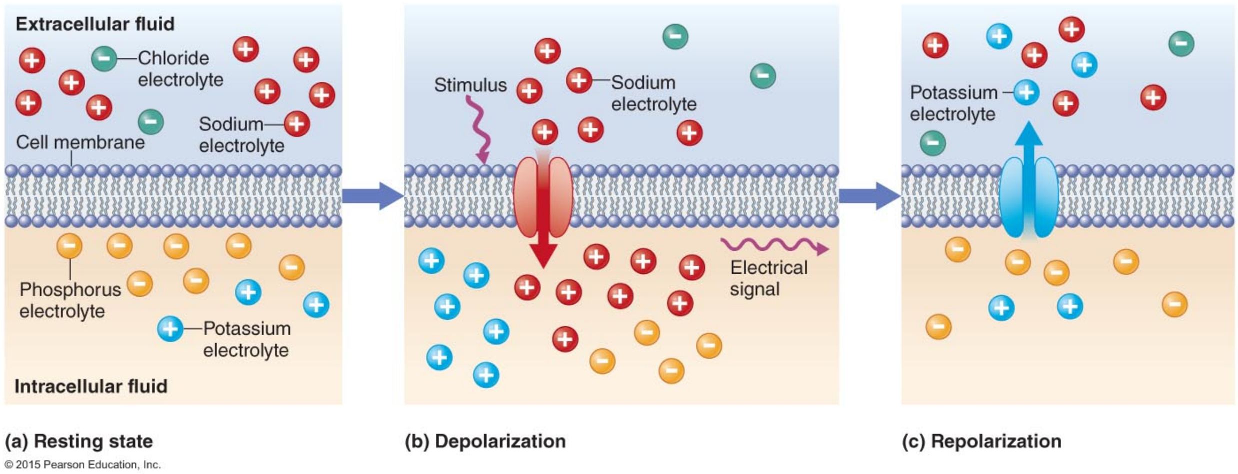



Figure 7.5: Role of Electrolytes in Nerve Function

- Electrolytes signal our muscles to contract
  - The movement of calcium ($Ca^{2+}$) into a muscle cell stimulates the muscle to contract
  - The ($Ca^{2+}$) is pumped back out of the cell after the muscle contraction

## 7.5 Maintaining Fluid Balance

- Fluid balance is maintained by different mechanisms prompting us to drink and retain fluid
- The thirst mechanism occurs from a cluster of nerve cells (in the hypothalamus) that stimulate our desire to drink
- However, the thirst mechanism is not always sufficient; the amount of fluids people drink may not be enough to achieve fluid balance
- Water lost from the body must be replaced
- Water is lost through urine, sweat, evaporation, exhalation, and feces
- Water is gained through beverages, food, and metabolic reactions
  - Metabolic water contributes about 10–14% of the water the body needs

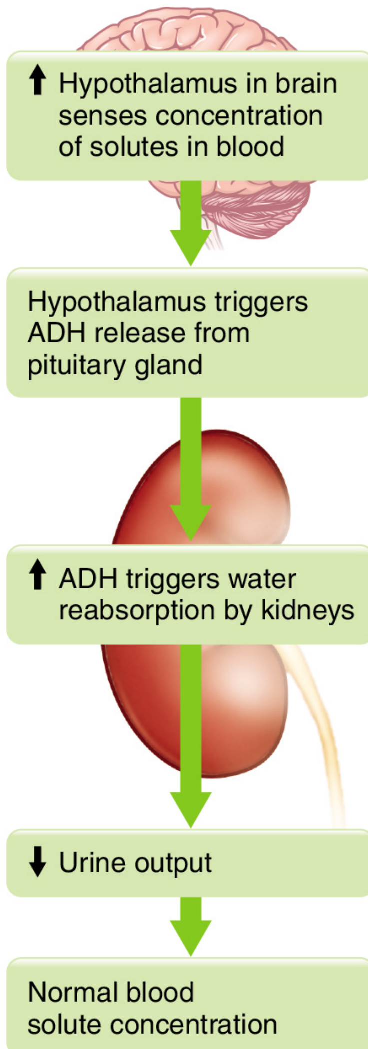



Figure 7.6: Fluid Balance

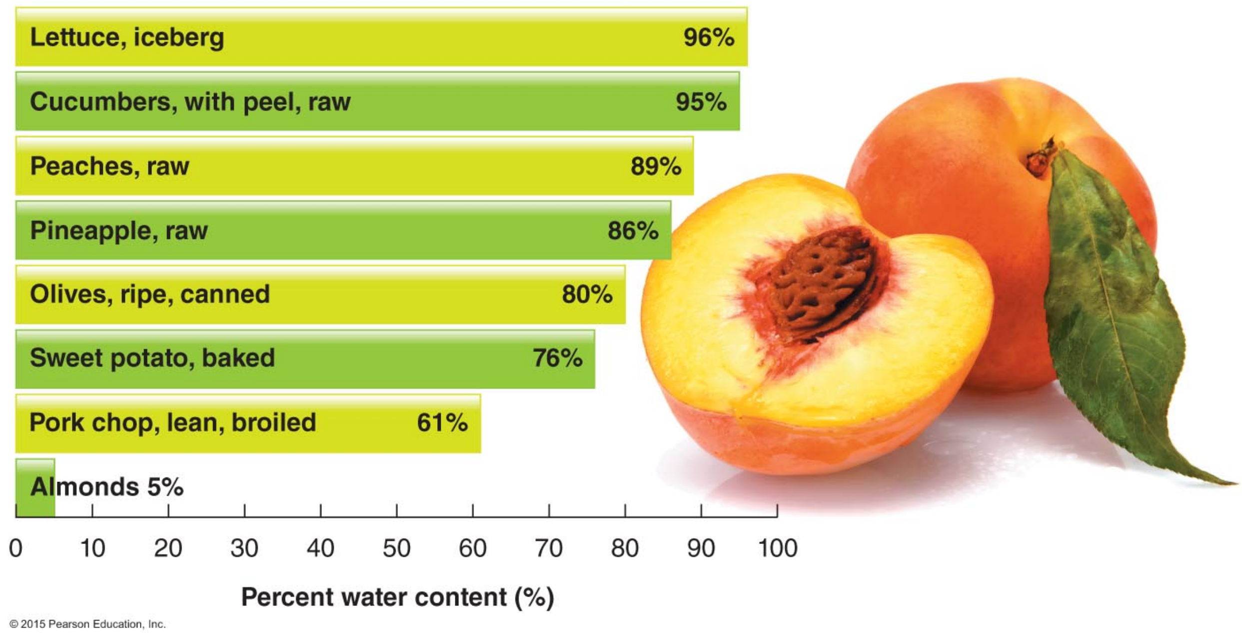



Figure 7.7: Water Content of Various Foods

- Loss of water

**Sensible water loss** occurs through urine and sweat

  - Most water is lost through urine
  - The kidneys control how much water is reabsorbed; excess water is processed by the kidneys and excretes as urine

**Insensible water loss** occurs through evaporation from the skin or exhalation from the lungs, as well as through feces

**Diuretics** increase fluid loss via the urine

## 7.6 Water

- Functions of water
  - Essential for life
  - Required for fluid and electrolyte balance and many metabolic reactions
- Recommended intake
  - Varies with environment and activity level

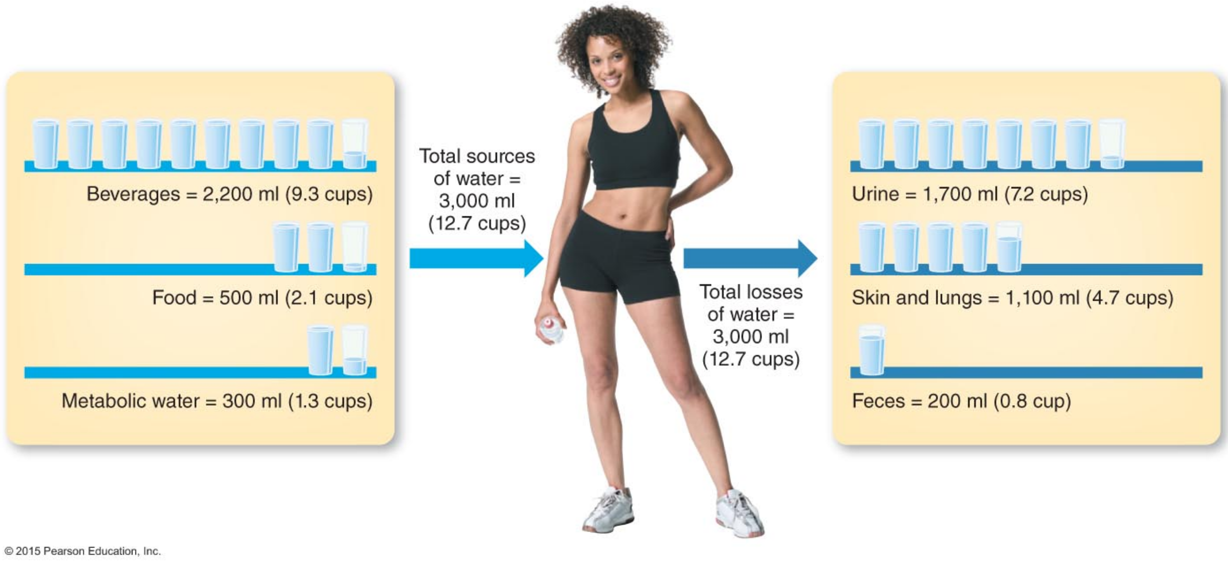



Figure 7.8: For a Woman Expending 2,500 kcal/day

- Surface water comes from lakes, rivers, and reservoirs
- Groundwater comes from underground rock formations called aquifers
- "Hard water" is relatively high in calcium
- The U.S. Environmental Protection Agency (EPA) sets and monitors standards for public water systems and is responsible for regulation of bottled water
- What is you drink too much water?
  - Becoming overhydrated is rare
  - Can resulted in a dilution of sodium (hyponatremia)
- What is you don't drink enough water?
  - Dehydration
  - Infants and the elderly are especially vulnerable

## 7.7 Commercial Beverages

- Low-fat and skim milk provide protein, calcium, phosphorus, vitamin D, and, usually, vitamin A
- Moderate consumption of beverages with caffeine is safe and potentially healthful
- Most soft drinks, juice drinks, flavored waters, and bottled tea and coffee drinks are loaded with added sugars

- "Designer waters" with added nutrients and/or herbs can add more than 300 Calories to the day's intake and rarely contribute to better health
- Many energy drinks, typically consumed quickly, contain a high amount of caffeine, which can cause a dramatic rise in blood pressure and heart rate
  - The can also contain a significant amount of added sugar

Table 7.1: Overview of Minearls Involved in Hydration and Neuromuscular Function

| Nutrient | Recommended Intake |
|---|---|
| Sodium | AI for 19 to 50 years of age: 1.5 g/day |
| Potassium | AI for 19 years of age and older: 4.7 g/day |
| Chloride | AI for 19 to 50 years of age: 2.3/day |
| Phosphorus | RDA for 19 years of age and older: 700 mg/day |

To see the full profile of all micronutrients, turn to the **In Depth** essay following Chapter 6, Vitamins and Minerals: Micronutrients with Macro Powers (pages 211–221).

## 7.8 Sodium

- Functions of sodium
  - Fluid and electrolyte balance
  - Associated with blood pressure and pH balance in the body
  - Required for nerve impulse transmission
  - Assists in the transport of certain nutrients (e.g., glucose) into body cells
- Recommended intake
  - 1.5 g/day is required
  - No more than 2.3 g/day is recommended
- Sources of sodium
  - Processed foods and restaurant foods are generally high in sodium

Table 7.2: High-Sodium Foods and Lower-Sodium Alternatives

| High-Sodium Food | Sodium (mg) | Lower-Sodium Food | Sodium (mg) |
|---|---|---|---|
| Dill pickle (1 large, 4 in.) | 1,731 | Low-sodium dill pickle (1 large, 4 in) | 23 |
| Ham, cured, roasted (3 oz) | 1,023 | Pork, loin roast (3 oz) | 54 |
| Turkey pastrami (3 oz) | 915 | Roasted turkey, cooked (3 oz) | 54 |
| Tomato juice, regular (1 cup) | 877 | Tomato juice, lower sodium (1 cup) | 24 |
| Macaroni and cheese (1 cup) | 800 | Spanish rice (1 cup) | 5 |
| Ramen noodle soup (chicken flavor) (1 package [85 g]) | 1,960 | Ramen noodle soup made with sodium-free chicken bouillon (1 cup) | 0 |
| Teriyaki chicken (1 cup) | 3,210 | Stir-fried pork/rice/vegetables (1 cup) | 575 |
| Tomato sauce, canned ($\frac{1}{2}$ cup) | 741 | Fresh tomato (1 medium) | 11 |
| Creamed corn, canned (1 cup) | 730 | Cooked corn, fresh (1 cup) | 28 |
| Tomato soup, canned (1 cup) | 695 | Lower-sodium tomato soup, canned (1 cup) | 480 |
| Potato chips, salted (1 oz) | 168 | Baked potato, unsalted (1 medium) | 14 |
| Saltine crackers (4 crackers) | 156 | Saltine crackers, unsalted (4 crackers) | 100 |

*Data from:* U.S. Department of Agriculture. 2011. USDA Nutrient Database for Standard Reference, Release 24.

- What is you consume too much sodium?
  - **Hypernatremia** – abnormally high blood sodium concentration
  - Can occur in patients with congestive heart failure or kidney disease
  - Results in high blood volume, edema, and high blood pressure
- What is you don't consume enough sodium?
  - **Hyponatremia** – an abnormally low blood sodium level
  - Can result from prolonged vomiting, diarrhea, or sweating
  - Has been seen in marathon athletes who consume too much water and fail to replace sodium

## 7.9 Potassium

- Functions of potassium
  - Fluid and electrolyte balance
  - Very important in muscle contractions and transmission of nerve impulses
  - High potassium intake helps to maintain a lower blood pressure
- Recommended intake
  - 4.7 g/day
- Sources of potassium

  - Processed foods are usually low in potassium
  - Fresh fruit and vegetables and whole grains are good sources of potassium

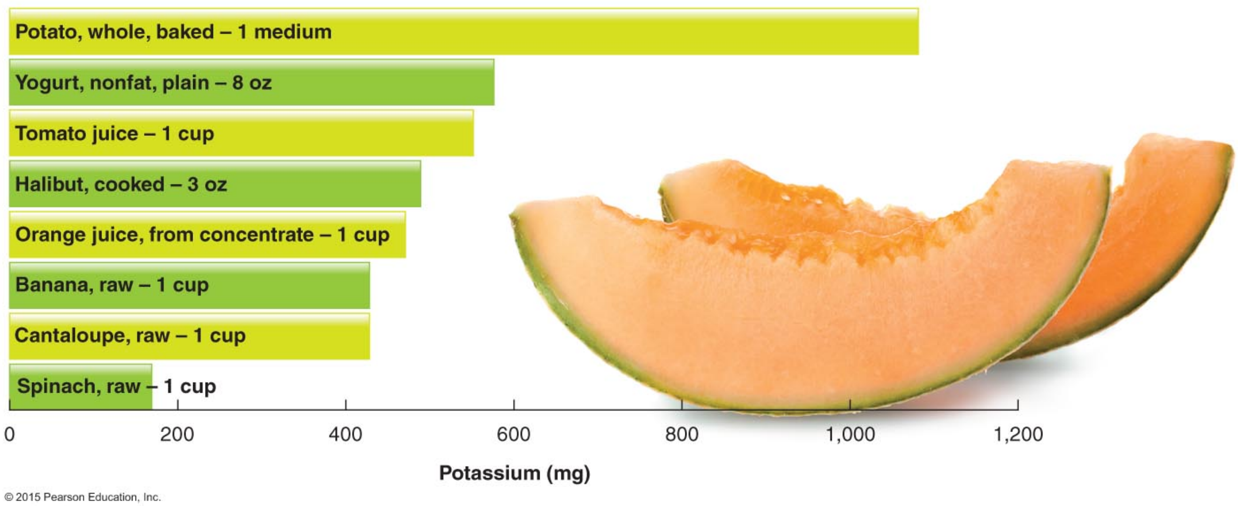



Figure 7.9: Common Food Sources of Potassium

- What if you consume too much potassium?
  - **Hyperkalemia** – a high blood potassium level
  - Can occur in patients with kidney disease
  - Can alter normal heart rhythm, resulting in a heart attach
- What if you don't consume enough potassium?
  - **Hypokalemia** – a low blood potassium level
  - Can be seen in patients with kidney disease or diabetic acidosis
  - Can occur when taking certain diuretic medications

## 7.10 Chloride

- Functions of chloride
  - Assists with maintaining fluid balance
  - Assists the immune system
  - Component of HCl in the stomach
- Recommended intake
  - Minimum recommendation is 2.3 g/day

- What if you consume too much chloride?
  - May lead to hypertension in salt-sensitive patients
- What if you don't consume enough chloride?
  - This is rare but can occur in people with eating disorders

## 7.11 Phosphorus

- Functions of phosphorus
  - The major intracellular negatively charged electrolyte
  - Required for fluid balance
  - Critical role in bone formation (85% of body's phosphorus is found in bone)
  - Regulated biochemical pathways by activating or deactivating enzymes
  - Found in ATP, DNA, RNA
- Recommended intake
  - Recommended Dietary Allowance (RDA) for phosphorus is 700 mg/day
- Sources of phosphorus
  - Widespread in many foods
  - Found in high amounts in foods that contain protein (e.g., meat, milk, eggs)

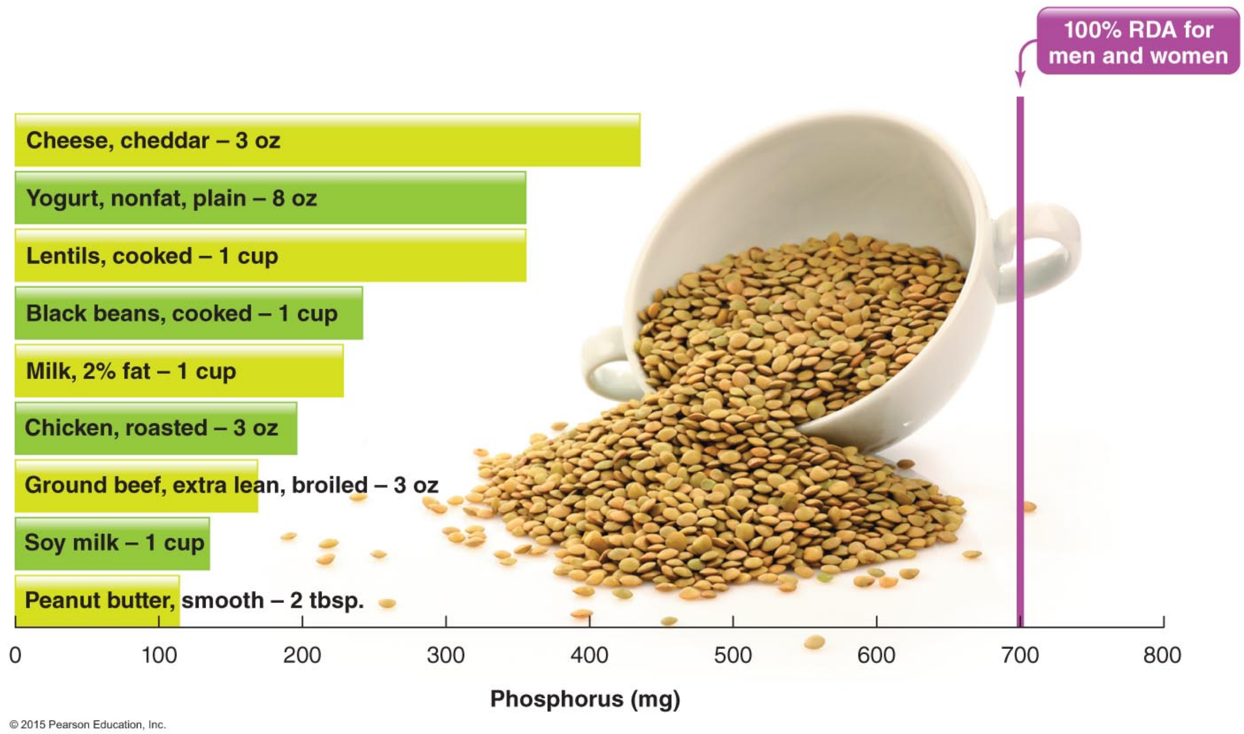



Figure 7.10: Common Food Sources of Phosphorus

- What if you consume too much phosphorus?
  - High blood levels of phosphorus can occur with kidney disease or when taking too much vitamin D supplements
  - Causes muscles spams, and convulsions
- What if you don't consume enough phosphorus?
  - Deficiencies of phosphorus are rare

## 7.12 Fluid and Electrolyte Balance Disorders

- Serious health problems that can occur when fluid excretion exceeds fluid intake include
  - Dehydration
    - Occurs when fluid excretion exceeds fluid intake
  - Heat illnesses
    - Heat cramps
    - Heat exhaustion
    - Heat stroke

## 7.13 Dehydration

- Occurs when water loss exceeds water intake
  - Commonly due to heavy exercise or high environmental temperatures
  - Infants and the elderly are more at risk
- Other common causes of dehydration include
  - Diarrhea
  - Vomiting
  - Fever
  - Burns, including sunburn
  - Poorly controlled diabetes
  - Abuse of diuretics or laxatives
- Dehydration is classified in terms of percentage of weight loss that is exclusively due to the loss of fluids

Table 7.3: Percentages of Body Fluid Loss Correlated with Weight Loss and Symptoms

| **Body Water Loss (%)** | **Weight Lost If You Weight 160 lb** | **Weight Lost If You Weight 130 lb** | **Symptoms** |
|---|---|---|---|
| 1–2 | 1.6–3.2 lb | 1.3–2.6 lb | Strong thirst, loss of appetite, feeling uncomfortable |
| 3–5 | 4.8–8.0 lb | 3.9–6.5 lb | Dry mouth, reduced urine output, greater difficulty working and concentrating, flushed skin, tingling extremities, impatience, sleepiness, nausea, emotional instability |
| 6–8 | 9.6–12.8 lb | 7.8–10.4 lb | Increased body temperature that doesn't decrease, increased heart rate and breathing rate, dizziness, difficulty breathing, slurred speech, mental confusion, muscle weakness, blue lips |
| 9–11 | 14.4–17.6 lb | 11.7–14.3 lb | Muscle spasms, delirium, swollen tongue, poor balance, and circulation, kidney failure, decreased blood volume and blood pressure |

*Data from: Nutrition and Aerobic Exercise,* edited by D. K. Layman. ©1986 American Chemical Society.

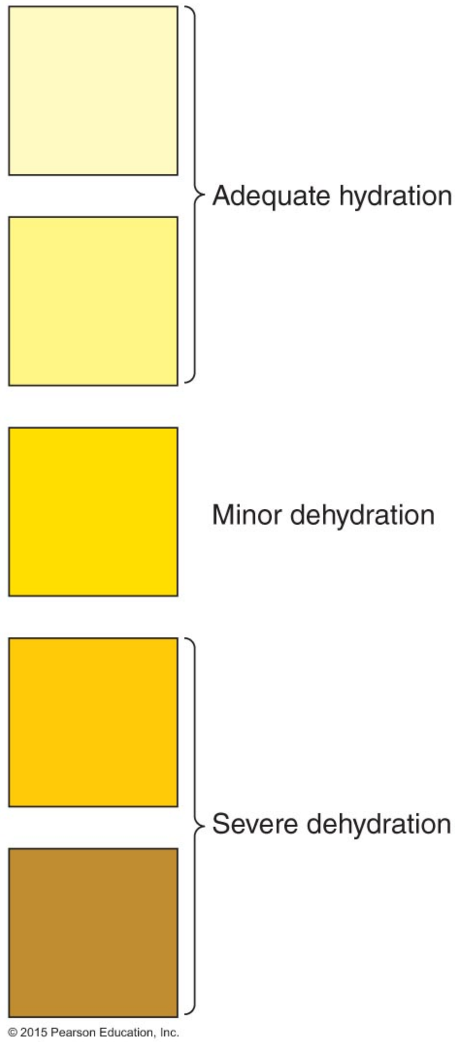



Figure 7.11: Using Urine Color to Gauge Hydration

## 7.14 Heat Illnesses

- Three common types of heat illnesses closely linked to dehydration are
  - Heat cramps
  - Heat exhaustion
  - Heatstroke

### 7.14.1 Heat Cramps

- Painful muscle cramps, usually in the abdomen, arms, or legs
- Develop during vigorous activity sessions in the heat

- Spasms can last seconds or minutes
- Important to stop activity immediately, cool down, and rest; cramps may signal a more serious problem

### 7.14.2 Heat Exhaustion

- Typically occurs from vigorous activity in heat
- May develop after several days in high heat when fluids are inadequate
- Symptoms include cramps, weakness, vomiting, dizziness, and elevated blood pressure and pulse
- Must be treated promptly and aggressively to prevent heatstroke from developing

### 7.14.3 Heatstroke

- Occurs if the body's temperature regulation mechanisms fail
- Occurs in hot, humid environments
- Symptoms include rapid pulse, hot and dry skin, high body temperature, and weakness
- Has been fatal for athletes during exercise in extreme heat
- If it occurs, provide immediate cooling and rest, and contact emergency medical help quickly

## 7.15 In Depth: Alcohol

- Alcohols are chemical compounds characterized by a hydroxyl group
- In common usage, beverages containing ethanol made from fermented fruits, vegetables, or grains


Figure 7.12: What Does One Drink Look Like?

- What is moderate alcohol intake?
  - A drink is defined as the amount of a beverage that provides $\frac{1}{2}$ fluid ounce of pure alcohol
  - **Proof** – a measurement of alcohol content
  - Moderate alcohol intake is defined as the consumption of up to one drink per day for women, and up to two drinks per day for men
- Benefits of moderate consumption include
  - Stress and anxiety reduction
  - Appetite improvement
  - Lower rates of heart disease
  - Possible lower risks for diseases such as diabetes, heart disease, and liver disease
- Concerns about moderate alcohol intake include
  - Women appear to be at higher risk of breast cancer
  - Increased risk of hypertension
  - Higher rates of bleeding in the brain

- Relatively high Calorie content
- Potential risk of adverse drug interactions

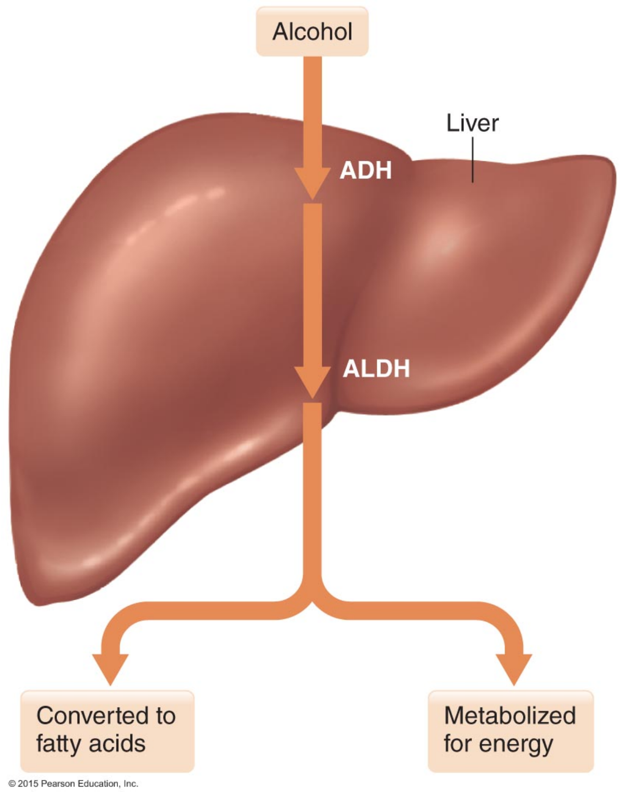



Figure 7.13: Metabolism of Alcohol

Table 7.4: Myths About Alcohol Metabolism

| **The Claim** | **The Reality** |
|---|---|
| Physical activity, such as walking around, will speed up the breakdown of alcohol. | Muscles don't metabolize alcohol; the liver does. |
| Drinking a lot of coffee will keep you from getting drunk. | Coffee intake simply leaves you both wired and drunk. |
| Using a sauna or steam room will force the alcohol out of your body. | Very little alcohol is lost in sweat; the alcohol will remain in your bloodstream. |
| Herbal and nutritional products are available that speed up the breakdown of alcohol. | No commercial supplement is effective in increasing the rate of alcohol metabolism. |

- Alcohol use disorder (AUD)
  - Medical diagnosis for problem drinking that has become severe and is characterized by either abuse or dependence

### 7.15.1 Types Alcohol Abuse

#### Alcohol abuse

excessive intake of alcohol

#### Binge drinking

consumption of five or more drinks per occasion

#### Alcoholism

a disease characterized by chronic dependence on alcohol

### 7.15.2 Effects of alcohol abuse

- A hangover is a consequence of drinking too much alcohol; symptoms include headache, fatigue, dizziness, muscle aches and nausea
- Even at low intakes, alcohol impairs reasoning and judgement
- **Alcohol poisoning** – a potentially fatal metabolic state involving cardiac or respiratory failure
- Alcohol abuse can lead to traumatic injury from falls, drownings, assaults, and traffic accidents

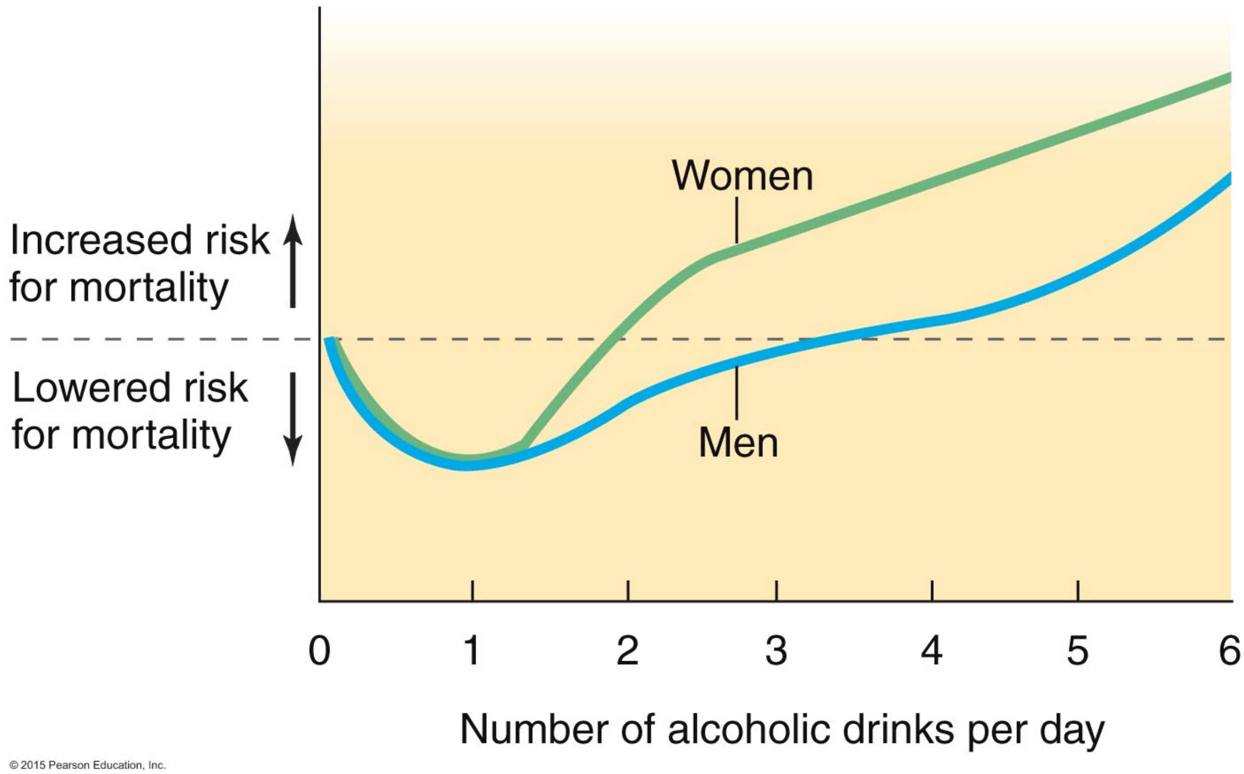



Figure 7.14: Effects of Alcohol on Mortality Risk

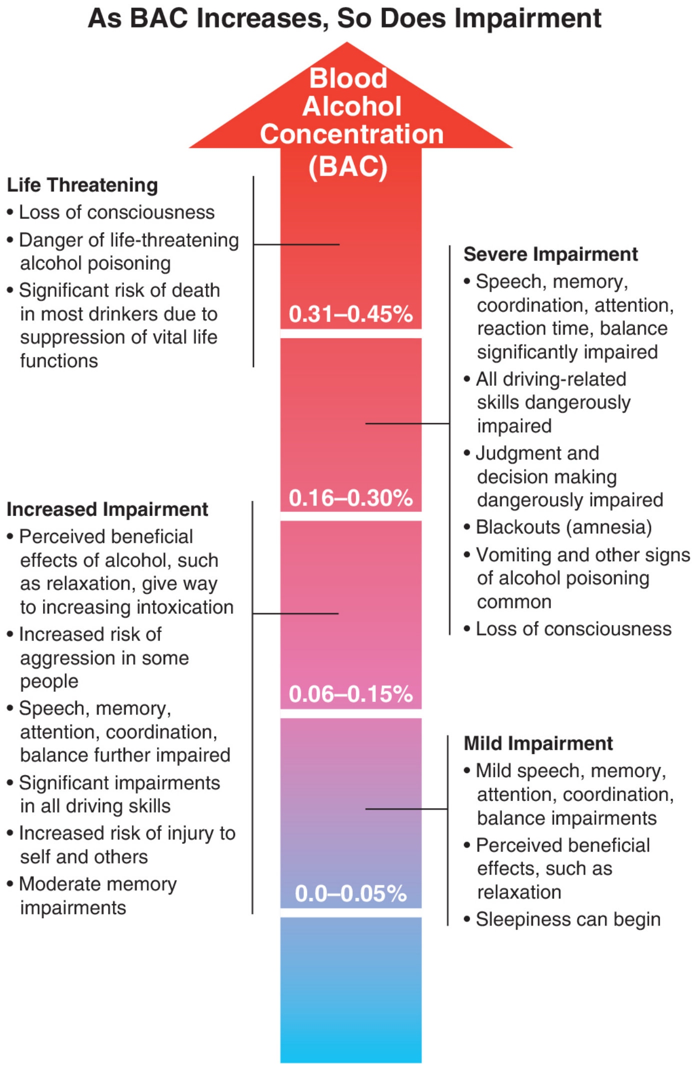


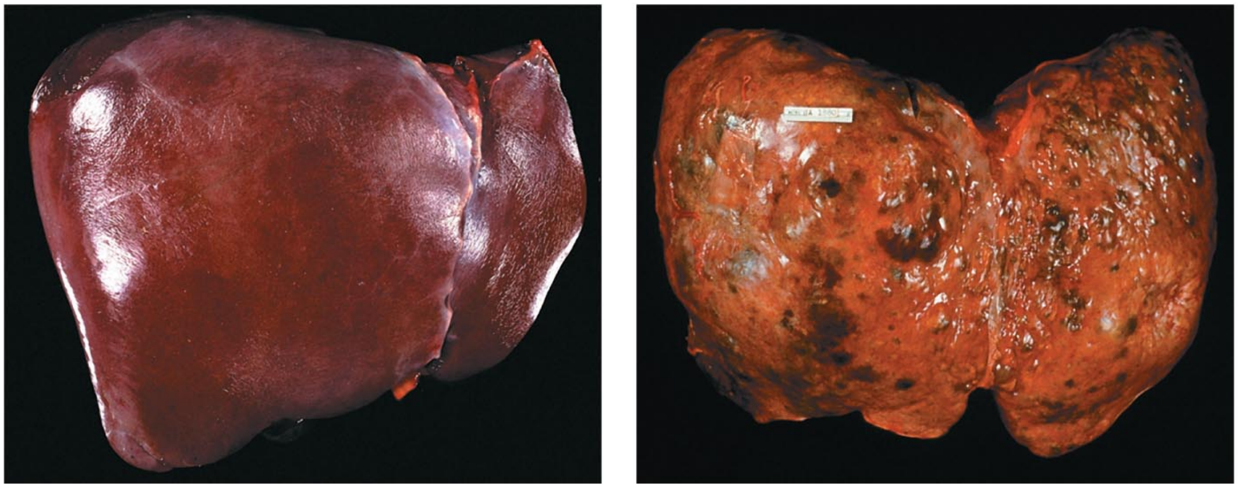

Figure 7.15: Effects of Alcohol on Brain Activity

- Effects of alcohol abuse:
  - When the rate of alcohol intake exceeds the ability of the liver to break alcohol down, liver cells are damaged or destroyed

    **Fatty liver** is an early but reversible sign of liver damage

    **Alcohol hepatitis** results in loss of appetite, nausea and vomiting, abdominal pain, and jaundice

    **Cirrhosis of the liver** involves permanent scarring after years of alcohol abuse



(a) (b)

Figure 7.16: Cirrhosis of the liver

- Chronically high intake increases risk of
  - Impaired bone health
  - Pancreatic injury and diabetes
  - Cancer
  - Abdominal obesity
  - Malnutrition

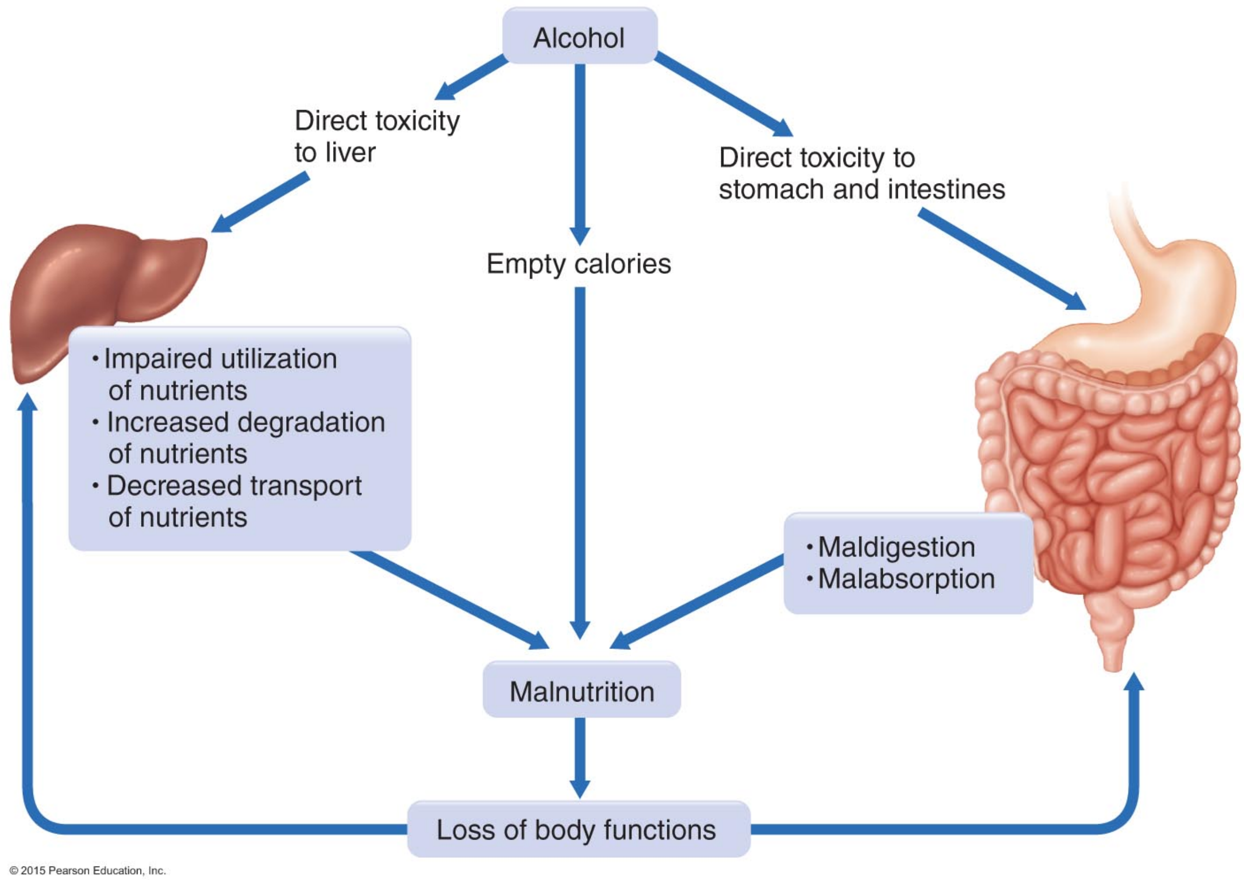



Figure 7.17: Alcohol-Related Malnutrition

- Fetal and infant health problems include
  - **Fetal alcohol syndrome (FAS)** – a set of serious, irreversible birth defects, including physical, emotional, behavioral, and developmental problems
  - **Fetal alcohol effects (FAE)** – subtler consequences that may be exhibited later, including hyperactivity, attention deficit disorder (ADD), and impaired learning abilities

Figure 7.18: Fetal Alcohol Syndrome (FAS)

- You should be concerned about your alcohol intake if you engage in binge drinking or drink at inappropriate times

- Speak with a trusted friend, coach, teacher, counselor, or healthcare provider

# Chapter 8

# Nutrients Essential to Key Body Functions

## 8.1 Regulating Metabolism

- Vitamins and minerals do not contain Calories but assist in generating energy provided by macronutrients in the diet

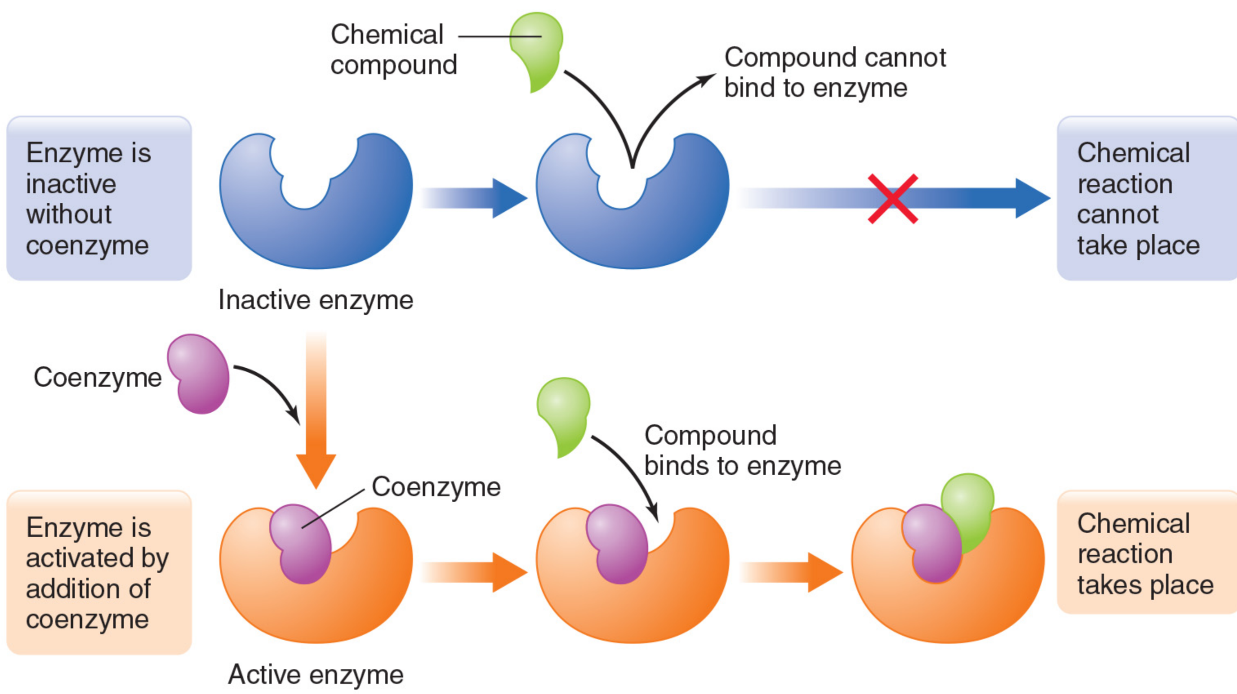



Figure 8.1: Enzymes

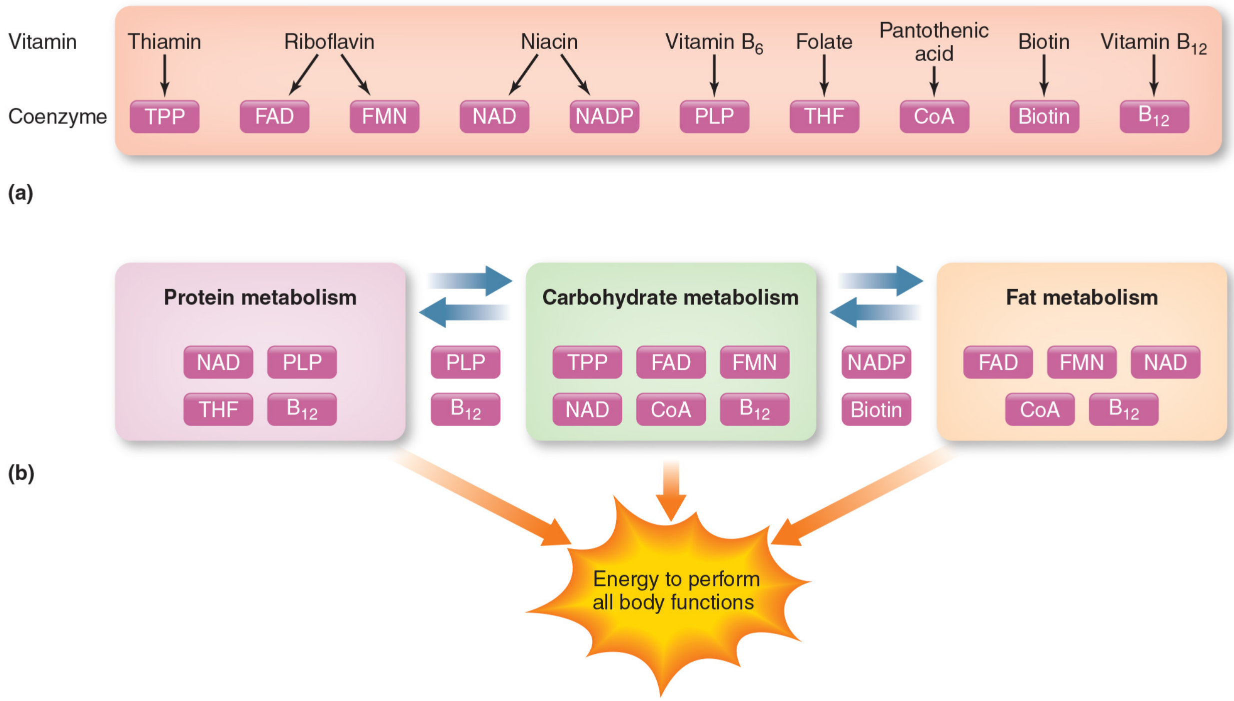



Figure 8.2: Enzymes

Table 8.1: Nutrient and Energy Metabolism

| Nutrient | Recommended Intake |
| --- | --- |
| Thiamin (vitamin B1) | RDA for 19 years of age and older:<br>Women = 1.1 mg/day<br>Men = 1.2 mg/day |
| Riboflavin (vitamin B2) | RDA for 19 years of age and older:<br>Women 1.1 mg/day<br>Men 1.3 mg/day |
| Niacin (nicotinamide and nicotinic acid) | RDA for 19 years of age and older:<br>Women 14 mg/day<br>Men 16 mg/day |
| Vitamin B6 (pyridoxine) | RDA for 19 to 50 years of age:<br>1.3 mg/day<br>RDA for 51 years of age and older:<br>Women = 1.5 mg/day<br>Men 1.7 mg/day |
| Folate (folic acid) | RDA for 19 years of age and older<br>400 $\mu$g/day |
| Vitamin B12 (cobalamin) | RDA for 19 years of age and older:<br>2.4 $\mu$g/day |
| Pantothenic acid | Al for 19 years of age and older:<br>5 mg/day |
| Biotin | Al for 19 years of age and older:<br>30 $\mu$g/day |
| Choline | Al for 19 years of age and older:<br>Women 425 mg/day<br>Men 550 mg/day |
| Iodine | RDA for 19 years of age and older:<br>150 $\mu$g/day |
| Chromium | RDA for 51 years of age and older:<br>Women 20 $\mu$g/day<br>Men 30 $\mu$g/day<br>RDA for 19 to 50 years of age:<br>Women 25 $\mu$g/day<br>Men 35 $\mu$g/day |
| Manganese | Al for 19 years of age and older:<br>Women 1.8 mg/day<br>Men = 2.3 mg/day |
| Sulfur | No DRI. |

To see the full profile of all micronutrients, turn to the In Depth essay following Chapter 6, Vitamins and Minerals: Micronutrients with Macro Powers (pages 211–221).

## 8.2 Thiamin ($B_1$)

- Coenzyme that plays a critical role in carbohydrate metabolism
- Involved in the metabolism of branched chain amino acids
- Deficiency known as "Beriberi"
- Sources include whole grains, pork, green vegetables, and okra.

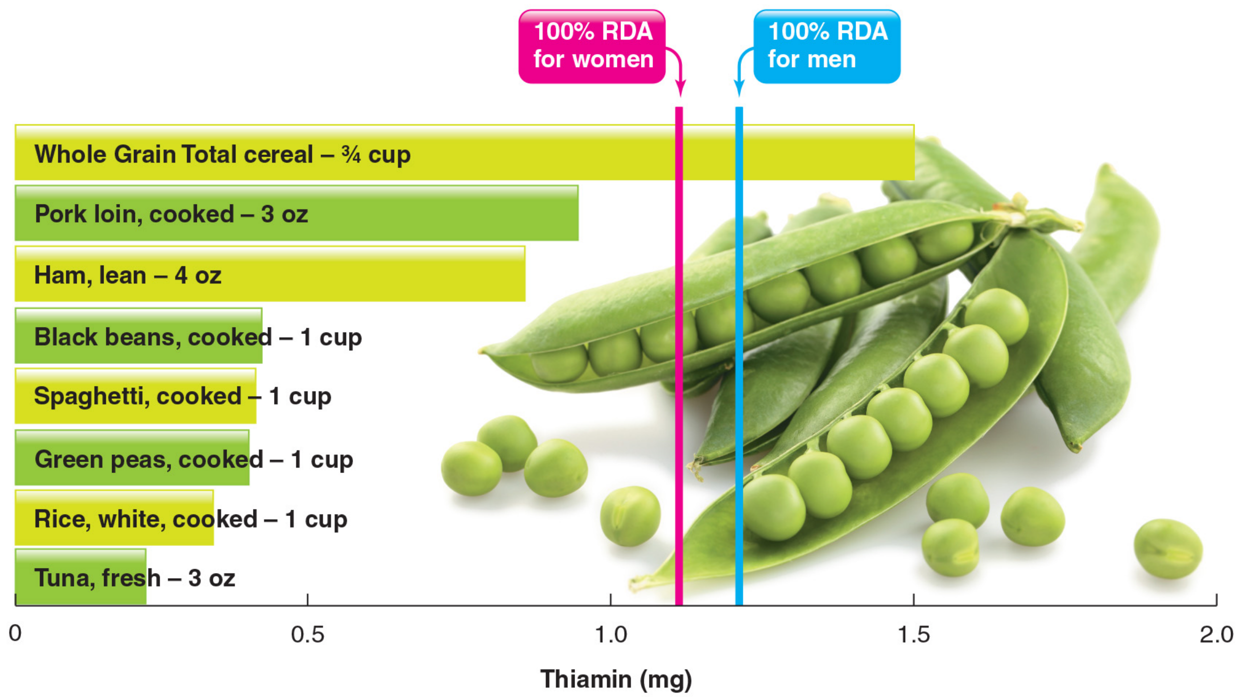



Figure 8.3: Thiamin

## 8.3 Riboflavin ($B_2$)

- Coenzyme in the metabolism of carbohydrates and fats
- Deficiency is known as ariboflavinosis
- No known toxicity
- Sources include milk, fish, eggs, and poultry products

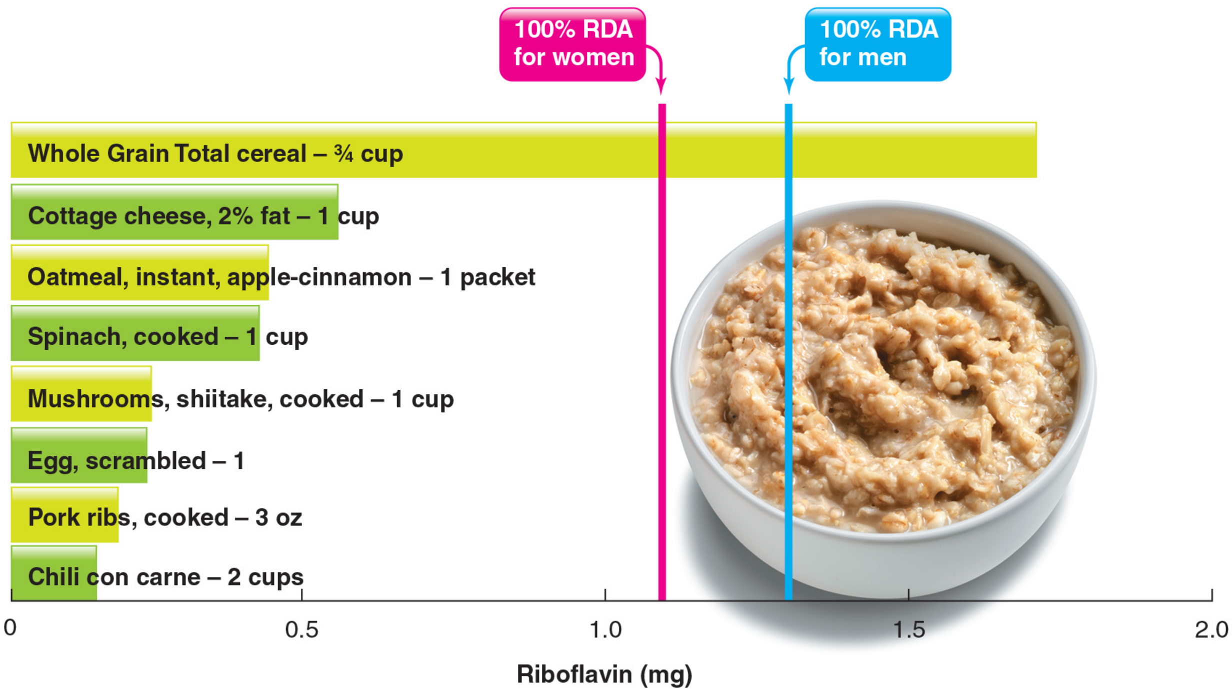



Figure 8.4: Riboflavin

## 8.4 Niacin ($B_3$)

- Plays a role in the metabolism of carbohydrates and fatty acids
- Assists in DNA replication and cell differentiation
- Deficiency called pellagra
  - Translated as "angry skin"
    - Dermatitis, diarrhea, dementia, and death
- Sources include meats, fish, and whole grains

## 8.5 Pantothenic Acid ($B_5$)

- Component of all energy producing pathways
  - Especially important for the breakdown and synthesis of fatty acids
- Found in widespread food sources such as meats, eggs, potatoes, oats, tomatoes, whole grains, and yeast

## 8.6 Pyrodoxine ($B_6$)

involved in

- Amino acid metabolism
- Neurotransmitter synthesis
- Carbohydrate metabolism
- Heme (hemoglobin) synthesis
- Immune function
- Reduction in cardiovascular disease
- Metabolism of other nutrients

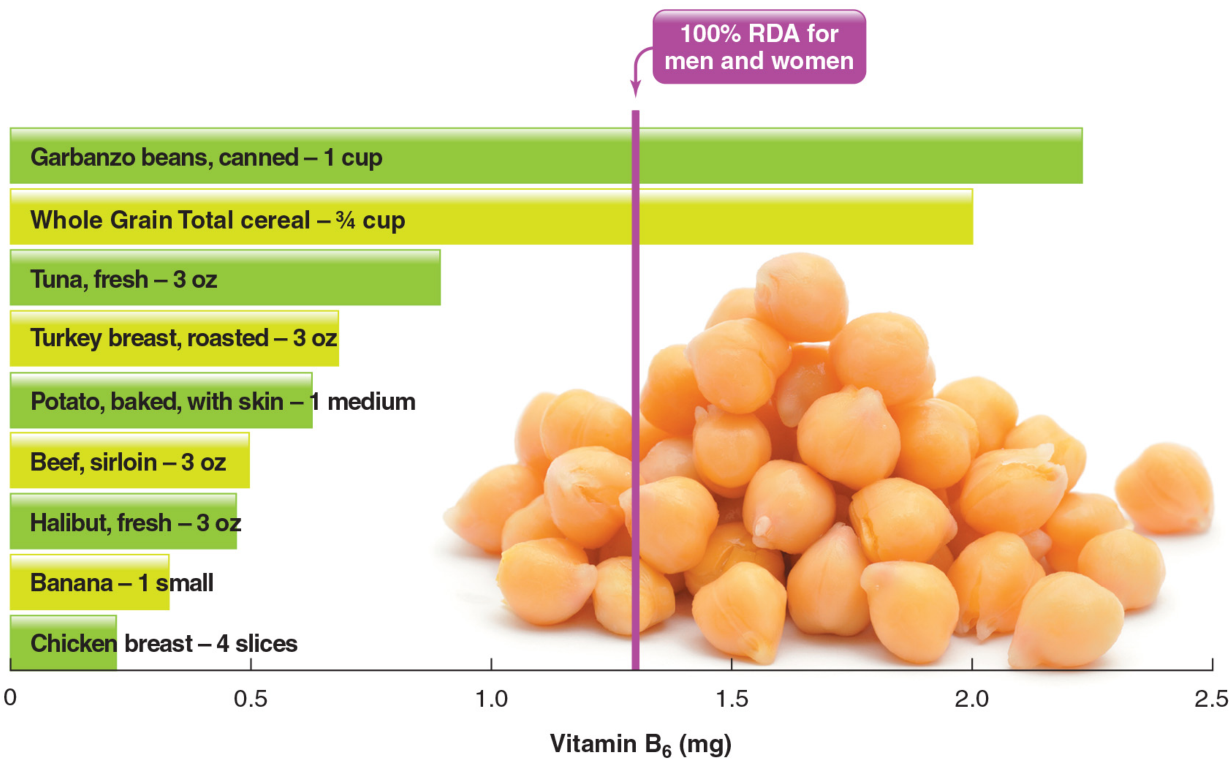



Figure 8.5: Pyrodoxine

## 8.7 Folate ($B_9$)

- Folate adds carbon units to other organic compounds
  - Nucleotide synthesis
  - Amino acid metabolism

  - Red blood cell synthesis
  - Critical role in spinal cord formation during pregnancy

- Sources include leafy greens, fortified grain products, and ready to eat cereals

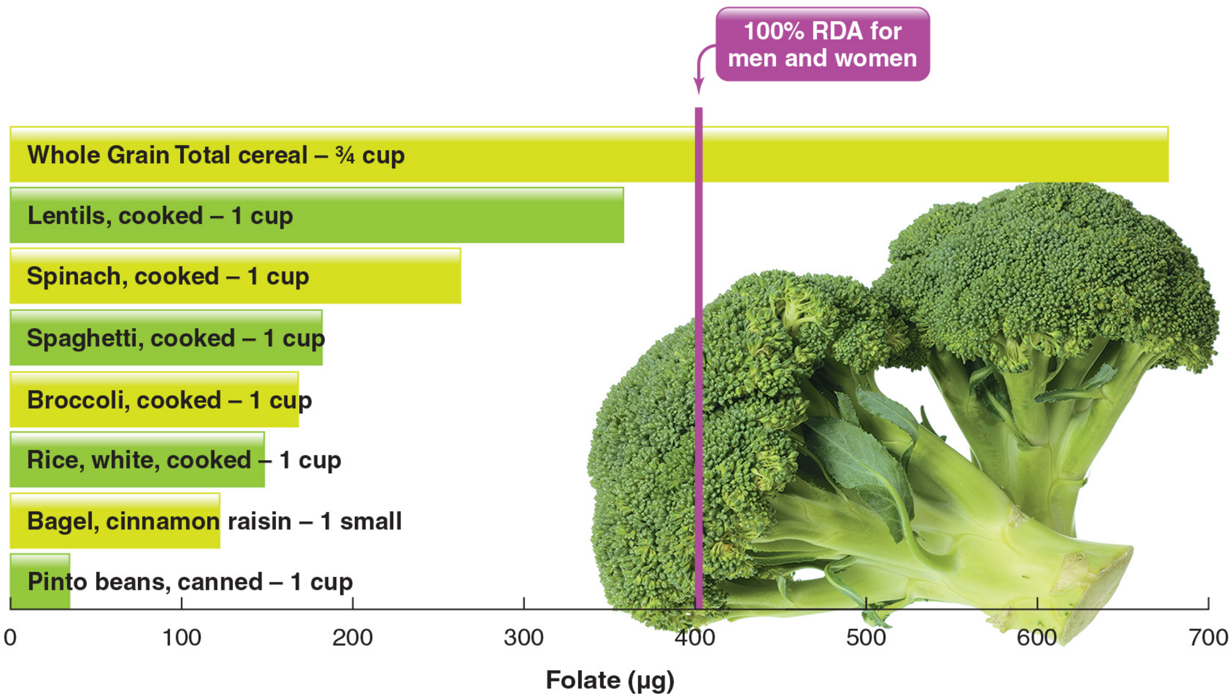



Figure 8.6: Folate

## 8.8 Cobalamin ($B_{12}$)

- Involved in metabolism of fatty acids
- Helps to maintain myelin sheath of nerves
- Helps to prevent the build up of homocysteine
- Sources include meats, dairy, eggs, fortified soy milk, and cereals
- No known toxicity
- Deficiency seen mainly in vegans

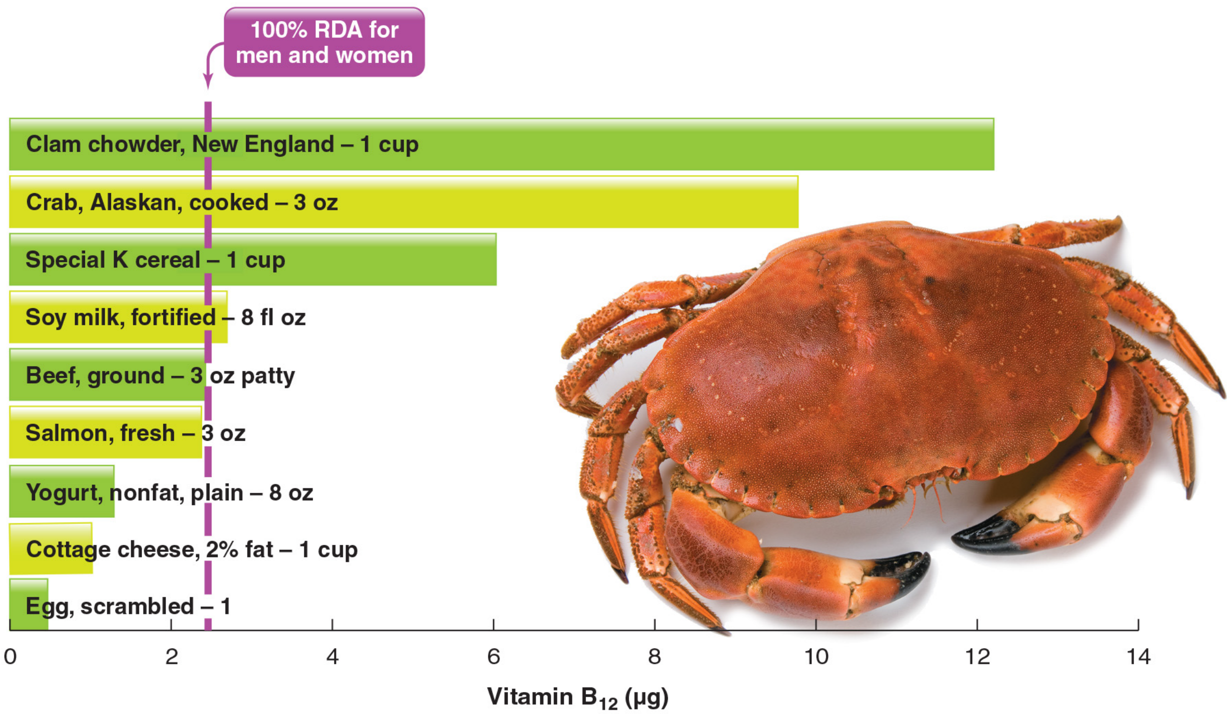



Figure 8.7: $B_{12}$

## 8.9 Antioxidants

- Micronutrients and phytochemicals that play a role in stabilizing free radicals include:
  - Vitamins E, C, and A
  - Minerals selenium, copper, iron, and manganese
- Carotenoids such as beta-carotene also appear to have antioxidant properties

## 8.10 Vitamin E

- Vitamin E is a fat-soluble vitamin made of
  - **Tocotrienol** – biologically inactive form
  - **Tocopherol** – biologically active form
- Functions of vitamin E
  - Primary role is as an antioxidant
  - Protects polyunsaturated fatty acids (PUFAs)
  - Protects low-density lipoproteins (LDLs)
- Recommended Dietary Allowance (RDA) is 15 mg alpha-tocopherol per day

- Tolerable upper limit (UL) is 1,000 mg per day

- Sources of vitamin E
  - Vegetable oils, nuts, seeds, wheat germ, soybeans
  - Animal and dairy products are poor sources

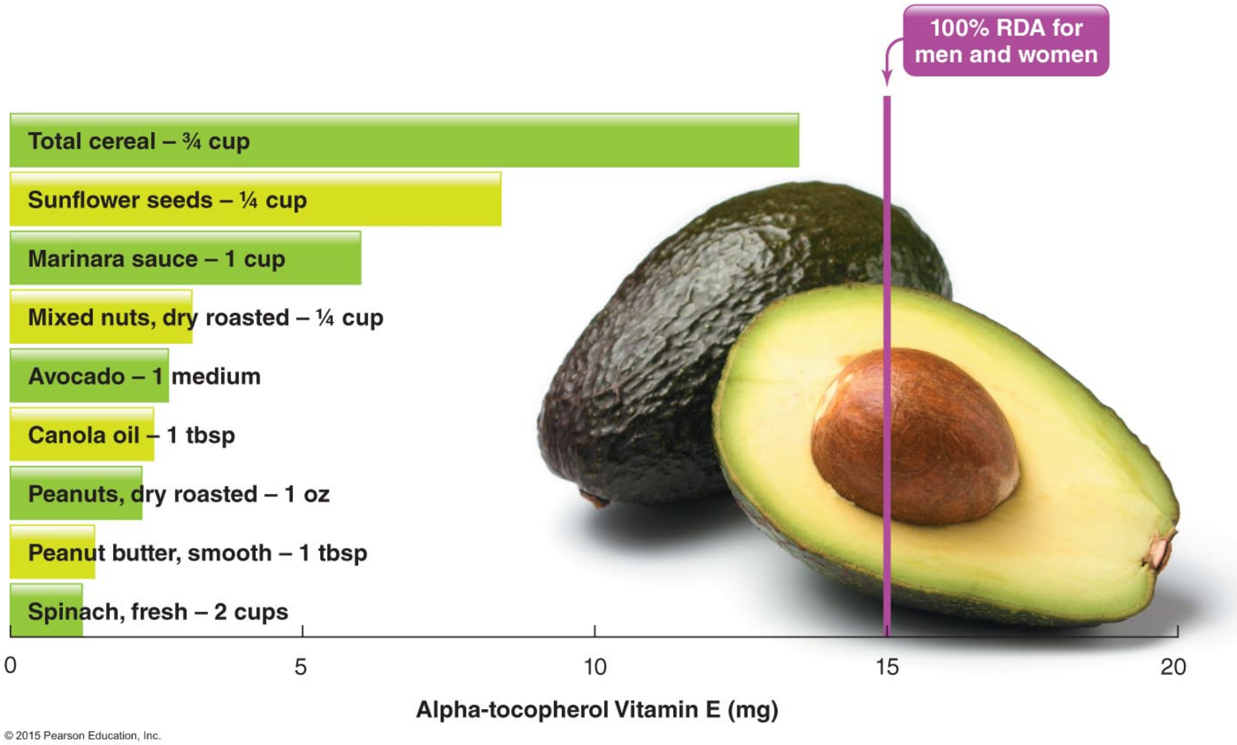



Figure 8.8: Common Food Sources of Vitamin E

- What if you consume too much vitamin E?
  - Some studies suggest possible links to vascular disease, diabetes, heart failure, and prostate cancer
  - Side effects such as nausea, intestinal distress, and diarrhea have been reported
  - Vitamin E can interfere with anticoagulant medications
  - Tolerable upper limit (UL) is 1,000 mg per day

- What if you don't consume enough vitamin E?
  - Vitamin E deficiencies are uncommon
  - Can result in fragile red blood cells (erythrocyte hemolysis)
  - Can cause loss of muscle coordination and reflexes
  - Can impair immune function

## 8.11 Vitamin C

- Vitamin C is a water-soluble vitamin that must be consumed in the human diet
- Functions of vitamin C
  - Antioxidant
  - Synthesis of collagen
  - Prevents the disease scurvy
  - Enhances the immune system
  - Regenerates vitamin E after oxidation
  - Enhances the absorption of iron
- Recommended intake
  - 90 mg/day for men; 75 mg/day for women
  - Smokers need an extra 35 mg/day
  - UL is 2,000 mg/day for adults
- Sources of vitamin C
  - Fresh fruits and vegetables
  - Heat destroys vitamin C
  - Cooking foods lowers their vitamin C content

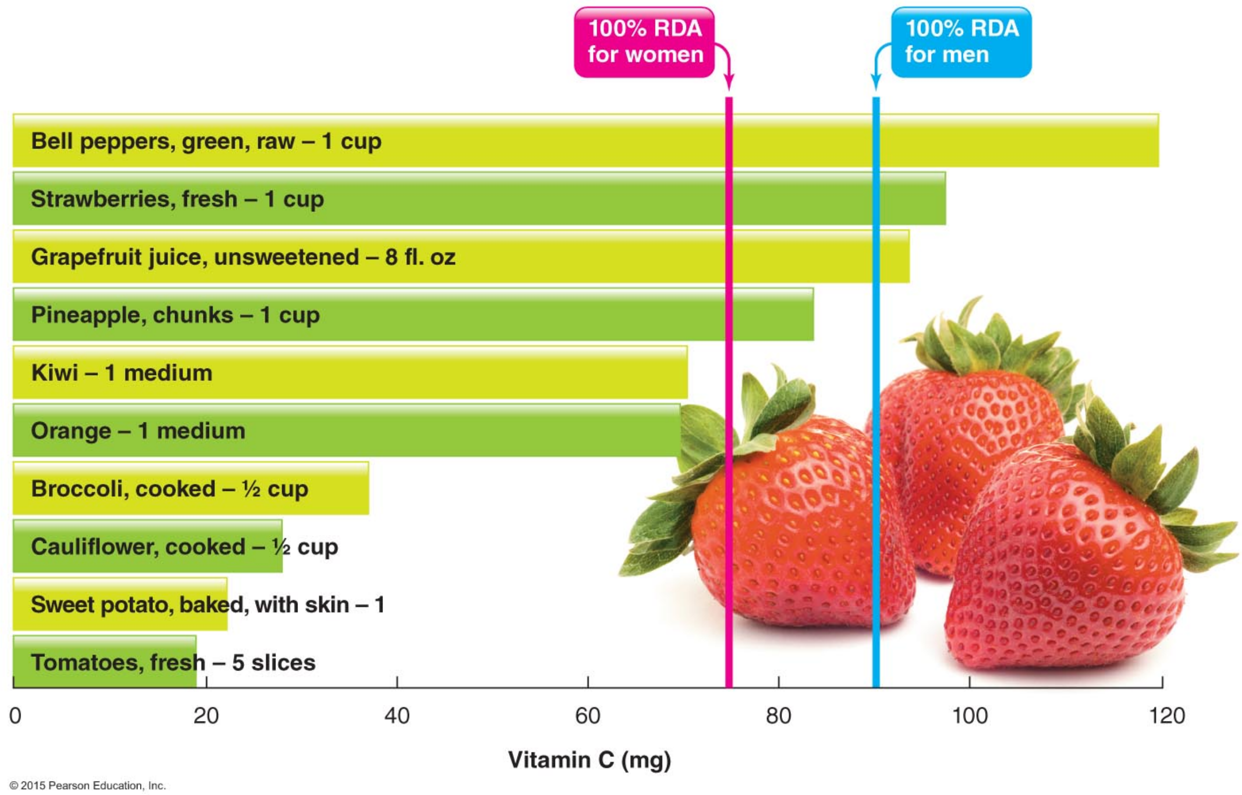



Figure 8.9: Common Food Sources of Vitamin C

- What if you consume too much vitamin C?
  - Megadoses (ten times or more of the recommended intake) of vitamin C can cause nausea, diarrhea, nosebleeds, and abdominal cramps
  - Can cause iron toxicity in people with hemochromatosis
  - Can lead to kidney stone formation in people with kidney disease
- What if you don't consume enough vitamin C?
  - Scurvy is the most common vitamin C deficiency disease
  - Bleeding gums, loose teeth, wounds that fail to heal, swollen ankles and wrists, bone pain and fractures, diarrhea, weakness, and depression
  - Anemia can also result from vitamin C deficiency

Figure 8.10: Scurvy

## 8.12 Selenium

- **Selenium** – a trace mineral found in a few amino acids in the body
- Functions of selenium
  - Antioxidant–part of the glutathione peroxidase enzyme system
  - Production of thyroxine, a thyroid hormone

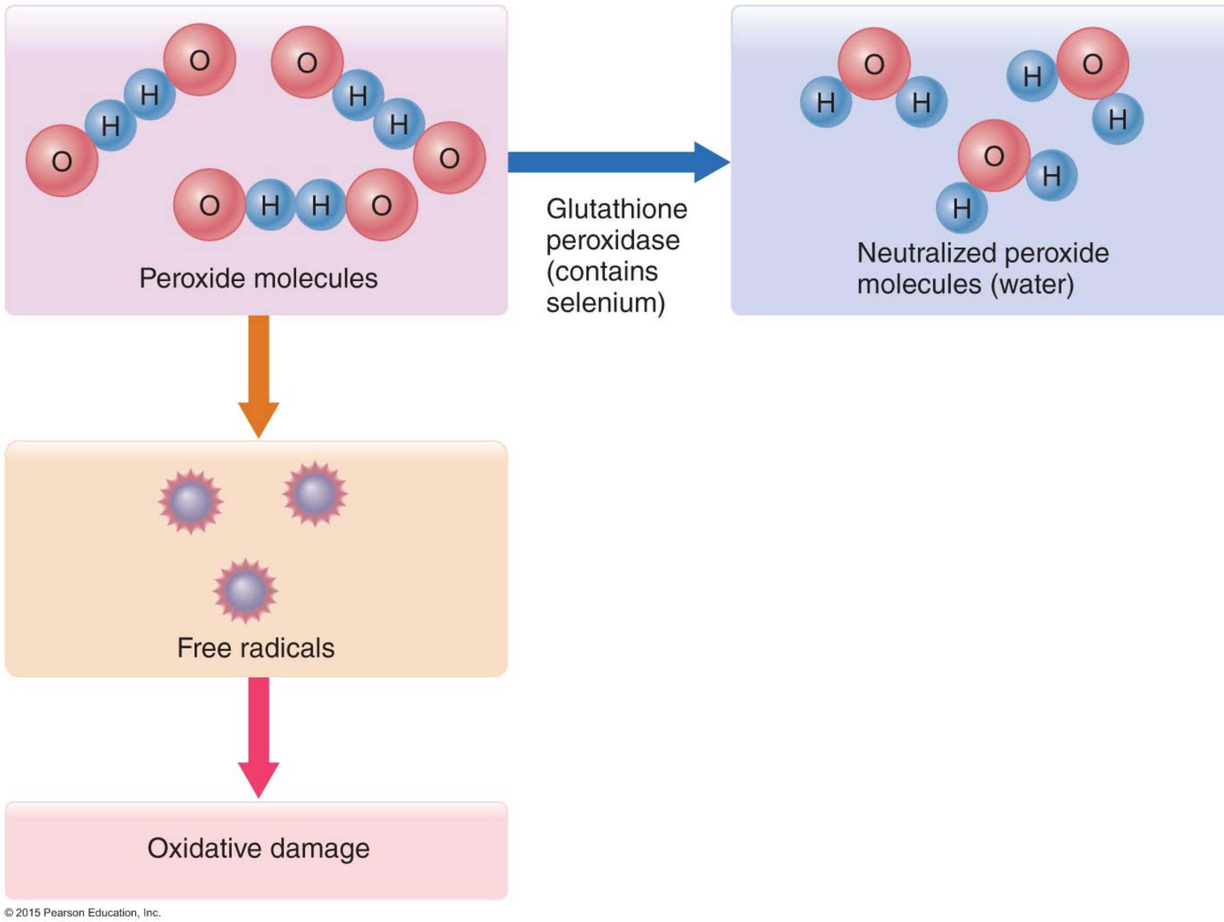



Figure 8.11: Neutralizing Peroxide Molecules

- Recommended intake
  - 55 µg/day for men and women
  - UL is 400 µg/day
- Sources of selenium
  - Rich sources include organ meats, pork, seafood, fish, and nuts

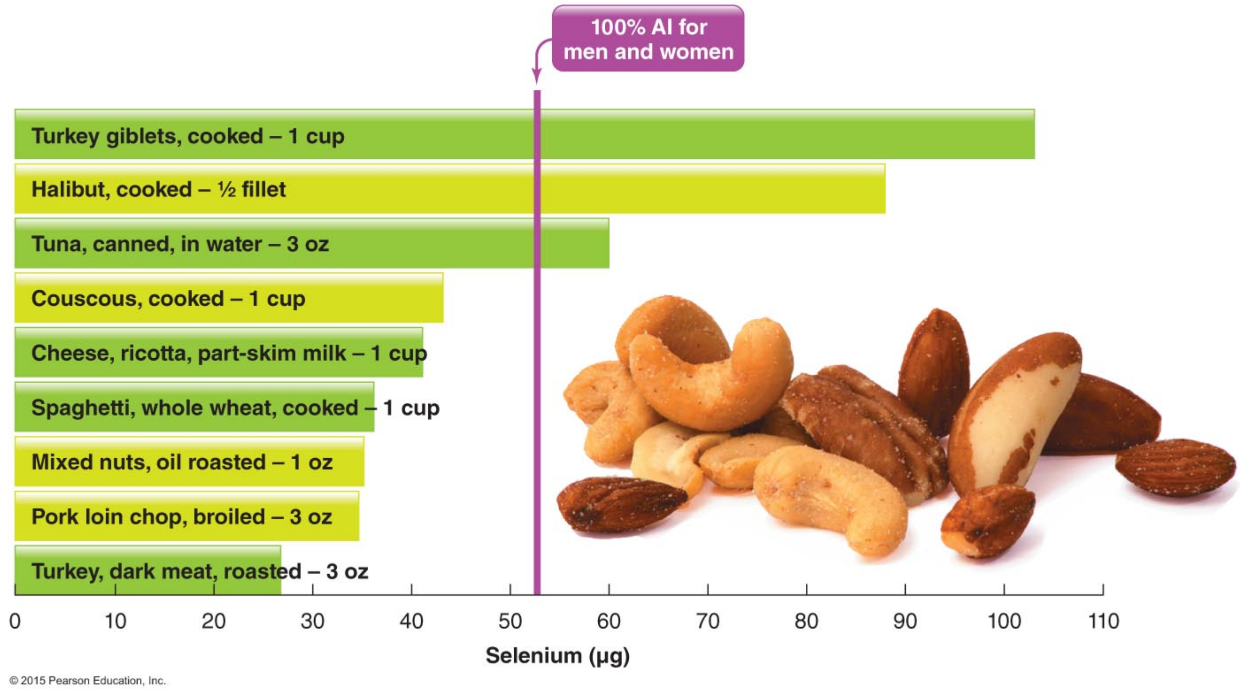



Figure 8.12: Common Food Sources of Selenium

- What if you consume too much selenium?
  - Selenium toxicity (brittle hair, nails, skin rashes) can result from supplements
- What if you don't consume enough selenium?
  - **Keshan disease** – a form of heart disease
  - **Kashin-Beck disease** – a type of arthritis

Figure 8.13: Kashin-Beck Disease

## 8.13 Copper, Iron, Zinc, and Manganese

**Cofactor** – a compound needed for proper functioning of an enzyme

- Copper, zinc, and manganese are cofactors for the superoxide dismutase antioxidant enzyme system
- Copper, iron, and zinc help us maintain the health of our blood
- Manganese is an important cofactor in carbohydrate (CHO) metabolism

## 8.14 Beta-Carotene

- In the class of chemicals called carotenoids
- A provitamin: inactive precursors that must be converted to the active form of a vitamin in the body
- The precursor of retinol, an active form vitamin A

- Functions of beta-carotene
  - A relatively weak antioxidant
  - Effective against oxidation in cell membranes and LDLs
- Carotenoids in general are known to
  - Enhance the immune system
  - Protect skin from damage by UV light
  - Protect eyes from damage
- Recommended intake
  - Beta-carotene is not considered an essential nutrient
  - No RDA has been established
- Sources of beta-carotene
  - Fruits and vegetables that are red, orange, yellow, and deep green
  - Carotenoids are better absorbed from cooked foods

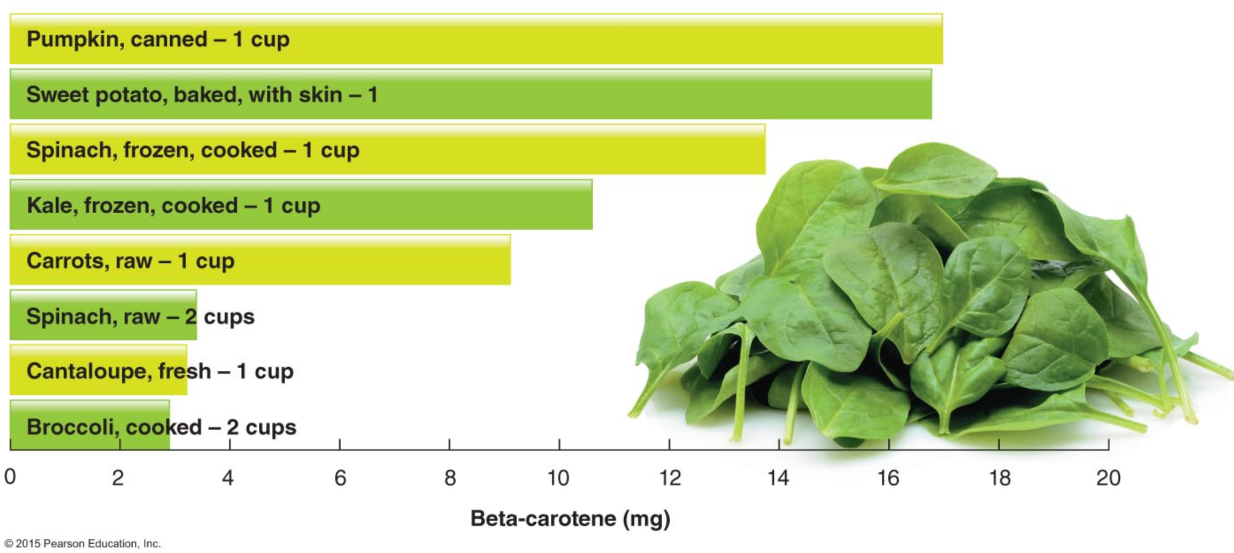



Figure 8.14: Common Food Sources of Beta-Carotene

- What if you consume too much beta-carotene?
  - Large quantities do not appear to be toxic
  - Skin may turn yellow or orange at high intakes; harmless and reversible
- What if you don't consume enough beta-carotene?
  - There are no known deficiency symptoms

## 8.15 Vitamin A

- Vitamin A is a fat-soluble vitamin
  - Excess vitamin A is stored in the liver, adipose tissue, kidneys, and lungs
  - There are three active forms of vitamin A
    * Retinol
    * Retinal
    * Retinoic acid

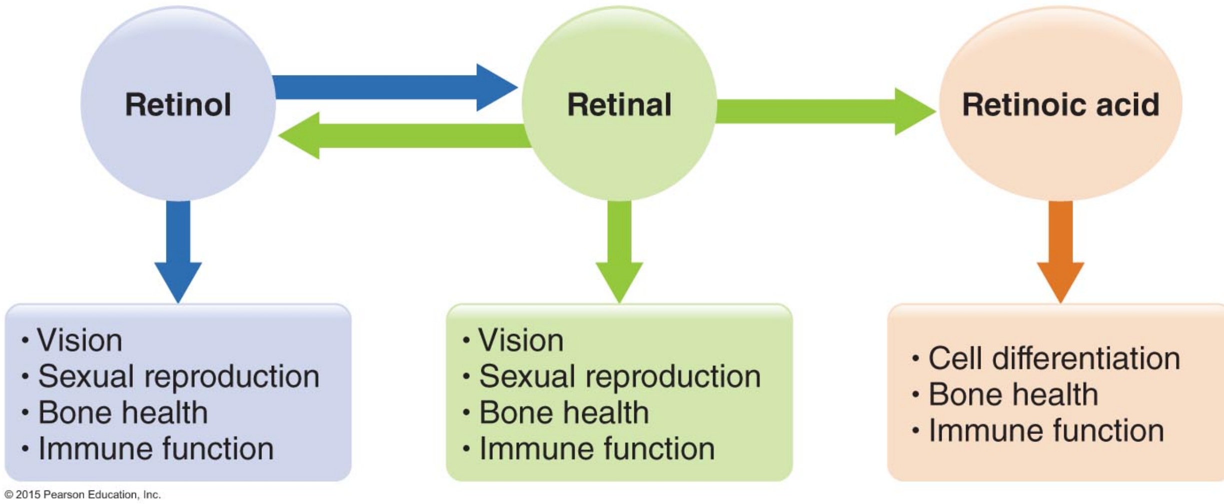



Figure 8.15: The Three Active Forms of Vitamin A

- Functions of vitamin A
  - Contributes to cell differentiation
  - Contributes to reproduction and bone growth
  - May act as an antioxidant
  - Essential to sight

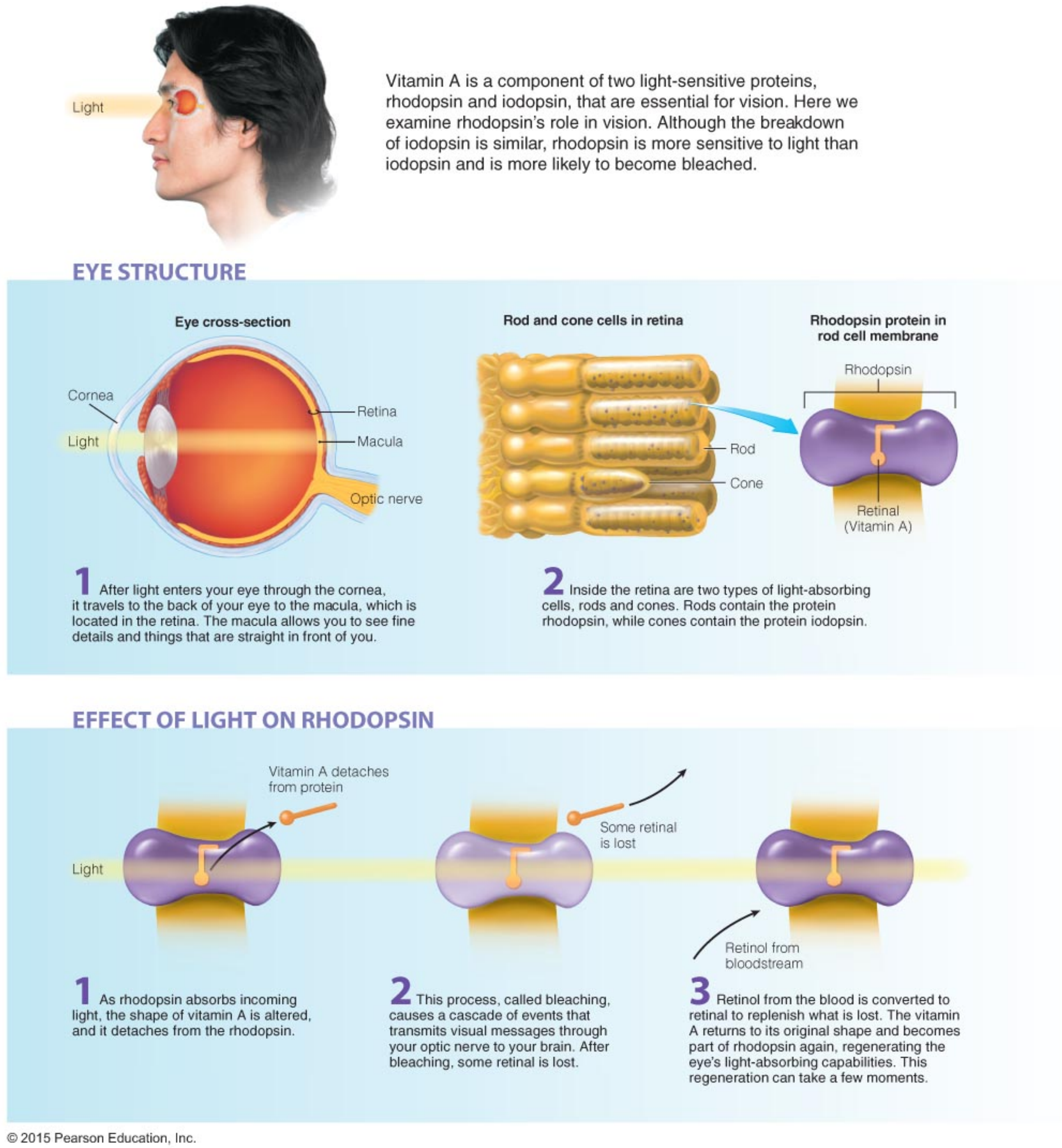



Figure 8.16: Vitamin A Is Essential to Sight


Figure 8.17: Vitamin A Is Essential to Sight

- Recommended intake
    - RDA is 900 µg/day for men, 700 µg/day for women
- Sources of vitamin A
    - Animal sources: liver, eggs
    - Plant sources such as the provitamin carotenoids (dark-green, orange, and deep-yellow fruits and vegetables)

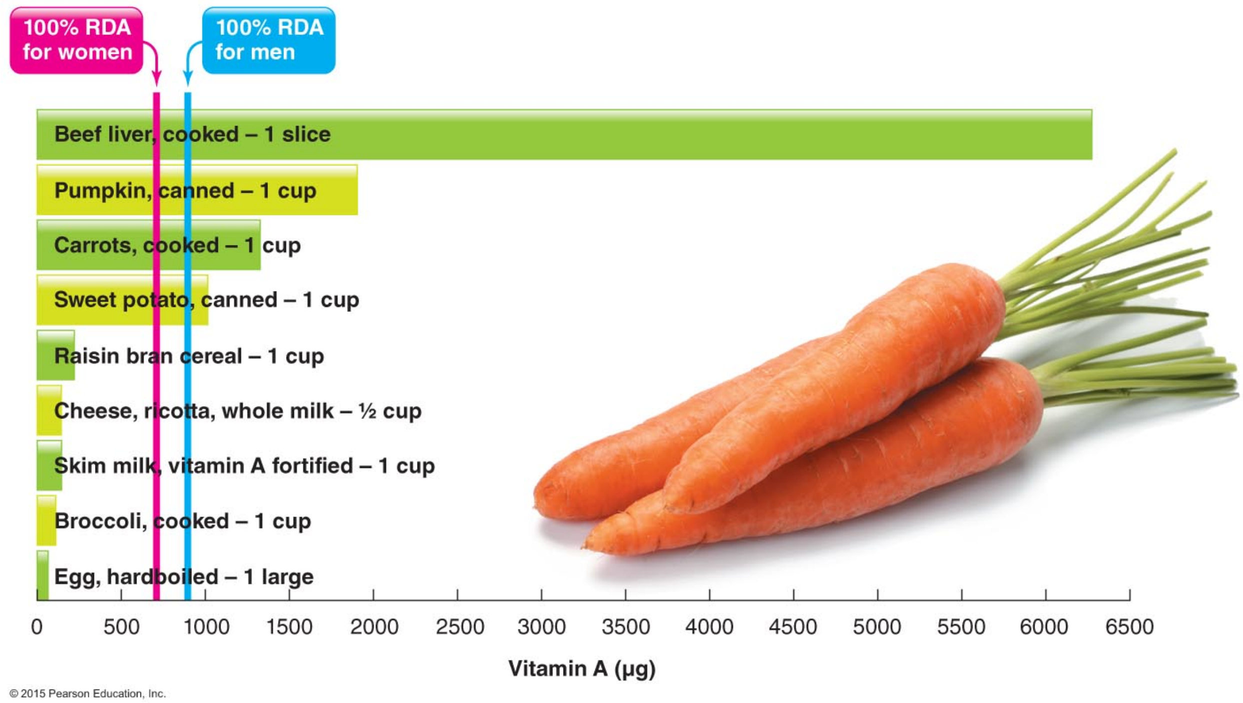



Figure 8.18: Common Food Sources of Vitamin A

- What if you consume too much vitamin A?
  - Vitamin A is highly toxic, especially from supplements
  - Birth defects and permanent damage to the liver and eyes can result
- What if you don't consume enough vitamin A?
  - Night blindness is the most common disease of vitamin A deficiency
  - Irreversible blindness (xerophthalmia)

## 8.16 In Depth: Cancer

- **Cancer** – a group of related diseases characterized by cells growing out of control
  - Composed of three steps
    - **Initiation** – a cell's DNA is mutated
    - **Promotion** – altered cell repeatedly divides
    - **Progression** – cells grow out of control

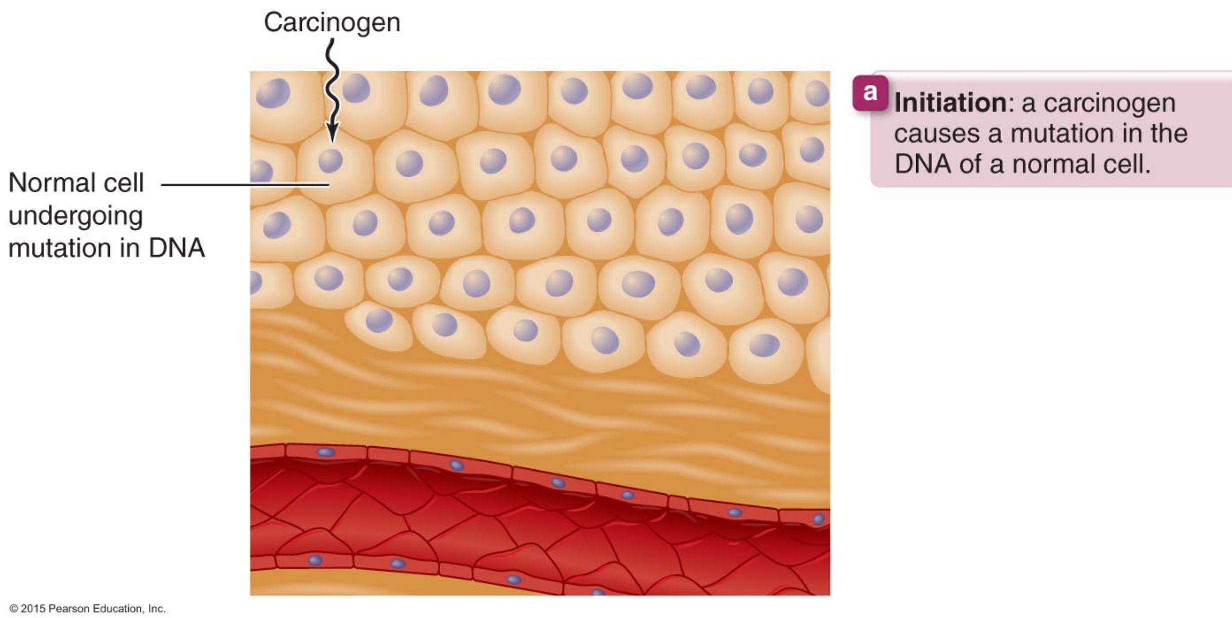



Figure 8.19: Cancer Initiation

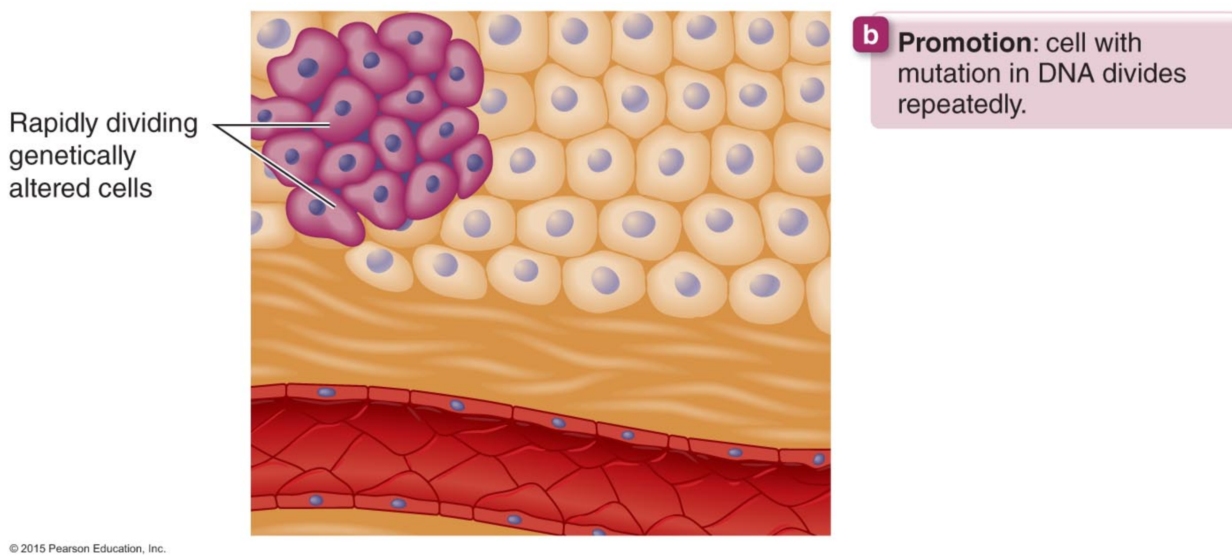



Figure 8.20: Cancer Promotion

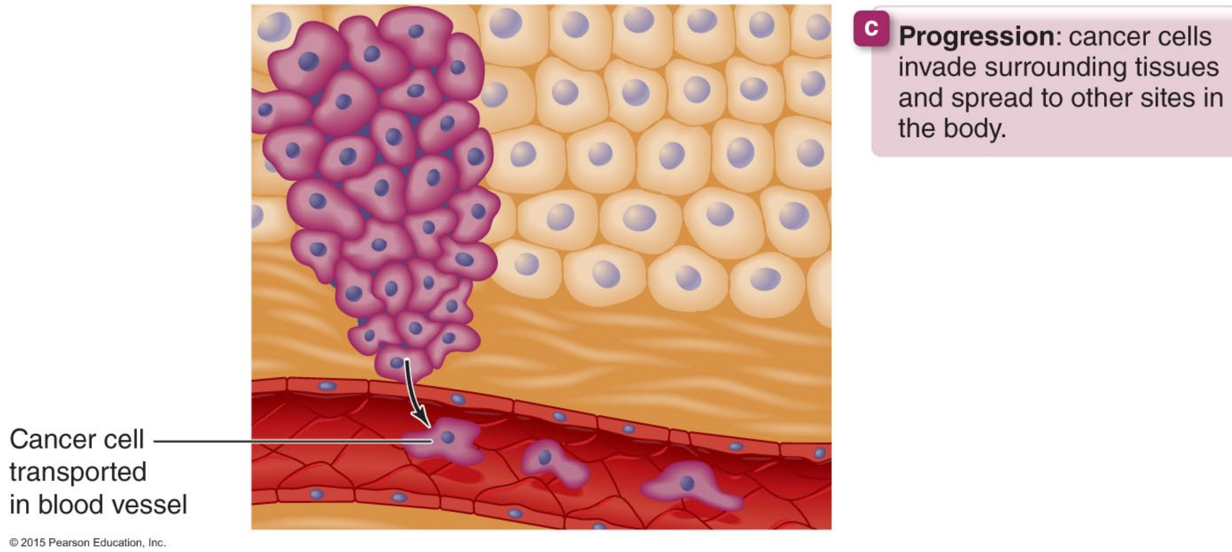



Figure 8.21: Cancer Progression

- Factors that increase cancer risk include
  - Family history of cancer
  - Tobacco use
  - Weight, poor diet, and sedentary lifestyle
  - Infectious agents (e.g., STDs)
  - Sun exposure (ultraviolet radiation)

Figure 8.22: A Normal Lung and the Lung of a Smoker

(a)

(b)

Figure 8.23: Effects of Tobacco Use

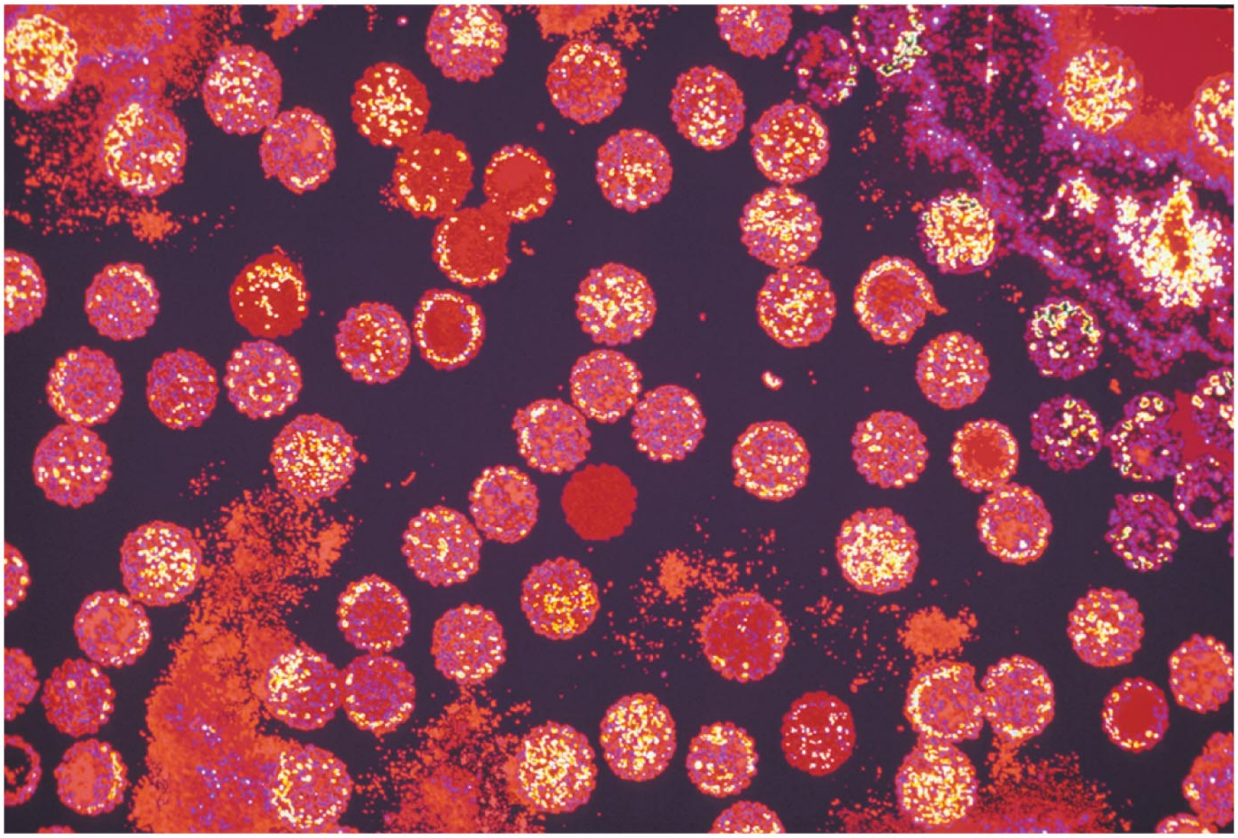


Figure 8.24: Human papillomavirus (HPV)

Figure 8.25: A Lesion Associated with Malignant Melanoma

### 8.16.1 Signs and Symptoms of Cancer

- Unexplained weight loss
- Fever
- Extreme fatigue
- Pain
- Skin changes
- Changes in bowel habits or bladder function
- Indigestion or trouble swallowing
- White patches inside the mouth or on the tongue
- Unusual bleeding or discharge
- Any thickening or lump
- Nagging cough or hoarseness

### 8.16.2 Cancer Treatments

- Treatment varies according to the location, the cell type, whether or not it has metastasized, and other individual factors
- Three major types of treatments:
  - Surgery
  - Radiation
  - Chemotherapy

### 8.16.3 Cancer Prevention

**Check:** get screenings and exams

**Quit:** stop smoking and alcohol abuse

**Move:** get regular physical activity

**Nourish:** maintain a recommended weight and eat a balanced, healthful diet

### 8.16.4 Role of Antioxidants in Cancer

- Antioxidants may contribute to reducing the risk of cancer
- Antioxidants may reduce cancer risk by
  - Enhancing the immune system
  - Preventing oxidative damage to cells
  - Inhibiting the growth of cancer cells and tumors
  - Inhibiting the capacity of cancer cells to avoid aging and programmed cell death (apoptosis)

# Chapter 9

# Nutrients Essential to Healthy Tissues

Table 9.1: Nutrients for Healthy Tissues

| Nutrient | Recommended Intake |
|---|---|
| Iron | RDA for 19 to 50 years of age:<br>Women 18 mg/day<br>Men = 8 mg/day |
| Zinc | RDA for 19 to 50 years of age:<br>Women = 8 mg/day<br>Men = 11 mg/day |
| Copper | RDA for 19 to 50 years of age: 90 $\mu$g/day |
| Vitamin B6 (pyridoxine) | RDA for 19 to 50 years of age: 1.3 mg/day<br>RDA for 51 years of age and older:<br>Women 1.5 mg/day<br>Men 1.7 mg/day |
| Folate (folic acid) | RDA for 19 years of age and older:<br>400 $\mu$g/day |
| Vitamin B12 (cobalamin) | RDA for 19 years of age and older:<br>2.4 $\mu$g/day |
| Vitamin K | Al for 19 to 50 years of age:<br>Women = 90 $\mu$g/day<br>Men 120 $\mu$g/day |
| Vitamin C | RDA for 19 years of age and older.<br>Women 75 mg/day<br>Men 90 mg/day<br>Smokers = 35 mg more per day than RDA |
| Calcium | RDA for 19 to 50 years of age: 1,000 mg/day<br>Women 51 years of age and older = 1,200 mg/day<br>Men 51 to 70 years of age = 1,000 mg/day; 70 years of age and older = 1,200 mg/day |
| Phosphorus | RDA for 19 years of age and older.<br>700 mg/day |
| Magnesium | RDA for 19 to 30 years of age:<br>Women = 310 mg/day<br>Men = 400 mg/day<br>RDA for 31 years of age and older:<br>Women = 320 mg/day<br>Men = 420 mg/day |
| Fluoride | RDA for 19 years of age and older:<br>Women = 3 mg/day |

## 9.1 Components of the Blood

- **Erythrocytes** – red blood cells
- **Leukocytes** – white blood cells; key to our immune function
- **Platelets** – cell fragments that assist in the formation of blood clots
- **Plasma** – the watery matrix of blood in which the cells and platelets flow

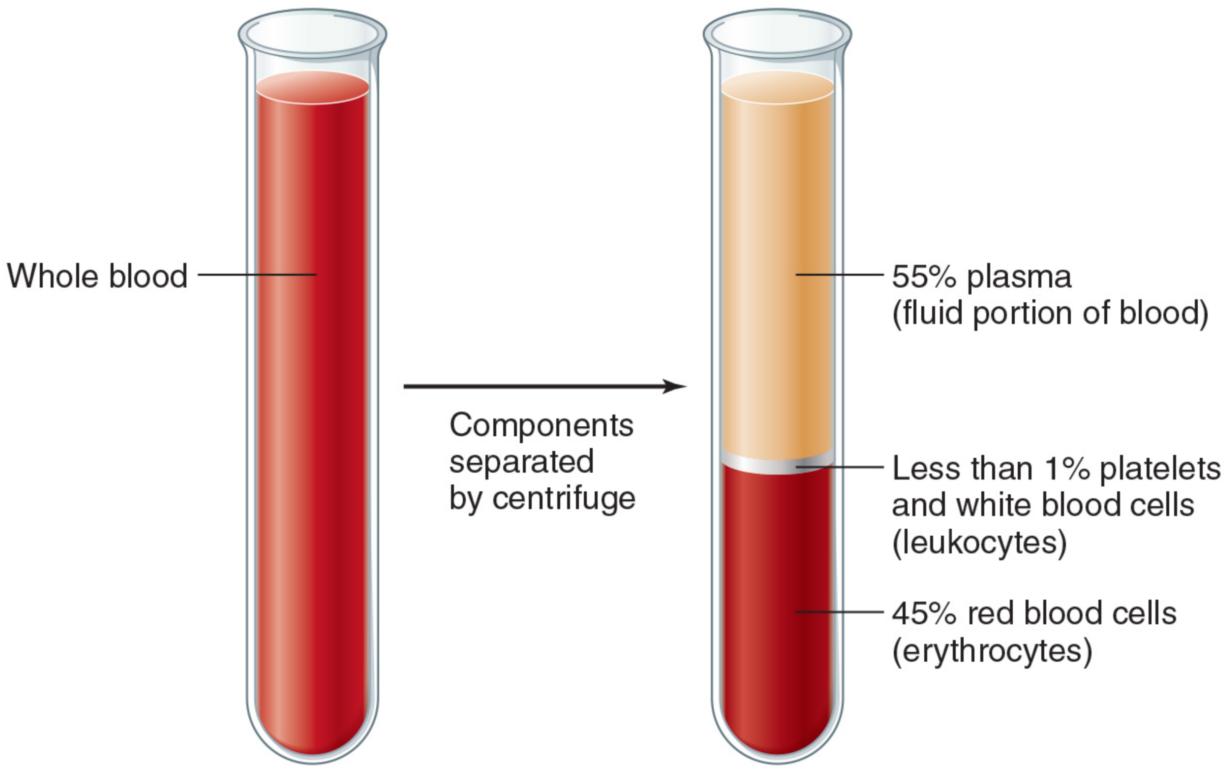



Figure 9.1: Components of the Blood

## 9.2 Iron

- Iron is a component of numerous proteins in the body
  - Approximately two-thirds of the body's iron is found in the hemoglobin, the oxygen-carrying protein, of the red blood cells
  - Iron can also be found in myoglobin, which is similar to hemoglobin but is found in the muscle cells

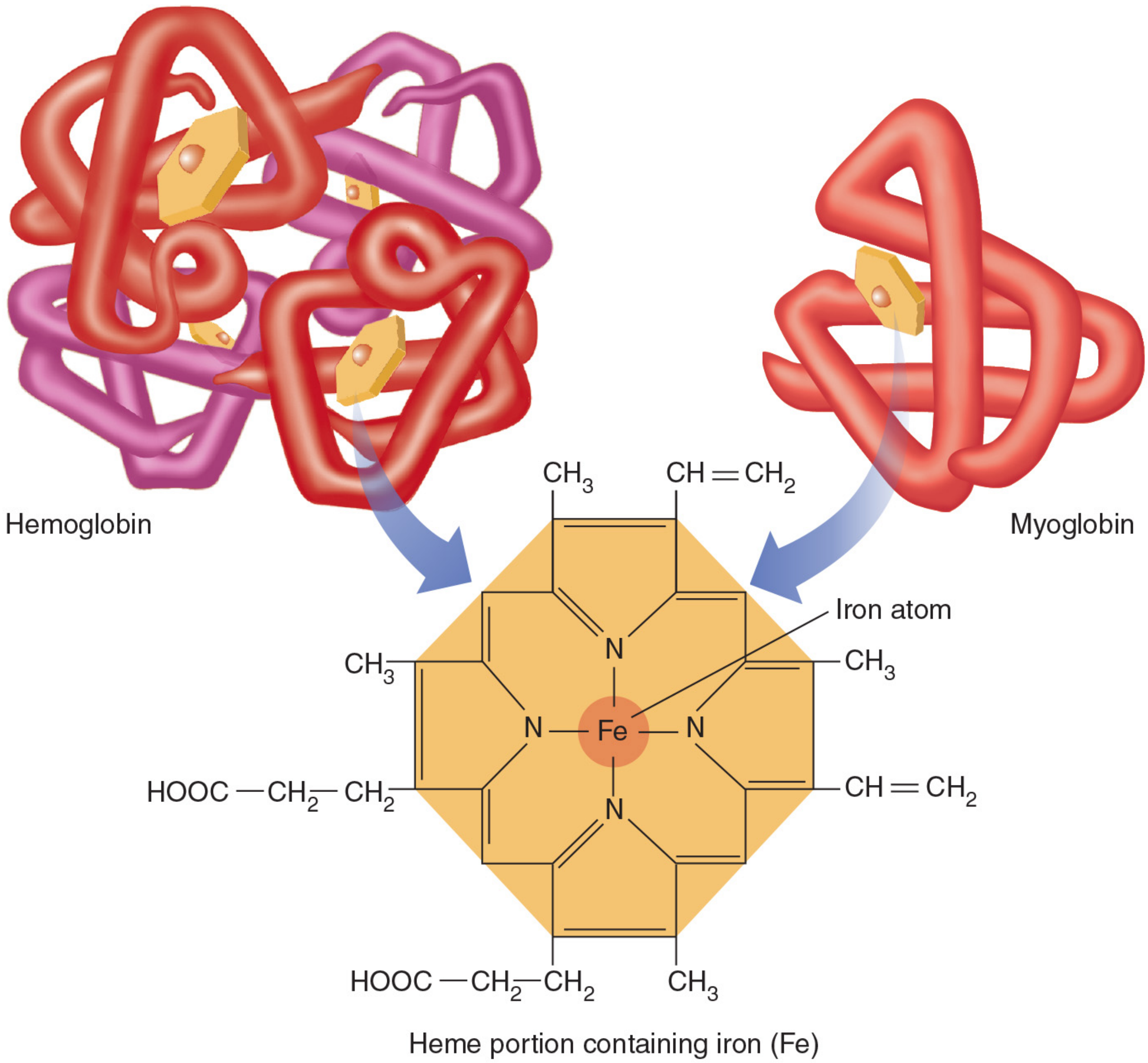



Figure 9.2: Iron

## 9.3 Iron Storage and Recycling

- Extra iron can be stored in the liver, intestinal mucosa, bone marrow, and spleen
- As red blood cells break down their iron is released and can be recycled
  - The liver and spleen are responsible for iron-recycling, which decreases our need for dietary iron

## 9.4 Iron Absorption

- The body's ability to absorb iron are influenced by:

    - Iron status
    - Stomach acid
    - Iron content in the diet
    - Type of iron consumed
    - Other dietary factors; phytates, polyphenols, and other minerals

- Sources: Beef, oysters, clams, turkey, chicken, pork, beans, lentils, spinach, tomatoes

Table 9.2: Circumstances Affecting Iron Status

| **Circumstances That Improve Iron Status** | **Circumstances That Diminish Iron Status** |
|---|---|
| • Use of oral contraceptives-reduces menstrual blood loss in women.<br>• Breastfeeding-delays resumption of menstruation in new mothers and thereby reduces menstrual blood loss. It is therefore an important health measure, especially in developing nations.<br>• Consumption of iron-containing foods and supplements. | • Use of hormone replacement therapy–can cause uterine bleeding.<br>• Eating a vegetarian diet–reduces or eliminates sources of heme iron.<br>• Intestinal parasitic infection–causes intestinal bleeding. Iron-deficiency anemia is common in people with intestinal parasitic infection.<br>• Blood donation–reduces iron stores; people who donate frequently, particularly premenopausal women, may require iron supplementation.<br>• Intense endurance exercise training–appears to increase risk for inflammation, suboptimal iron intake, increased iron loss due to rupture of red blood cells, and losses in sweat and feces. |

Source: Data from Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc © 2002 by the National Academy of Sciences, National Academies Press.

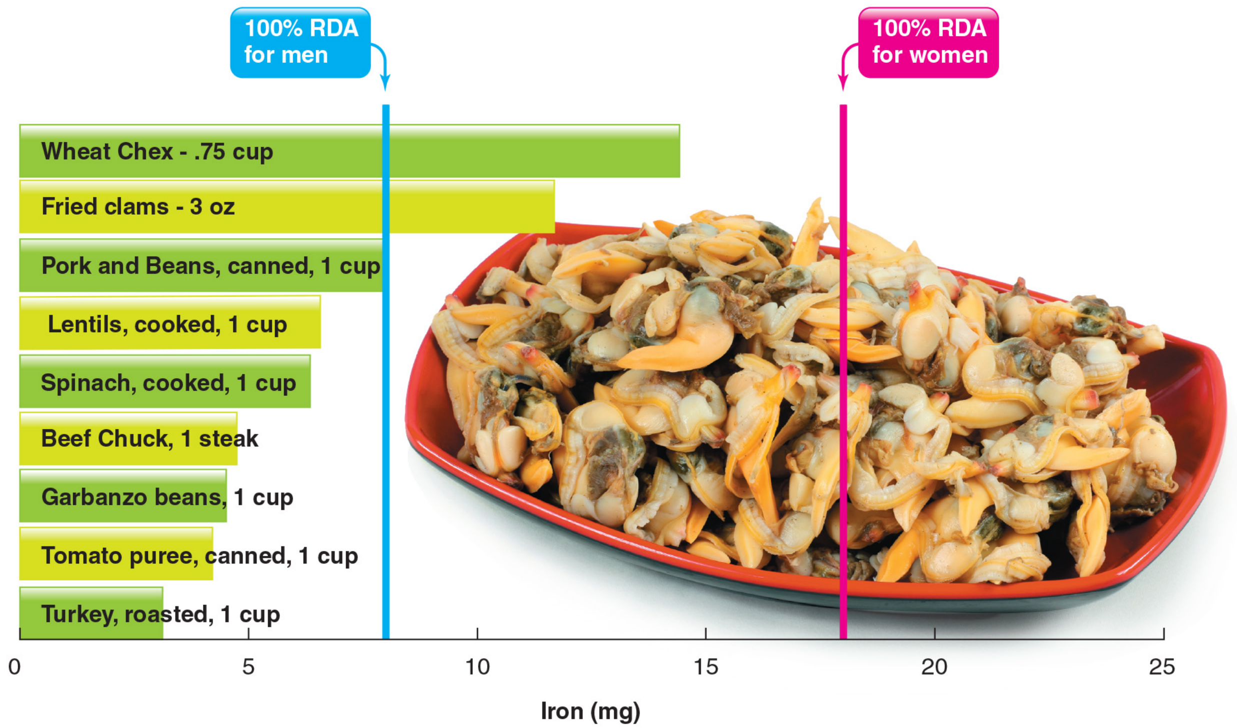



Figure 9.3: Common Food Sources of Iron

- Iron toxicity
  - In the U.S. accidental iron overdose is the leading cause of death in children under 6
  - Can cause nausea and constipation in mild cases
- Iron deficiency
  - Iron deficiency anemia causes the red blood cells to be smaller and paler than normal

## 9.5 Zinc

- Functions of zinc include
  - Enzymatic functions–over 300 enzymes in the human body use zinc
  - Structural functions–helps to stabilize proteins so that they function properly
  - Regulatory functions–helps to regulate gene expression

  Only 10–35% of dietary zinc is absorbed Factors decreasing absorption include:

  - Non-heme iron intake
  - Phytates

  - Fiber

- Sources
  - Oysters
  - Beef
  - Crab
  - Lobster
  - Pork
  - Cashews
  - Garbanzo beans
  - Cheese
  - Yogurt

- Toxicity is rare, but is mainly seen with over consumption of zinc supplements

- Deficiency is rare in the U.S. but can be seen in other countries where diets are predominantly bread or grain based
  - Symptoms include growth retardation, delayed sexual maturation, and increased risk of infections

## 9.6 Copper

- Trace mineral that is crucial for blood health
  - Component of ceruloplasmin
    * Protein used in iron transport
  - Energy metabolism
  - Building of connective tissues

- Sources:
  - Oysters
  - Lobster
  - Nuts
  - Seeds
  - Pork
  - Spinach

- Toxicity is not well studied in humans

- Deficiencies are rare but can lead to
  - Inhibition of hemoglobin synthesis
  - Inadequate iron utilization
  - Microcytic anemia

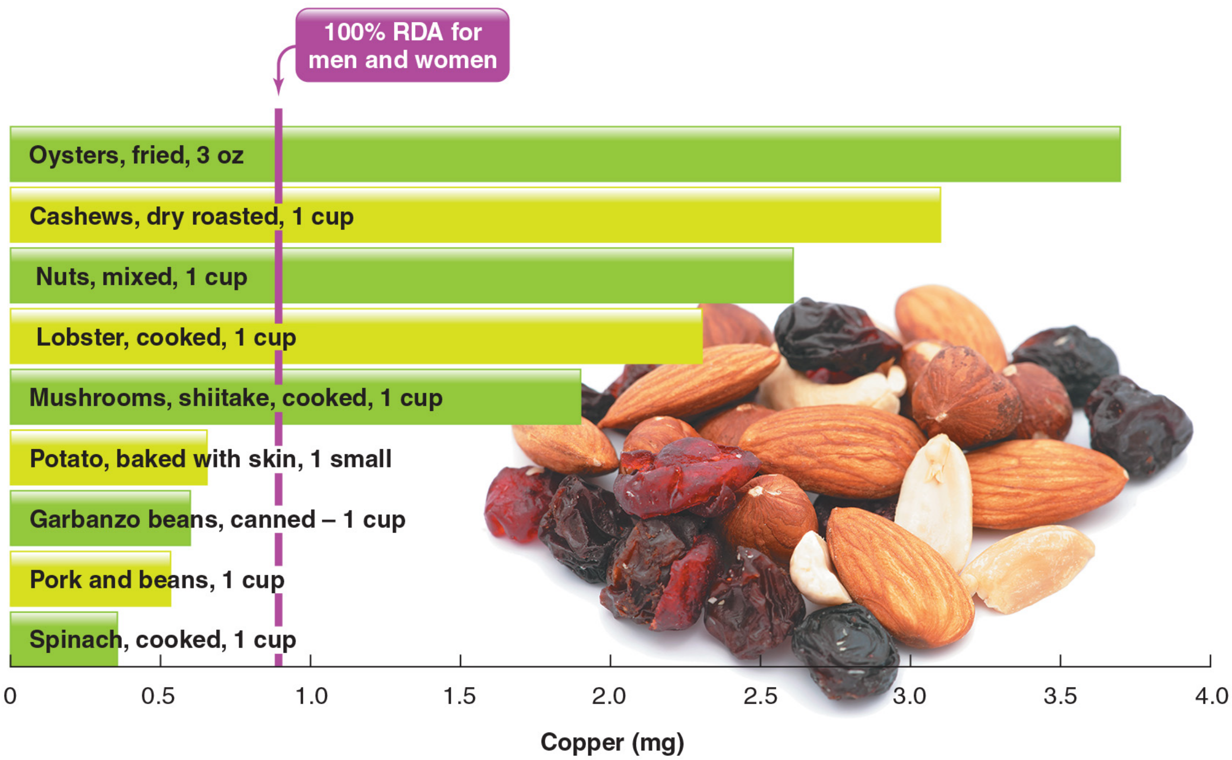



Figure 9.4: Copper

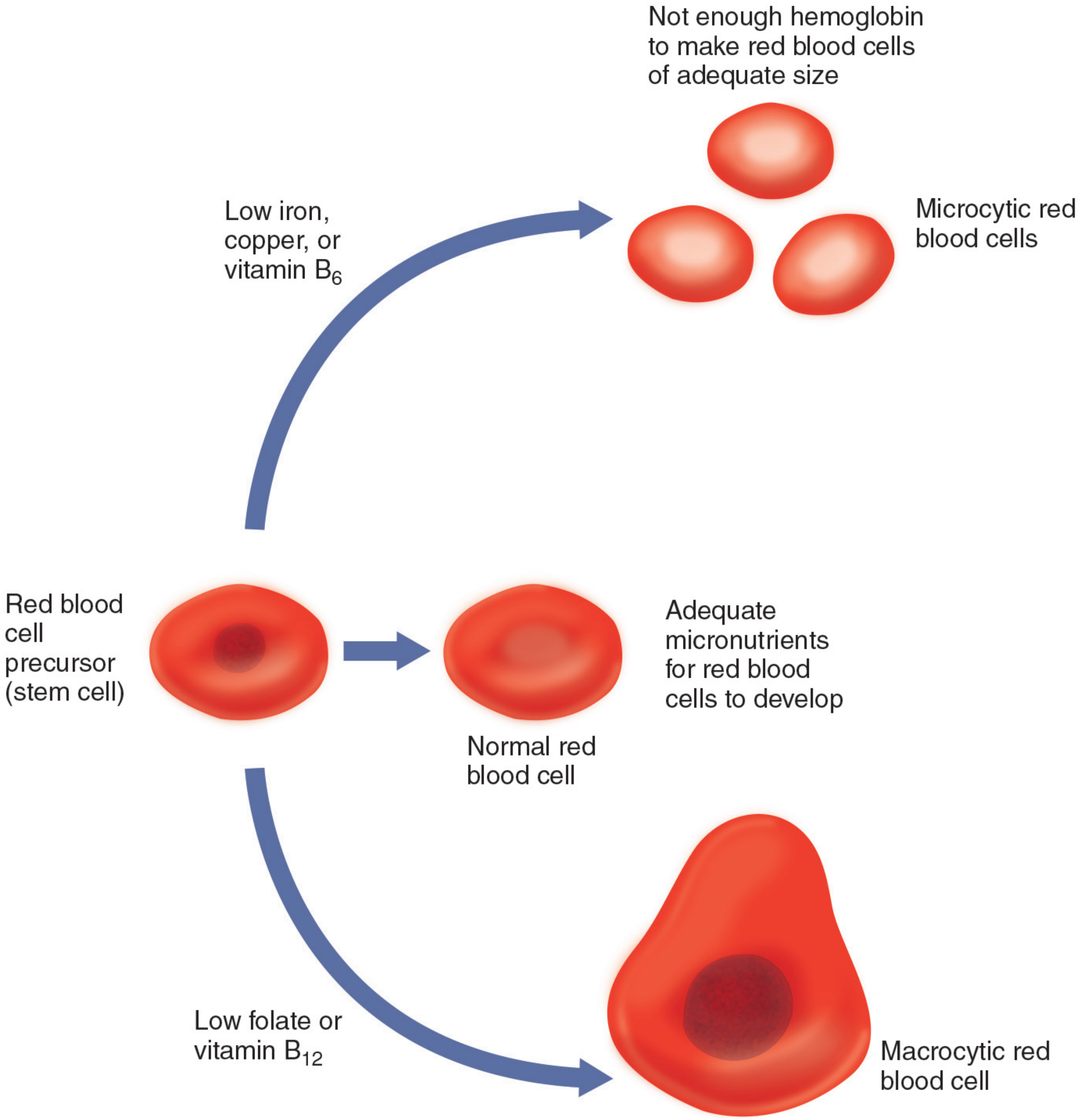



Figure 9.5: Vitamin Roles in Blood Formation

## 9.7 Vitamin K

- Fat-soluble vitamin
- Stored primarily in the liver

- Types:
  - **Phylloquinone** – plant form of vitamin K
  - **Menaquinone** – form of vitamin K produced by bacteria in the large intestine
- Functions of vitamin K
  - Blood clotting (prothrombin synthesis)
  - Bone metabolism (osteocalcin synthesis)
- Recommended intake
  - There is no RDA for vitamin K
  - AI values are 120 $\mu$g/day for men and 90 $\mu$g/day for women
- Sources of vitamin K
  - Green leafy vegetables, vegetable oils
- What if you consume too much vitamin K?
  - No side effects from large quantities
- What if you don't consume enough vitamin K?
  - Reduced blood clotting, excessive bleeding
  - Occurs with diseases that limit absorption of fat in the small intestine

## 9.8 Vitamin C

- Vitamin C helps to produce and maintain healthy collagen
  - Collagen is a fibrous protein found in the bone, teeth, tendons, blood vessels, and gum tissue
- Assists in the synthesis of
  - DNA
  - Bile
  - Serotonine
  - Carnitine
- Recommended intake
  - 90 mg/day for men; 75 mg/day for women
  - Smokers need an extra 35 mg/day

  - UL is 2,000 mg/day for adults
- Sources of vitamin C
  - Fresh fruits and vegetables
  - Heat destroys vitamin C
  - Cooking foods lowers their vitamin C content

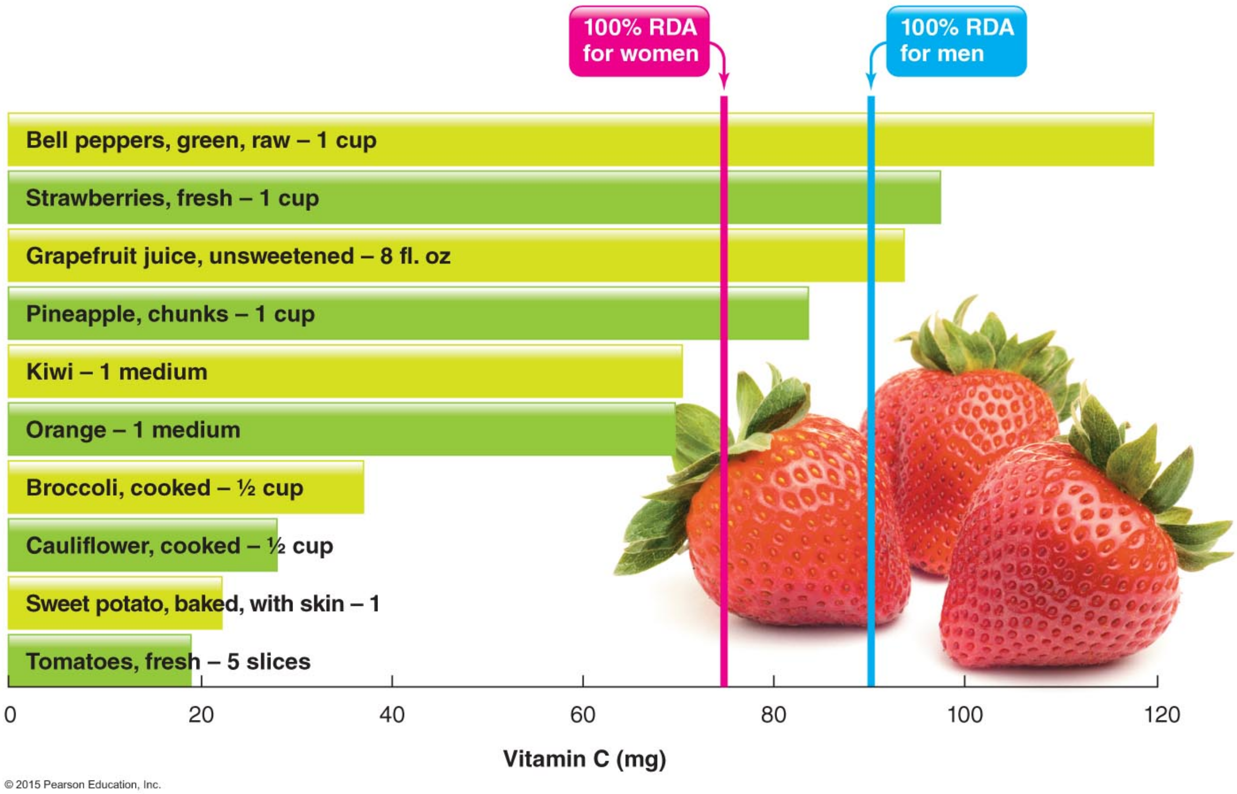



Figure 9.6: Common Food Sources of Vitamin C

- What if you consume too much vitamin C?
  - Megadoses (ten times or more of the recommended intake) of vitamin C can cause nausea, diarrhea, nosebleeds, and abdominal cramps
  - Can cause iron toxicity in people with hemochromatosis
  - Can lead to kidney stone formation in people with kidney disease
- What if you don't consume enough vitamin C?
  - Scurvy is the most common vitamin C deficiency disease
    * Bleeding gums, loose teeth, wounds that fail to heal, swollen ankles and wrists, bone pain and fractures, diarrhea, weakness, and depression

  - Anemia can also result from vitamin C deficiency

Figure 9.7: Scurvy

## 9.9 Bone Health

- Bone structure
  - Provides strength to support the body
  - Allows for flexibility
  - Contains about 65% minerals, providing the hardness of bone
  - Contains 35% organic structures for strength, durability, and flexibility
  - **Collagen** – fibrous protein in bone tissue

Table 9.3: Functions of Bone in the Human Body

| Functions Related to Structure and Support | Functions Related to Metabolic Processes |
|---|---|
| • Bones provide physical support for organs and body segments.<br>• Bones protect vital organs; for example, the rib cage protects the lungs, the skull protects the brain, and the vertebrae of the spine protect the spinal cord.<br>• Bones work with muscles and tendons to allow movement-muscles to attach to bones via tendons, and their contraction produces movement at the body's joints. | • Bone tissue acts as a storage reservoir for many minerals, including calcium, phosphorus, and fluoride. The body draws upon such deposits when these minerals are needed for various body processes; however, this can reduce bone mass.<br>• Most blood cells are produced in the bone marrow. |

- Two types of bone tissue
  - **Cortical bone (compact bone)** – very dense tissue making up 80% of the skeleton
    - Outer surface of all bones
    - Many of the small bones (wrists, hands, feet)
  - **Trabecular bone (spongy bone)** – "scaffolding" on the inside of bones; supports cortical bone and makes up 20% of the skeleton
    - Faster turnover rate

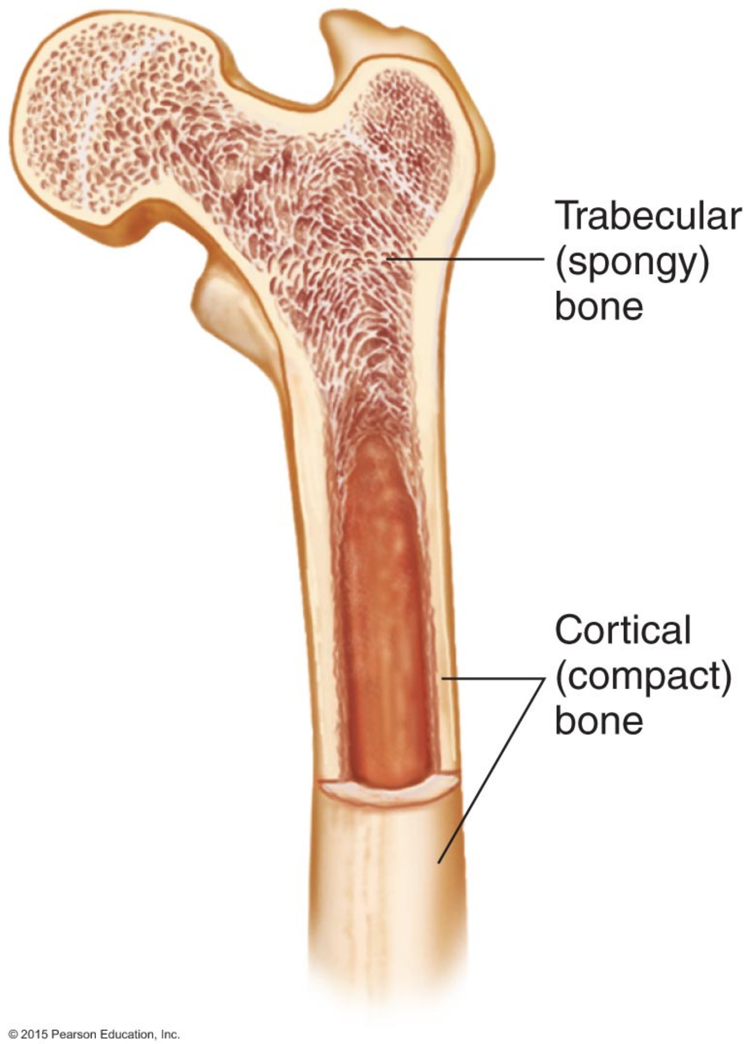



Figure 9.8: Bone Structure

- Bones develop through three processes

  **Bone growth** increase in bone size

  **Bone modeling** shaping of bone

  - Size and shape do not change significantly after puberty
  - **Bone density** – degree of compactness of bone tissue; continues to develop into early adulthood

  **Bone remodeling** reshaping of bone; occurs throughout life

  - Bone remodeling involves
    - **Resorption** – surface of bones is broken down by osteoclasts
      - **Osteoclasts** – cells that erode the surface of bones
    - Formation of new bone by cells called osteoblasts
      - Osteoblasts produce the collagen-containing component of bone

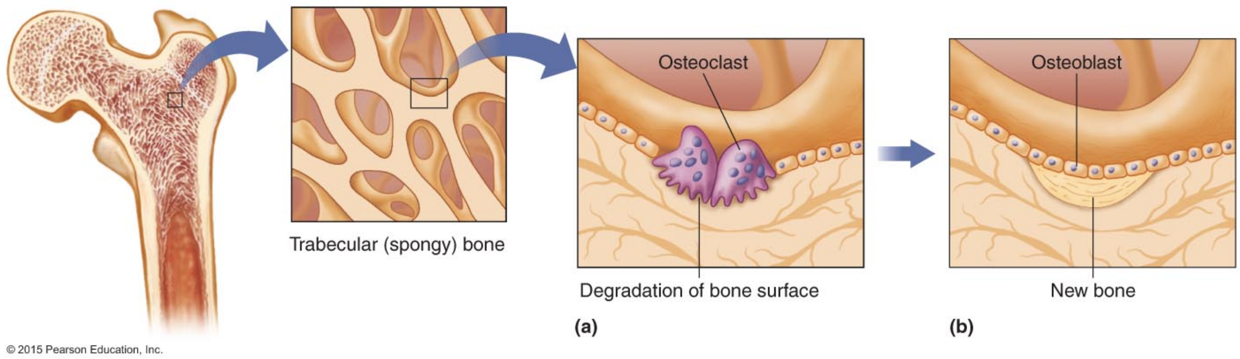



Figure 9.9: Bone Remodeling

## 9.10 Assessing Bone Health

- Dual-energy x-ray absorptiometry (DXA or DEXA)
  - Measures bone density
  - Uses very-low-level x-ray energy
  - Provides a full body scan or can be used to scan peripheral regions (hip, wrist, heel)
  - Is a noninvasive procedure
  - Recommended for postmenopausal women
  - A T-score is obtained, which compares bone density to that of a healthy 30-year-old

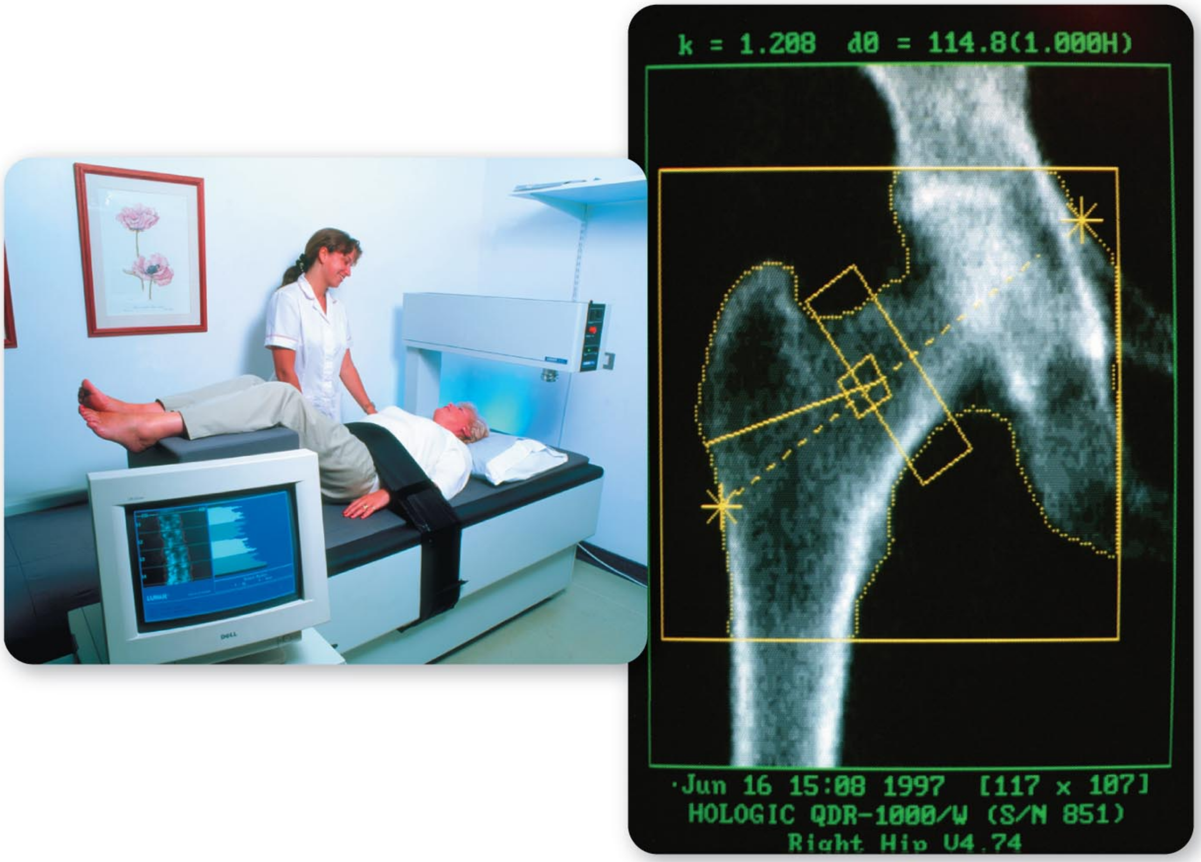



Figure 9.10: DXA

## 9.11 Calcium

- The most abundant major mineral in the body
  - 99% of body calcium is found in bone
  - 1% is found in blood and soft tissues
- Functions of calcium
  - Forms and maintains bones and teeth
  - Assists with acid–base balance
  - Critical for normal transmission of nerve impulses
  - Assists in muscle contraction
- Blood calcium level is tightly controlled
- Low calcium level
  - Parathyroid hormone (PTH) is released

  - PTH stimulates activation of vitamin D
  - PTH and vitamin D cause
    * Kidneys to retain more calcium
    * Osteoclasts to break down bone and release calcium
    * Stimulation of calcium absorption from intestines
- High calcium level
  - Thyroid gland releases calcitonin
  - Calcitonin functions to
    * Prevent calcium reabsorption from kidneys
    * Limit calcium absorption from intestines
    * Inhibit osteoclasts from breaking down bone

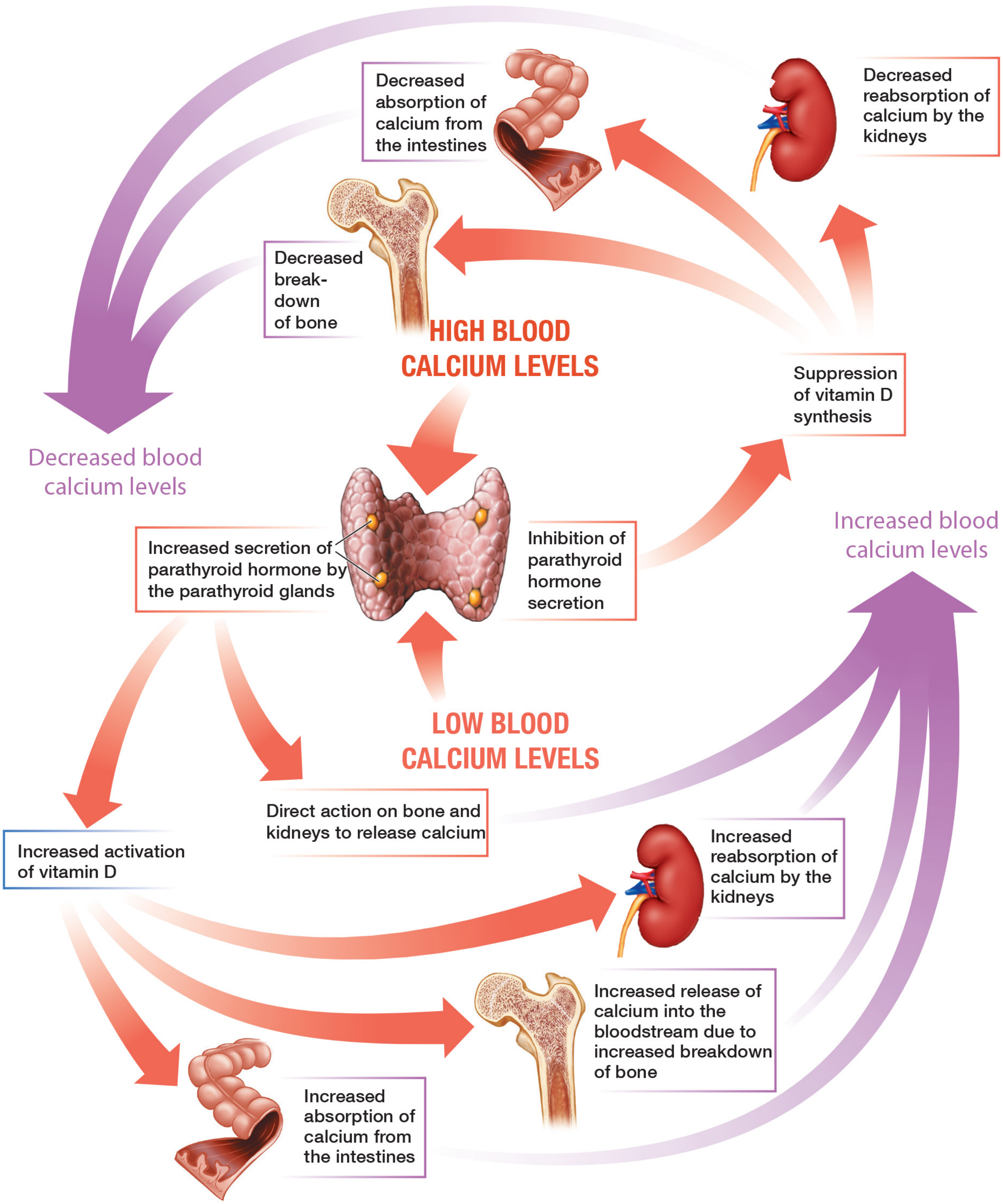



Figure 9.11: Regulation of Blood Calcium Levels

- Sources:
  - Dairy

- Collard greens
- Sardines
- Kale
- Tofu

- Bioavailability: degree to which a nutrient is absorbed
- Calcium bioavailability depends on need and age
  - Infants, children, and adolescents can absorb more than 60%
  - Pregnant and lactating women can absorb 50%
  - Healthy adults typically absorb 30%
  - Older adults absorb less
  - Bodies cannot absorb over 500 mg at one time
  - Numerous factors in food influence absorption

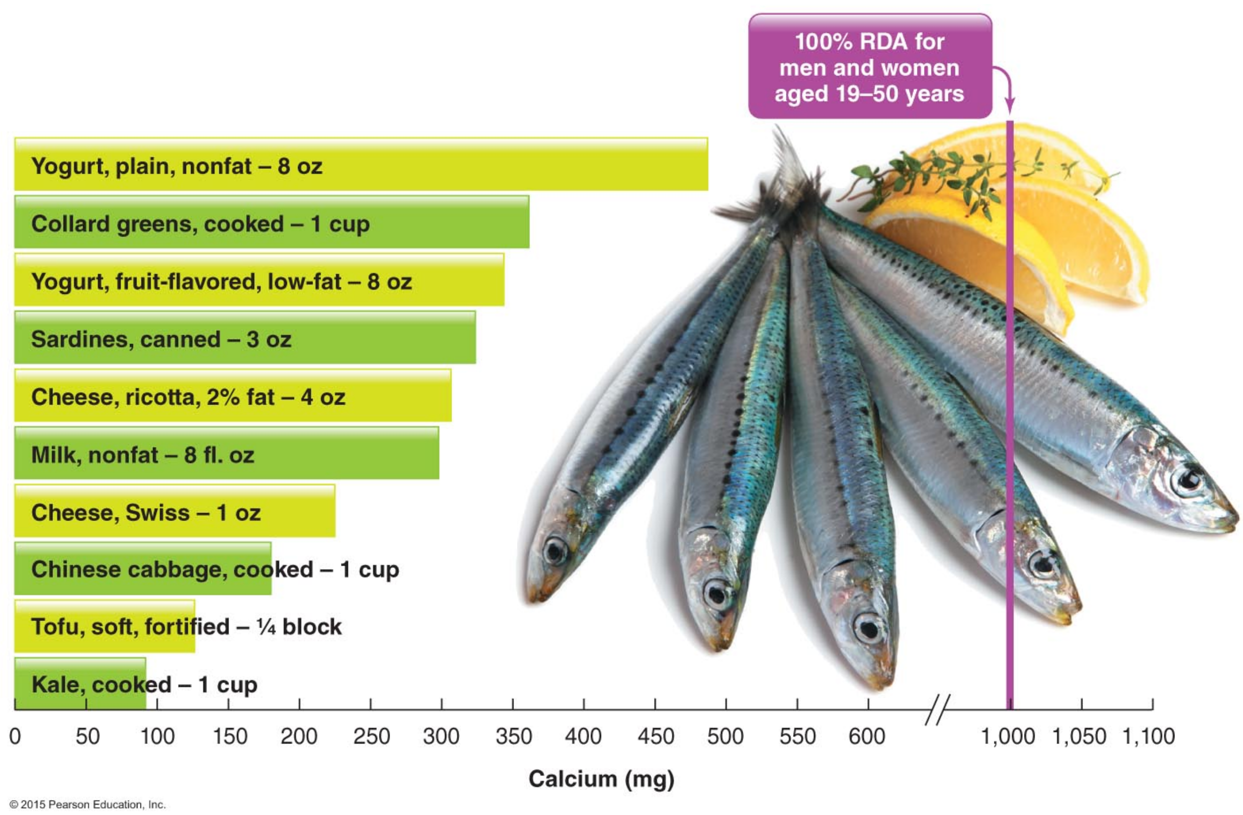



Figure 9.12: Common Food Sources of Calcium

- What if you consume too much calcium?
  - Excess calcium is excreted from the body

  - Calcium supplements can lead to mineral imbalances
  - Hypercalcemia (high blood calcium) can be caused by cancer and overproduction of PTH
- What if you don't consume enough calcium?
  - Hypocalcemia (low blood calcium) can be caused by kidney disease or vitamin D deficiency

## 9.12 Phosphorus

- Phosphorus (as phosphate) is the primary intracellular negatively charged electrolyte
- Functions of phosphorus
  - Critical to mineral composition of bone
  - Required for proper fluid balance
  - Component of lipoproteins, cell membranes, DNA and RNA, and several energy molecules
- Recommended intake
  - RDA for phosphorus is 700 mg/day
- Sources of phosphorus
  - High in protein-containing foods such as milk, meats, and eggs
  - In processed foods as a food additive
  - In soft drinks as phosphoric acid
- What if you consume too much phosphorus?
  - Kidney disease and excessive vitamin D supplements or consumption of too many phosphorus-containing antacids can cause elevated phosphorus levels, muscle spasms, and convulsions
- What if you don't consume enough phosphorus?
  - Deficiencies are rare in healthy adults
  - Malnutrition, critical illness

## 9.13 Magnesium

- The bones contain 50–60% of the body's magnesium
- Functions of magnesium
  - A mineral found in bone structure
  - Cofactor for over 300 enzyme systems
  - Required for the production of ATP
  - Plays an important role in DNA and protein synthesis and repair
- Recommended intake
  - RDA varies based on age and gender
  - 310 mg/day for women aged 19–30
  - 400 mg/day for men aged 19–30
- Sources of magnesium
  - Green leafy vegetables, whole grains, seeds, nuts, seafood, beans, some dairy products

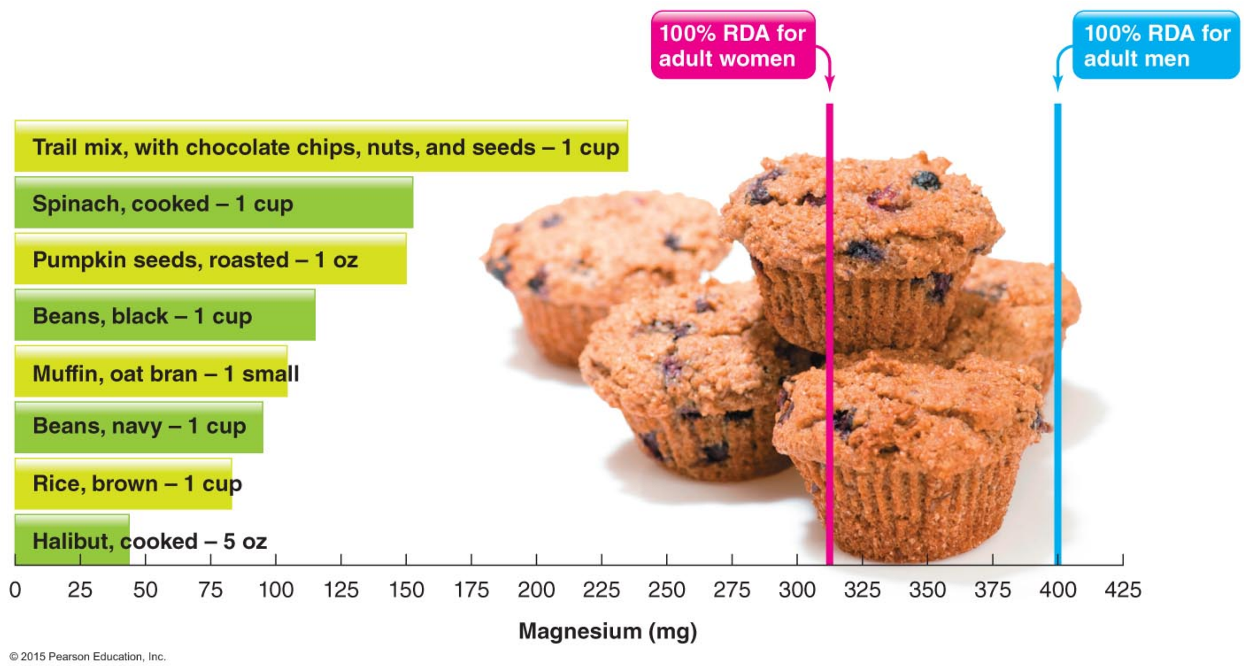



Figure 9.13: Common Food Sources of Magnesium

- What if you consume too much magnesium?
  - No toxicity from magnesium in food

- Magnesium supplements can cause diarrhea, nausea, cramps, dehydration, and cardiac arrest
- **Hypermagnesemia** – high blood magnesium levels

- What if you don't consume enough magnesium?
  - Hypomagnesemia can result in low blood calcium and osteoporosis
  - Other symptoms include muscle cramps, spasms, nausea, weakness, and confusion

## 9.14 Fluoride

- Fluoride is a trace mineral
  - 99% of the body's fluoride is stored in teeth and bones
- Functions of fluoride
  - Development and maintenance of teeth and bones
  - Combines with calcium and phosphorus to make tooth enamel stronger, which protects teeth from dental caries (cavities)
- Recommended intake
  - RDA for women is 3 mg/day
  - RDA for men is 4 mg/day
- Sources of fluoride
  - Fluoridated dental products
  - Fluoridated water
- What if you consume too much fluoride?
  - **Fluorosis (excess fluoride)** – creates porous tooth enamel; teeth become stained and pitted
- What if you don't consume enough fluoride?
  - Dental caries (cavities)

Figure 9.14: Fluorosis

## 9.15 Vitamin D

- Fat-soluble vitamin
- Excess is stored in liver and fat tissue
- Can be synthesized by the body by exposure to UV light from the sun
- Is considered a hormone because it is synthesized in one location and acts in other locations

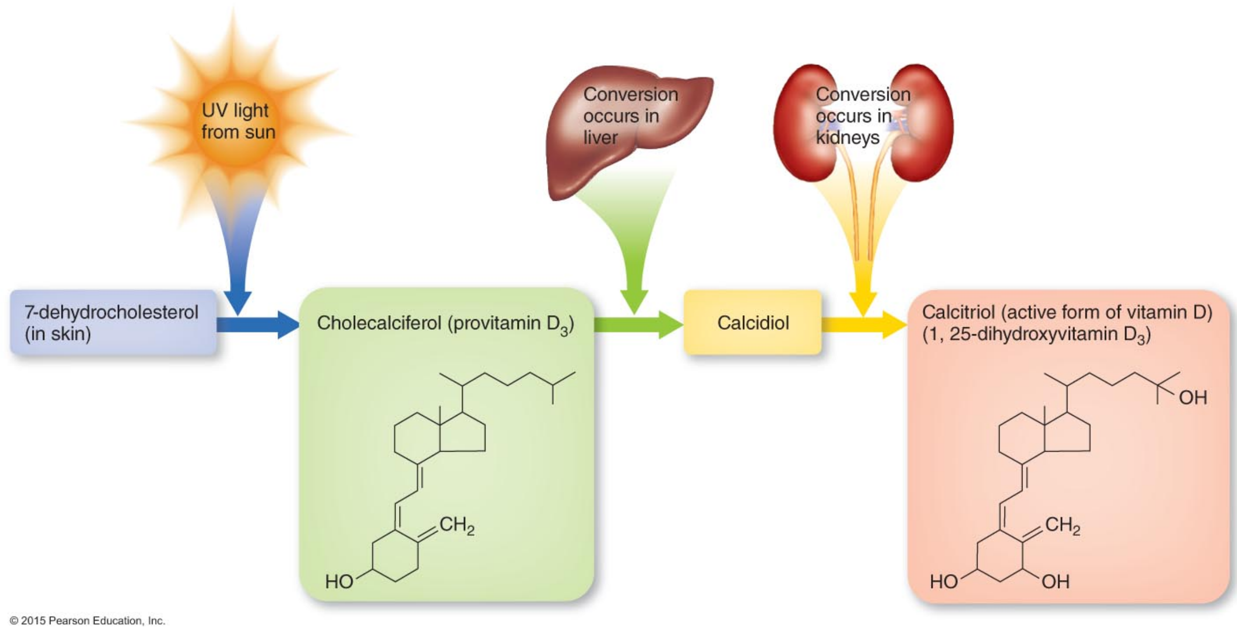



Figure 9.15: Conversion of Sunlight into Vitamin D


Figure 9.16: Vitamin D and Sunlight in North America

- Functions of vitamin D
  - Required for calcium and phosphorus absorption
  - Regulates blood calcium levels
  - Stimulates osteoclasts
  - Necessary for calcification of bone
- Sources of vitamin D

- Most foods naturally contain very little vitamin D
  - Vitamin $D_2$ or ergocalciferol is found in plant foods
  - Vitamin $D_3$ or cholecalciferol is found in animal foods

- Most vitamin D is obtained from fortified foods such as milk and cereal products
- Vegetarians not consuming dairy foods receive vitamin D from the sun, fortified soy products, or supplements

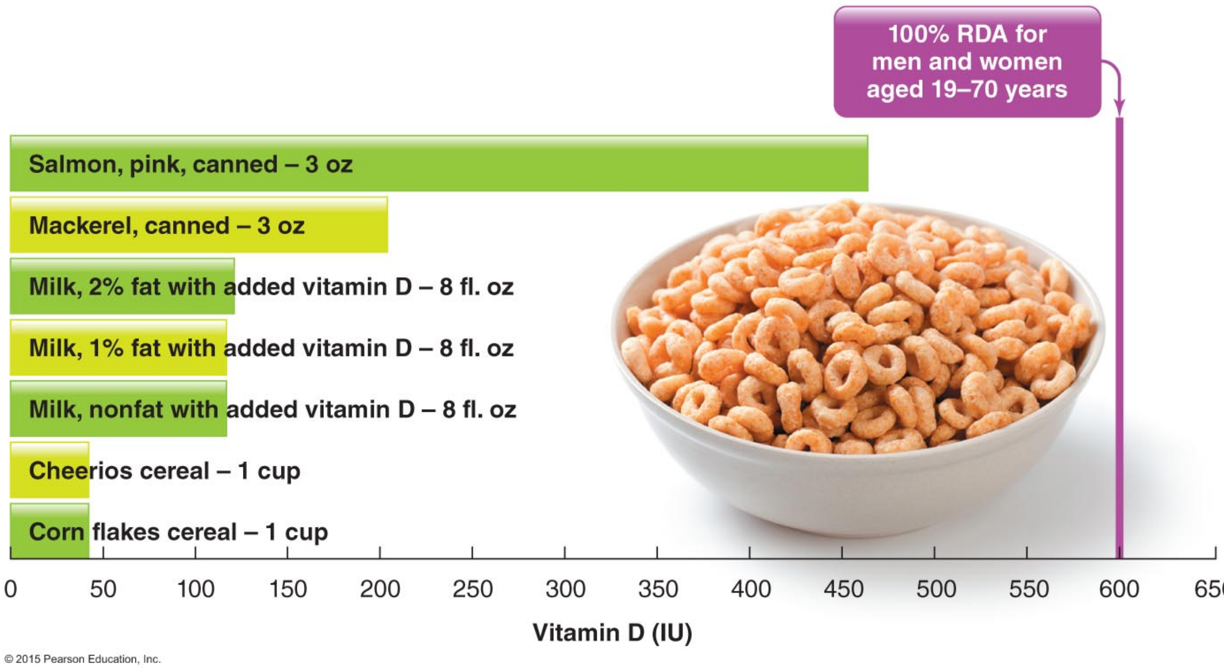



Figure 9.17: Common Food Sources of Vitamin D

- What if you consume too much vitamin D?
  - Occurs with vitamin supplements, *not* excessive exposure to sunlight
  - Results in **hypercalcemia** – high blood calcium
- What if you don't consume enough vitamin D?
  - Occurs with diseases that reduce intestinal absorption of fat and limited exposure to sunlight
  - **Rickets** – inadequate mineralization or demineralization of bones; occurs in children
  - **Osteomalacia** – loss of bone mass in adults

## 9.16 In Depth: Osteoporosis

- Osteoporosis is a disease characterized by
  - Low bone mass
  - Deterioration of bone tissue
  - Fragile bones, leading to bone fractures
  - Compaction of bone; decreased height
  - Shortening and hunching of the spine: dowager's hump

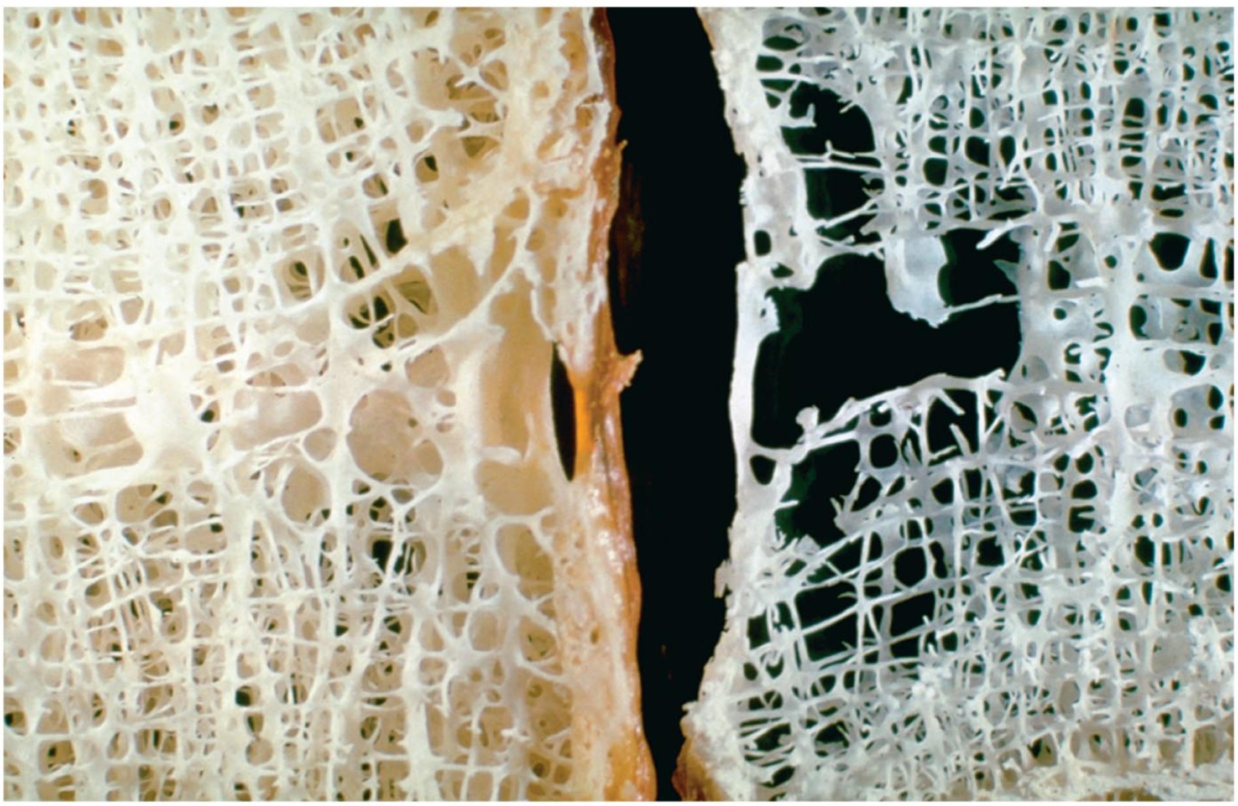


Figure 9.18: Osteoporosis

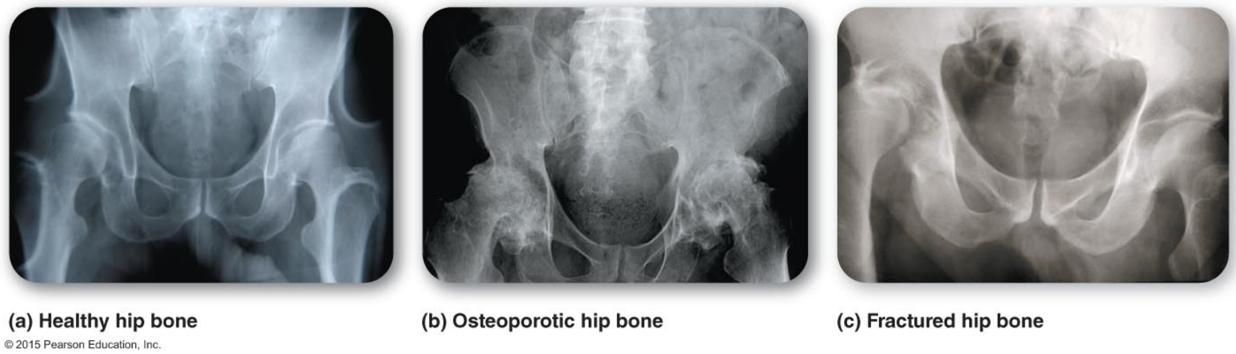



Figure 9.19: Osteoporosis

- Factors influencing the risk of osteoporosis include
  - Age
  - Gender
  - Genetics
  - Tobacco, alcohol, and caffeine use
  - Nutrition
  - Physical activity
  - History of amenorrhea (loss of menstrual function)

Table 9.4: Risk Factors for Osteoporosis

| **Modifiable Risk Factors** | **Nonmodifiable Risk Factors** |
| --- | --- |
| Smoking | Older age (elderly) |
| Low body weight | Caucasian or Asian race |
| Low calcium intake | History of fractures as an adult |
| Low sun exposure | Family history of osteoporosis |
| Alcohol abuse | Gender (female) |
| History of amenorrhea (failure to menstruate) in women with inadequate nutrition | History of amenorrhea (failure to menstruate) in women with no recognizable cause |
| Estrogen deficiency (females) | |
| Testosterone deficiency (males) | |
| Repeated falls | |
| Sedentary lifestyle | |

Source: Information adapted from the National Osteoporosis Society. 2014. Factors that increase your risk of osteoporosis and fracture. https://www.nos.org.uk/healthy-bones-and-risks/are-you-at-risk

- Age is a factor for osteoporosis because

  - Bone mass decreases with age
  - Age-related hormonal changes influence bone density (reduced estrogen and testosterone production)
  - Older adults are less able to absorb vitamin D

- Gender is a risk factor for osteoporosis
  - 80% of Americans with osteoporosis are women
  - Women have lower bone density than men
  - Estrogen loss in postmenopausal women causes increased bone loss
  - Women live longer than men
  - Social pressure on girls to be thin leads some to harmful dieting when bone mass is still building

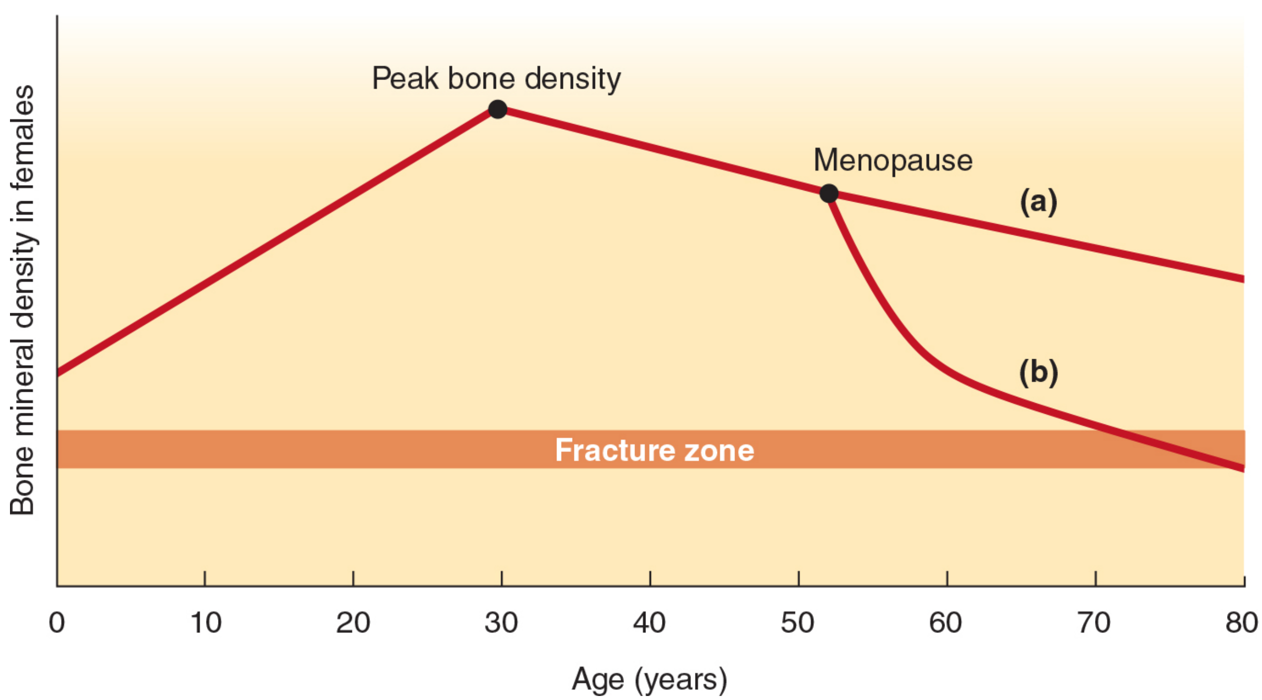



Figure 9.20: Osteoporosis

- Tobacco, alcohol, and caffeine use
  - Cigarette smoking decreases bone density due to its effects on hormones that influence bone formation and resorption
- Alcohol consumption beyond 1–2 drinks per day is associated with a higher risk of fractures
- Caffeine increases calcium loss in the urine

- Nutritional factors influence risk
  - Diets high in fruits and vegetables are associated with improved bone health
- Physical activity influences risk
  - Regular exercise causes stress to bones, leading to increased bone mass
  - Weight-bearing activities (walking, jogging) are especially helpful in increasing bone mass
- There is no cure for osteoporosis
- The progression of osteoporosis may be slowed by
  - Adequate calcium and vitamin D intake
  - Regular exercise
  - Some medications, including hormone replacement therapy (HRT)

# Chapter 10

# Achieving and Maintaining a Healthful Body Weight

## 10.1 What Is a Healthful Body Weight?

- A healthful weight
  - Is appropriate for your age
  - Is maintained without constant dieting
  - Is compatible with normal blood pressure, lipid levels, and glucose tolerance
  - Is based on family history of body shape and weight
  - Promotes good eating habits and allows for regular physical activity
  - Is acceptable to you

## 10.2 Evaluating Body Weight

- A person's actual weight is not the only factor to consider
- Determining if a person's body weight is healthful should include
  - Determining the body mass index (BMI)
  - Measuring body composition
  - Assessing the pattern of fat distribution
- Body mass index (BMI)
  - Expresses the ratio of a person's weight to the square of his or her height
  - BMI = weight (kg)/height $(m)^2$
  - BMI values below 18.5 or above 30 have increased risks of health problems
  - BMI results are distorted in people with high muscle mass (athletes and lactating women)

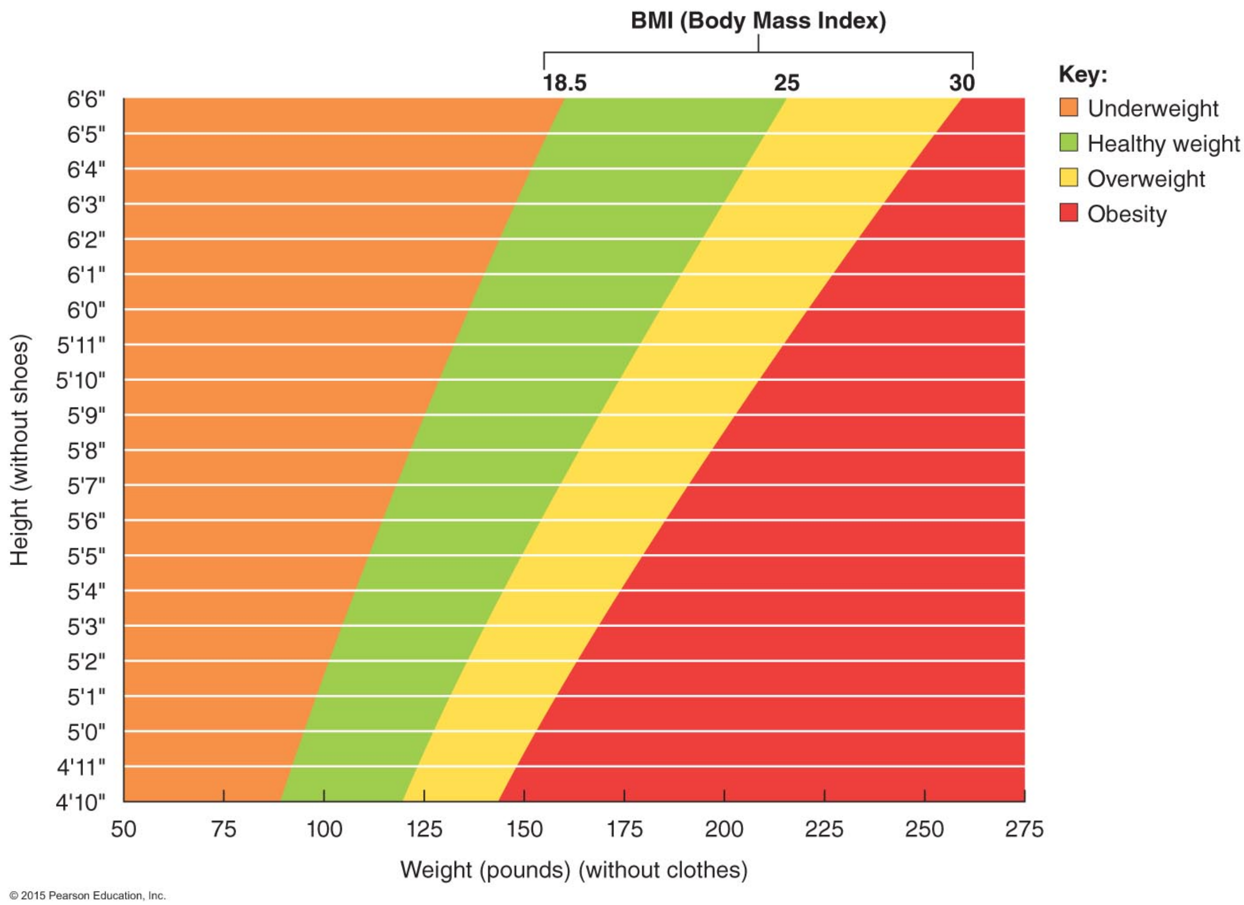



Figure 10.1: Estimating BMI

- **Underweight** – having too little body fat to maintain health
- **Overweight** – having a moderate amount of excess body fat
- Normal weight: appropriate weight for height. Associated with the lowest disease risk
- **Obesity** – having an excess of body fat that adversely affects health
- **Morbid obesity** – body weight exceeding 100% of normal, creating a very high risk of serious health complications

## 10.3 Evaluating Body Weight

- Body composition
  - Measurement of body fat and lean body mass
  - Can be measured by
    - Underwater weighing
    - Skinfold measurements

* Bioelectrical impedance analysis (BIA)
* Dual-energy x-ray absorptiometry (DXA)
* Bod Pod

| Method | | Limitations |
|---|---|---|
| **Underwater weighing:** Considered the most accurate method. Estimates body fat within a 2–3% margin of error. This means that if your underwater weighing test shows you have 20% body fat, this value could be no lower than 17% and no higher than 23%. Used primarily for research purposes. |  | • Subject must be comfortable in water.<br>• Requires trained technician and specialized equipment.<br>• May not work well with extremely obese people.<br>• Must abstain from food for at least 8 hours and from exercise for at least 12 hours prior to testing. |
| **Skinfolds:** Involves "pinching" a person's fold of skin (with its underlying layer of fat) at various locations of the body. The fold is measured using a specially designed caliper. When performed by a skilled technician, it can estimate body fat with an error of 3–4%. This means that if your skinfold test shows you have 20% body fat, your actual value could be as low as 16% or as high as 24%. |  | • Less accurate unless technician is well trained.<br>• Proper prediction equation must be used to improve accuracy.<br>• Person being measured may not want to be touched or to expose their skin.<br>• Cannot be used to measure obese people, as their skinfolds are too large for the caliper. |
| **Bioelectrical impedance analysis (BIA):** Involves sending a very low level of electrical current through a person's body. As water is a good conductor of electricity and lean body mass is made up of mostly water, the rate at which the electricity is conducted gives an indication of a person's lean body mass and body fat. This method can be done while lying down, with electrodes attached to the feet, hands, and the BIA machine. Hand-held and standing models (which look like bathroom scales) are now available. Under the best of circumstances, BIA can estimate body fat with an error of 3–4%. |  | • Less accurate.<br>• Body fluid levels must be normal.<br>• Proper prediction equation must be used to improve accuracy.<br>• Should not eat for 4 hours and should not exercise for 12 hours prior to the test.<br>• No alcohol should be consumed within 48 hours of the test.<br>• Females should not be measured if they are retaining water due to menstrual cycle changes. |
| **Dual-energy x-ray absorptiometry (DXA):** The technology is based on using very-low-level x-rays to differentiate among bone tissue, soft (or lean) tissue, and fat (or adipose) tissue. It involves lying for about 30 minutes on a specialized bed fully clothed, with all metal objects removed. The margin of error for predicting body fat ranges from 2% to 4%. |  | • Expensive; requires trained technician with specialized equipment.<br>• Cannot be used to measure extremely tall, short, or obese people, as they do not fit properly within the scanning area. |
| **Bod Pod:** A machine that uses air displacement to measure body composition. This machine is a large, egg-shaped chamber made from fiberglass. The person being measured sits inside, wearing a swimsuit. The door is closed and the machine measures how much air is displaced. This value is used to calculate body composition. It appears promising as an easier and equally accurate alternative to underwater weighing in many populations, but it may overestimate body fat in some African American men. |  | • Expensive.<br>• Less accurate in some populations. |



Figure 10.2: Body Composition Assessment Methods

- Fat distribution pattern
  - Measured by waist-to-hip ratio and waist circumference
    * Disease risk is associated with a waist-to-hip ratio of higher than 0.90 in men, and 0.80 in women
  - **Apple-shaped fat patterning** – upper body
    * Increased risk of chronic diseases (type 2 diabetes, heart disease, hypertension)
  - **Pear-shaped fat patterning** – lower body
    * No significant increased risk of chronic diseases

Figure 10.3: Determining Fat Patterns

## 10.4 Gaining or Losing Weight

- Whether a person gains or loses weight depends on
  - Energy intake versus energy expenditure
  - Genetic factors
  - Composition of the diet
  - Metabolic factors
  - Physiologic factors
  - Cultural and economic factors
  - Social factors

## 10.5 Energy Balance

- Occurs when energy intake = energy expenditure
- Energy intake = kcal from food
- Energy expenditure
  - Energy expended at rest (basal metabolic rate)
  - Physical activity
  - Thermic effect of food

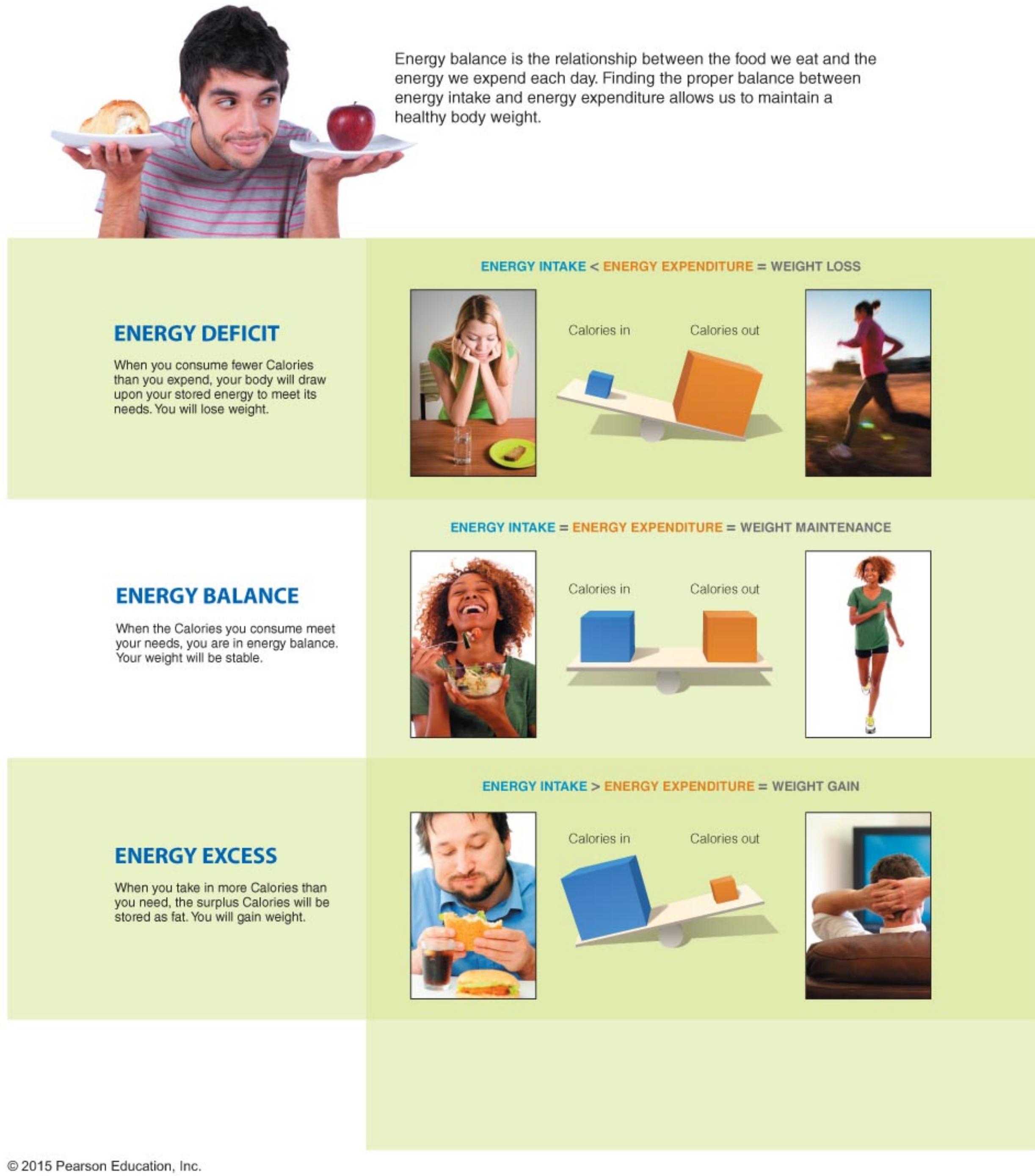



Figure 10.4: Energy Balance

- Basal metabolic rate (BMR)
  - Energy expended to maintain basal, or resting, functions of the body
  - 60–75% of total energy expenditure
  - More lean tissue increases your BMR

- BMR decreases with age, 3–5% per decade after age 30

Table 10.1: Factors Affecting Basal Metabolic Rate (BMR)

| **Factors That Increase BMR** | **Factors That Decrease BMR** |
|---|---|
| Higher lean body mass | Lower lean body mass |
| Greater height (more surface area) | Lower height |
| Younger age | Older age |
| Elevated levels of thyroid hormone | Depressed levels of thyroid hormone |
| Stress, fever, illness | Starvation, fasting or very-low-Calorie diets |
| Male gender | Female gender (due to decreased lean tissue) |
| Pregnancy and lactation | |
| Certain drugs, such as stimulants, caffeine, and tobacco | |

- Thermic effect of food (TEF)
  - Energy expended to digest, absorb, transport, metabolize, and store food
  - 5–10% of total expenditure
  - Lowest for fat and highest for protein
- Physical activity
  - 15–35% of daily energy expenditure
  - Factors that influence energy expended
    * The more muscle groups used, the greater the energy expenditure
    * Intensity
    * Duration
    * Body size

Table 10.2: Energy Costs of Physical Activities

| **Activity** | **Intensity** | **Energy Cost (kcal/kg body weight/min)** |
|---|---|---|
| Sitting, studying (including reading or writing) | Light | 0.022 |
| Cooking or food production (sitting or standing) | Light | 0.033 |
| Walking (e.g., to neighbor's house) | Light | 0.042 |
| Stretching–Hatha yoga | Moderate | 0.042 |
| Cleaning (dusting, straightening up, vacuuming, changing linen, carrying out trash) | Moderate | 0.058 |
| Weight lifting (free weights, Nautilus or universal type) | Light or moderate | 0.050 |
| Bicycling, 10 mph | Leisure (work or pleasure) | 0.067 |
| Walking, 4 mph (brisk pace) | Moderate | 0.083 |
| Aerobics | Low impact | 0.083 |
| Weight lifting (free weights, Nautilus or universal type) | Vigorous | 0.100 |
| Bicycling, 12 to 13.9 mph | Moderate | 0.133 |
| Running, 5 mph (12 minutes per mile) | Moderate | 0.138 |
| Running, 6 mph (10 minutes per mile) | Moderate | 0.163 |
| Running, 8.6 mph (7 minutes per mile) | Vigorous | 0.205 |

## 10.6 Genetic Factors

- Different ideas have been suggested to explain the impact of genetics on body fat
  - FTO gene
  - Thrifty gene theory
  - Set-point theory

### 10.6.1 FTO gene

- Fat mass and obesity-associated gene
- 44–65% of people have at least one copy
- Stimulates excessive food intake
- Physical activity can attenuate the gene's influence

### 10.6.2 Thrifty gene theory

- Proposes that a gene (or genes) causes people to be energetically thrifty
- Proposes that people with this gene expend less energy than other people and therefore gain weight
- A "thrifty gene" has not been identified

### 10.6.3 Set-point theory

- Proposes that each person's weight stays within a small range (set point)
- The body compensates for changes in energy balance and keeps a person's weight at his or her set point
- Can change with time, as diet and activity levels vary over a long period of time

### 10.6.4 Protein leverage hypothesis

- Humans have evolved to have a fixed daily dietary protein target that must be reached to optimize physiologic functioning
- Diets high in carbohydrates and fats and low in protein may cause people to overeat

### 10.6.5 Drifty gene hypothesis

- Suggests that in the new food environment some people become obese while others do not
- This effect may be due to random mutations and drift in genes that control upper body fatness
- These genes are originally thought to be neutral but over time and evolved to predispose us to obesity

### 10.6.6 Metabolic Factors

- Relatively low metabolic rate
- Low level of spontaneous physical activity
- Low sympathetic nervous system activity
- Low fat oxidation
- Low levels of thyroid hormones
- Certain prescription medications

### 10.6.7 Physiologic Factors

- Hunger and satiety
- Specific proteins and hormones
  - Leptin
  - Ghrelin
  - Peptide YY, or PYY
  - Brown adipose tissue
  - Serotonin and cholecystokinin (CCK)
  - Blood glucose levels
  - Stomach expansion
  - Nutrient absorption from the small intestine
  - Beta-endorphins
  - Neuropeptide Y
  - Decreased blood glucose levels

### 10.6.8 Leptin

- Leptin is a hormone produced by fat cells that causes reduced food intake, reduced weight, and decreased body fat in mice
- The role of leptin in human obesity is being studied

### 10.6.9 Ghrelin

- Protein synthesized in the stomach
- Stimulates appetite by acting on the hypothalamus

### 10.6.10 Peptide YY, or PYY

- Produced in the GI tract
- Decreases appetite
- Obese people have lower levels when fasting

### 10.6.11 Cultural and Economic Factors

- Food choices
  - The composition of a person's diet should remain balanced
- Levels of physical activity
  - Minor changes can add up
- Economic status
  - Food choices and eating behaviors are affected
- Cultural customs
- Changes in work and leisure activity levels
- Larger body size acceptance/cultural norms
- Lack of access to healthcare and health information
- Lack of access to affordable, healthful foods
- Lack of access to positive role models
- Personal safety issues
- Transportation issues

## 10.7 Sociocultural Factors

- Social factors influencing our diet and activity levels include
  - Expectations of family and friends
  - Holiday foods, fast foods, and serving sizes
  - Television and other amusements that do not involve physical activity
  - Work responsibilities that do not involve physical activity
  - Media images and social pressures to achieve unrealistic weight goals

## 10.8 Achieve and Maintain Healthful Weight

- Healthful weight change requires
- Gradual and reasonable changes in energy intake
- Regular and appropriate physical exercise
- Application of behavior modification techniques

## 10.9 Diets focusing on Macronutrient Composition

- Diets high in carbohydrates and moderate fat and protein
  - DASH diet, USDA Food Guide, Weight Watchers, and Jenny Craig
- Diets low in carbohydrate and high in fat and protein
  - Atkins, Sugar Busters!, and the Paleo diet

## 10.10 Weight-Loss Strategies

- Guidelines for successful weight loss
- Set realistic goals
  - Specific
  - Reasonable
  - Measurable
    - Monitor progress regularly
- Eat smaller portions of lower-fat foods
  - Reduce consumption of high-fat and high-energy foods
  - Consume foods high in nutrient density
- Participate in regular physical activity
  - Critical for long-term maintenance of weight loss
- Incorporate appropriate behavior modifications
  - Mindful eating: refers to a nonjudgmental awareness of emotional and physical sensations one experiences while eating

## 10.11 Behavior Modification

- Mindful eating tips
  - Focus only on eating
  - Savor each bite
  - Recruit all of your senses
  - Pause and rest between bites
  - Try 10 minutes of silence

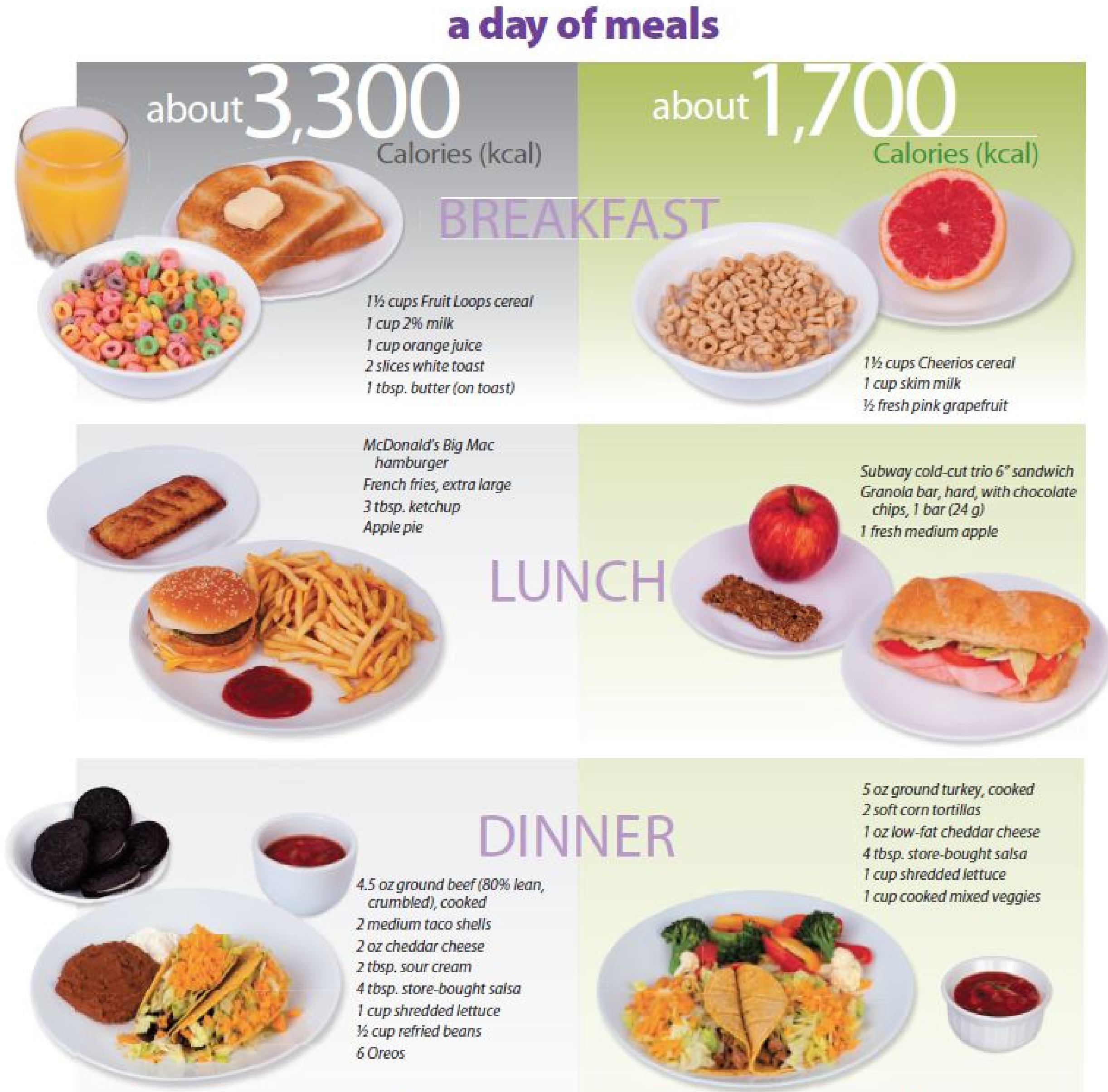



Figure 10.5: The Energy Density of Meals

## 10.12 Underweight

- BMI below 18.5 kg/m$^2$
- Increases the risk of infections and illness
- Can be just as unhealthy as overweight
- Effective weight gain should include
  - Eating 500 to 1,000 extra kcal/day

  - Eating frequently throughout the day
  - Selecting healthful, energy-dense foods
  - Avoiding tobacco products, which depress appetite and increase BMR
  - Regular exercise with resistance training

## 10.13 Obesity

- BMI between 30 and 39.9 kg/m$^2$
- Morbid obesity
  - Body weight exceeding 100% of normal
  - BMI greater than or equal to 40 kg/m$^2$
- Chronic diseases and complications linked to obesity include
  - Hypertension
  - Dislipidemia
  - Type 2 diabetes
  - Heart disease
  - Stroke
  - Gallbladder disease
  - Osteoarthritis
  - Sleep apnea
- Chronic diseases and complications linked to obesity include
  - Certain cancers
  - Menstrual irregularities and infertility
  - Gestational diabetes, premature fetal deaths, neural tube defects, and complications during labor and delivery
  - Depression
  - Alzheimer's disease, dementia, and cognitive decline

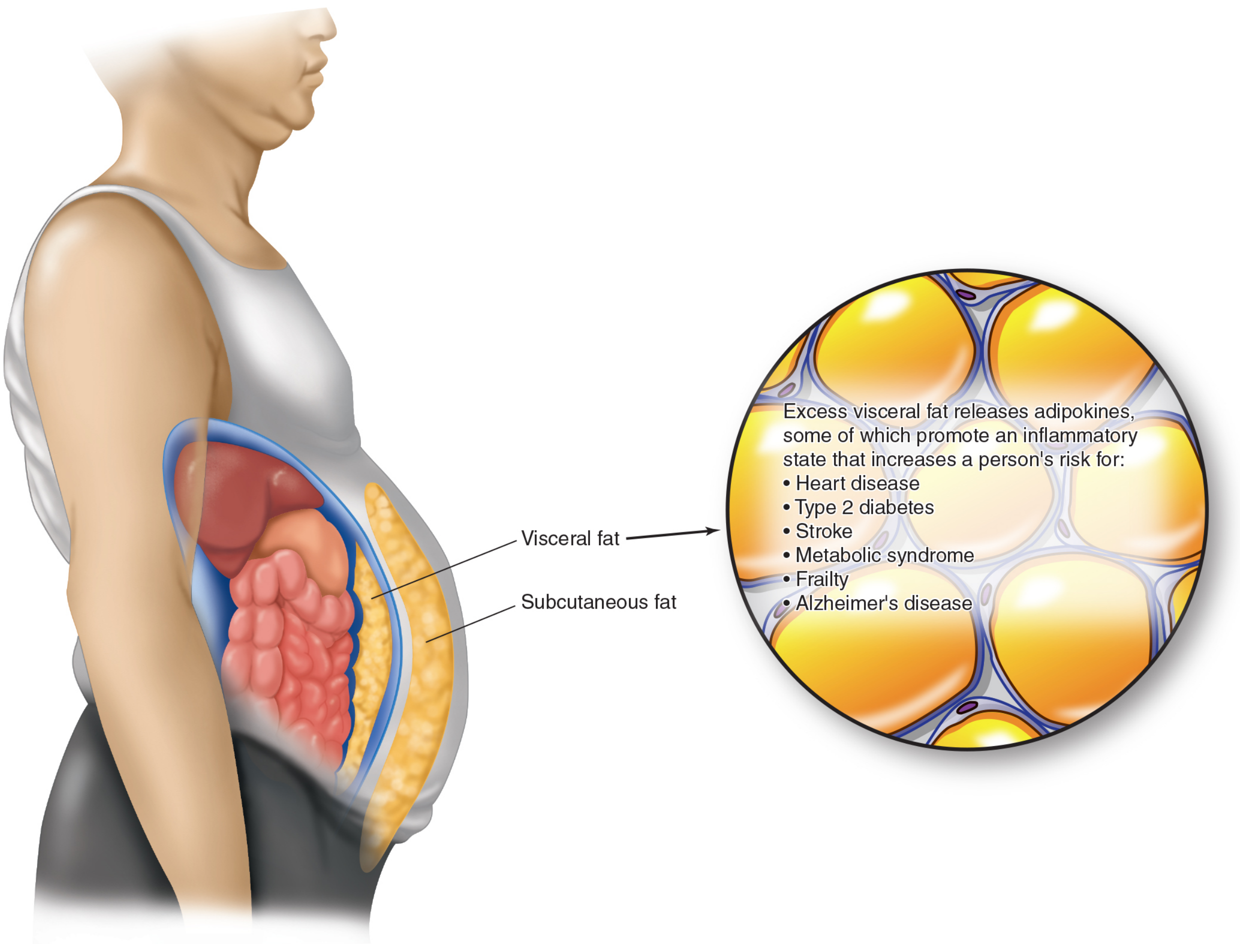



Figure 10.6: Abdominal Obesity

### 10.13.1 Metabolic Syndrome

- Abdominal obesity is one of the five risk factors of the metabolic syndrome
- People with metabolic syndrome are
  - Twice as likely to develop heart disease
  - Five times as likely to develop type 2 diabetes
- Factors that can influence the chance of developing obesity include
  - Biology (genetics, metabolic, environment)
  - Physical activity environment
  - Individual physical activity
  - Individual psychology
  - Societal influences
  - Food environment
  - Food consumption

### 10.13.2 Obesity Responds to Diet and Exercise

- Diet and exercise are the first line of defense against obesity
- Dietary and physical activity changes should be made gradually
- Physical activity for at least 30 minutes per day 5 days per week, but up to 60 minutes per day may be more beneficial for some people
- Treatments for obesity may include
  - Low-energy diet and regular exercise
  - Counseling or psychotherapy
  - Prescription medications
  - Surgery
    * Sleeve gastrectomy
    * Gastric bypass
    * Gastric banding

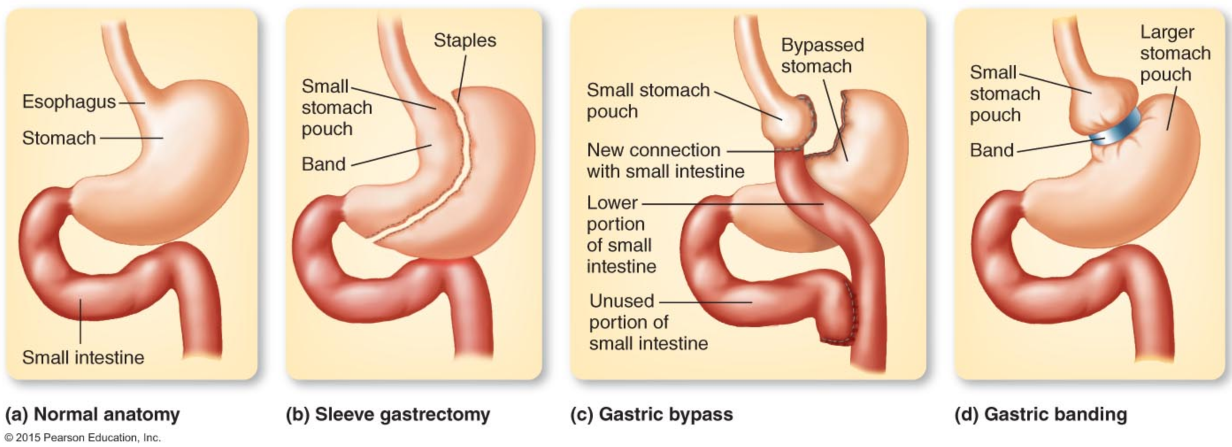



Figure 10.7: Weight-Loss Surgery

# Chapter 11

## 11.1 Physical Activity and Fitness

- **Physical activity** – any muscle movement that increases energy expenditure
- **Leisure-time physical activity** – any activity unrelated to a person's occupation
  - For example, hiking, walking, biking
  - Includes **exercise** – purposeful, planned physical activity
- The components of physical fitness are achieved through three types of exercise
  - Aerobic exercise
  - Resistance training
  - Stretching
- **Physical fitness** – the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and meet unforeseen emergencies
  - The components of physical fitness are
    * Cardiorespiratory fitness
    * Musculoskeletal fitness
    * Flexibility
    * Body composition

Table 11.1: Components of Fitness

| Fitness Component | Recommended Intake |
|---|---|
| Cardiorespiratory | Examples of Activities that Improve Fitness in Each Component Aerobic-type activities, such as walking, running, swimming, cross-country skiing |
| Musculoskeletal fitness: | Resistance training, weight lifting, calisthenics, sit-ups, push-ups |
| Muscular strength | Weight lifting or related activities using heavier weights with few repetitions |
| Muscular endurance | Weight lifting or related activities using lighter weights with more repetitions |
| Flexibility | Stretching exercises, yoga |
| Body composition | Aerobic exercise, resistance training |

## 11.2 Physical Activity and Chronic Disease

- Regular physical activity
  - Reduces the risk of heart disease, stroke, and high blood pressure
  - Reduces the risk of obesity
  - Reduces the risk of type 2 diabetes
  - May reduce the risk of colon cancer
  - Reduces the risk of osteoporosis


Figure 11.1: Health Benefits of Physical Activity

## 11.3 Physical Activity and Most Americans

- Despite the clear benefits of regular physical activity,
  - 79.9% of U.S. adults do not perform sufficient physical activity
  - 23.7% of U.S. adults admit to doing no leisure-time physical activity at all

Table 11.2: Rates of Physical Activity in the United States

| Nutrient | Functions | Suggested Intake |
|---|---|---|
| Energy | Supports exercise, activities of daily living, and basic body functions | Depends on body size and the type, intensity, and duration of activity<br>For many female athletes: 1,800 to 3,500 kcal/day<br>For many male athletes: 2,500 to 7,500 kcal/day |
| Carbohydrate | Provides energy, maintains adequate muscle glycogen and blood glucose; high complex carbohydrate foods provide vitamins and minerals | 45–65% of total energy intake<br>Depending on sport and gender, should consume 6–10 g of carbohydrate per kg body weight per day |
| Fat | Provides energy, fat-soluble vitamins, and essential fatty acids; supports production of hormones and transport of nutrients | 20–35% of total energy intake |
| Protein | Helps build and maintain muscle; provides building material for glucose; energy source during endurance exercise; aids recovery from exercise | 10–35% of total energy intake<br>1.2-2.0 g per kg body weight |
| Water | Maintains temperature regulation (adequate cooling); maintains blood volume and blood pressure; supports all cell functions | Consume fluid before, during, and after exercise<br>Consume enough to maintain body weight<br>Consume at least 8 cups (64 fl. oz) of water daily to maintain regular health and activity<br>Athletes may need up to 338 liters (170 fl. oz) every day; more is required if exercising in a hot environment |
| B-vitamins | Critical for energy production from carbohydrate, fat, and protein | May need slightly more (one to two times the RDA) for thiamin, riboflavin, and vitamin $B_6$ |
| Calcium | Builds and maintains bone mass; assists with nervous system function, muscle contraction, hormone function, and transport of nutrients across cell membrane | Meet the current RDA:<br>14–18 years: 1,300 mg/day<br>19–50 years: 1,000 mg/day<br>51–70 years: 1,000 mg/day (men): 1,200 mg/day (women)<br>71 and older: 1,200 mg/day |
| Iron | Primarily responsible for the transport of oxygen in blood to cells; assists with energy production | Consume at least the RDA: Males: 14–18 years: 11 mg/day 19 and older: 8 mg/day Females:<br>14–18 years: 15 mg/day 19–50 years: 18 mg/day 51 and older: 8 mg/day |

## 11.4 Designing a Sound Fitness Program

- For a sound fitness program:
  - Start by assessing your current level of fitness
  - Identify your personal fitness goals
  - Make your program varied, consistent, and fun
  - Appropriately overload your body
  - Include a warm-up and cool-down period
  - Start out slowly and gradually build up the time you spend each day until you reach 30 minutes

## 11.5 Sound Fitness Program

- A sound physical fitness program meets your personal fitness goals
- An individual's fitness program may vary depending on whether he or she is
  - Training for athletic competition
  - Working toward cardiorespiratory fitness
  - Trying to maintain overall health
- A sound physical fitness program is fun
- An individual's fitness program should focus on what he or she enjoys
  - Outdoor activities
  - Social recreation
- A sound physical fitness program includes variety and consistency
- Variety can be achieved by
  - Combining aerobic exercise, resistance training, and stretching
  - Combining indoor and outdoor exercises
  - Taking different routes when walking or jogging
  - Including entertainment such as music
  - Participating in different activities each week
- A sound physical fitness program appropriately overloads the body

**Overload principle** – put additional physical demands on the body to improve fitness

- Too much physical exertion is not recommended
- The FITT principle can be used to determine appropriate overload

## 11.6 The FITT Principle

**Frequency:** the number of activity sessions per week

- Desired frequency varies with fitness goals

**Intensity:** the amount of effort expended or how difficult the activity is to perform

- Desired intensity may be based on maximal heart rate

**Time of activity:** how long each session lasts

**Type of activity:** the range of activities engaged in to promote health and physical fitness

| | Frequency | Intensity | Time and Type |
|---|---|---|---|
| Cardiorespiratory fitness  | At least 30 minutes most days of the week | 50–70% maximal heart rate for moderate intensity;<br>70–85% maximal heart rate for vigorous intensity | At least 30 consecutive minutes<br><br>Choose swimming, walking, running, cycling, dancing, or other aerobic activities |
| Muscular fitness  | 2–3 days per week | 70–85% maximal weight you can lift | 1–3 sets of 8–12 lifts for each set<br><br>A minimum of 8–10 exercises involving the major muscle groups such as arms, shoulders, chest, abdomen, back, hips, and legs, is recommended. |
| Flexibility  | 2–4 days per week | Stretching through full range of motion | For stretching, perform 2–4 repetitions per stretch. Hold each stretch for 15–30 seconds. Or try yoga, tai chi, or other flexibility programs. |



Figure 11.2: Using the FITT Principle

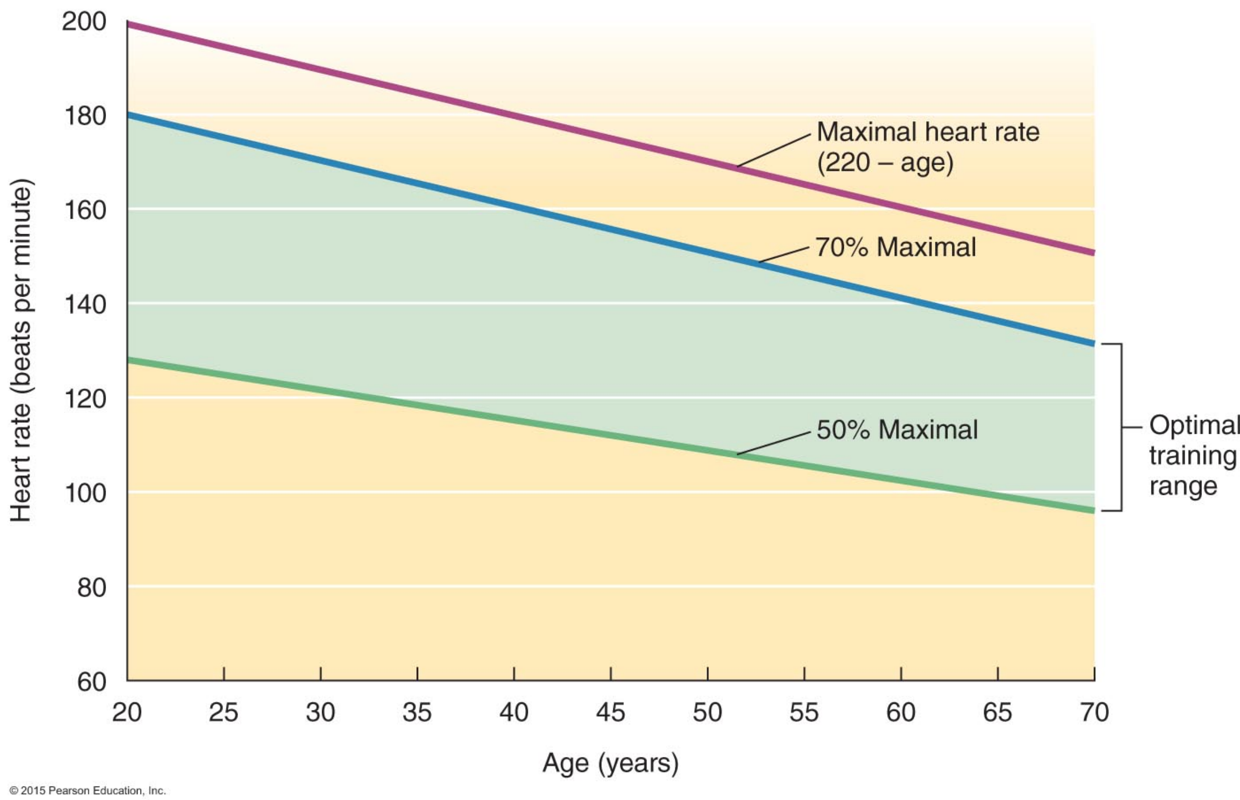



Figure 11.3: Maximal Heart Rate Training Chart

## 11.7 Sound Fitness Program

A sound physical fitness program includes a warm-up period and a cool-down period

### 11.7.1 Warm-Up

- Should be brief (5 to 10 minutes), gradual, and sufficient to increase muscle and body temperature
- Includes aerobics, calisthenics, and stretching
- Enhances flexibility and helps prepare you psychologically for the activity to come

### 11.7.2 Cool-down

- Should be gradual
- Includes some of the same activities as in the exercise session, along with stretching
- Assists in preventing injury and may help reduce muscle soreness

## 11.8 Fuel for Physical Activity

- The common currency for energy in the body is adenosine triphosphate, or ATP
- After depleting ATP stores, muscles turn to other energy sources
  - Creatine phosphate (CP) stores energy that can be used to generate ATP
    - Creatine phosphate can be broken down to support the regeneration of ATP for enough energy for 3–15 seconds of maximal physical effort

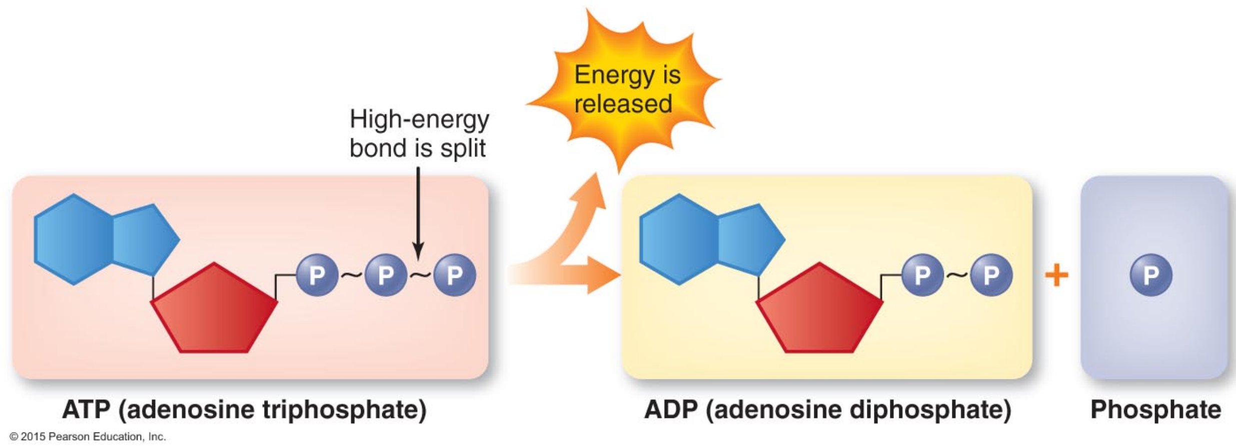



Figure 11.4: Adenosine Triphosphate (ATP)

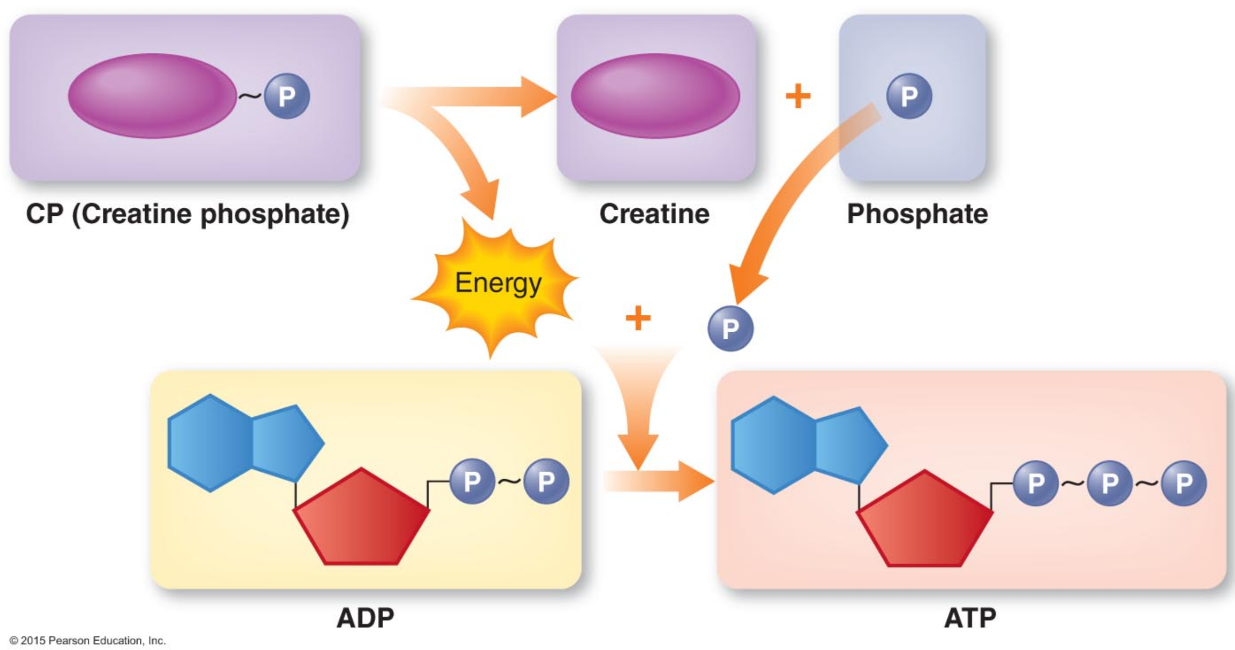



Figure 11.5: Creatine Phosphate (CP)


Figure 11.6: Energy Balance

- Metabolism of glucose
  - Anaerobic (without oxygen) breakdown of glucose yields two ATP molecules
    - Lactic acid is produced

  - Aerobic (with oxygen) breakdown of glucose yields 36–38 molecules of ATP
    * $CO_2$ and $H_2O$ are produced

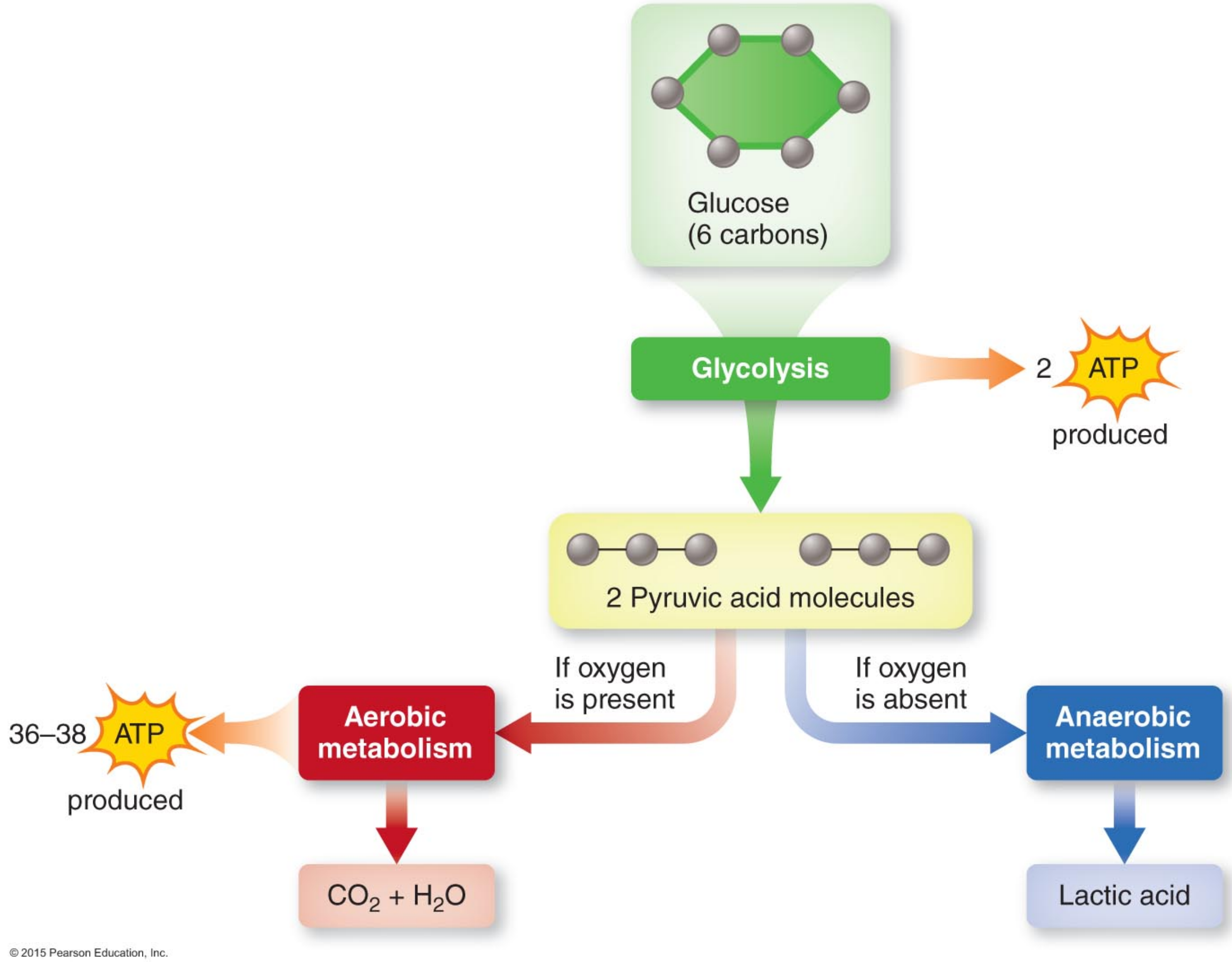



Figure 11.7: Metabolism of Glucose

- Stored triglycerides (fats) can be metabolized to generate ATP
  - For low-intensity exercise
  - For exercise of long duration
  - A very abundant energy source, even in lean people
  - Provides more than two times the energy per gram as carbohydrate
- Carbohydrates and fats can both be used as energy sources for the production of ATP
  - Carbohydrates are mostly used for high-intensity activity
  - Fats are used for low-intensity exercise
- Proteins (amino acids) are not a major fuel source for exercise

– 1–6% of energy needs during exercise


Figure 11.8: Fat and Carbohydrate Contributions

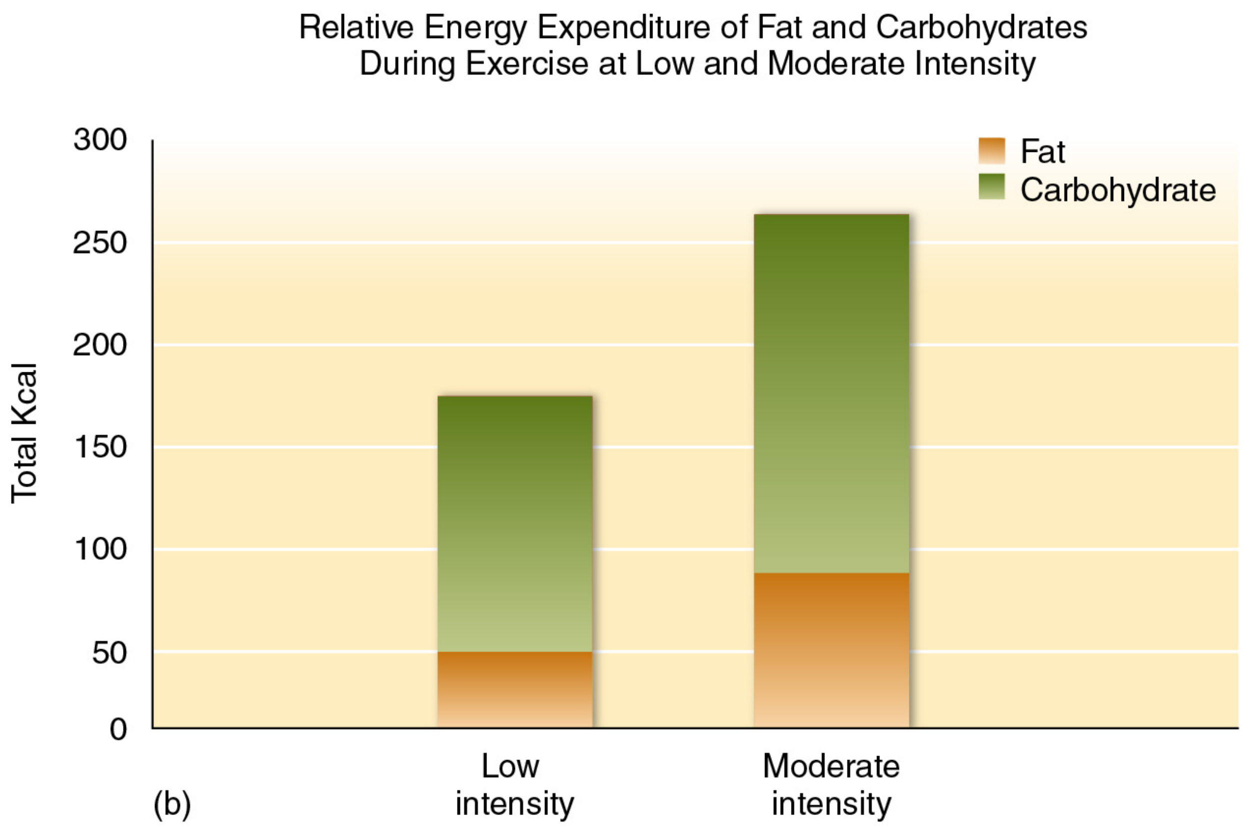



Figure 11.9: Fat and Carbohydrate Contributions (cont.)

## 11.9 Energy Needs for Physical Activity

- Energy needs
  - Energy needs may be higher for athletes
  - Different energy needs for males and females
  - Depend on body size
  - Depend on the type, intensity, and duration of physical activity

Table 11.3: Nutrients for Vigorous Physical Activity

| Nutrient | Functions | Suggested Intake |
|---|---|---|
| Energy | Supports exercise, activities of daily living, and basic body functions | Depends on body size and the type, intensity, and duration of activity<br>For many female athletes: 1,800 to 3,500 kcal/day<br>For many male athletes: 2,500 to 7,500 kcal/day |
| Carbohydrate | Provides energy, maintains adequate muscle glycogen and blood glucose; high complex carbohydrate foods provide vitamins and minerals | 45–65% of total energy intake<br>Depending on sport and gender, should consume 6–10 g of carbohydrate per kg body weight per day |
| Fat | Provides energy, fat-soluble vitamins, and essential fatty acids; supports production of hormones and transport of nutrients | 20–35% of total energy intake |
| Protein | Helps build and maintain muscle; provides building material for glucose; energy source during endurance exercise; aids recovery from exercise | 10–35% of total energy intake<br>1.2-2.0 g per kg body weight |
| Water | Maintains temperature regulation (adequate cooling); maintains blood volume and blood pressure; supports all cell functions | Consume fluid before, during, and after exercise<br>Consume enough to maintain body weight<br>Consume at least 8 cups (64 fl. oz) of water daily to maintain regular health and activity<br>Athletes may need up to 338 liters (170 fl. oz) every day; more is required if exercising in a hot environment |
| B-vitamins | Critical for energy production from carbohydrate, fat, and protein | May need slightly more (one to two times the RDA) for thiamin, riboflavin, and vitamin $B_6$ |
| Calcium | Builds and maintains bone mass; assists with nervous system function, muscle contraction, hormone function, and transport of nutrients across cell membrane | Meet the current RDA:<br>14–18 years: 1,300 mg/day<br>19–50 years: 1,000 mg/day<br>51–70 years: 1,000 mg/day (men): 1,200 mg/day (women)<br>71 and older: 1,200 mg/day |
| Iron | Primarily responsible for the transport of oxygen in blood to cells; assists with energy production | Consume at least the RDA: Males:<br>14–18 years: 11 mg/day 19 and older: 8 mg/day Females:<br>14–18 years: 15 mg/day 19–50 years: 18 mg/day 51 and older: 8 mg/day |

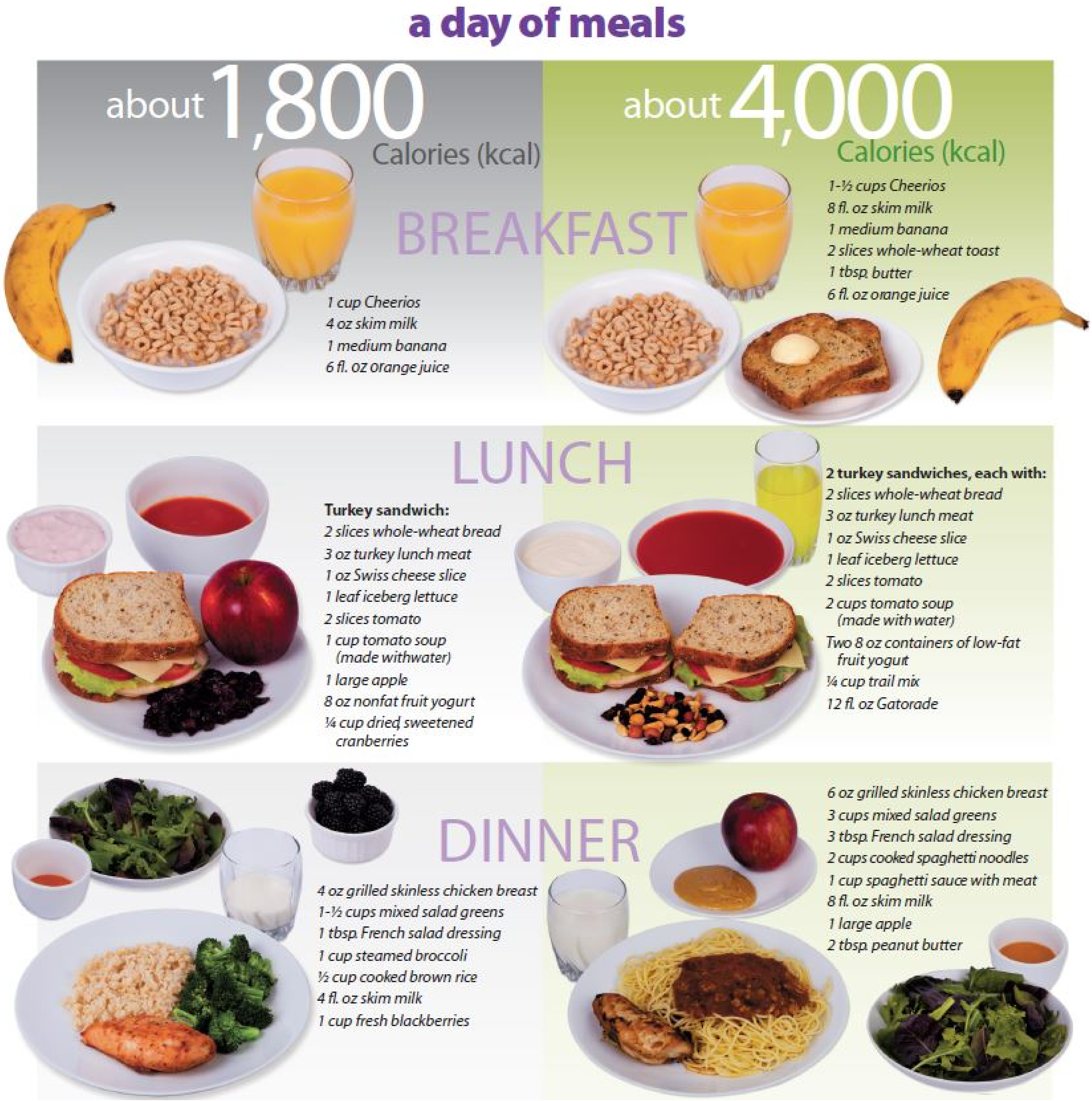



Figure 11.10: Eating for Athletes

## 11.10 Carbohydrate Intake for Physical Activity

- Athletes should consume carbohydrate within the AMDR of 45–65% of total energy intake
- Athletes should consume a daily carbohydrate intake of 6–10 grams per kg body weight to optimize glycogen stores
- Good sources are fiber-rich, less-processed foods such as whole grains, cereals, vegetables, and juices

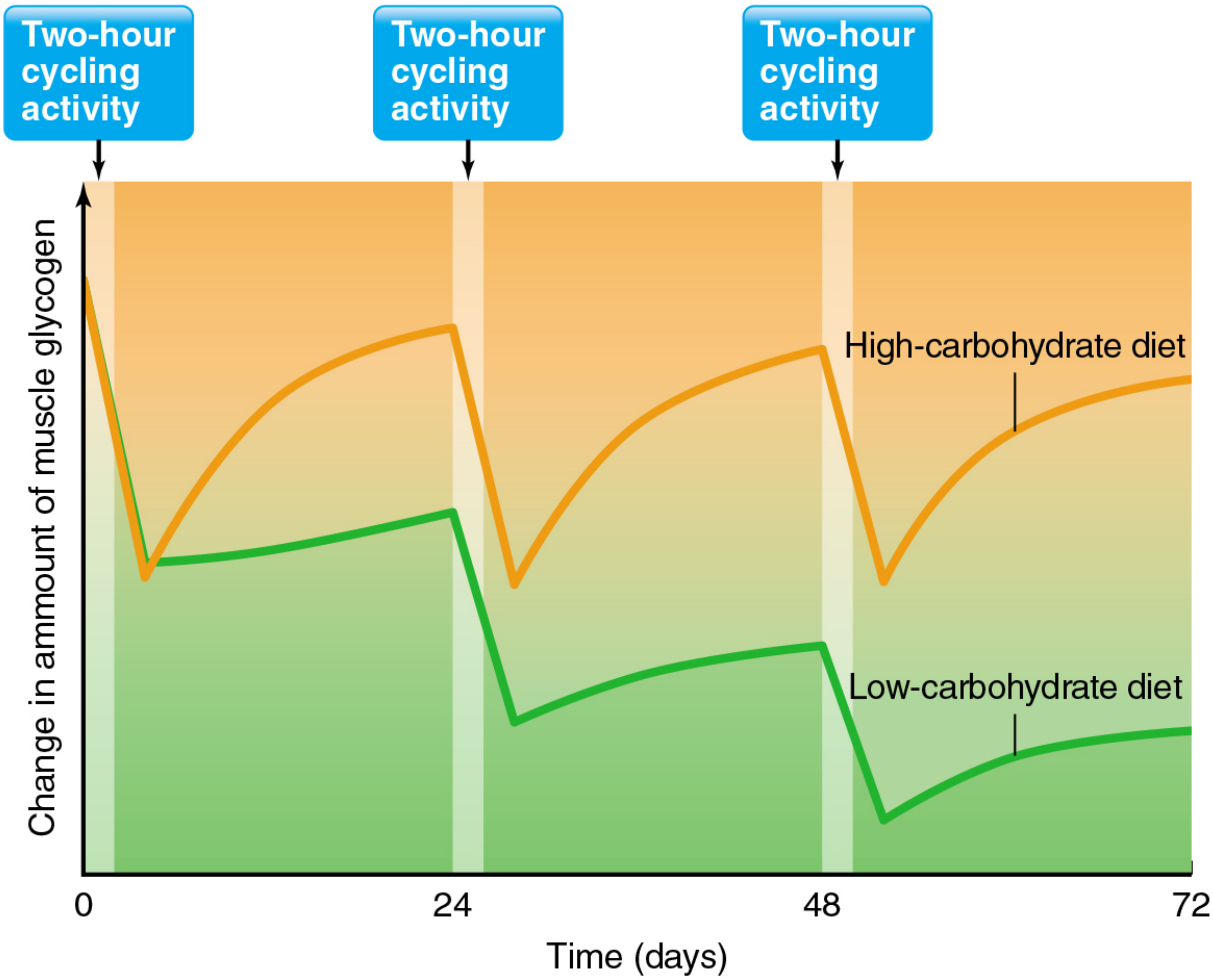



Figure 11.11: Carbohydrates and Muscle Glycogen Stores

Table 11.4: Carbohydrate and Total energy in Various Foods

| **Food** | **Amount** | **Carbohydrate (g)** | **Energy from Carbohydrate (%)** | **Total Energy (kcal)** |
|---|---|---|---|---|
| Sweetened applesauce | 1 cup | 50 | 97 | 207 |
| Large apple with | 1 each | 50 | 82 | 248 |
| saltine crackers | 8 each | | | |
| Whole-wheat bread | 1-oz slice | 50 | 71 | 282 |
| with jelly | 4 tsp. | | | |
| and skim milk | 12 fl. oz | | | |
| Spaghetti (cooked) | 1 cup | 50 | 75 | 268 |
| with tomato sauce | $\frac{1}{4}$ cup | | | |
| Brown rice (cooked) | 1 cup | 100 | 88 | 450 |
| with mixed vegetables | $\frac{1}{2}$ cup | | | |
| and apple juice | 12 fl. oz | | | |
| Grape-Nuts cereal | $\frac{1}{2}$ cup | 100 | 84 | 473 |
| with raisins | $\frac{3}{8}$ cup | | | |
| and skim milk | 8 fl. oz | | | |
| Clif Bar (chocolate chip) | 2.4 oz | 43 | 75 | 230 |
| Meta-Rx (fudge brownie) | 100 g | 41 | 41 | 400 |
| Power Bar (chocolate) | 1 bar | 45 | 75 | 240 |
| PR Bar Ironman | 1 bar | 22 | 44 | 200 |

Source: Data adapted from Manore, M. M., N. L. Meyer, and J. L. Thompson. 2009. Sport Nutrition for Health and Performance, 2nd ed. Champaign, IL: Human Kinetics.

- Carbohydrate loading, or glycogen loading, involves altering training and carbohydrate intake so that muscle glycogen storage is maximized
  - May benefit athletes competing in marathons, distance swimming, cross-country skiing, and triathlons
  - Does not always improve performance
  - Can lead to adverse side effects

Table 11.5: Carbohydrate Loading Guidelines

| Days Prior to Event | Exercise Duration (in minutes) | Carbohydrate Content of Diet (g per kg body weight) |
|---|---|---|
| 6 | 90 (at 90% max effort) | 5 (moderate) |
| 5 | 40 (at 70% max effort) | 5 (moderate) |
| 4 | 40 (at 70% max effort) | 5 (moderate) |
| 3 | 20 (light training) | 10–12 (high) |
| 2 | 20 (light training) | 10–12 (high) |
| 1 | Rest | 10–12 (high) |
| Day of race | Competition | Pre-competition food and fluid |

Sources: Current Trends in Performance Nutrition, by Marie Dunford. Copyright © 2005 by Human Kinetics, Champaign, IL. Reprinted with permission; and American College of Sports Medicine, Academy of Nutrition and Dietetics, and Dietitians of Canada. 2016. Nutrition and Athletic Performance. Joint Position Statement. Medicine and Science in Sports and Exercise 48(3):543-568.

## 11.11 Fat Intake for Physical Activity

- Fat intake of 20–35% of total energy intake is generally recommended for both athletes and non-athletes, with less than 10% as saturated fat
- Fat provides energy, fat-soluble vitamins, and essential fatty acids
  - Inadequate levels can prove detrimental to training and performance

## 11.12 Protein Intake for Physical Activity

- Protein intakes suggested for active people range from 1.2 to 2.0 grams per kg of body weight
- High-quality sources include lean meats, poultry, fish, eggs, low-fat dairy products, legumes, and soy products

## 11.13 Fluid Intake for Physical Activity

- Fluids
  - Enable the body's primary cooling mechanism, evaporative cooling
  - Are necessary to prevent dehydration and heat-related illnesses
- Fluid intake is critical for physically active people

  - Drink fluids before, during, and after exercise
  - Consume enough to maintain body weight
  - Training in hot environments requires careful attention to water intake

## 11.14 Fluid Intake and Physical Activity

- Heat production during exercise can increase 15 to 20 times compared to inactivity
- The body cools itself through evaporative cooling, but heat illness can occur with dehydration
  - Heat syncope
  - Heat cramps
  - Heat exhaustion

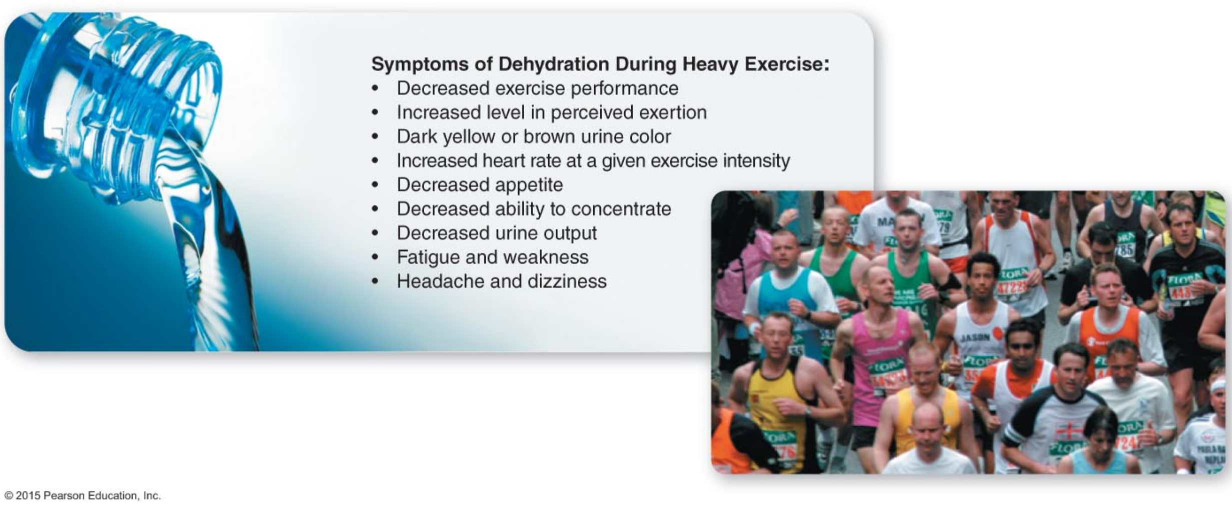



Figure 11.12: Dehydration Symptoms

Table 11.6: Guidelines for Fluid Replacement

| Activity Level | Environment | Fluid Requirements (liters per day) |
|---|---|---|
| Sedentary | Cool | 2–3 |
| Active | Cool | 3–6 |
| Sedentary | Warm | 3–5 |
| Active | Warm | 5–10 |

**Before Exercise or Competition**

- Drink adequate fluids during the 24 hours before event; should be able to maintain body weight.
- Slowly drink about 0.17 to 0.34 fl. oz per kg body weight of water or a sports drink in the 2 to 4 hours prior to exercise or event to achieve urine that is pale yellow in color while allowing sufficient time for excretion of excess fluid prior to exercise.
- Consuming beverages with sodium and/or small amounts of salted snacks at a meal will help stimulate thirst and retain fluids consumed.

**During Exercise or Competition**

- Amount and rate of fluid replacement depend on individual sweating rate, exercise duration, weather conditions, and opportunities to drink.
- Drink sufficient fluids during exercise to replace sweat losses such that total fluid loss is less than 2% of body weight.

**Following Exercise or Competition**

- Consume about 3 cups of fluid for each pound of body weight lost.
- Fluids after exercise should contain water to restore hydration status and sodium to support rehydration.
- Consume enough fluid to permit regular urination and to ensure the urine color is very light or light yellow in color; drinking about 125–150% of fluid loss is usually sufficient to ensure complete rehydration.

**In General**

- Products that contain fructose should be limited, as these may cause gastrointestinal distress.
- Alcohol should be avoided, as it increases urine output and reduces fluid retention.

Source: American College of Sports Medicine, Academy of Nutrition and Dietetics, and Dietitians of Canada. 2016. Nutrition and Athletic Performance. Joint Position Statement. Medicine and Science in Sports and Exercise 48(3):543-568.

## 11.15 Micronutrient Intake for Physical Activity

- The requirements for some vitamins and minerals may be elevated in athletes
  - B-vitamins
  - Calcium
  - Iron
- Adequate intake of these nutrients can be met with a healthy, balanced diet and should not require supplementation

## 11.16 Ergogenic Aids

- **Ergogenic aids:** – substances used to improve exercise and athletic performance
  - Many of these products are not effective
  - Some of these products are dangerous
  - Reliable research and accurate information on these products are hard to find
- Ergogenic aids used to build muscles and increase strength include
  - Anabolic steroids
    * Effective but illegal; numerous serious side effects
  - Andro (androstenedione) and DHEA (dehydroepiandrosterone)
    * Precursors of testosterone
    * Not been shown to be effective
  - GHB (gamma-hydroxybutyric acid)
    * Severe side effects and some reported deaths
- Creatine
  - It may improve performance in sprint activities
  - It may be beneficial to increase strength gained during resistance exercise
  - Relatively minor side effects
  - Effects of long-term use are unknown
- Protein and amino acid supplements
  - Not been shown to be effective
- Ergogenic aids used to increase energy levels and optimize fuel use include
  - Caffeine

    * Increases fat use for energy during exercise
    * In energy drinks, associated with serious side effects in children, adolescents, and young adults
  - Ephedrine
    * Stimulant banned in the United States
    * Serious side effects and some reported deaths
    * Also known as ephedra and ma huang

- Ergogenic aids found to be ineffective include
  - Carnitine
    * Claimed to increase transport of fatty acids into the mitochondria so they can be used for energy
  - Chromium
    * Claimed to enhance insulin's action
  - Ribose
    * Claimed to increase work output and speed up recovery time
- One more ergogenic aid that may have beneficial effects:
  - Beta-alanine
    * Increases the production of carnosine
    * Supplementation may enhance a person's ability to perform short-term, high-intensity activity and may delay muscle fatigue
    * Several weeks of supplementation are needed to affect performance

## 11.17 In Depth: Disorders Related to Body Image, Eating, and Exercise

- Disordered eating
  - A variety of atypical eating behaviors that people use to achieve a lower body weight
    * Ex: going on a diet, refusing to eat fat
  - Eating disorder
    * A psychiatric condition that involves extreme body dissatisfaction and long-term eating patterns that negatively affect body functioning

### 11.17.1 Body Image

- Body image
  - A person's perception, feelings about, and critique of his or her body's appearance and functioning
- Body image can affect eating and exercise behaviors

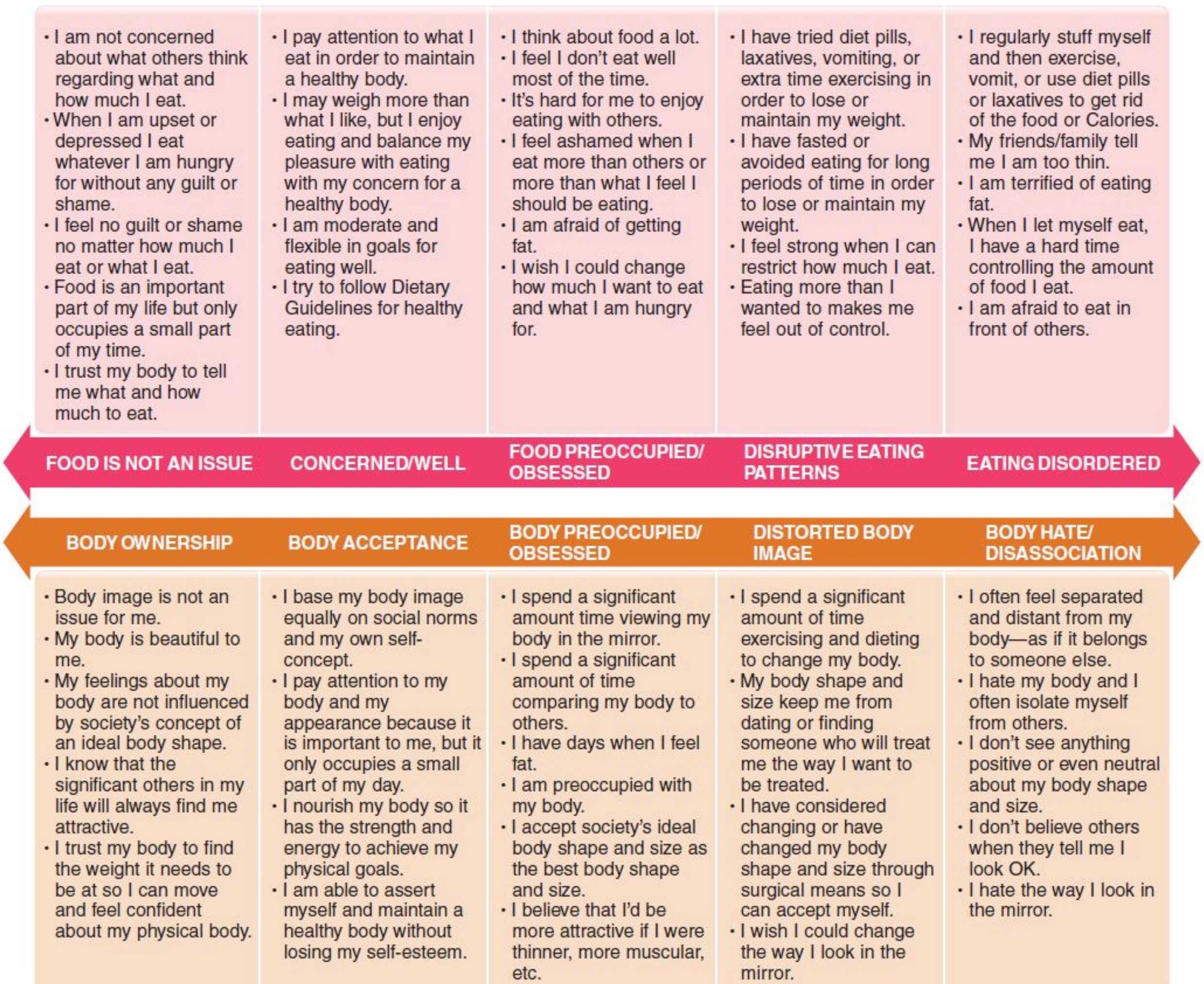



Figure 11.13: Body Image

### 11.17.2 Body Dysmorphic Disorder

- Body dysmorphic disorder (BDD) is a clinically diagnosed psychiatric disorder characterized by a disabling preoccupation with perceived defects in appearance
  - May affect up to 2.4% of the population

  - Equally common in males and females

- Muscle dysmorphia
  - Pathological pursuit of increased muscularity that causes individuals to engage in highly disordered eating behaviors

### 11.17.3 Contributing Factors

- Several factors may influence disorders related to body image, eating, and exercise
  - Genetics
  - Family environment
  - Anxiety, compulsivity, abnormal eating behaviors
  - Media
  - Social/cultural values
  - Other psychological disorders

### 11.17.4 Anorexia Nervosa

- A serious, potentially life threatening eating disorder that is characterized by self-starvation
- Self-starvation can lead to deficiencies in essential nutrients and energy required for the human body to function normally
- Signs and symptoms
  - Restrictive eating patterns
  - Eliminating food groups
  - Intense fear of weight gain
  - Amenorrhea (loss of menstrual cycle for 3 months or more)
  - Distorted body image
- Health risks:
  - Deficiency in total Calories and micronutrients
  - Body will be forced to use fat stores and lean tissue for energy
  - Reduction of non-vital bodily functions
  - Electrolyte imbalances
    * Can lead to heart failure or death

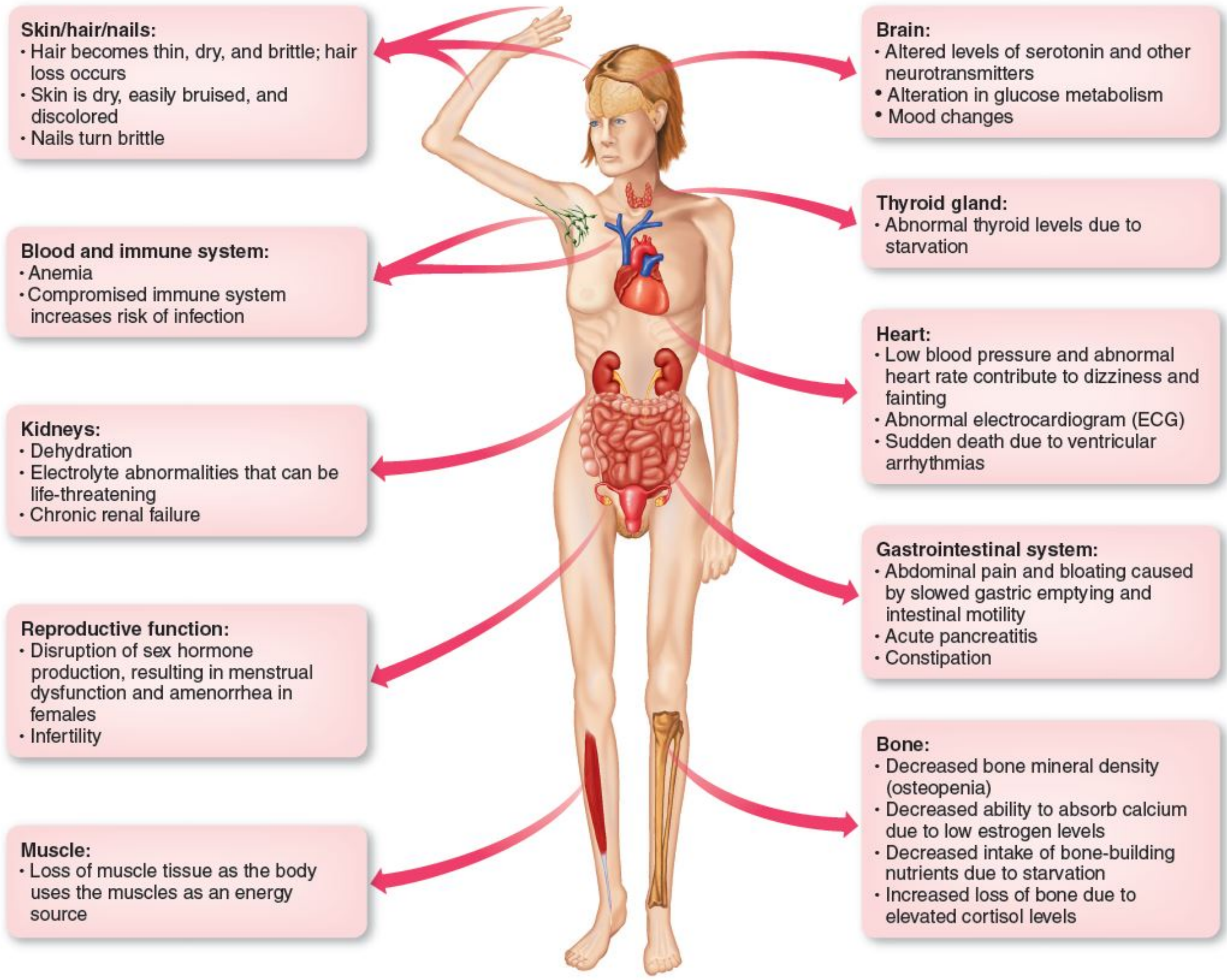



Figure 11.14: Anorexia Nervosa

### 11.17.5 Bulimia Nervosa

- Characterized by repeated episodes of binge eating and purging

  **Binge eating:** a consumption of a quantity of food that is large in size for the person and the amount of time in which the food is eaten

  **Purging:** compensatory behavior used to prevent weight gain. Methods include vomiting, laxative or diuretic abuse, enemas, fasting, and excessive exercise

- Signs and symptoms
  - Recurrent episodes of binge eating
  - Recurrent inappropriate compensatory behavior in order to prevent weight gain
  - Chronically inflamed and sore throat
  - Swollen glands in the neck and jaw

  - Worn tooth enamel

- Health risks
  - 3–5% of adult female population
  - 2% of adult male population
  - Increased risk of being overweight/obese due to increase in caloric consumption
  - Increased blood lipids
  - Low self-esteem
  - Depression

#### 11.17.6 Night-Eating Syndrome

- A disorder characterized by intake of the majority of the days energy between 8 pm and 6 am
- Individuals with this disorder also experience mood and sleep disorders

#### 11.17.7 Female Athlete Triad

- Syndrome that consists of three clinical conditions in some physically active females
  - Low energy availability
  - Amenorrhea
  - Low bone density
- Typically seen in female athletes who participate in activities that emphasize leanness

# Chapter 12

# Food Safety and Technology: Protecting Our Food

## 12.1 Why Is Food Safety Important?

- Foodborne illness: illness transmitted from food or water that contains a microscopic organism, its toxic secretions, or a toxic chemical
  - 48 million Americans report foodborne illness each year (one in six)
  - 128,000 hospitalizations per year
  - 3,000 deaths per year

## 12.2 Government Regulators

- Food Safety and Inspection Service (FSIS)
  - Require multistep protocol called the Hazard Analysis Critical Control Point (HACCP) system
  - Designed to identify biological, chemical, and other potential food-safety hazards during distribution and sales
- Multiple government agencies are involved in ensuring the safety and quality of the food supply
  - Centers for Disease Control and Prevention (CDC)
    * Promotes/educates the public about health and safety
    * Tracks foodborne illness outbreaks
  - U.S. Department of Agriculture (USDA)
    * Oversees meat, poultry, and eggs
  - Environmental Protection Agency (EPA)
    * Regulates use of pesticides

    * Establishes water quality standards

- Food and Drug Administration (FDA)
    * Regulates food standards for all food products (except meat, poultry, and eggs) and bottled water
    * Regulates food labeling and enforces pesticide use regulations

Table 12.1: Government Regulation Agencies

| Name of Agency | Year Founded | Role in Food Regulations | Website |
|---|---|---|---|
| U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) | 1785 | Oversees safety of meat, poultry, and processed egg products; also ensures accuracy of meat and poultry labeling | www.fsis.usda.gov |
| U.S. Food and Drug Administration (FDA) | 1862 | Regulates food standards of food products (except meat, poultry, and eggs) and bottled water; regulates food labeling and enforces pesticide use as established by EPA | www.fda.gov |
| Centers for Disease Control and Prevention (CDC) | 1946 | Works with public health officials to promote and educate the public about health and safety; is able to track information needed in identifying foodborne illness outbreaks | www.cdc.gov |
| U.S. Environmental Protection Agency (EPA) | 1970 | Regulates use of pesticides and which crops that can be applied to; establishes standards for water quality | www.epa.gov |

## 12.3 Food Production – Changes over 100 years

- Has become increasingly complex
- Oversight has decreased
- More foods are mass-produced
- Ingredients come from various sources
- Contamination can occur at any point from farm to table

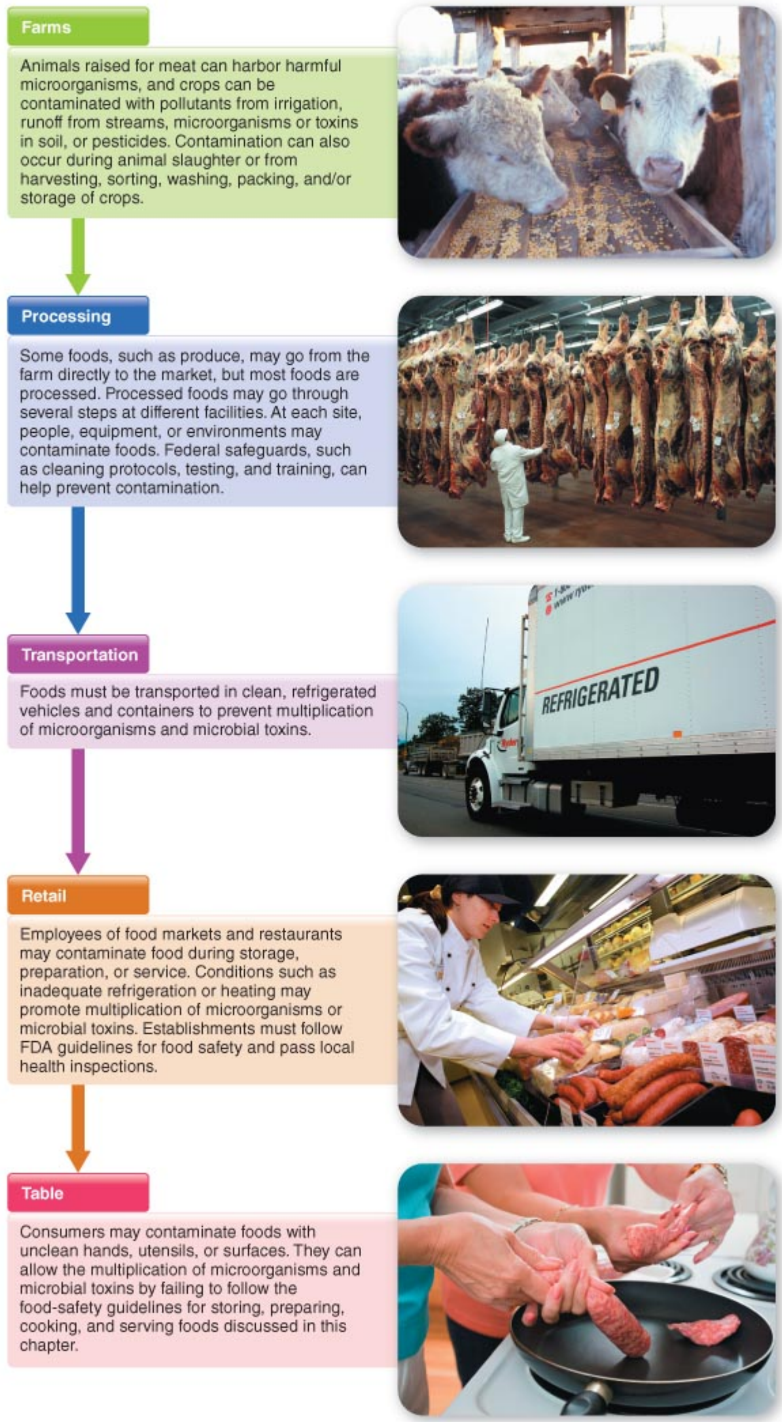





Figure 12.1: Food from Farm to Table

## 12.4 Causes of Foodborne Illness

- Two types of foodborne illness

  - Food infection
    * Illness resulting from eating food contaminated with living organisms
  - Food intoxication
    * Illness resulting from eating food in which microbes have secreted toxins (poisons)
- Viruses and bacteria are the most common microbes causing foodborne illnesses
- Other sources of contamination include parasites, fungi, and prions

### 12.4.1 Norovirus

Of the viruses, norovirus causes more foodborne illness than the other 30 known pathogens put together
Often referred to as “the stomach flu”
Affects 19–21 million infections per year

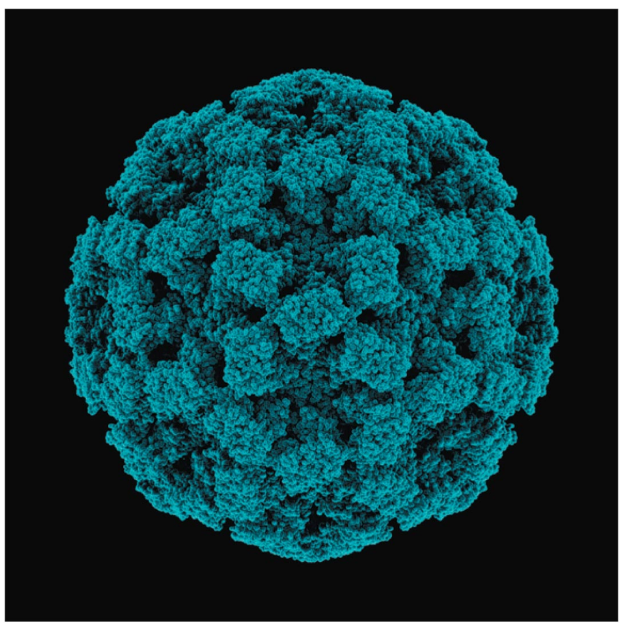


Figure 12.2: Norovirus

- The most common bacterial causes of foodborne illness are
  - Salmonella
  - Clostridium perfringens
  - Campylobacter
  - Staphylococcus aureus
  - Escherichia coli
  - Listeria monocytogenes
- The most deadly is ____________

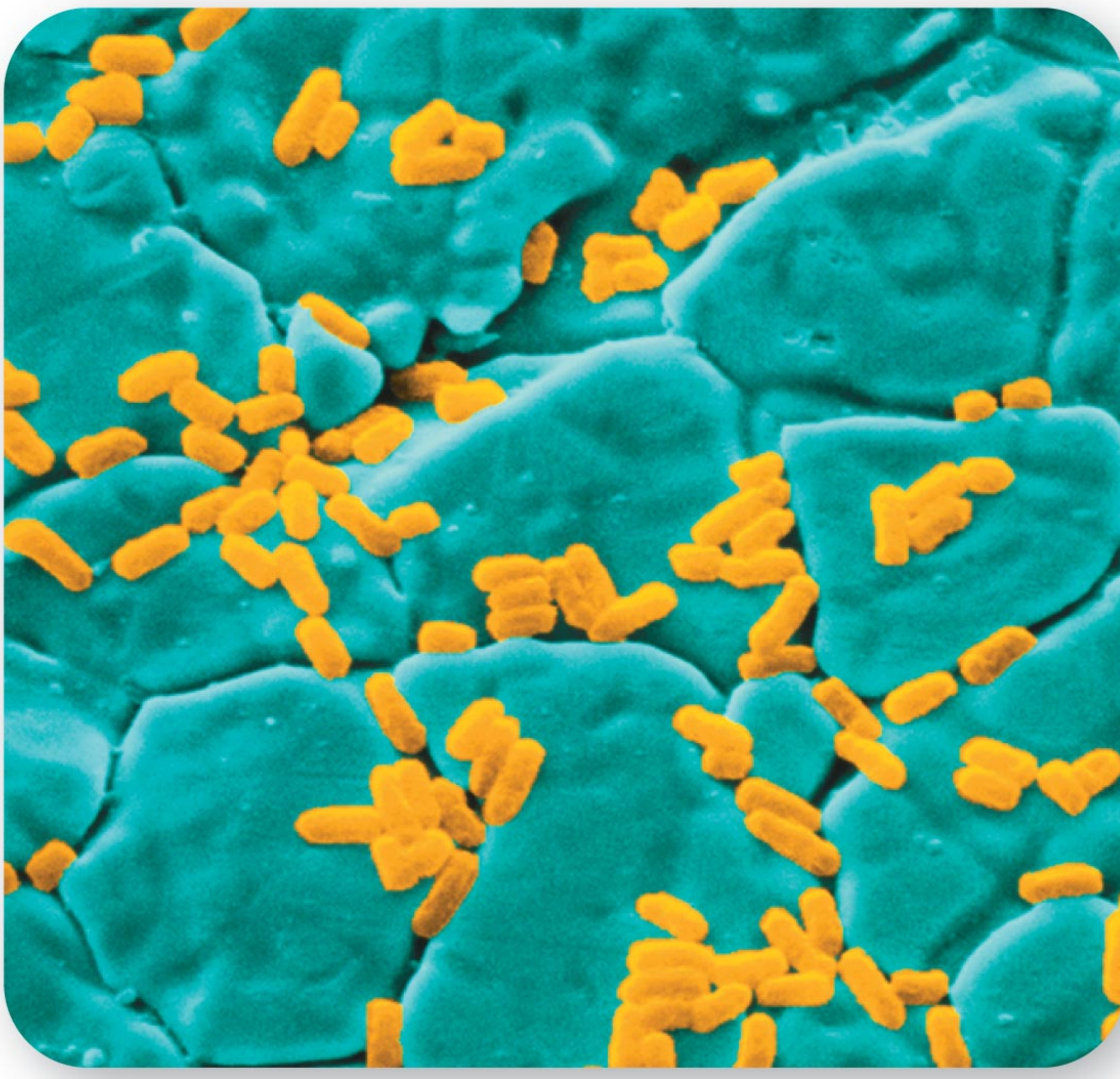


Figure 12.3: Salmonella

**TABLE 12.2** Key Bacteria of Concern in Foodborne Illnesses and Deaths

| Bacteria | Incubation Period | Duration | Symptoms | Foods Most Commonly Affected | Steps for Prevention |
|---|---|---|---|---|---|
| *Campylobacter* (several species) | 1–7 days | 2–10 days | Headache<br>Diarrhea<br>Nausea<br>Abdominal cramps | Raw and undercooked meat, poultry, eggs<br>Cake icing<br>Untreated water<br>Unpasteurized milk | Only drink pasteurized milk.<br>Cook foods properly.<br>Avoid cross-contamination. |
| *Clostridium perfringens* | 8–22 hours | 24 hours | Abdominal cramps<br>Diarrhea<br>Dehydration | Beef<br>Poultry<br>Gravies<br>Leftovers | Cook foods thoroughly and serve hot.<br>Refrigerate leftovers promptly.<br>Reheat leftovers thoroughly before serving. |
| *Escherichia coli* (some strains produce an enterotoxin) | 1–10 days | 5–7 days | Abdominal cramps<br>Diarrhea (often bloody)<br>Vomiting | Water; unpasteurized milk, cheese, juice, or cider; undercooked meat; raw produce | Cook foods thoroughly.<br>Avoid cross-contamination.<br>Only drink pasteurized milk and juice.<br>Practice proper handwashing and sanitizing. |
| *Listeria monocytogenes* | 1–42 days | Days to weeks | Fever<br>Muscle aches<br>Diarrhea<br>Sometimes headache and confusion | Meats, especially hot dogs and deli meats<br>Vegetables<br>Dairy products, especially raw milk and soft cheeses<br>Smoked fish | Cook foods thoroughly and serve hot. Wash produce carefully.<br>If pregnant, do not consume deli meats, smoked fish, or products containing raw milk. |
| *Salmonella* (more than 2,300 types) | 12–24 hours | 4–7 days | Nausea<br>Diarrhea<br>Abdominal pain<br>Chills<br>Fever<br>Headache | Raw or undercooked eggs, poultry, and meat<br>Raw milk and dairy products<br>Seafood<br>Fruits and vegetables | Cook foods thoroughly.<br>Avoid cross-contamination.<br>Only drink pasteurized milk.<br>Practice proper handwashing and sanitizing. |
| *Staphylococcus aureus* (which produces an enterotoxin) | 1–6 hours | 1–2 days | Sudden, severe nausea and vomiting<br>Abdominal cramps<br>Diarrhea may occur | Custard- or cream-filled baked goods<br>Ham<br>Poultry<br>Dressings, sauces, and gravies<br>Eggs<br>Potato salad | Refrigerate foods.<br>Practice proper handwashing and sanitizing. |

*Sources:* Data from Iowa State University Extension, Food Safety. 2015. *What Are the Most Common Foodborne Pathogens?* http://www.extension.iastate.edu/foodsafety/L1.7; U.S. Food and Drug Administration, Foodborne Illnesses: What You Need to Know, 2015, January 29. http://www.fda.gov/Food/FoodborneIllnessContaminants/FoodborneIllnessesNeedToKnow/default.htm; and U.S. Centers for Disease Control and Prevention, Foodborne Outbreak Online Database (FOOD Tool): 1998–2014. 2015, October 8. http://wwwn.cdc.gov/foodborneoutbreaks.

Figure 12.4: Bacterial Causes of Foodborne Illness

- **Parasites** – microorganisms that simultaneously derive benefit from and harm their host
  - Only responsible for about 2% of foodborne illnesses
  - Most common examples are helminths and protozoa
- Other microorganisms causing illness include
  - Viruses such as hepatitis A
  - Helminths or worms, such as tapeworms, flukes, and roundworms
  - Giardia, causing a diarrheal illness called giardiasis
  - Protozoa are most commonly the cause of waterborne illness
  - Fungi (yeast and mold), which cause food spoilage


Figure 12.5: Tapeworms

Figure 12.6: Molds

- Some microbes cause illness by secreting toxins
  - Clostridium botulinum produces botulism toxin, which blocks nerve transmissions to muscle cells
  - Toxins can be neurotoxins (damage the nervous system) or enterotoxins (damage the gastrointestinal tract)
  - Fungi produce mycotoxins
  - Toxic algae can contaminate fish and shellfish
  - A variety of plant toxins can also cause illness

Figure 12.7: Mushrooms Can Contain Dangerous Toxins

## 12.5 Conditions That Help Microbes Multiply

- Four factors affect the survival and reproduction of food microorganisms:
  1. Those that can cause human illness thrive in the temperature danger zone
  2. Many thrive in environments of high humidity
  3. Most have a preferred acidity range
  4. Many—though not all—depend on oxygen content to function

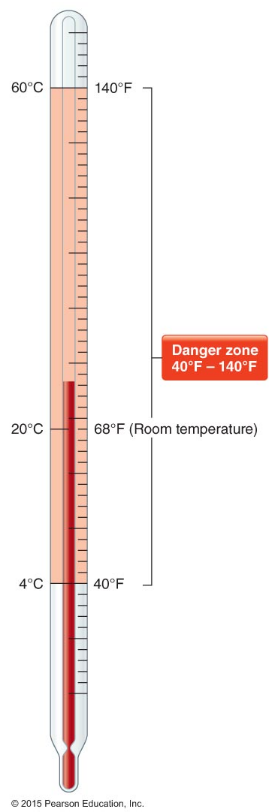



Figure 12.8: The Danger Zone

## 12.6 Preventing Foodborne Illness

When preparing foods at home, be sure to

- Wash hands and kitchen surfaces often
- Separate foods to prevent cross-contamination
- Chill or freeze foods to prevent microbes from growing
- Cook foods to their proper temperature

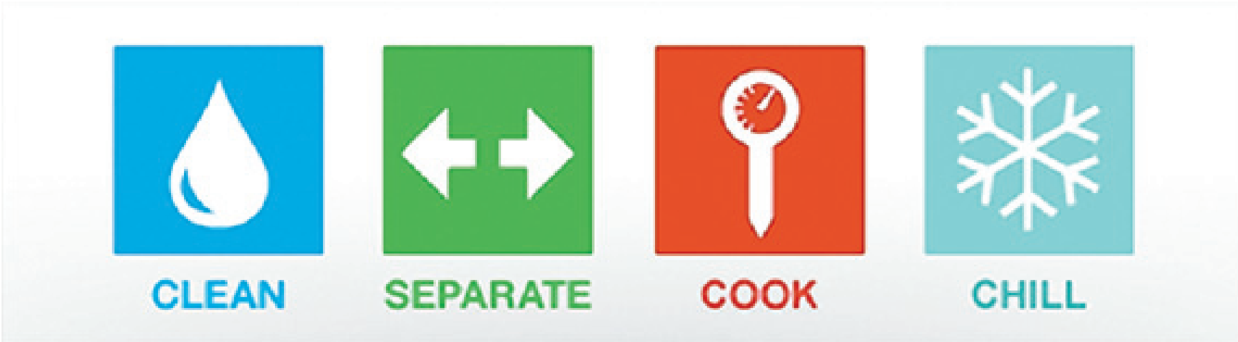



Figure 12.9: Reducing Foodborne Illness

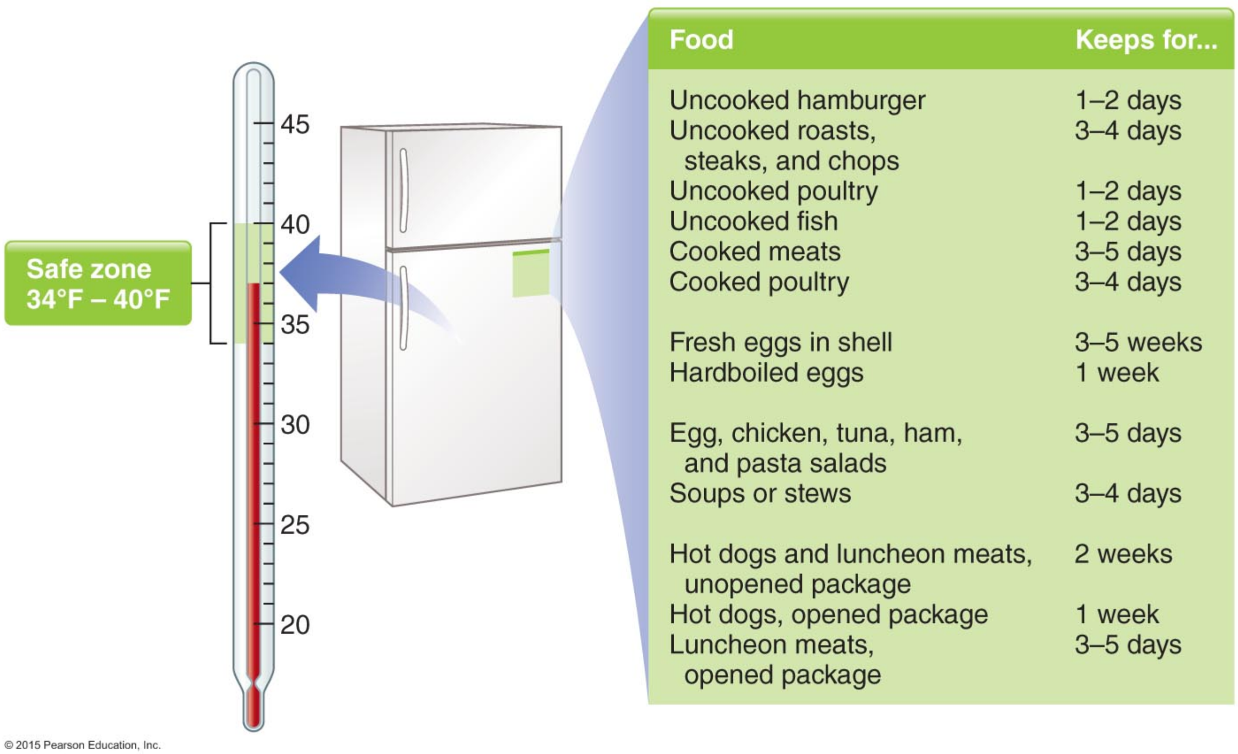



Figure 12.10: Keeping Foods Refrigerated

- Foods should be cooked thoroughly to kill microbes
- Leftovers should be stored in the refrigerator for a limited period of time
- Food should be thawed slowly in the refrigerator
- When shopping, purchase refrigerated and frozen foods last

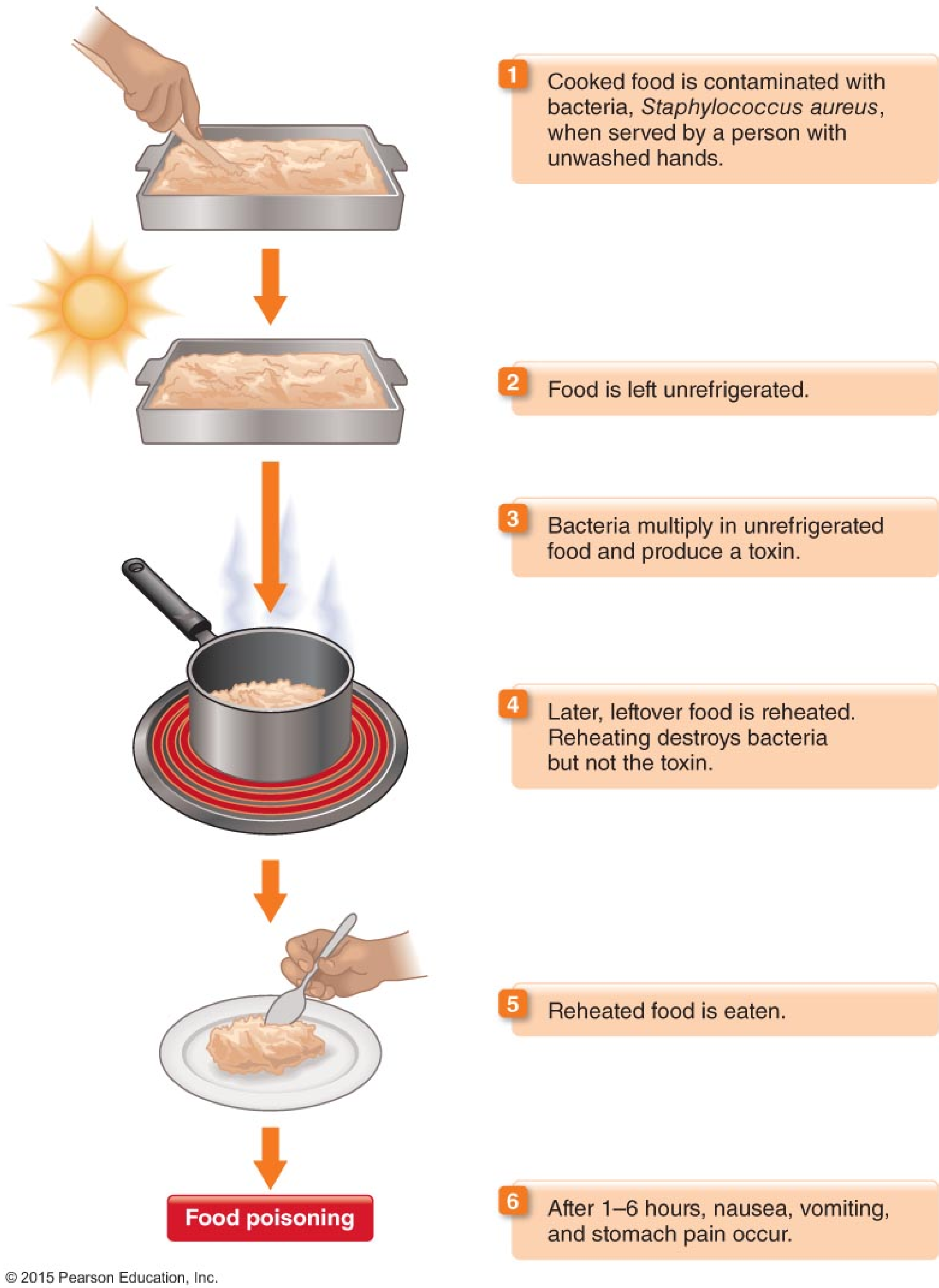



Figure 12.11: Food Contamination

- When eating out:
  - Eat at restaurants that look clean
  - Insist that food be cooked thoroughly
- When traveling:
  - Avoid raw foods, salads, unpasteurized milk, and uncooked fruits and vegetables
  - Select beverages carefully
  - Use a waterless antibacterial hand cleanser frequently

## 12.7 Preventing Food Spoilage

- Spoilage can be prevented by many natural techniques
  - Salting or sugaring
  - Drying
  - Smoking
  - Cooling
- More modern techniques of preventing spoilage include
  - Canning
  - Pasteurization
  - Irradiation
  - Aseptic packaging
  - Modified atmosphere packaging
  - High-pressure processing

Figure 12.12: The USDA's Radura

## 12.8 Food Additives

- Food additives are chemicals that do not occur naturally in the food but are added to enhance the food in some way – can include:
  - Nutrients and preservatives
  - Flavorings
  - Colorings
  - Other agents
- More than 3,000 food additives are used in the United States

**TABLE 12.3 Examples of Common Food Additives**

| Food Additive | Foods Found in |
|---|---|
| **Coloring Agents** | |
| Beet extract | Beverages, candies, ice cream |
| Beta-carotene | Beverages, sauces, soups, baked goods, candies, macaroni and cheese mixes |
| Caramel | Beverages, sauces, soups, baked goods |
| Tartrazine | Beverages, cakes and cookies, ice cream |
| **Preservatives** | |
| Alpha-tocopherol (vitamin E) | Vegetable oils |
| Ascorbic acid (vitamin C) | Breakfast cereals, cured meats, fruit drinks |
| BHA | Breakfast cereals, chewing gum, oils, potato chips |
| BHT | Breakfast cereals, chewing gum, oils, potato chips |
| Calcium proprionate/sodium proprionate | Bread, cakes, pies, rolls |
| EDTA | Beverages, canned shellfish, margarine, mayonnaise, processed fruits and vegetables, sandwich spreads |
| Propyl gallate | Mayonnaise, chewing gum, chicken soup base, vegetable oils, meat products, potato products, fruits, ice cream |
| Sodium benzoate | Carbonated beverages, fruit juice, pickles, preserves |
| Sodium chloride (salt) | Most processed foods |
| Sodium nitrate/sodium nitrite | Bacon, corned beef, lunch meats, smoked fish |
| Sorbic acid/potassium sorbate | Cakes, cheese, dried fruits, jellies, syrups, wine |
| Sulfites (sodium bisulfite, sulfur dioxide) | Dried fruits, processed potatoes, wine |
| **Texturizers, Emulsifiers, and Stabilizers** | |
| Calcium chloride | Canned fruits and vegetables |
| Carageenan/pectin | Ice cream, chocolate milk, soy milk, frostings, jams, jellies, cheese, salad dressings, sour cream, puddings, syrups |
| Cellulose gum/guar gum/gum arabic/ locust gum/xanthan gum | Soups and sauces, gravies, sour cream, ricotta cheese, ice cream, syrups |
| Gelatin | Desserts, canned meats |
| Lecithin | Mayonnaise, ice cream |
| **Humectants** | |
| Glycerin | Chewing gum, marshmallows, shredded coconut |
| Propylene glycol | Chewing gum, gummy candies |

Figure 12.13: Common Food Additives

- Sulfates and nitrites are preservatives that have raised health concerns

- Before a new additive can be used in food, the producer must demonstrate its safety to the FDA
- Substances already recognized as safe and exempt from stringent testing are referred to as generally recognized as safe (GRAS)

## 12.9 Genetic Modification in Food Production

- In genetic modification, the DNA of an organism is altered to bring about changes in its seeds or offspring
  - Recombinant DNA technology is a type of genetic modification in which DNA from different sources is combined
  - An increasing number and quantity of food crops have been genetically modified

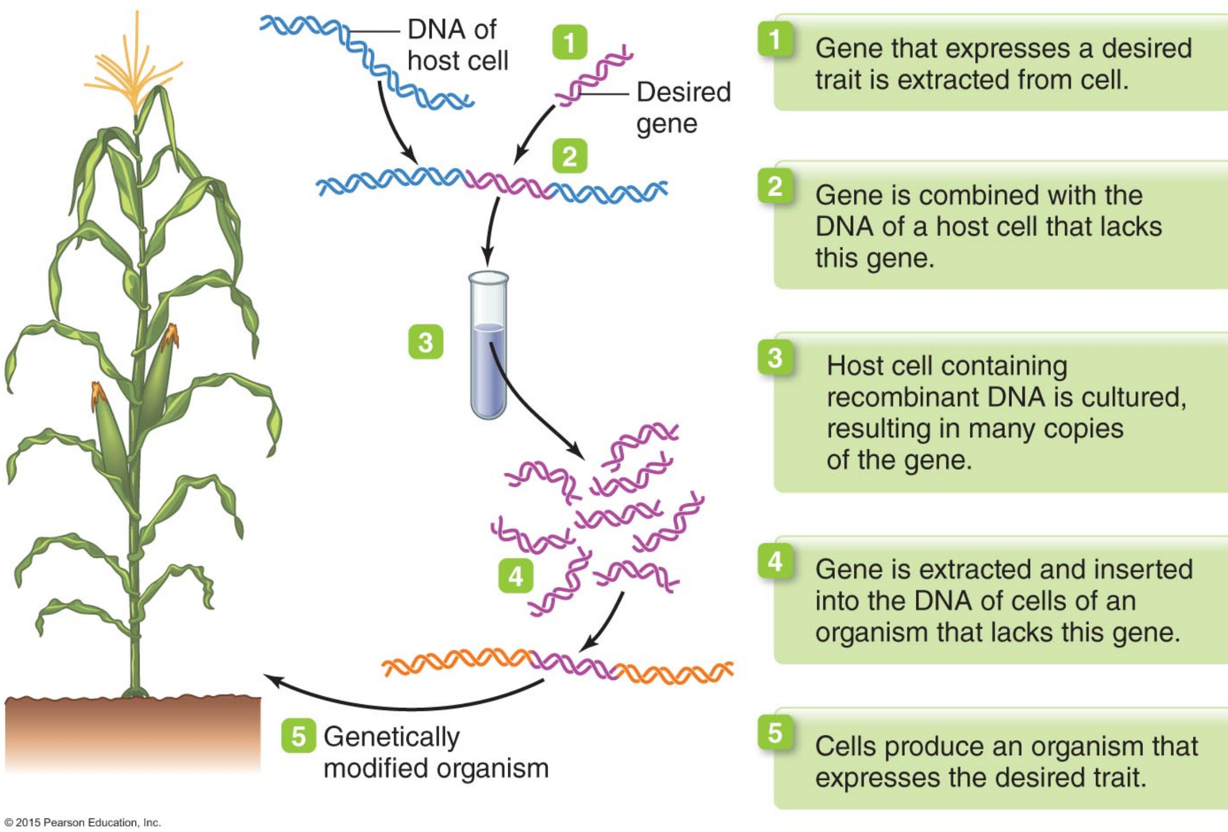



Figure 12.14: Recombinant DNA Technology

## 12.10 Benefits to Genetic Modification

- GM crops grow faster and have a higher yield

- Drought-resistant crops help to conserve water
- Reduced energy use to grow, pesticides, emissions from greenhouse gases, and increased soil preservation
- GM crops can be produced with higher nutrient contents
- Improved farmer profits benefit the economy
- Health risks
  - **Allergenicity** – genes transferred from common allergen foods could affect those with allergies
    * No currently reports however
  - Consuming crops that are antimicrobial could potential hard the cells of our body or our microbial flora in the GI tract
  - Genes from GM crops have migrated to conventional crops miles away
  - Possible link to cancer
- Environmental risks
  - Loss of biodiversity
  - Generation of superweeds
  - Threats to other species
- Economic instability

## 12.11 Should We Label GM Foods?

- Labeling would allow consumers to know if their food contained GM products
- The European Union has long required that GM foods are labeled clearly
- In 2016 the FDA did not require such labeling
- GM crops have been used in the United States for 20 years without labeling

## 12.12 Residues on Foods

- Various chemicals can persist and even accumulate in foods
- These residues can include
  - Persistent organic pollutants
  - Insecticides, herbicides, and fungicides
  - Growth hormone

## 12.13 Persistent Organic Pollutants

- Persistent organic pollutants (POPs): chemicals released into the atmosphere from industry, agriculture, automobiles, and waste disposal
  - Found in virtually all categories of foods
  - Include
    * Mercury and lead, which are nerve toxins
    * Dioxins, which increase risk of cancer and other disorders

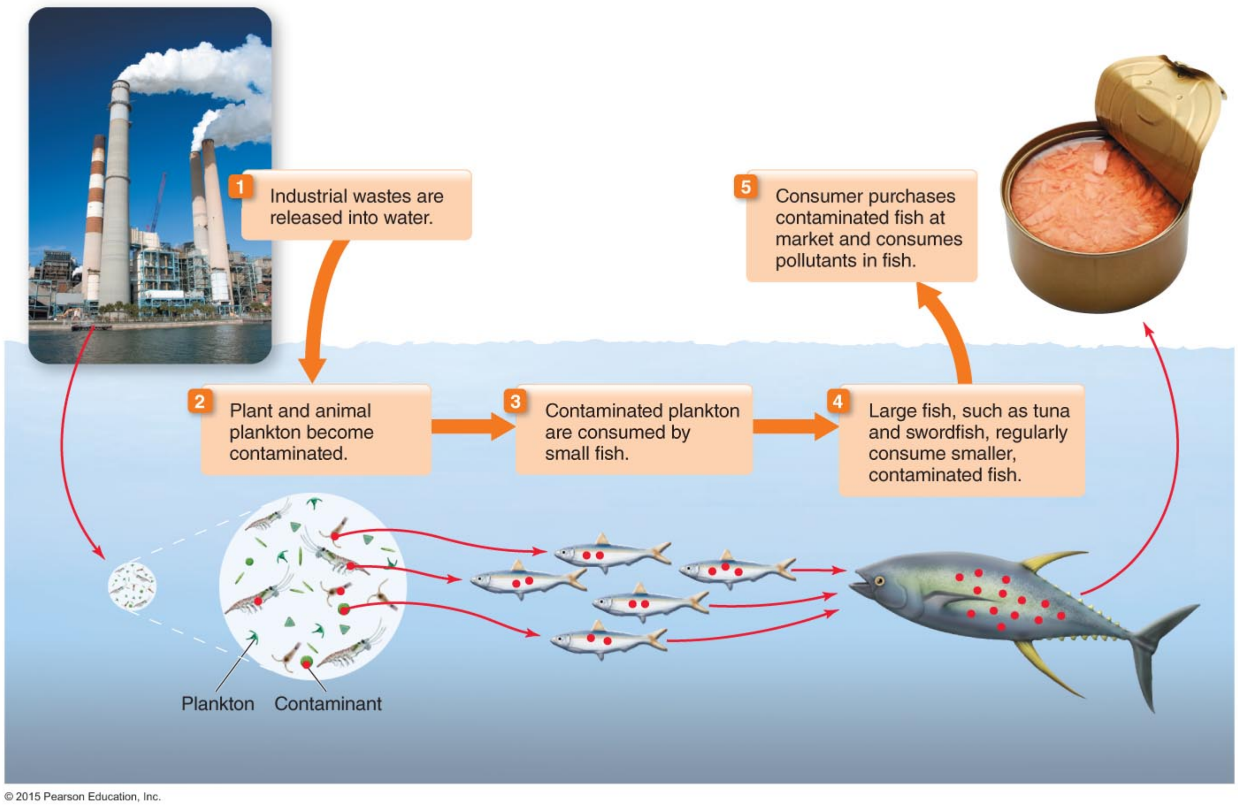



Figure 12.15: Biomagnification of POPs

## 12.14 Pesticides

- Pesticides are used to help protect against crop losses, reduce the incidence of disease, and increase crop yields
  - Most common are insecticides, herbicides, and fungicides
  - Can be natural or synthetic
  - Can remain as toxins on foods
  - Regulated by the EPA

## 12.15 Growth Hormones and Antibiotics

- Recombinant bovine growth hormone (rBGH) is a genetically engineered growth hormone given to cows
  - Increases muscle mass; decreases fat
  - Increases milk production
  - One-third of all U.S. dairy cows receive rBGH
  - Risks to humans are still being studied
- Antibiotics are routinely given to animals raised for food to reduce the number of disease outbreaks
  - Risks to humans are still being studied
  - May be developing significant reservoirs for antibiotic-resistant strains of bacteria, or "superbugs"
- Exposure to growth hormones and antibiotics can be reduced by selecting organic foods, free-range meats, and vegetarian meals

## 12.16 Organic Foods

- Organic foods are grown without the use of synthetic pesticides
  - Standards for organic production are regulated by the USDA

**100% organic:** only organic ingredients

**Organic:** 95% of ingredients are organic

**Made with organic ingredients:** 70% or more of ingredients are organic

Figure 12.16: USDA Organic Seal

## 12.17 In Depth: Supplements

- Supplements, according to the FDA, are a product containing ingredients like vitamins, minerals, herms, amino acids, or enzymes
- In 2014 sales of dietary supplements reached nearly $37 billion
- Are supplements safe?
  - In 2015, 14 U.S. Attorneys General signed a letter to congress requesting for an investigation of the dietary supplement industry
  - This comes after an audit for DNA testing of ingredients found they did not contain ingredients listed, but did contain heavy metals

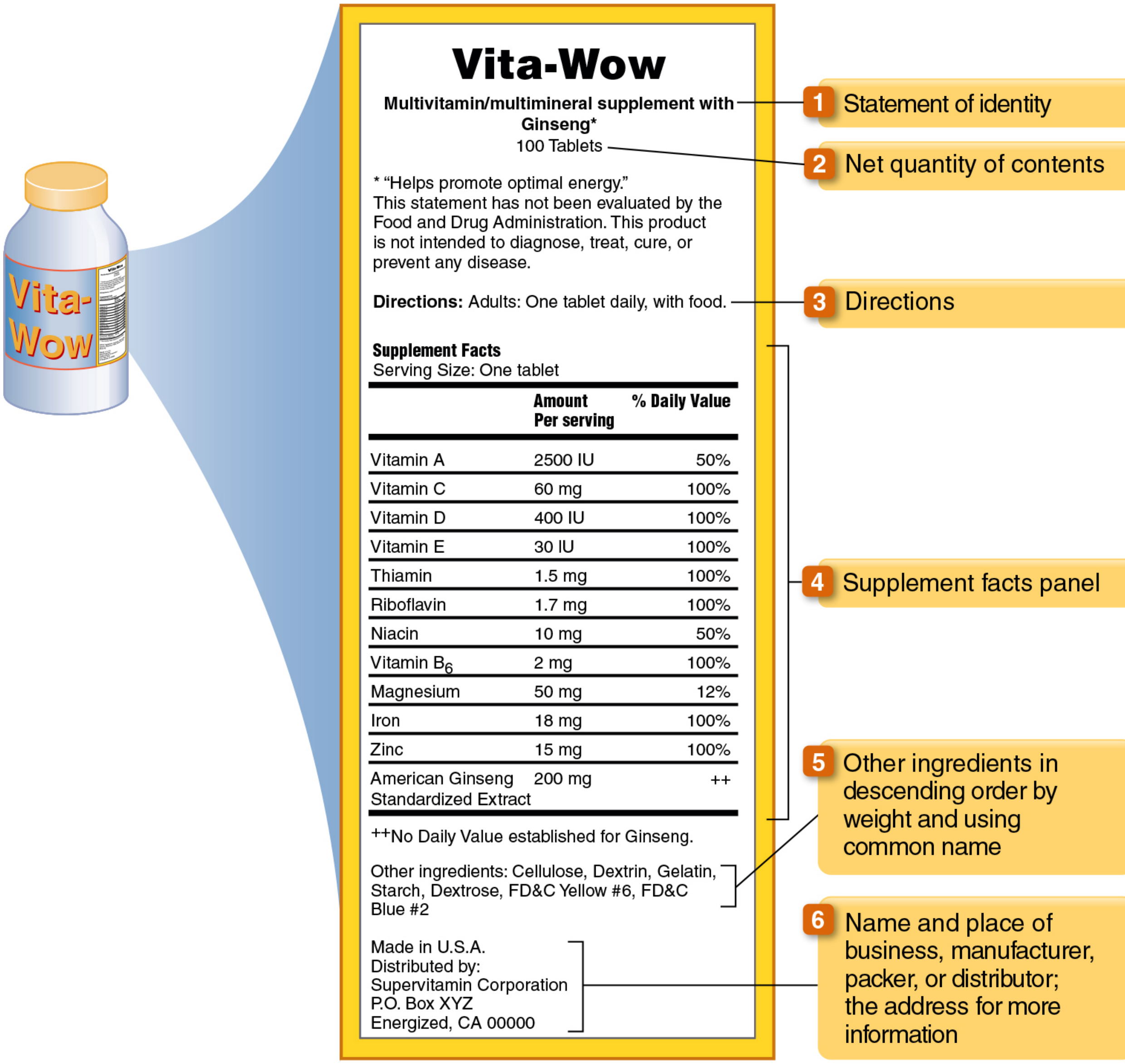



Figure 12.17: Supplements

- The FDA does not have the authority to review safety and efficacy of supplements
- It is the responsibility of the manufacturer to prove the safety of supplements
- Manufacturers do not have to tell the FDA they have added an ingredient
- The FDA does not regulate practices to ensure the purity

### 12.17.1 Herbal supplements

- The plant or part of the plant that is used to flavor, scent, and/or potential health-related properties

- The National Center for Complimentary and Integrative Health (NCCIH)
- Consult a healthcare provider before beginning a supplement

**TABLE 1** **Potentially Harmful Herbal Supplements**

| Herb | Potential Risks |
|---|---|
| Bitter orange | Increased blood pressure and heart rate; heart attack; stroke |
| Ephedra (also known as *ma huang,* Chinese ephedra, and epitonin) | High blood pressure, irregular heartbeat, nerve damage, insomnia, tremors, headaches, seizures, heart attack, stroke, possible death |
| Kava (also known as *kava kava*) | Liver damage; death |
| Licorice root | High blood pressure, fluid retention, hypokalemia |
| Noni | Liver damage |
| Thunder god vine | Diarrhea, nausea, skin rash, headache, hair loss, menstrual changes, male infertility; can be fatal if improperly extracted |
| Willow bark | Reye's syndrome (a potentially fatal reaction that may occur when children take aspirin), allergic reaction in adults |
| Yohimbe | High blood pressure, increased heart rate, headache, anxiety, dizziness, nausea, vomiting, tremors, insomnia |

*Source:* Data from National Center for Complementary and Integrative Health (NCCIH). 2016. *Herbs at a Glance.* https://nccih.nih.gov/health/herbsataglance.htm

Figure 12.18: Potentially Harmful Herbal Supplements

- Surveys show that 67% of Americans use a vitamin or mineral supplement

- 35% use "specialty" supplements
- 23% use botanicals
- 17% use sports supplements

**TABLE 2** Individuals Who May Benefit from Micronutrient Supplementation

| Type of Individual | Specific Supplements That May Help |
|---|---|
| Newborns | Routinely given a single dose of vitamin K at birth |
| Infants | Depends on age and nutrition; may need iron, vitamin D, or other nutrients |
| Children not drinking fluoridated water | Fluoride supplements |
| Children with poor eating habits or overweight children on an energy-restricted diet | Multivitamin and multimineral supplement that does not exceed the RDA for the nutrients it contains |
| Pregnant teenagers | Iron and folic acid; other nutrients may be necessary if diet is very poor |
| Women who may become pregnant | Multivitamin or multivitamin and multimineral supplement that contains 0.4 mg of folic acid |
| Pregnant or lactating women | Multivitamin and multimineral supplement that contains iron, folic acid, zinc, copper, calcium, vitamin $B_6$, vitamin C, and vitamin D |
| People on prolonged or highly calorically restrictive weight-reduction diets | Multivitamin and multimineral supplement |
| People recovering from serious illness or surgery | Multivitamin and multimineral supplement |
| People with HIV/AIDS or other wasting diseases; people addicted to drugs or alcohol | Multivitamin and multimineral supplement or single-nutrient supplements |
| People who do not consume adequate calcium | Calcium should be consumed in whole foods and beverages; however, for some populations, supplements may be prescribed |
| People with low exposure to sunlight | Vitamin D |
| People eating a vegan diet | Vitamin $B_{12}$, riboflavin, calcium, vitamin D, iron, and zinc |
| People who have had portions of their intestinal tract removed; people who have a malabsorptive disease | Depends on the exact condition; may include various fat-soluble and/or water-soluble vitamins and other nutrients |
| Elderly people | Multivitamin and multimineral supplement, vitamin $B_{12}$ |

Figure 12.19: Individuals Who May Benefit from Micronutrient Supplementation

# Chapter 13

# Food Equity, Sustainability, and Quality: The Challenge of "Good Food"

## 13.1 Food Insecurity

**Food insecurity** – unreliable access to a sufficient supply of nourishing food

- About 17.4 million U.S. households (roughly 14%) experienced food insecurity in 2011
- About 6.8 million households experienced very low food security–eating patterns were disrupted and food intake was reduced
- Those at higher risk are households with lower incomes

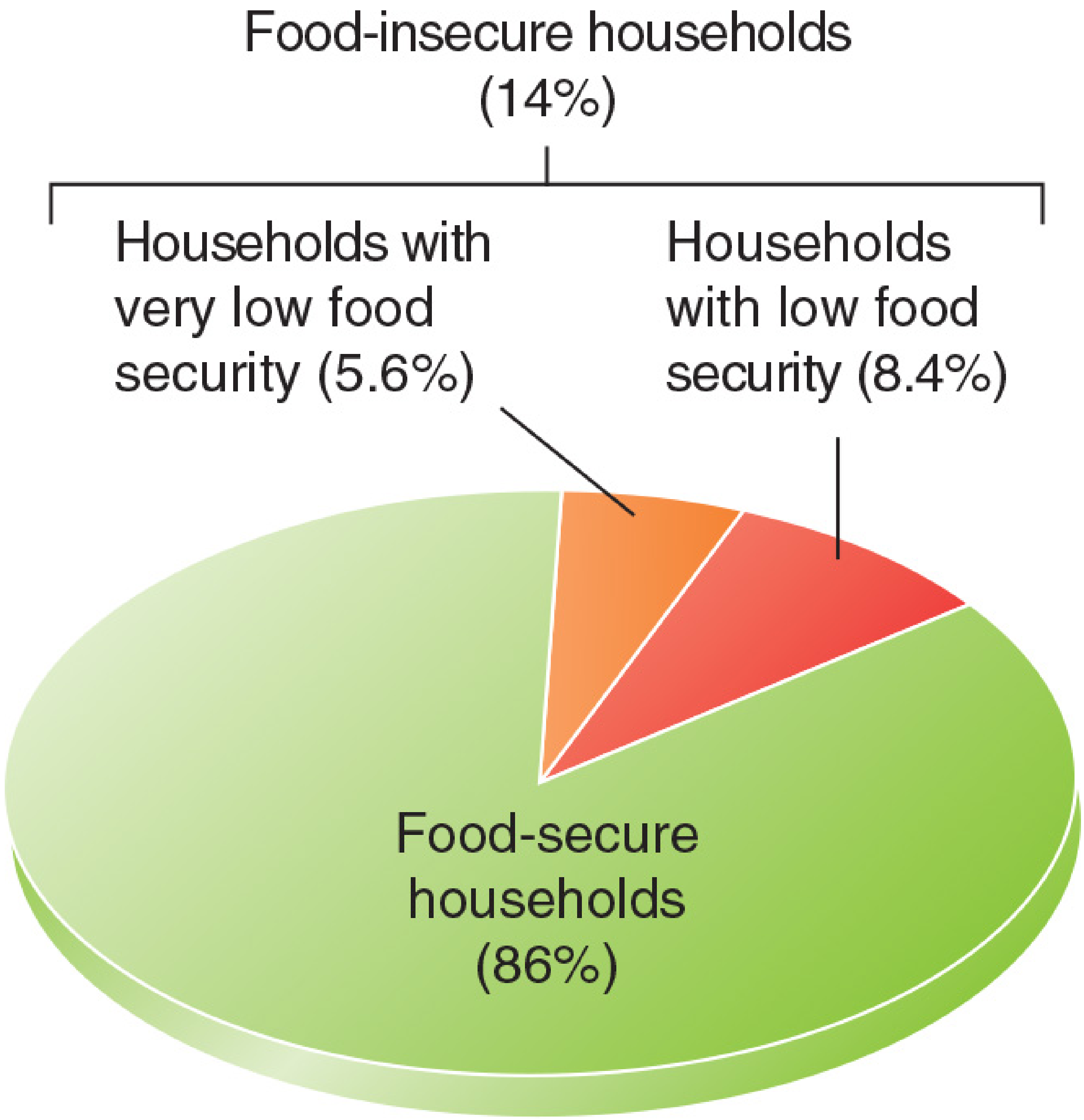



Figure 13.1: Food Insecurity

## 13.2 Food Access

- Famine is a severe food shortage affecting a large percentage of the population in a limited geographical area
  - 20–43 million people died in the great famine in China from 1958 to 1961
- Overpopulation can occur when resources are insufficient to support the number of people living there

  - Uneven distribution of food

## 13.3 Chronic Hunger

- Local conditions can contribute to chronic hunger
  -
  - Cash cropscrops grown to be sold rather than eaten, such as cotton or tobacco
  - Lack of infrastructure
  - Impact of disease

## 13.4 Climate Change Threatens Food Security

- Global warming is the general term used for the increase of about 1.5°F in temperature that has occurred on the Earth's surface over the past century.
  - Many scientists believe this is due to the carbon dioxide produced by human activities
  - A 2015 study attributed 75% of heat extremes and 18% of precipitation extremes to global warming

## 13.5 Sustainability

- Sustainability is the ability to satisfy basic economic, social, and security needs now and in the future without undermining the natural resource base and environmental quality on which life depends
  - Sustainable practices can help
    * Reduce pollution of soil and water
    * Maintain or improve food diversity
    * Reduce the number of food deserts–geographic areas where people lack access to affordable, nutritious food

Figure 13.2: Food Ethics: Sustainability

- Food movement initiatives that aim to promote sustainability and food diversity include
  - Family farms
  - Community supported agriculture (CSA)
  - Farmers' markets
  - Urban agriculture
  - School gardens
  - Entrepreneurship investing in food startups
  - Corporate involvement

## 13.6 Industrial Agriculture

- Green Revolution
  - Massive program that has improved the technology and practices in agriculture
- High yield varieties (HYVs)

- New forms of food products (like grains) that were produced by cross-breeding plants and selecting the most desirable traits

## 13.7 Food Diversity

Food diversity is the variety of difference species of food crops available

- In the 1960s the federal Agricultural Adjustment Act provided financial incentives for farmers to grow singles crops that were cultivated on a massive scale called monocultures

## 13.8 Food Industry Influences America's Diet

- In 2015 lobbyists were recorded spending the following amounts to promote certain aspects of food production
  - Livestock: $2.9 million
  - Dairy: $7 million
  - Sugar: $10.3 million
  - Food manufacturers: $18.3 million
  - Beer, wine, and liquor: $25 million

## 13.9 International Initiatives

- There are many international initiatives that strive to increase access to nourishing foods
  - WHO and UNICEF promote breastfeeding
  - United Nations World Food Programme
  - USAID and Peace Corps agricultural education programs

## 13.10 National and Local Programs

- In the United States many programs help to increase access to nourishing foods
  - SNAP
  - WIC
  - National School Lunch and Breakfast Program
  - USDA Commodity Food Program
  - CDC Healthful Corner Store

## 13.11 Food Ethics: Food Equity

- **Fair trade** – trading partnership promoting equity in international trading relationships and contributing to sustainable development by securing the rights of marginalized producers and workers
  - Born in response to the exploitation of farm laborers around the world
  - Depends on support from consumers purchasing Fair Trade products
- **Food equity** – sharing the world's food and other resources fairly
  - One in seven people in the world is chronically undernourished, almost all of them in developing nations
  - The major cause of undernutrition is unequal distribution of food because of poverty




Figure 13.3: Food Ethics: Food Equity

## 13.12 Choose Foods That Are Healthful for You

- Buy organic or reduce synthetic pesticide use
- Purchase local produce and support local economy
- Choose whole foods or less processed foods
- Avoid empty Calorie foods and beverages
- When eating out ask for nutrition information

## 13.13 In Depth: Malnutrition

- Approximately 51 million children do not weigh enough for their height
- Severe acute malnutrition (SAM)
  - Condition in which energy intake is so inadequate that the child experiences a lower body weight than normal
- Approximately 161 million children experience stunted growth which causes them to be shorter than expected for their age.
- SAM dramatically increases a population's rate of :

  **Maternal mortality:** deaths of a woman during pregnancy, childbirth, or in the immediate postpartal period

  **Infant mortality:** deaths of infants between birth and 1 year of age

- Micronutrient deficiencies can lead to preventable diseases
  - Iron deficiency anemia (most common deficiency worldwide)
  - Prenatal iodine for fetal brain development
  - Vitamin A deficiency is the leading cause of blindness in children

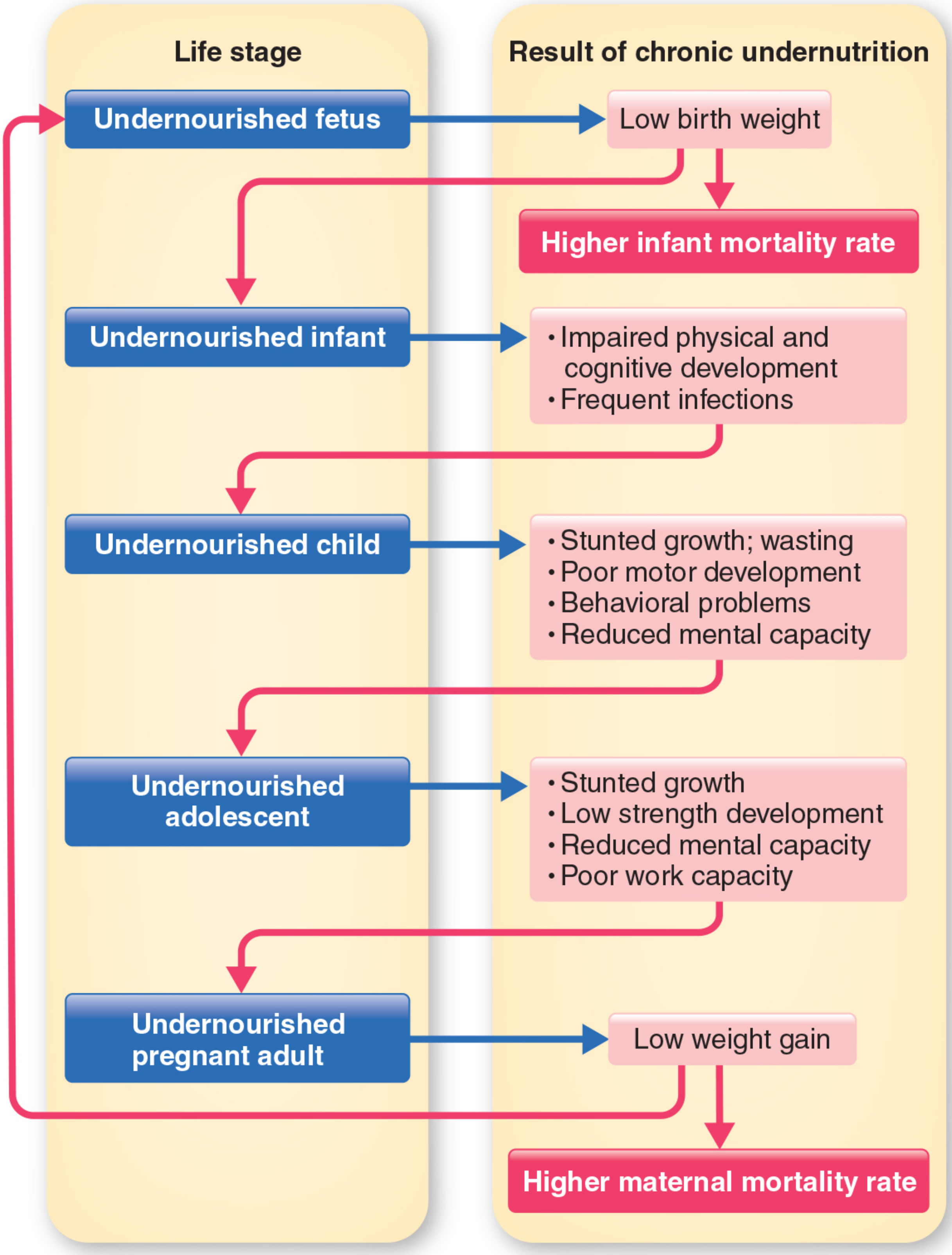



Figure 13.4: Malnutrition

- Nutrition paradox is characterized by the coexistence of stunting and overweight/obesity within the same region, the same household, and even the same person
  - The WHO identifies two key factors:
    - A trend toward decreased physical activity
    - A global shift toward increased consumption of energy dense foods
- Poverty-obesity paradox occurs when obesity is more prevalent in low-income populations
  - Some researchers have also observed a so-called hunger-obesity paradox in which low income people are obese while also deficient in one or more nutrients
- Food deserts also contribute to malnutrition and poor food access
  - Characterized as geographic areas where people lack access to fresh, healthful, and affordable food

# Chapter 14

# Nutrition Through the Life Cycle: Pregnancy and the First Year of Life

## 14.1 Nutrition Before Conception

- Some deficiency-related problems develop very early in pregnancy
- Neural tube defects
  - Related to inadequate level of folate
  - Affects the embryo in the first few weeks
  - Adequate folate (400 $\mu$g daily) before conception can reduce the risk
- A healthful diet before conception includes
  - Avoiding teratogens: substances that cause birth defects
    - Includes avoiding alcohol and illegal drugs
  - Avoiding other possible hazards
    - Smoking, caffeine, medications, some herbs, and supplements
  - Body mass index (BMI) between 19.8 and 26.0 kg/m$^2$ and appropriate level of physical activity
- A healthful diet before conception reduces the risk of developing nutrition-related disorders during pregnancy, such as
  - Gestational diabetes
  - Hypertensive disorders

## 14.2 Nutrition During Pregnancy

- A full-term pregnancy lasts 38 to 42 weeks

**First trimester:** conception to week 13

**Second trimester:** week 14 to week 27

**Third trimester:** week 28 to week 40

- Embryonic stage: approximately day 15 to week 8
- After week 8, the developing baby is called a fetus

### 14.2.1 First trimester

- Zygote (fertilized egg) travels through the fallopian tube and implants in the wall of the uterus
- Development of organs, limb buds, facial features, and placenta
- Embryos are extremely vulnerable to teratogens during this time

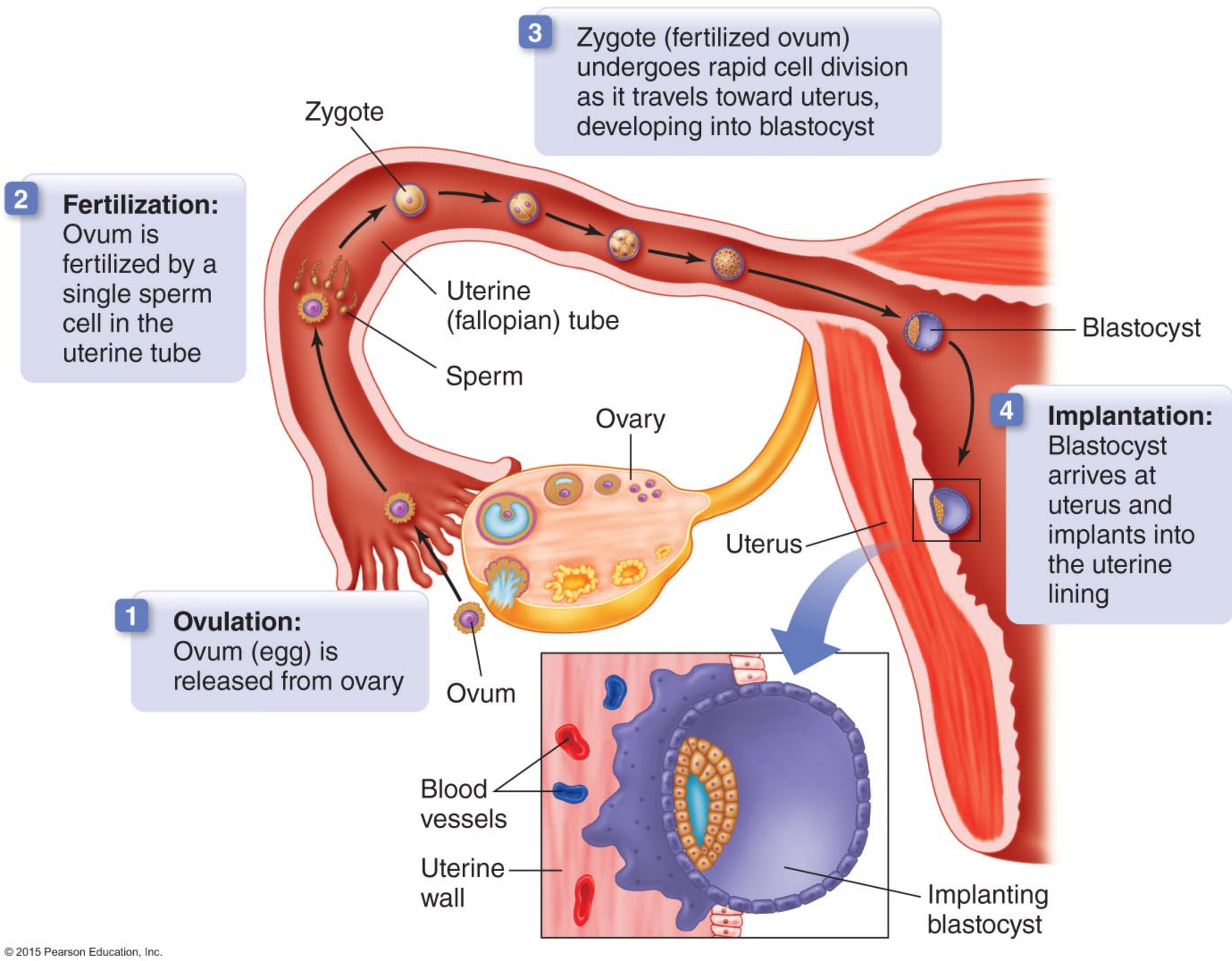




Figure 14.1: Ovulation, Conception, and Implantation

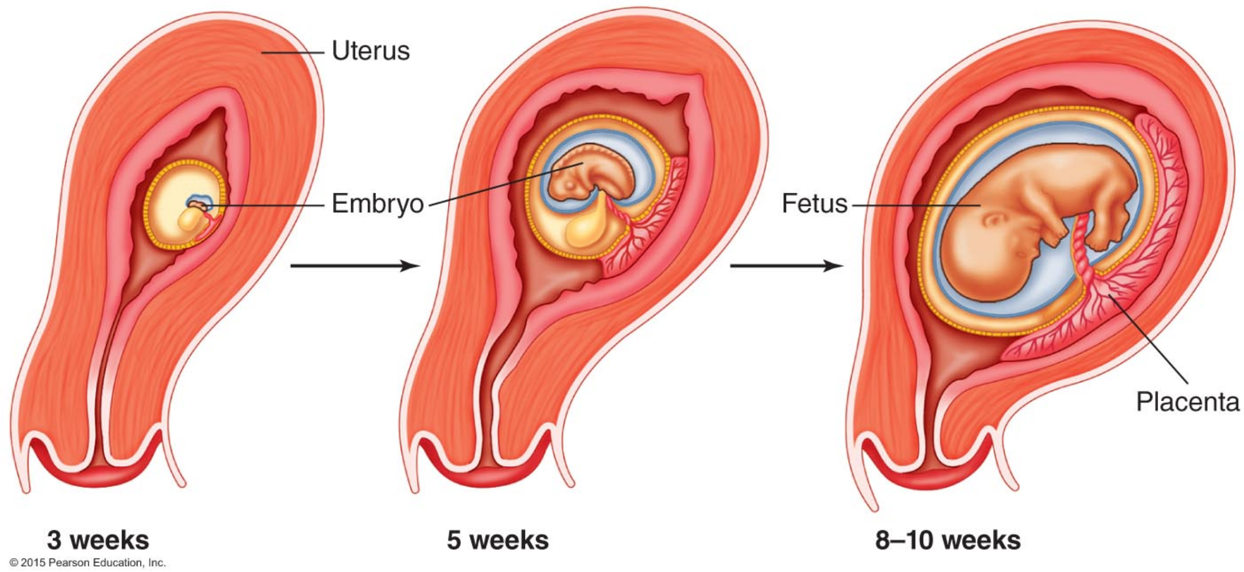



Figure 14.2: The First 10 Weeks

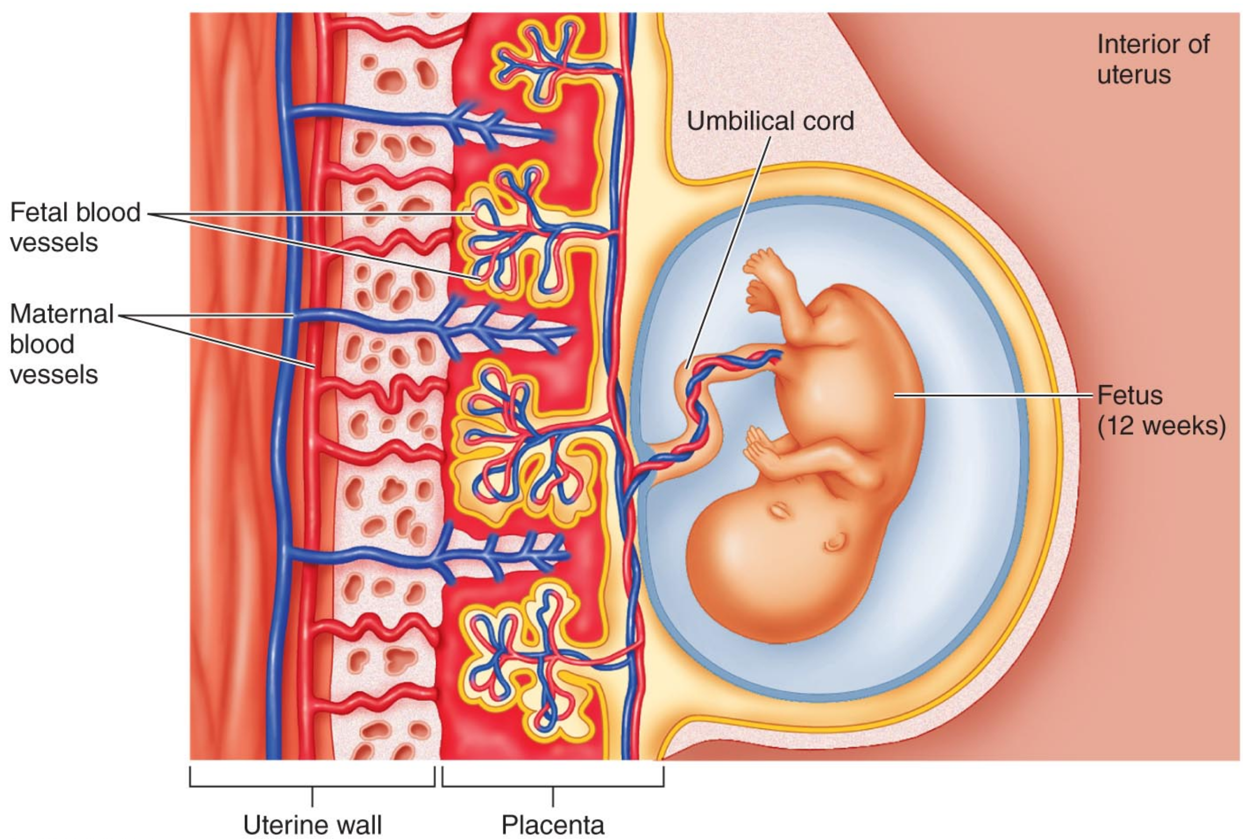



Figure 14.3: Placental Development

### 14.2.2 Second trimester

- Weeks 14–27
- Continued development of organ systems
- Growth from approximately 3 inches to over 1 foot long by the end of the second trimester

### 14.2.3 Third trimester

- Weeks 28 to birth
- Time of considerable growth
- Fetus gains three-quarters of its weight in this time
- Brain growth is also extensive
- Lungs become fully mature
- A balanced, adequate diet for the mother is essential during this time

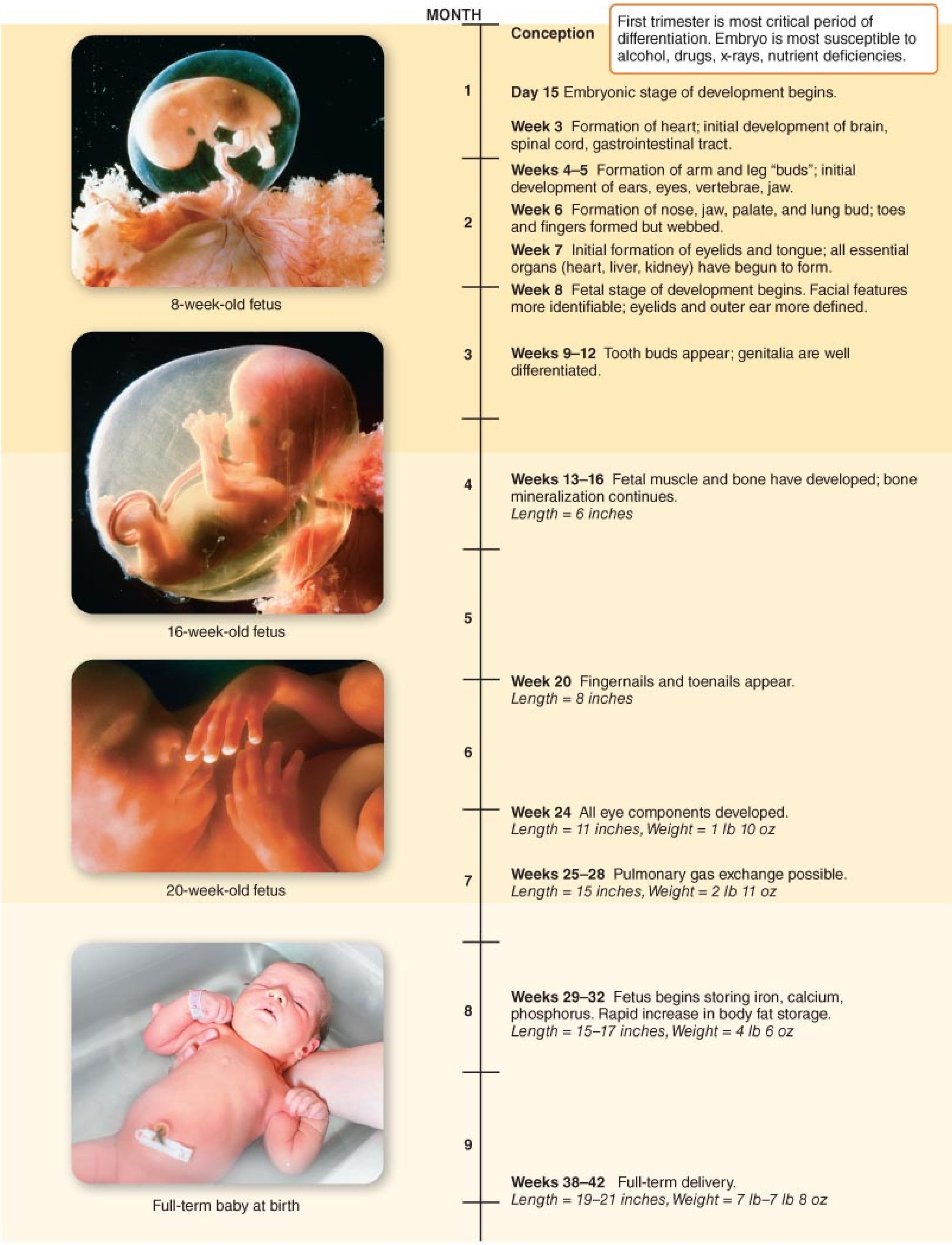





Figure 14.4: Embryonic and Fetal Development

- An undernourished mother is more likely to give birth to a low-birth-weight baby
  - Low birth weight: describes any baby born weighing less than 5.5 pounds
  - Increased risk of infections, learning disabilities, impaired physical development, and death in the first year

Figure 14.5: Low-Birth-Weight Twins and Healthy Infant

- Preterm babies are born before 38 weeks and may be low-birth-weight babies
- Small-for-gestational-age babies are born at term but weigh less than would be expected for their gestational age
- Nutrition plays a major role in these conditions
- Weight gain during pregnancy
  - Women who do not gain enough weight are at risk of having a low-birth-weight baby
  - Too much weight gain is also risky
  - Women should not diet during pregnancy since this may deprive the fetus of critical nutrients

Table 14.1: Recommended Weight Gain for Women During Pregnancy

| **Pregnancy Weight Status** | **Body Mass Index (kg/m$^2$)** | **Recommended Weight Gain** |
|---|---|---|
| Normal | 18.5–24.9 | 25–35 |
| Underweight | <18.5 | 28–40 |
| Overweight | 25.0–29.9 | 15–25 |

*Source*: Data adapted from Rasmussen, K. M., abd A. L. Yaktine, eds. 2009. *Weight Gain During Pregnancy: Reexamininig the Guidliines.* Institute of Medicine; National Research Council. Washington, DC: National Academies Press.

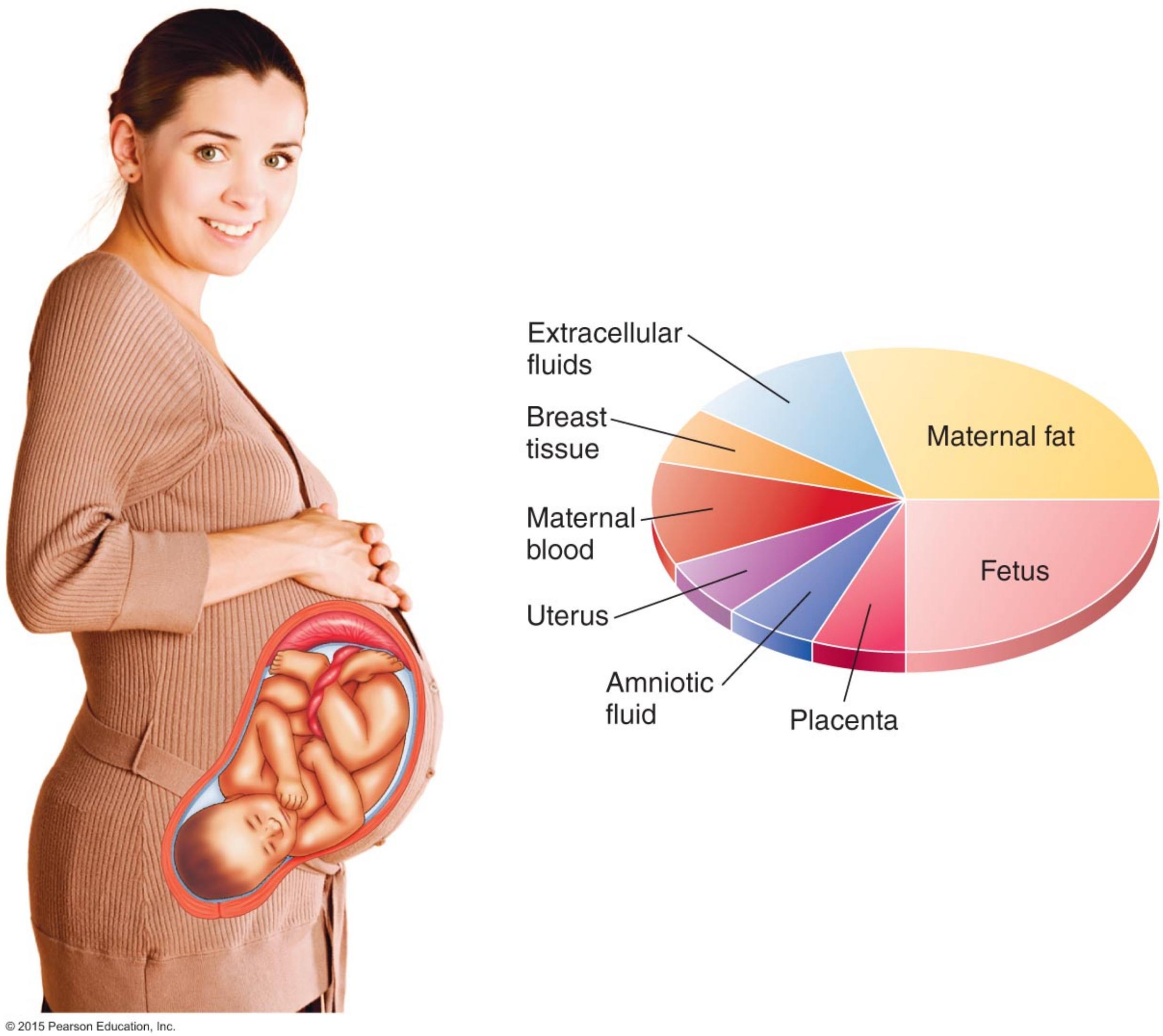



Figure 14.6: Weight Gain During Pregnancy

- The requirement for nearly all nutrients increases during pregnancy
- Pregnant women must pay attention to their intake of:
  - Macronutrients
  - Micronutrients
  - Fluids

## 14.3 Macronutrients

### 14.3.1 Energy

- An additional 300 to 450 kcal/day may be required in the second and third trimesters

- Nutrient-dense foods are essential in order to obtain sufficient nutrients

### 14.3.2 Protein and carbohydrate

- 1.1 g/day/kg body weight ( ∼additional 25 g/day) of protein
- At least 175 g/day of carbohydrates

### 14.3.3 Fat

- The percentage of Calories obtained from fat should not change during pregnancy
- Limit saturated fat; avoid trans fats
- Consume rich sources of docosahexaenoic acid (DHA), an omega-3 polyunsaturated fatty acid

## 14.4 Micronutrients

Table 14.2: The micronutrients that are most critical during pregnancy include

| | |
|---|---|
| folate | calcium |
| vitamin $B_{12}$ | iron |
| vitamin C | zinc |
| vitamin A | sodium |
| vitamin D | iodine |

Table 14.3: Nutrient Recommendations

| **Micronutrient** | **Prepregnancy** | **Pregnancy** | **% Increase** |
|---|---|---|---|
| Folate | 400 $\mu$g/day | 600 $\mu$g/day | 50 |
| Vitamin $B_{12}$ | 2.4 $\mu$g/day | 2.6 $\mu$g/day | 8 |
| Vitamin C | 75 mg/day | 85 mg/day | 13 |
| Vitamin A | 700 $\mu$g/day | 770 $\mu$g/day | 10 |
| Vitamin D | 600 IU/day | 600 IU/day | 0 |
| Calcium | 1,000 mg/day | 1,000 mg/day | 0 |
| Iron | 18 mg/day | 27 mg/day | 50 |
| Zinc | 8 mg/day | 11 mg/day | 38 |
| Sodium | 1,500 mg/day | 1,500 mg/day | 0 |
| Iodine | 150 mg/day | 220 mg/day | 47 |

### 14.4.1 Folate

- Required for cell division

- Critical in the first 28 days for development of the neural tube, which becomes the brain and spinal cord
- 400 $\mu$g/day for sexually active women
- 600 $\mu$g/day for pregnant women
- Deficiency is associated with anencephaly and spina bifida

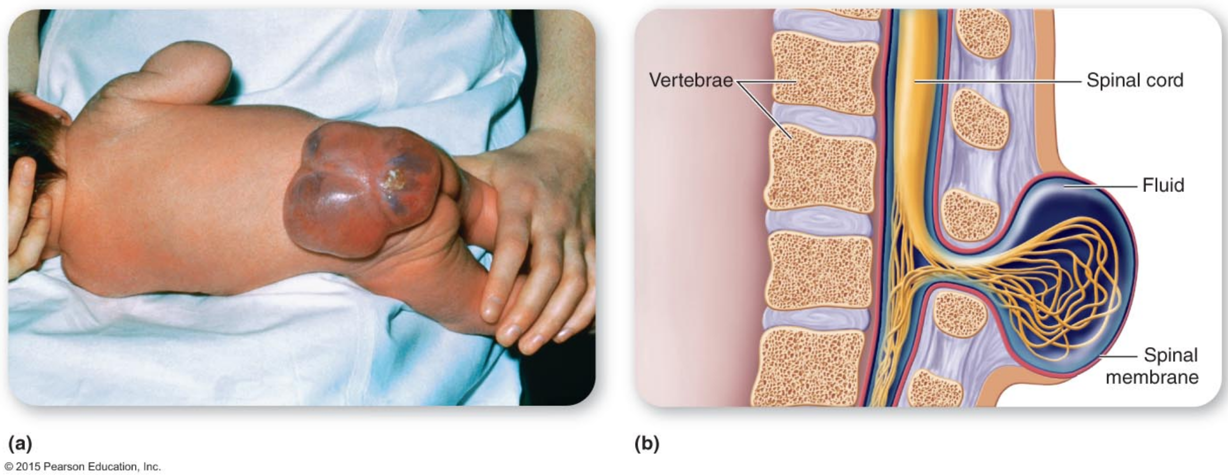



Figure 14.7: Spina Bifida

### 14.4.2 Vitamin $B_{12}$

- Regenerates the active form of folate
- 2.6 $\mu$g/day during pregnancy

### 14.4.3 Vitamin C

- Production of collagen (connective tissue)
- 85 mg/day during pregnancy
- Deficiency results in elevated risk of preterm births and preeclampsia

### 14.4.4 Vitamin A

- Needs increase by 10% in pregnancy
  - 770 $\mu$g/day
- Excess vitamin A can cause fetal abnormalities
- Supplementation is not recommended due to toxicity risk
- Beta-carotene (provitamin A) is not associated with birth defects

### 14.4.5 Vitamin D

- Adequate intake (AI) does not increase during pregnancy
- Excessive vitamin D can cause developmental disabilities in newborns
- If exposure to sunlight is limited or milk consumption is low, supplementation is advised
- Prenatal vitamin supplements contain 10 $\mu$g/dose

### 14.4.6 Calcium

- 1,000 mg/day, same as for non-pregnant women
- Calcium absorption is more efficient during pregnancy

### 14.4.7 Iron

- Increased need for red blood cells increases the need for iron by 50–80% (27 mg/day)
- Fetal need for iron increases in the third trimester
- Iron stores of mother are depleted to support needs of the fetus
- Iron-deficiency anemia is common during pregnancy

### 14.4.8 Zinc

- Critical for making proteins, DNA, and RNA
- Need increases 38% during pregnancy (11 mg/day)

### 14.4.9 Sodium

- 1,500 mg/day, same as for non-pregnant women

### 14.4.10 Iodine

- Need for iodine increases significantly
- 220 $\mu$g/day can be obtained from iodized salt

## 14.5 Fluids During Pregnancy

- The amount of fluids needed increases to 3 liters per day
  - Increase in maternal blood volume
  - Body temperature regulation
  - Production of amniotic fluid to protect and cushion the fetus
  - Combat fluid retention and constipation
  - Reduce risk of urinary tract infections

### 14.5.1 Nutrition-Related Concerns

- Nutrition-related problems during pregnancy can include
  - Morning sickness
  - Food and nonfood cravings and aversions
  - Gastroesophageal reflux (GER)/heartburn
  - Constipation
  - Gestational diabetes
  - Preeclampsia (maternal blood pressure increase)

## 14.6 Morning Sickness

- **Morning sickness** – nausea and vomiting associated with pregnancy
  - Can occur at any time; often lasts all day
  - May begin after the first missed period and can last 12 to 16 weeks
  - Can be severe enough to require hospitalization
  - No cure, but symptoms can be reduced

## 14.7 Cravings and Aversions

- Most women crave a certain type of food (sweet, salty) rather than a specific food
  - Little evidence supports the idea that cravings indicate a deficiency
  - Due to hormonal fluctuations, physiologic changes, or familial or cultural roots
  - **Pica** – craving a nonfood item (ice, clay, laundry starch)
  - Food aversions are common but not universal among pregnant women

### 14.7.1 Gastroesophageal Reflux (GER)

- Gastroesophageal reflux (GER) is common during pregnancy
- Tips to help minimize it include
  - Avoid excessive weight gain
  - Chew food slowly
  - Wait for 1 hour after eating before lying down
  - Sleep with your head elevated

## 14.8 Constipation

- Pregnancy hormones that cause smooth muscles to relax also slow the movement of material through the large intestine
- Reduce constipation by consuming 25–35 g/day of fiber and plenty of fluids, and remaining physically active

## 14.9 Gestational Diabetes

- **Gestational diabetes** – insufficient insulin production or insulin resistance that increases blood glucose levels during pregnancy
  - Affects as many as 10% of U.S. pregnancies
  - Condition resolves after birth occurs
  - Risk of delivering a large baby
  - Gestational diabetes increases a woman's risk of developing type 2 diabetes

## 14.10 Gestational Hypertension

- **Preeclampsia** – pregnancy-induced hypertension
  - Affects up to 10% of U.S. pregnancies
  - Can be fatal if left untreated
  - Deficiencies in vitamin C, vitamin E, and magnesium increase the risk
  - Treatment focuses on managing blood pressure and often includes bed rest
  - The only cure is childbirth

## 14.11 Foodborne Illness

- Pregnancy alters a woman's immune system leaving them more vulnerable to infectious diseases including foodborne illnesses
  - Listeriosis: a serious and sometimes fatal illness caused my listeria monocytogenes
  - Third leading cause of death by foodborne illness
  - Severe infections of listeria can lead to premature birth or miscarriage

## 14.12 Food Safety

- Pregnant women should avoid consuming
  - Unpasteurized milk, raw or partially cooked eggs, raw or undercooked meat/fish/poultry, unpasteurized juices, and raw sprouts
  - Large fish such as shark, swordfish, and king mackerel, along with canned albacore tuna
  - Soft cheeses unless the label specifically states the product is made with pasteurized milk

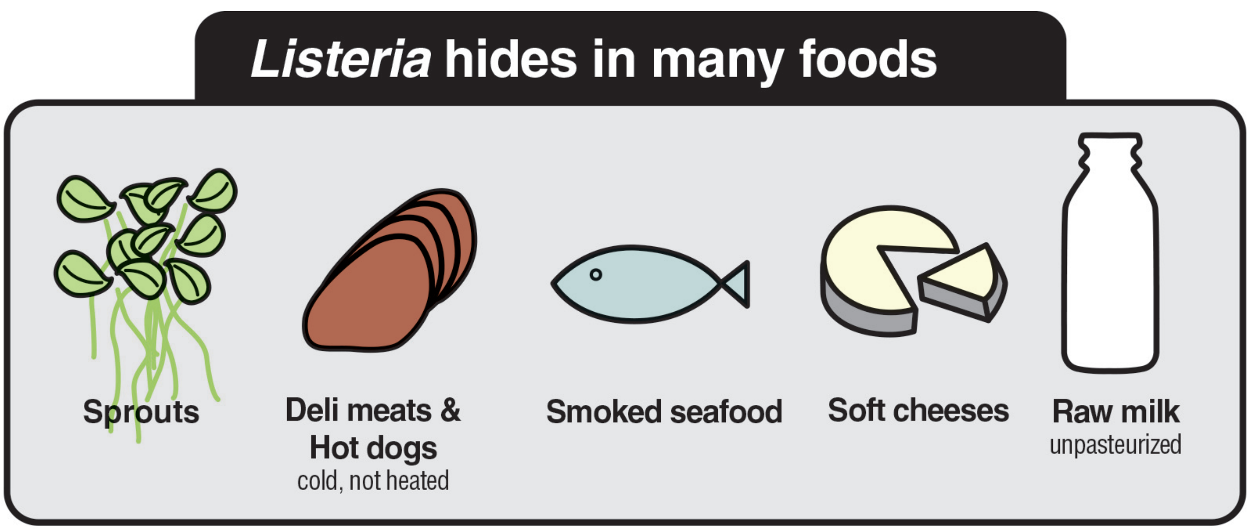



Figure 14.8: Foodborne Illness

## 14.13 Nutrition-Related Concerns

- Adolescent pregnancy
- Vegetarianism
- Exercise

- Caffeine consumption
- Alcohol consumption
- Smoking
- Illegal drug use
- Food safety

## 14.14 Adolescent Pregnancy

- Nutritional needs of pregnant adolescents are higher than those of adult women
- Adolescent bodies are still growing and changing, adding to the nutritional needs of pregnancy
- 24 births for every 1,000 adolescents; currently the lowest adolescent pregnancy rate in 60 years

## 14.15 Vegetarianism

- A vegetarian consuming eggs and dairy products has the same nutritional concerns as a nonvegetarian

Table 14.4: A complete vegetarian (vegan) must carefully monitor the intake of

| | |
|---|---|
| vitamin D | calcium |
| vitamin $B_6$ | iron |
| vitamin $B_{12}$ | zinc |

## 14.16 Exercise During Pregnancy

- Reduces risk of gestational diabetes and preeclampsia
- Helps prevent excessive prenatal weight and body fat gain
- Improves mood, energy level, sleep patterns
- Enhances posture and balance
- Improves muscle tone, strength, and endurance
- Reduces lower back pain and shortens the duration of active labor
- Reduces risk of preterm birth and large-for-gestational age infants

## 14.17 Consumption of Caffeine

- Caffeine is a stimulant that crosses the placenta and reaches the fetus
- 200–300 mg of caffeine per day very likely will cause no harm
- Some studies have linked 100 mg per day intakes to an increased risk of miscarriage, stillbirth, preterm birth, and decreased birth weight

## 14.18 Consumption of Alcohol

- Alcohol is a known teratogen that crosses the placenta and is associated with various birth defects, delivery complications, sudden infant death syndrome, and increased risk of miscarriage
- Fetal alcohol syndrome (FAS): variety of characteristics associated with prenatal exposure to high quantities of alcohol
  - Malformations of face, limbs, heart, and nervous system
  - Many developmental disabilities

## 14.19 Smoking and Drug Use

- Maternal smoking exposes the fetus to toxins
  - Smoke contains lead, cadmium, cyanide, nicotine, and carbon monoxide
  - Fetal blood flow is reduced
  - Increased risk of miscarriage, stillbirth, placental abnormalities, preterm delivery, and low birth weight
- Most drugs pass through the placenta into fetal blood
  - Newborns suffer withdrawal symptoms

## 14.20 Breastfeeding

- **Lactation** – production of breast milk
  - **Prolactin** – hormone responsible for the synthesis of milk
    - Produced toward the end of pregnancy
    - Suppressed by estrogen and progesterone until childbirth
- **Colostrum** – first milk produced (from birth up to 3 days after); rich in proteins, antibodies, vitamins, and minerals

– **Oxytocin** – hormone responsible for milk let-down

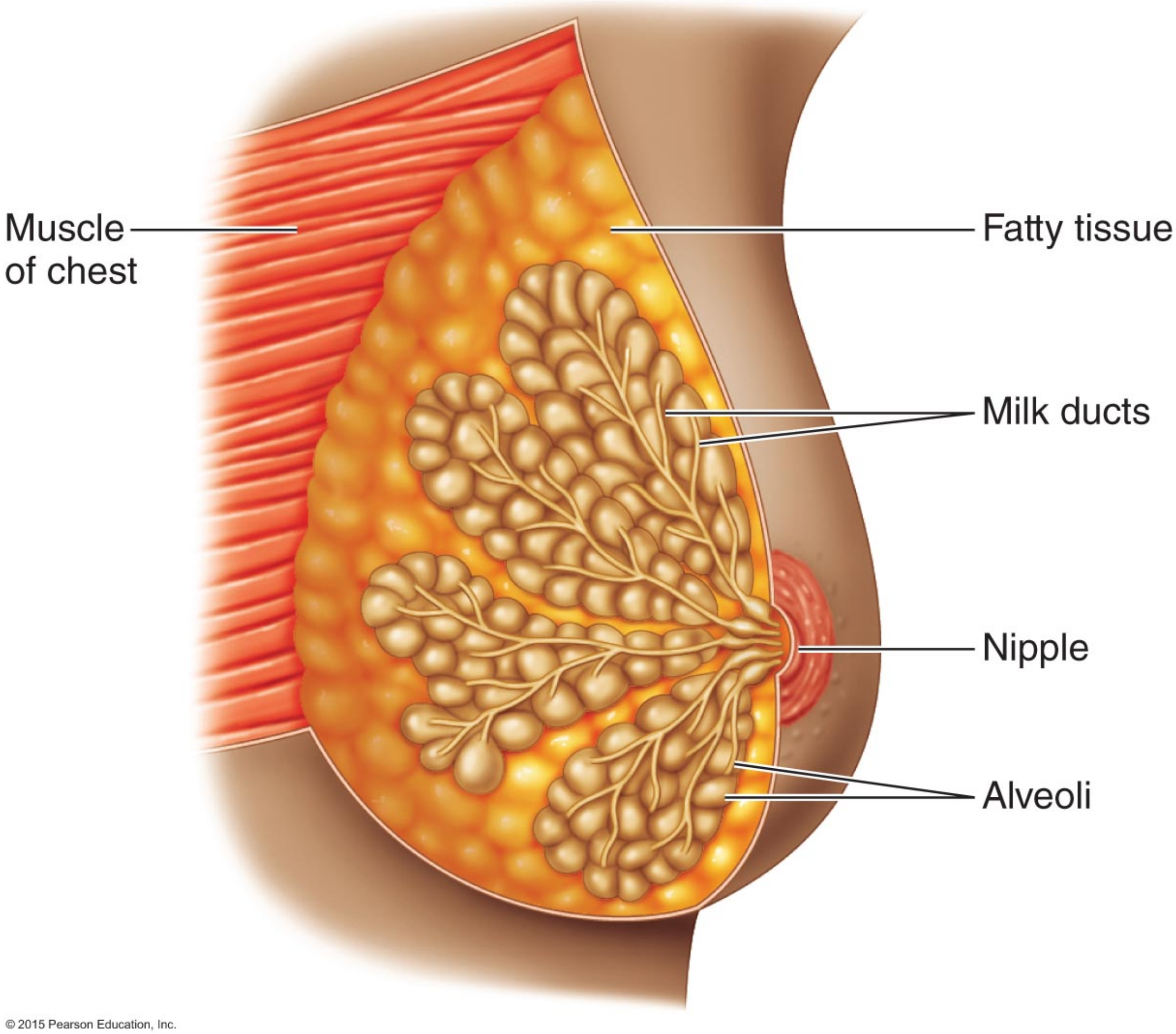



Figure 14.9: Anatomy of the Breast

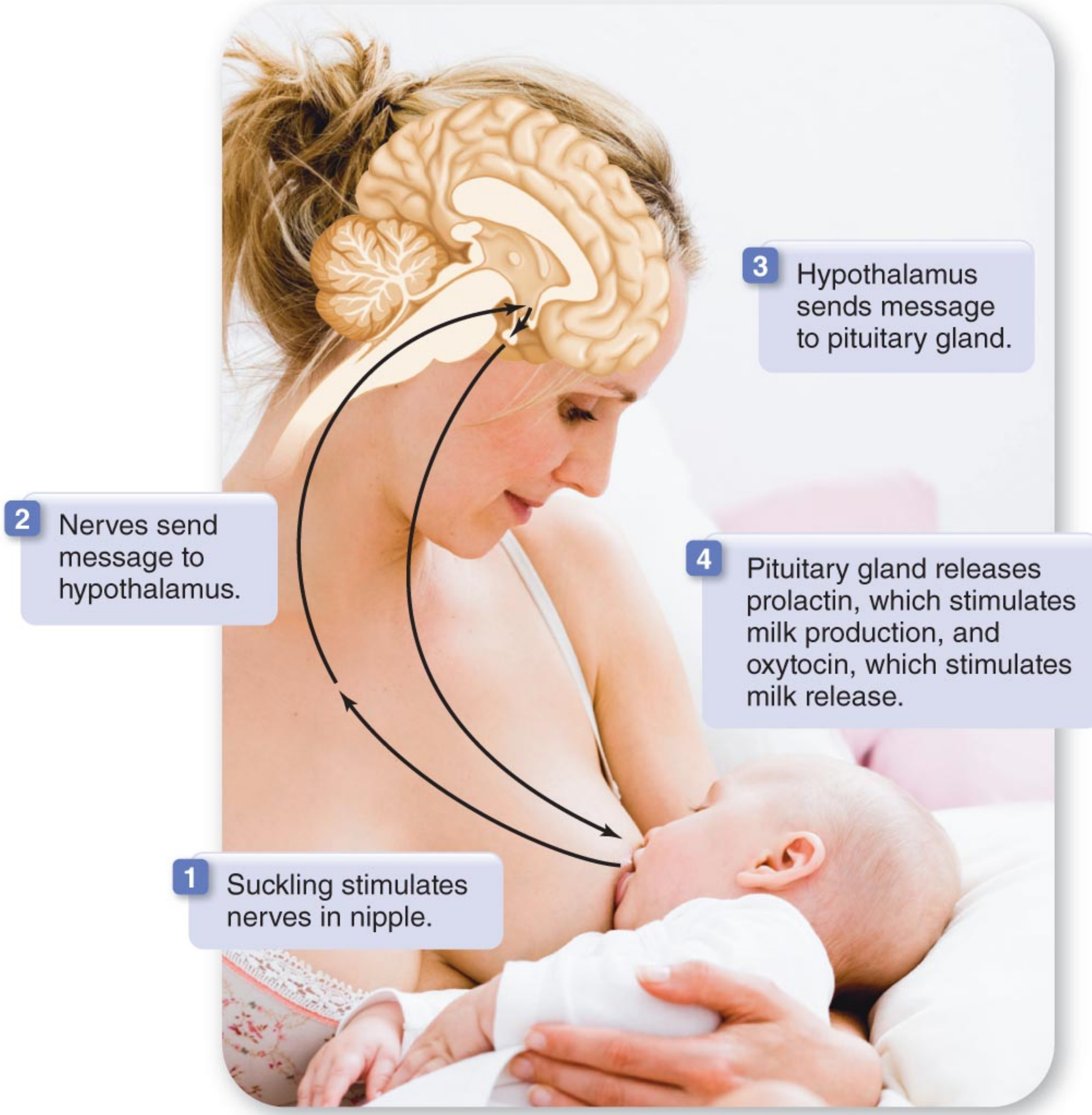





Figure 14.10: Milk and Mother–Child Interaction

- Milk production requires 700–800 kcal/day
- Lactating women should consume 330 kcal/day above their prepregnancy needs the first 6 months, 400 kcal/day the second 6 months
- This allows a woman to gradually lose weight (1–4 pounds per month)
- 15–20 g of protein and 80 g of carbohydrate required per day above prepregnancy needs

- Fluid and many micronutrient needs are increased

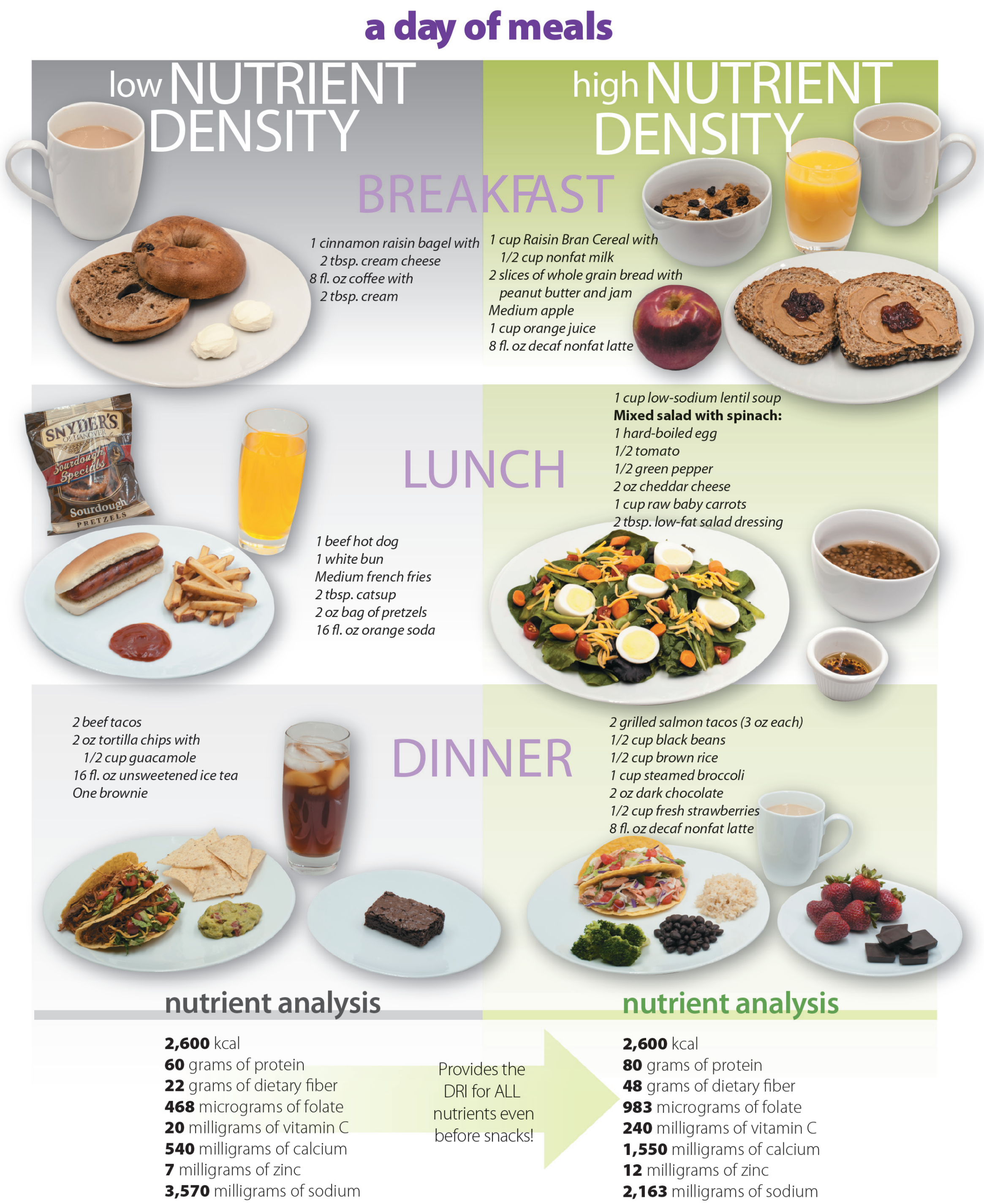



Figure 14.11: Breastfeeding

### 14.20.1 The Benefits of Breastfeeding

- High-quality nutrition
- Protection from infections, allergies, and residues
- Assists the mother in weight loss
- Suppresses ovulation
- Provides an opportunity for bonding
- Convenience and cost efficient
- Nutritional quality of breast milk
  - The main protein, lactalbumin, is easily digested
  - Primary carbohydrate is lactose
  - Rich source of readily absorbed calcium and magnesium
- Composition of milk changes during a feeding

  **Foremilk:** watery and low in fat

  **Hindmilk:** very high in fat
- It is important to let infant suckle for at least 20 minutes

## 14.21 Challenges Associated with Breastfeeding

- Many harmful substances are passed into breast milk, including
  - Illegal drugs, caffeine, nicotine, and prescription and over-the-counter medications
- HIV is passed through breast milk
- Conflicts with mother's employment
- Social concerns

## 14.22 Infant Nutrition

- Optimal nutrition is critical in the first year
  - High energy needs, 40–50 kcal/lb/day
  - 40–50% of energy should come from fat
  - Iron, vitamin D, zinc, fluoride, and iodide needs are a concern
  - The nervous system continues to develop

- Infants typically grow 10 inches in length and triple their weight in the first year
- Infants' nutritional needs are unique
  - Their energy needs are high to support rapid growth
  - Their digestive tracts and kidneys are still immature
  - They are small in size

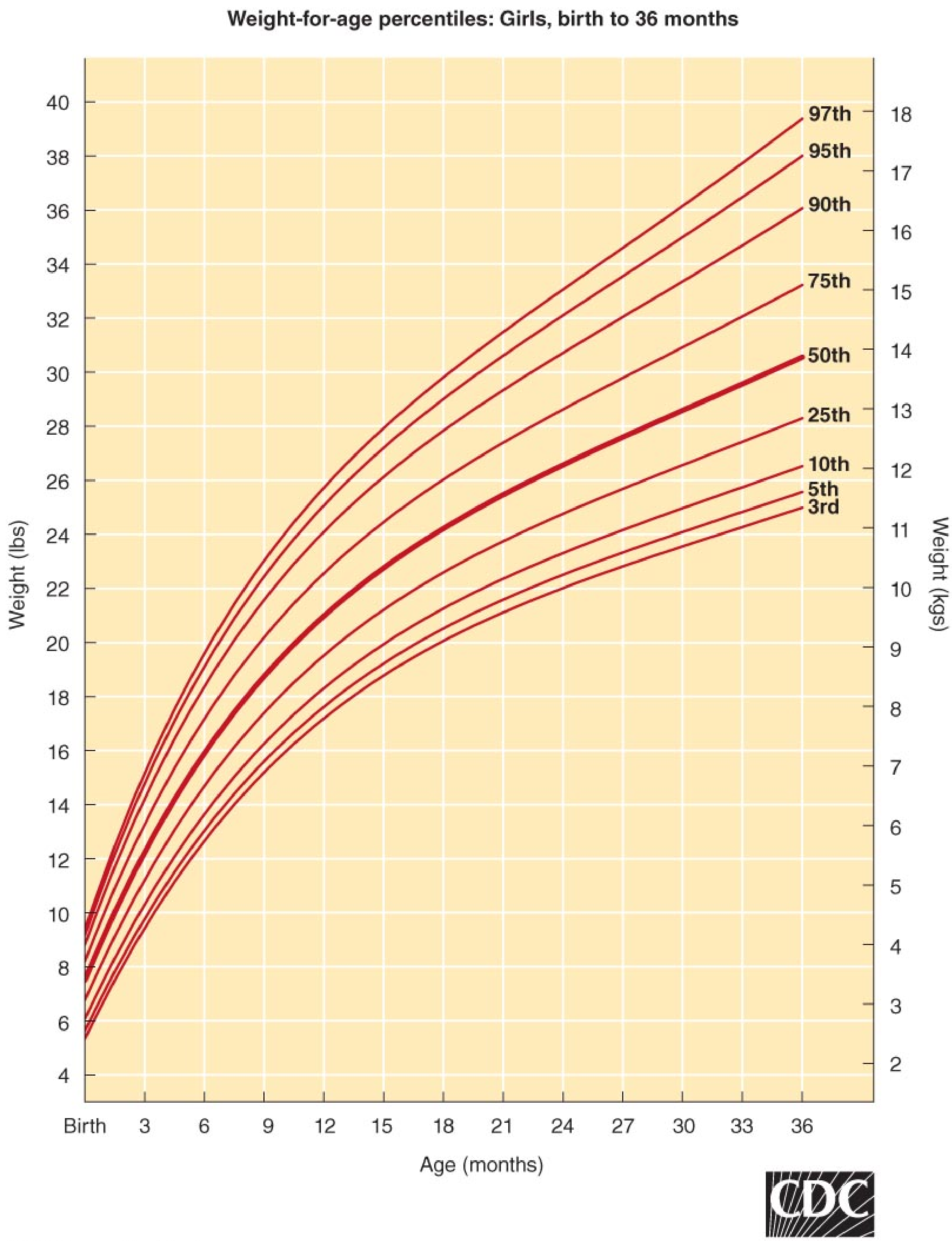





Figure 14.12: Weight-to-Age Growth Chart

### 14.22.1 Infant Nutrient Needs

- 40–50 kcals per pound of body weight per day
  - Approximately 600–650 kcals per day at around 6 months of age
  - Breastmilk and commercial formulas are energy and nutrient dense to meet these demands
- Breast milk or formula should be supplemented with solid food beginning at 4 to 6 months
- 40–50% of energy needs should be consumed from fat during the first year of life
- No more than 20% of an infant's daily energy needs should be consumed from protein

## 14.23 Supplements for Infants?

- Several micronutrients may need supplementation
  - Vitamin D because of limited exposure to sunlight
  - Iron–stores are depleted by the sixth month
  - Fluoride for tooth development
  - Vitamin $B_{12}$ if the mother is a vegan
  - Water is generally not required unless loss is excessive (diarrhea, vomiting, fever, hot weather)
- Care must be taken to prevent oversupplementation

## 14.24 Formulas

- Very tightly regulated by federal government
  - Minimum and maximum standards for 29 nutrients
  - Protein source: casein or whey from cow's milk
  - Carbohydrate source: lactose and sucrose
  - Fat source: vegetable oils or microbiologically produced lipids
- Specialized formulas are available: soy-based, predigested, others for certain medical conditions

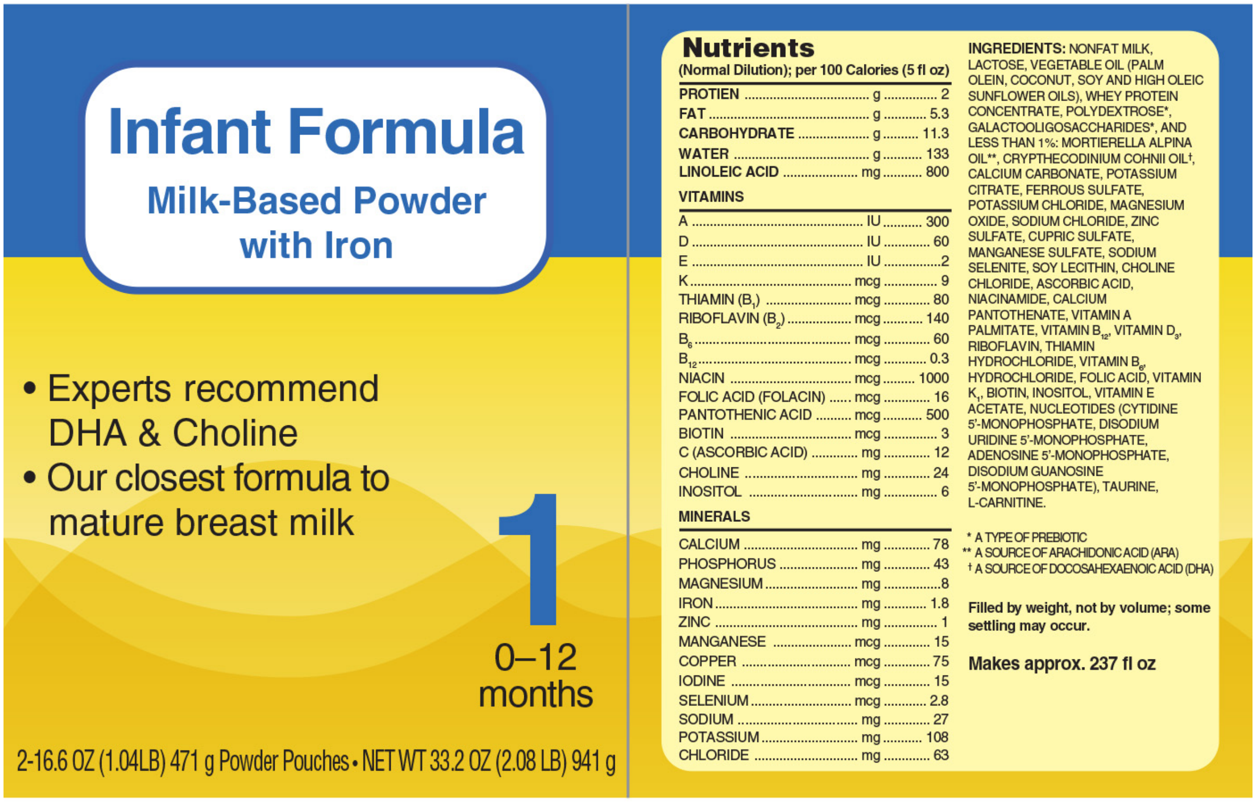



Figure 14.13: Infant Formula Label

### 14.24.1 When to Introduce Solid Food

- Introduce solid food at 6 months
  - Tongue movement allows swallowing
  - Muscle development allows infant to sit up
  - Digestive system and kidneys have matured
  - Less likely to develop food allergies
  - Iron-fortified cereals are well tolerated
- Infants should not eat
  - Foods they could choke on
  - Corn syrup or honey
  - Goat's milk
  - Cow's milk
  - Too much salt or sugar
- Nutrition-related concerns for infants include

- Allergies
- Dehydration
- Colic
- Anemia
- Nursing bottle syndrome
- Lead poisoning

### 14.24.2 Allergies

- Solid foods should be introduced one at a time for a week to watch for allergies
- Cow's milk, egg whites, peanuts, and wheat commonly trigger food allergies

### 14.24.3 Dehydration

- Extremely dangerous for infants
- Caused by diarrhea, vomiting, and inadequate fluid intake
- Pediatric electrolyte solution may be used

### 14.24.4 Colic

- Uncontrollable crying that can last for hours
- Precise cause is unknown

### 14.24.5 Anemia

- Infants are born with enough iron for only 6 months
- Anemia can develop
- Iron-fortified cereal/supplement may be needed

### 14.24.6 Nursing bottle syndrome

- Leaving an infant alone with a bottle can lead to cavities (dental caries) and tooth decay
- The high-carbohydrate fluid provides an optimal food source for bacteria that cause dental caries
- Rather than a bottle, begin using a cup by 8 months and no bottle after 18 months

Figure 14.14: Nursing Bottle Syndrome

### 14.24.7 Lead poisoning

- Especially toxic to infants because the brain and nervous system are still developing
- Results in reduced mental capacity, behavioral problems, and impaired growth
- Remove old, lead-based paint
- Allow tap water to run a minute before use to discard lead leached from pipes
- Use only cold tap water because hot tap water is more likely to leach lead

## 14.25 In Depth: The Fetal Environment

- Increased evidence suggests that the fetal environment–including a mother's nutritional status–can influence risks for obesity and chronic diseases later in life
- This relationship has been called "fetal origins theory"
- If exposed to famine in the first trimester, the child has increased risk of obesity, coronary heart disease, abnormal serum lipid profile, and metabolic syndrome
- **Fetal adaptation** – when a fetus is exposed to harmful elements, it goes into "survival mode": hormones shift to promote energy storage, and enzymes can increase or decrease the size and function of various body organs

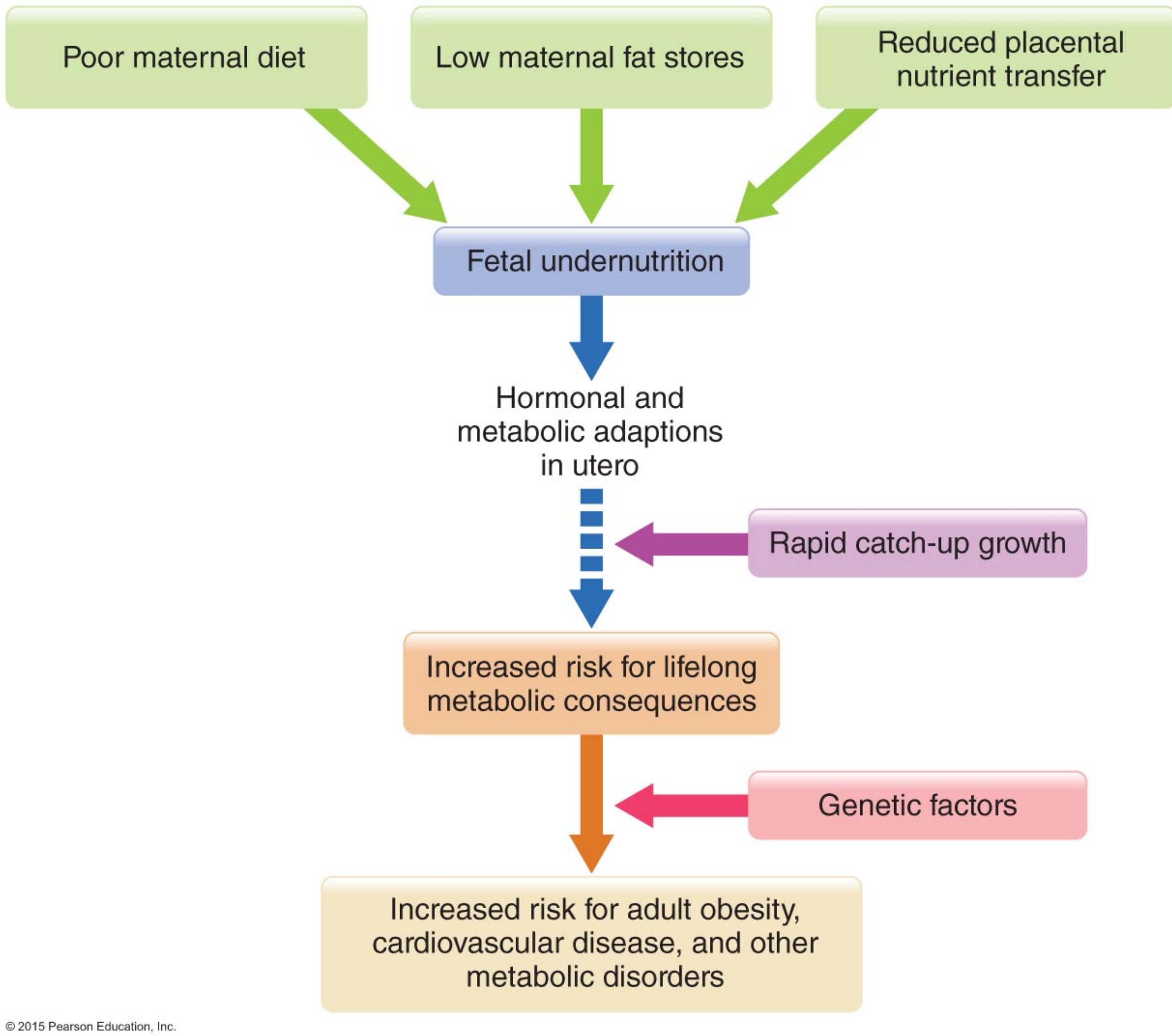



Figure 14.15: The Fetal Environment

- Fetal stressors that influence adult health include nutrient deficiencies
  - Low maternal intake of calcium increases risk of hypertension in offspring
  - Poor maternal folate intake is linked to neural tube defects and early signs of atherosclerosis
  - Zinc deficiency has been linked to later-life disorders such as diabetes and atherosclerosis
- Strong evidence links maternal dietary excesses to health problems in adult offspring
  - Maternal obesity may account for changes in the "programming" of the fetal brain, resulting in lifelong health consequences
  - Maternal obesity increases rates of spina bifida, neural tube defects, infant heart defects, cleft lip and palate, and abnormal arms or legs

  - Maternal diabetes can increase risks of infant type 2 diabetes, overweight, and metabolic syndrome

- Other detrimental maternal impacts on a fetus include exposure to
  - Alcohol
  - Tobacco
  - Toxic agents, such as environmental pollutants

# Chapter 15

# Nutrition Through the Life Cycle: Childhood to Late Adulthood

## 15.1 Toddlers

- Age 1 to 3 years
  - Rapid growth rate of infancy begins to slow
  - Gain 5.5 to 7.5 inches and 9 to 11 pounds
  - High energy requirement due to increased activity level
- Macronutrients
  - 30–40% of total kcal from fat
  - 1.10 g of protein per kg body weight per day
  - 130 g carbohydrates per day
  - 14 g fiber per 1,000 kcal of energy consumed
- Micronutrients
  - Ensure adequate intake of the micronutrients obtained from fruits and vegetables, including
  - Vitamins A, C, E; calcium; iron; zinc
  - Calcium is necessary to promote optimal bone mass
  - Iron-deficiency anemia is the most common nutrient deficiency in young children
- Fluid needs
  - 1.3 liters/day
- Supplements

– Toddlers may need supplements due to their erratic eating habits, especially for fluoride

– Supplements should not exceed 100% of the Daily Value for any nutrient

Table 15.1: Nutrients for Children and Adolescents

| **Nutrient** | **Toddles (1–3) Years** | **Children (4–8) Years** | **Children (9–13) Years** | **Adolescents (14–18 Years)** |
|---|---|---|---|---|
| **Fat** | No RDA | No RDA | No RDA | No RDA |
| **Protein** | 1.10 g/kg body weight per day | 0.95 g/kg body weight per day | 0.95 g/kg body weight per day | 0.85 g/kg body weight per day |
| **Carbohydrate** | 130 g/day | 130 g/day | 130 g/day | 130 g/day |
| **Vitamin A** | 300 $\mu$g/day | 400 $\mu$g/day | 600 $\mu$g/day | Boys: 900 $\mu$g/day<br>Girls: 700 $\mu$g/day |
| **Vitamin C** | 15 mg/day | 25 mg/day | 45 mg/day | Boys: 75 mg/day<br>Girls: 65 $\mu$g/day |
| **Vitamin E** | 6 mg/day | 7 mg/day | 11 mg/day | 15 mg/day |
| **Calcium** | 700 mg/day | 1,000 mg/day | 1,300 mg/day | 1,300 mg/day |
| **Iron** | 7 mg/day | 10 mg/day | 8 mg/day | Boys: 11 mg/day<br>Girls: 15 mg/day |
| **Zinc** | 3 mg/day | 5 mg/day | 8 mg/day | Boys: 11 mg/day<br>Girls: 9 mg/day |
| **Fluid** | 1.3 liters/day | 1.7 liters/day | Boys: 2.4 liters/day<br>Girls: 2.1 liters/day | Boys: 3.3 liters/day<br>Girls: 2.3 liters/day |

- Nutritious food choices
  – Most toddlers have an innate ability to match their intake with their needs
  – Keeping a nutritious variety of foods available encourages a healthful diet
  – Food should not be forced on a child
  – Do not use bribery to encourage children to eat
  – Foods prepared should be fun

Figure 15.1: Fun Food

Figure 15.2: Portion Sizes for Preschoolers

## 15.2 Vegan Diets for Toddlers

- Vegan diets may not be healthful for toddlers. Due to the restriction of no foods from animal origin there are potential risks:
  - Protein
  - Calcium
  - Zinc and iron
  - Vitamins D and $B_{12}$
  - Fiber

## 15.3 Young Children

- Age 4 to 8 years
  - Dietary Reference Intake (DRI) values are the same for both boys and girls through the age of about 8

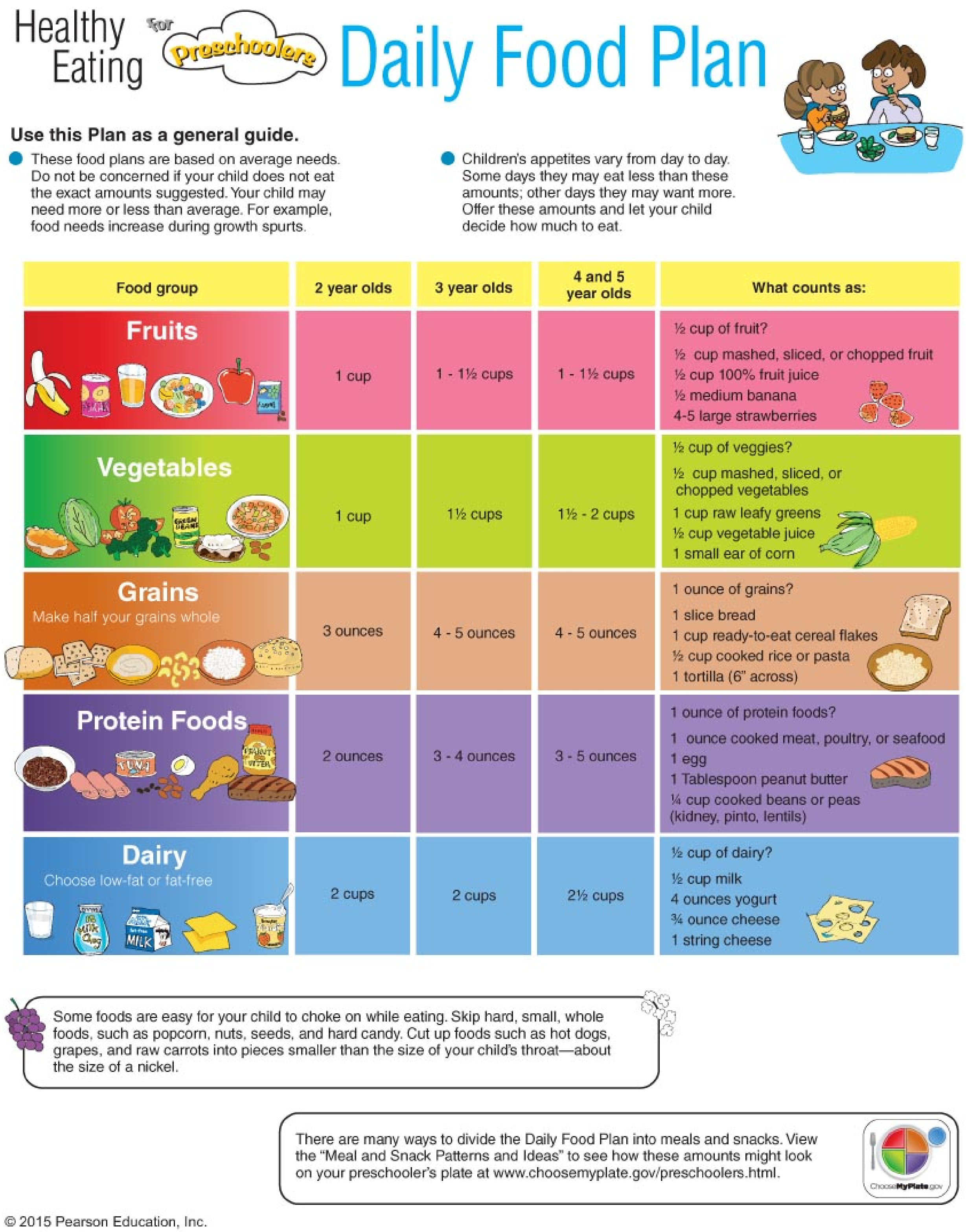
  - Growth rate is 2 to 4 inches per year

- Macronutrients
  - Total fat intake should gradually drop to a level closer to adult fat intake
  - 25–35% of total energy from fat
  - 0.95 g of protein per kg body weight per day
  - 130 g carbohydrate per day
  - 14 g fiber per 1,000 kcal of energy consumed

- Micronutrients
  - Vitamins and minerals from fruits and vegetables continue to be a concern
  - Vitamins A, C, E; calcium; iron; zinc
  - Increases in DRIs compared to toddlers

- Fluid
  - 1.7 liters/day (about 5–8 cups), including water

- Supplements
  - May be recommended when particular food groups are not eaten regularly
  - Supplements should be appropriate for the child's age



Healthy Eating for Preschoolers Daily Food Plan

**Use this Plan as a general guide.**

- These food plans are based on average needs. Do not be concerned if your child does not eat the exact amounts suggested. Your child may need more or less than average. For example, food needs increase during growth spurts.
- Children's appetites vary from day to day. Some days they may eat less than these amounts; other days they may want more. Offer these amounts and let your child decide how much to eat.

| Food group | 2 year olds | 3 year olds | 4 and 5 year olds | What counts as: |
|---|---|---|---|---|
| Fruits | 1 cup | 1 - 1½ cups | 1 - 1½ cups | ½ cup of fruit?<br>½ cup mashed, sliced, or chopped fruit<br>½ cup 100% fruit juice<br>½ medium banana<br>4-5 large strawberries |
| Vegetables | 1 cup | 1½ cups | 1½ - 2 cups | ½ cup of veggies?<br>½ cup mashed, sliced, or chopped vegetables<br>1 cup raw leafy greens<br>½ cup vegetable juice<br>1 small ear of corn |
| Grains<br>Make half your grains whole | 3 ounces | 4 - 5 ounces | 4 - 5 ounces | 1 ounce of grains?<br>1 slice bread<br>1 cup ready-to-eat cereal flakes<br>½ cup cooked rice or pasta<br>1 tortilla (6" across) |
| Protein Foods | 2 ounces | 3 - 4 ounces | 3 - 5 ounces | 1 ounce of protein foods?<br>1 ounce cooked meat, poultry, or seafood<br>1 egg<br>1 Tablespoon peanut butter<br>¼ cup cooked beans or peas (kidney, pinto, lentils) |
| Dairy<br>Choose low-fat or fat-free | 2 cups | 2 cups | 2½ cups | ½ cup of dairy?<br>½ cup milk<br>4 ounces yogurt<br>¾ ounce cheese<br>1 string cheese |

Some foods are easy for your child to choke on while eating. Skip hard, small, whole foods, such as popcorn, nuts, seeds, and hard candy. Cut up foods such as hot dogs, grapes, and raw carrots into pieces smaller than the size of your child's throat—about the size of a nickel.

There are many ways to divide the Daily Food Plan into meals and snacks. View the "Meal and Snack Patterns and Ideas" to see how these amounts might look on your preschooler's plate at www.choosemyplate.gov/preschoolers.html.

ChooseMyPlate.gov



Figure 15.3: MyPlate Daily Food Plan for Preschoolers

- Nutritious food choices

  - Parents can teach children about healthful food choices
    * Some foods "help us grow healthy and strong"
    * Some foods are better used as occasional treats
  - Eating a balanced breakfast has many benefits
  - Some school lunch programs are in need of updated and more healthful menu selections

## 15.4 Children: Nutrition-Related Concerns

- Overweight and obesity
- Dental caries
- Inadequate calcium intake
- Body image concerns
- Childhood food insecurity

## 15.5 Older Children

- Age 9 to 13 years
  - Growth is slow and steady–2 to 4 inches per year
  - Growth is primarily driven by hormones during puberty
  - Children begin to make their own food choices
  - Activity levels vary
- Macronutrients
  - 25–35% of total energy from fat
  - 0.95 g protein per kg body weight per day
  - 130 g carbohydrates per day
  - 45–60% of kcal from carbohydrates
  - 14 g fiber per 1,000 kcal of energy consumed
- Micronutrients
  - Micronutrient needs rise sharply as children approach puberty
  - Meeting the needs for calcium and iron is very important
- Fluid

  - Adequate intake (AI) of fluids varies by gender, ranging from 2.1 liters/day (females) to 2.4 liters/day (males)
- Supplements
  - A vitamin/mineral supplement supplying no more than 100% of the daily values may be warranted
- Nutritious food choices
  - Peer pressure can influence a child's food choices
  - Healthy role models, such as athletes, can be used to encourage good choices
  - School lunches must meet U.S. Department of Agriculture (USDA) guidelines, but this does not control what the child actually eats

## 15.6 Adolescents

- Age 14 to 18 years
  - Growth spurts begin at age 9 to 10 for girls and 10 to 11 for boys
  - Weight and body composition also change

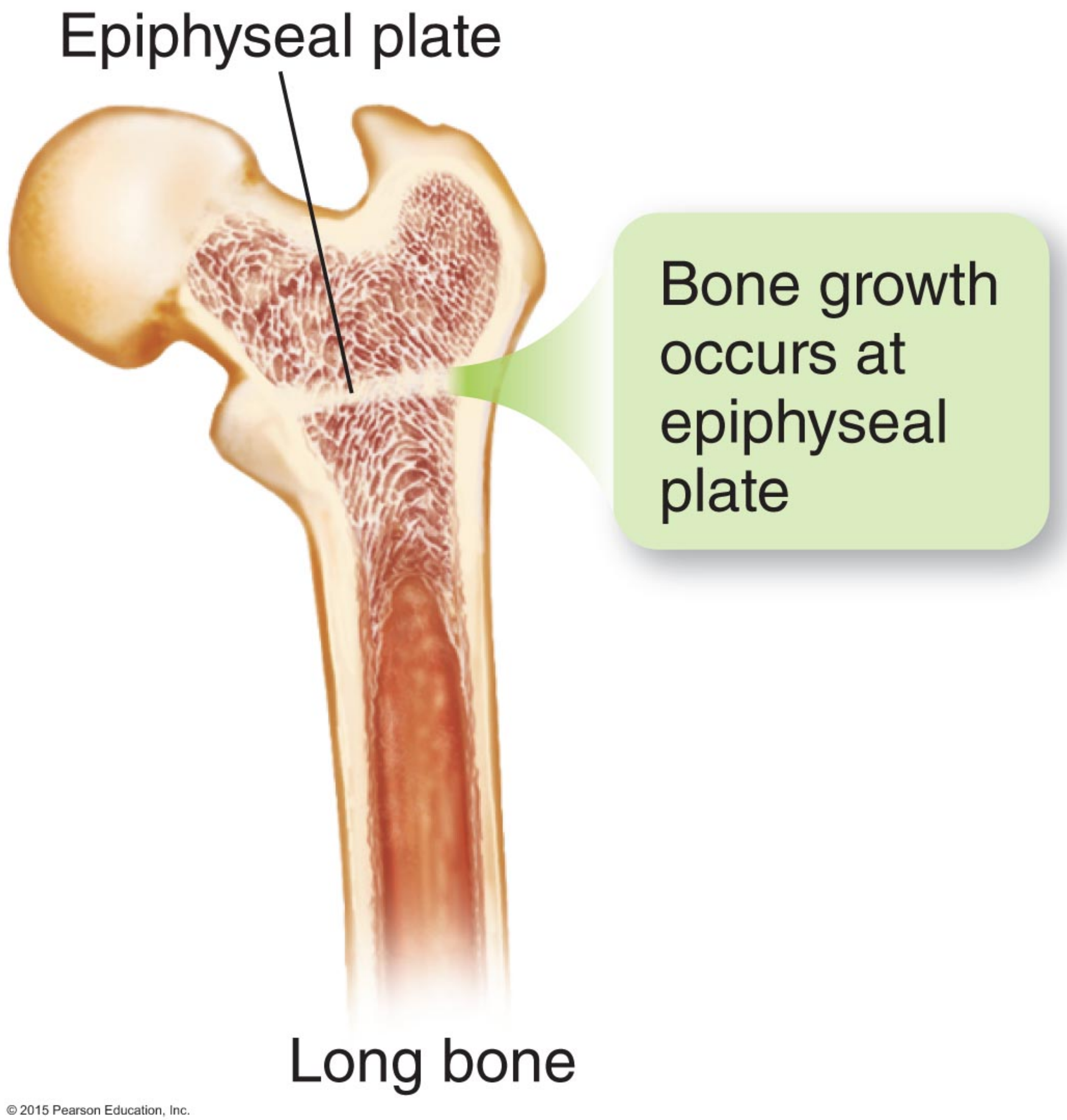



Figure 15.4: Skeletal Growth

- Macronutrients
  - Estimated energy requirements (EERs) for adolescents are based on gender, age, activity level, height, and weight
  - 25–35% of total energy from fat
  - 45–65% of kcal from carbohydrates
  - 0.85 g protein per kg body weight per day

  - 26 g of fiber per day

- Micronutrients
  - Calcium and vitamin D intakes must be sufficient for achieving peak bone density
  - Iron needs are relatively high
    * 15 mg/day for girls
    * 11 mg/day for boys
  - Vitamin A is critical for supporting rapid growth and development

- Fluid
  - The need to maintain fluid intake is increased by higher activity levels
  - Boys: 3.3 liters/day
  - Girls: 2.3 liters/day

- Supplements
  - A multivitamin can be a safety net but should not replace a healthful diet

- Nutritious food choices
  - Peer influences and fast-paced lifestyle can lead adolescents to choose fast foods
  - Parents can act as role models and keep healthful food choices available
  - Adequate intake of fruits, vegetables, and whole grains should be encouraged

- Nutrition-related concerns
  - Bone density concerns arise from inadequate calcium intake
  - Eating disorders and poor body image problems can begin during these years
  - Hormonal changes are largely responsible for acne flare-ups
  - Cigarette smoking, alcohol consumption, and illegal drug use all have a significant impact on growth and health

## 15.7 Pediatric Obesity

- Obesity in children
  - **Obese** – a BMI at or above the 95th percentile
  - Increased risk of developing type 2 diabetes, hypertension, and other serious medical problems

- Overweight children are at much greater risk of becoming overweight adults

- Obesity is now epidemic in the United States among school-aged children

- Caused by too many Calories and not enough physical activity
- Dietary Guidelines for Americans recommend that children be very active for at least 1 hour per day

### 15.7.1 Prevention

- Constructive support for physical activity
- Healthful, balanced, regular meals
- Developing healthful eating habits early in life
- Family-wide support for nutritious food choices
- Parental control of food purchase and preparation
- Minimize the amount of meals eaten out of the home, especially fast food
- School support for healthful food choices
- Daily activity and exercise

Table 15.2: Examples of Physical Activities for Children and Adolescents

| **Type of Physical Activity** | **Age Group: Children** | **Age Group: Adolescents** |
|---|---|---|
| Moderate-intensity aerobic | - Active recreation, such as hiking, skateboarding, rollerboarding<br>- Bicycle riding<br>- Brisk walking | - Active recreation, such as canoeing, hiking, skateboarding, rollerboarding<br>- Brisk walking<br>- Bicycle riding (stationary or road bike)<br>- Housework and yard word, such as sweeping or pushing a lawn mower<br>- Games that require catching and throwing, such as baseball and softball |
| Vigorous-intensity aerobic | - Active games involving running and chasing, such as tag<br>- Bicycle riding<br>- Jumping rope<br>- Martial arts, such as karate<br>- Running<br>- Sports such as soccer, ice or field hockey, basketball, swimming, tennis<br>- Cross-country skiing | - Active games involving running and chasing, such as flag football<br>- Bicycle riding<br>- Jumping rope<br>- Martial arts, such as karate<br>- Running<br>- Sports such as soccer, ice or field hockey, basketball, swimming, tennis<br>- Vigorous dancing<br>- Cross-country skiing |
| Muscle-strengthening | - Games such as tug-of-war<br>- Modified push-ups (with knees on the floor)<br>- Resistance exercises using body weight or resistance bands<br>- Rope or tree climbing<br>- Sit-ups (curl-ups or crunches)<br>- Swinging on playground equipment/bars | - Games such as tug-of-war<br>- Push-ups and pull-ups<br>- Resistance exercises with exercise bands, weight machines, hand-held weights<br>- Climbing wall<br>- Sit-ups (curl-ups or crunches) |
| Bone-strengthening | - Games such as hopscotch<br>- Hopping, skipping, jumping<br>- Jumping rope | - Hopping, skipping, jumping<br>- Jumping rope<br>- Running |

## 15.8 Older Adults

- Physiologic changes to the bodies of older adults, age 65 years and older, include
  - Decreased muscle and lean tissue
  - Increased fat mass
  - Decreased bone density
  - Impaired absorption of nutrients
  - Taste and smell perception is often diminished
- Macronutrients
  - Energy needs usually decrease due to reduced activity levels and lower lean body mass
  - General recommendations for fat, carbohydrate, and protein intakes are the same as for younger adults
  - Recommended to not consume more than 30% of energy from sugars
  - Fiber recommendations are slightly lower for older adults
- Micronutrients
  - Calcium and vitamin D requirements increase due to poor calcium absorption
  - Iron needs decrease
  - Zinc intake should be maintained for optimizing immune function
  - Adequate intake of B-vitamins is a special concern
  - Vitamin A requirements are the same as for all adults, but older adults should be careful to not exceed the RDA

**TABLE 15.3 Nutrient Recommendations That Change with Increased Age**

| Changes in Nutrient Recommendations | Rationale for Changes |
|---|---|
| **Vitamin D**<br>Increased need for vitamin D from 600 IU/day for adults age 18–70 years to 800 IU/day for adults over age 70 years | Decreased bone density<br>Decreased ability to synthesize vitamin D in the skin |
| **Calcium**<br>Increased need for calcium from 1,000 mg/day for adults 19–50 years to 1,200 mg/day for women 51 years of age and older, and men 71 years and older | Decreased bone density<br>Decreased absorption of dietary calcium |
| **Fiber**<br>Decreased need for fiber from 38 g/day for young men to 30 g/day for men 51 years and older; decreases for women from 25 g/day for young women to 21 g/day for women 51 years and older | Decreased energy intake |
| **B-Vitamins**<br>Increased need for vitamin $B_6$ and need for vitamin $B_{12}$ as a supplement or from fortified foods | Lower levels of gastric juice<br>Decreased absorption of food $B_{12}$ from gastrointestinal tract<br>Increased need to reduce homocysteine levels and to optimize immune function |

Table 15.3: Nutrients Recommendations That Change with Increased Age

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|---|---|
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| | |

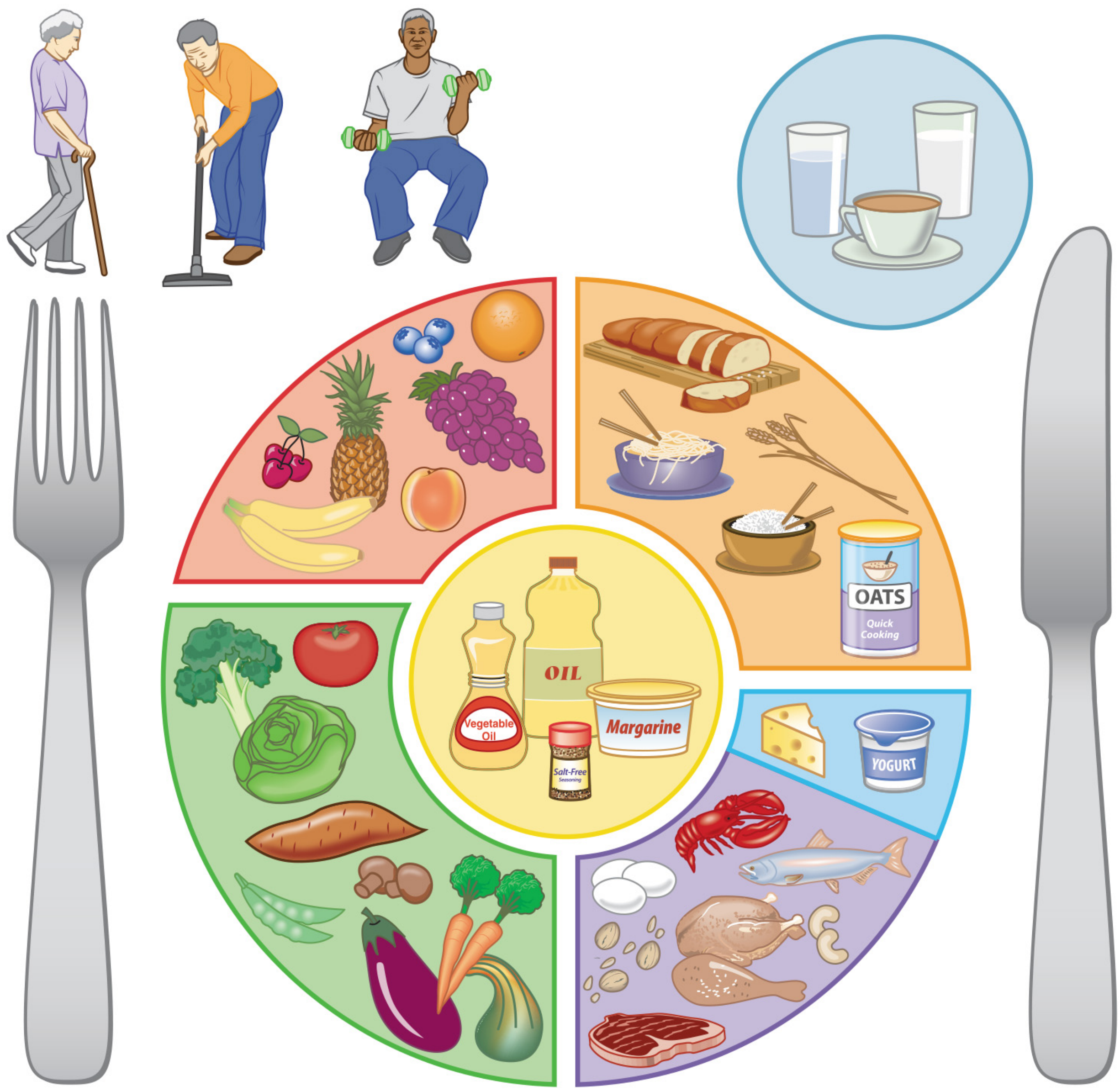


Figure 15.5: MyPlate for Older Adults

- Fluid
    - AI for fluid is the same as for younger adults
        - Men: 3.7 liters/day
        - Women: 2.7 liters/day
    - Older adults are especially susceptible to dehydration because changes in kidney function in older adults can impair their thirst mechanism
    - Important to seek medical attention for incontinence and to drink plenty of fluids
- Nutrition-related concerns

  - Many chronic diseases are more prevalent in overweight or obese adults
  - Underweight may result from illness, disability, loss of sense of taste or smell, depression, and social isolation
  - Dental health issues may cause older adults to avoid meats, firm fruits, and vegetables

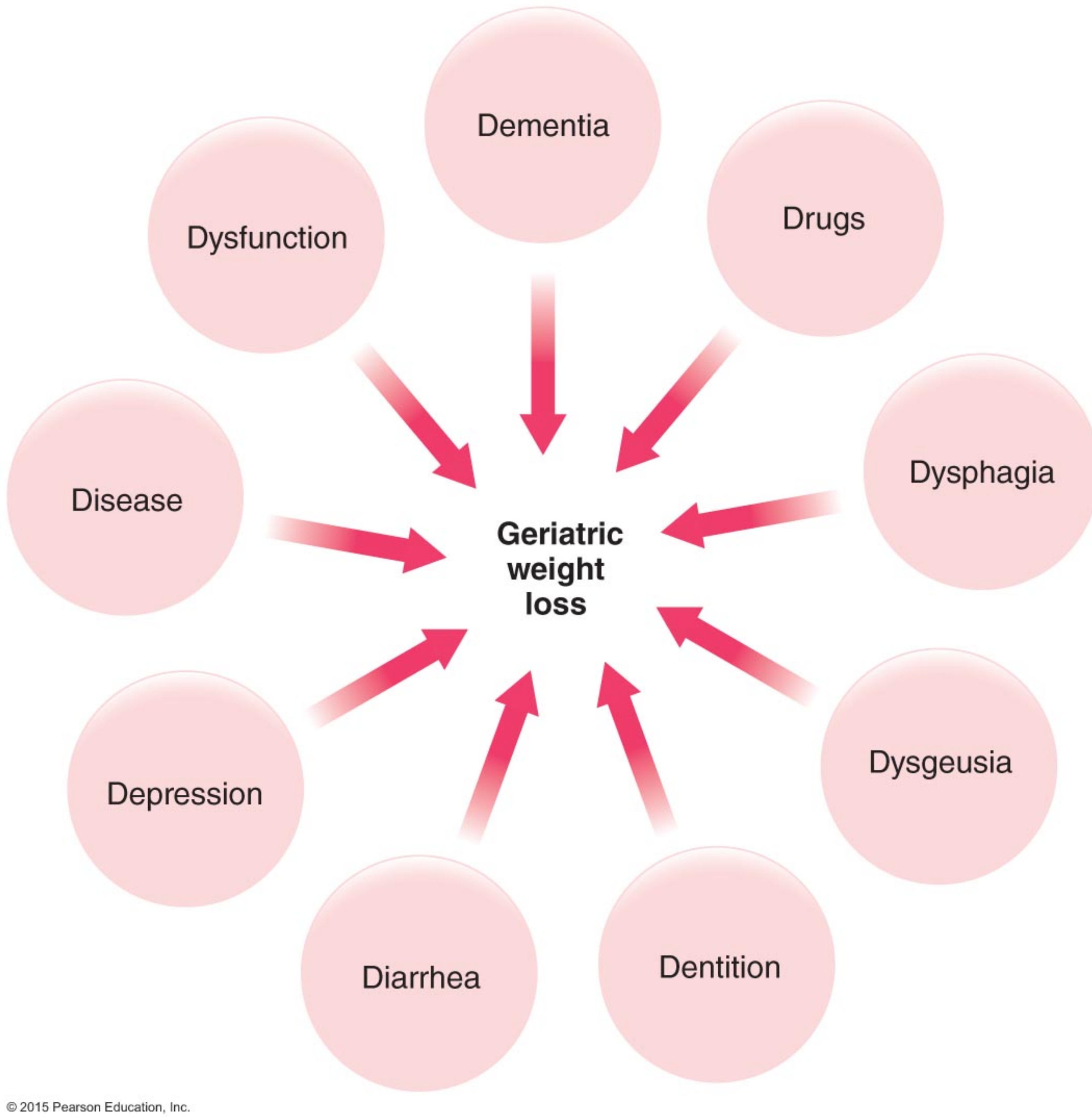


Figure 15.6: Nine Ds of Geriatric Weight Loss

- Nutrition-related concerns
  - Age-related eye diseases can cause vision impairment and blindness

    * Macular degeneration and cataracts
  - Some prescription medications can alter nutrient absorption or decrease appetite
  - Financial and mobility problems

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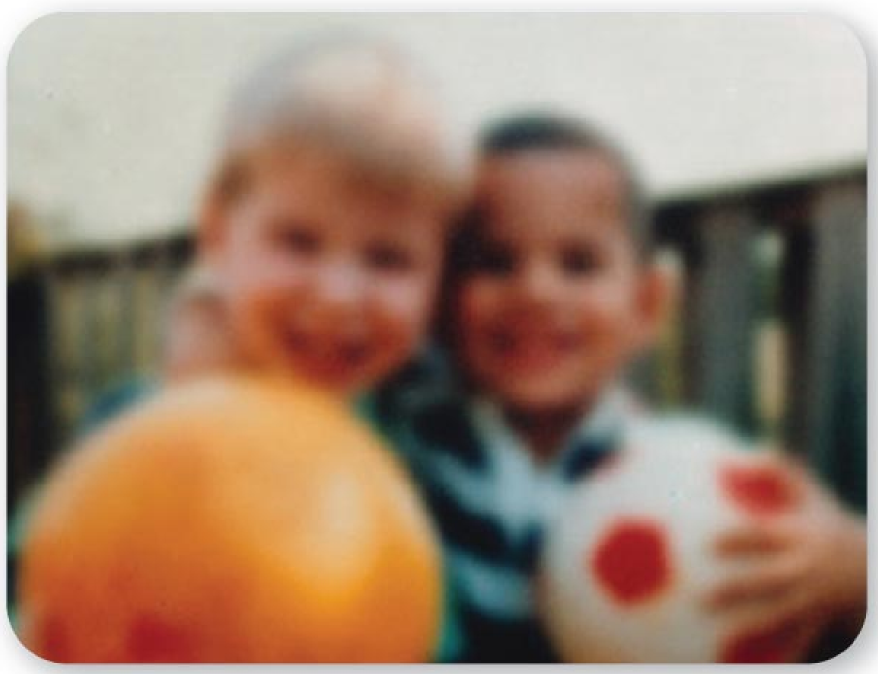

**(b)**

Figure 15.7: Macular Degeneration and Cataracts

**TABLE 15.4 Examples of Common Drug–Nutrient Interactions**

| Category of Drug | Interactions |
|---|---|
| Antacids | May decrease the absorption of iron, calcium, folate, vitamin $B_{12}$ |
| Antibiotics | May reduce the absorption of calcium, fat-soluble vitamins; reduces the production of vitamin K by gut bacteria |
| Anticonvulsants | Interfere with activation of vitamin D |
| Anticoagulants ("blood thinners") | Reduce the activity of vitamin K |
| Antidepressants | May cause weight gain as a result of increased appetite |
| Antiretroviral agents (used in treatment of HIV/AIDS) | Reduce absorption of most nutrients |
| Aspirin | Lowers blood folate levels; increases iron loss due to gastrointestinal bleeding |
| Diuretics | May increase urinary excretion of potassium, sodium, calcium, magnesium; may cause retention of potassium, other electrolytes |
| Laxatives | Increase fecal excretion of dietary fat, fat-soluble vitamins, calcium, and other minerals |

Figure 15.8: Common Drug–Nutrient Interactions

## 15.9 In Depth: The Fountain of Youth

- Growing numbers of people are experimenting with new methods to achieve greater longevity
  - Calorie restriction
  - Intermittent fasting
  - Supplements

### 15.9.1 Calorie restriction (CR)

- Researchers have not identified a precise number of Calories to qualify as "restricted"
- Typically involves eating fewer Calories than your body needs to maintain normal weight
- Should allow for differences in gender, height, age, body composition, activity level, and so forth

- Many people practicing CR strive to consume 20–30% fewer Calories than usual

### 15.9.2 Metabolic effects of Calorie restriction

- Decreased fat mass and lean body mass
- Decreased blood glucose levels
- Decreased LDL and total cholesterol and increased HDL cholesterol
- Decreased core body temperature and blood pressure
- Decreased energy expenditure
- Decreased oxidative stress
- Lower levels of DNA damage
- Lower levels of chronic inflammation
- Protective changes in some hormone levels

### 15.9.3 Challenges of Calorie restriction

- Data are still preliminary
- May be ethical concerns for some people's participation (potential malnutrition)
- Much of the data are self-reported from CR groups
- May be necessary for CR to last many years to see longevity benefits
- Reported side effects include constant hunger, feeling cold, lower sex drive
- Long-term effects are not known

### 15.9.4 Alternatives to Calorie restriction

- Intermittent fasting (IF):
  - Alters the pattern of food consumption
  - Has shown positive effects in animals
  - May be tolerable for more people
- Limiting total protein intake
- Exercise-induced leanness

### 15.9.5 Supplements

- The "anti-aging" market is rife with supplements making longevity claims
- No research trials to date have shown a clear connection between increased nutrient intake from supplements and lower rates of death
- Greatly increased nutrient intake levels may pose dangers to some people
- Many non-nutrient supplements (such as gingko, DHEA) can have potentially serious side effects
- *Proven* things you can do to increase your chances of living a long and healthful life:
  - Get regular physical activity
  - Eat nutritious, balanced meals
  - Take only supplements recommended by a qualified healthcare provider, in only the amounts recommended
  - Maintain a healthful body weight
  - Don't smoke or use tobacco products
  - Consume alcohol in moderation