Chapter 8: Minerals and Water
Objectives for Chapter 8

• Explain the importance and functions of water in the body.
• Describe water balance and how the body maintains it.
• Identify daily water needs and the best sources for it.
• Explain what minerals are and why you need them.
Objectives for Chapter 8, Continued

- Name the functions, sources, and deficiency/toxicity of:
  - Sodium
  - Potassium
  - Calcium
  - Phosphorus
  - Magnesium
  - Chloride
  - Sulfur
  - Iron
  - Copper
  - Zinc
  - Selenium
  - Fluoride
  - Chromium
  - Iodine
  - Manganese
  - Molybdenum
Why Is Water So Important?

- Water is the most abundant substance in body
  - Average healthy adult is about 60 percent water
    - Muscle tissue is 75 percent water, fat up to 20 percent
  - Can survive only a few days without water
  - Water is balanced among fluid compartments
    - **Intracellular fluids**: inside cells
    - **Extracellular fluids**: interstitial fluid between cells and fluid in the blood
  - **Electrolytes**: minerals that help maintain fluid balance
Intracellular and Extracellular Fluid
Your Body is Mostly Water

Female, 137 lbs.  Male, 168 lbs.
Water as Part of Body Fluids

Extracellular fluid compartments

Blood fluids

Interstitial fluids

Cells

Intracellular fluid compartment

Red blood cells

Figure 8.2
Role of Electrolytes in Water Balance
Why Is Water So Important?, Continued

- Acts as universal solvent and transport medium
  - Medium for chemical reactions in body
  - As part of blood, helps transport oxygen, nutrients, hormones to cells
  - As part of interstitial fluid, helps transport waste products away from cells for excretion
- Helps maintain body temperature
- Lubricant for joints, eyes; part of mucus and saliva
- Protective cushion for brain, organs, fetus
Water Helps Regulate Your Body Temperature

1. The water in blood carries heat to the capillaries at the skin surface.

2. The heat is released at the skin surface. Evaporation of sweat cools the skin.

3. Cooled blood returns to the body core.
What Is Water Balance and How Do You Maintain It?

- **Water balance**: \( \text{water consumed} = \text{water lost} \)
- You take in water through beverages and food
- You lose water through your kidneys (as urine), large intestine, lungs, skin
  - **Insensible water loss**: through evaporation from skin and when you exhale
  - **Sensible water loss**: through urine, feces, and sweat
The Concept of Water Balance: Intake Equals Output

- **Water Intake**
  - 10.5 cups
  - 6.5 cups Beverages
  - 3 cups Food
  - 1 cup Metabolism

- **Water Output**
  - 10.5 cups
  - 6 cups Kidneys (urine)
  - 3 cups Skin and Lungs
  - 1 cup Sweat
  - 0.5 cup Intestines (stool)

Figure 8.4
Water Balance
Losing Too Much Water Can Cause Dehydration

• Dehydration can result from inadequate water intake or too much water loss from diarrhea, vomiting, high fever, or use of diuretics

• Your thirst mechanism signals dehydration
  • Dry mouth due to increased electrolyte concentration in blood: less water available to make saliva
  • Blood volume decreases, sodium concentration increases in blood
    • Brain triggers thirst mechanism and secretion of antidiuretic hormone (ADH) to reduce urine output
    • Fluid inside cells moves into blood by osmosis
A Simple Demonstration of Osmosis

1. A selectively permeable filter is placed in a glass of pure water.
2. Salt is added to the water on one side of the filter.
3. Drawn by the high concentration of electrolytes, pure water flows to the “salt water” side of the filter.
Losing Too Much Water Can Cause Dehydration, Continued

• Other ways to tell if you're dehydrated:
  • Cornerstone method: measure body weight before and after exercise
    • Weight loss = water loss
  • Monitor urine color
    • Color darkens with concentration, indicating water loss
Urine Color Can Signal Dehydration

Figure 8.6
Consuming Too Much Water Can Cause Hyponatremia

- **Hyponatremia** is a condition of too little sodium in the blood
- For healthy individuals who consume a balanced diet, it is difficult to consume too much water
- However, some individuals have experienced water toxicity
  - Examples: soldiers in training, endurance athletes
Fluid Balance During Exercise

The health of our body's cells depends on maintaining the proper balance of fluids and electrolytes on both sides of the cell membrane, both at rest and during exercise. Let's examine how this balance can be altered under various conditions of exercise and fluid intake.

**MODERATE EXERCISE**
When you are appropriately hydrated, engaged in moderate exercise, and not too hot, the concentration of electrolytes is likely to be the same on both sides of cell membranes. You will be in fluid balance.

**STRENUOUS EXERCISE WITH RAPID AND HIGH WATER INTAKE**
If a person drinks a great deal of water quickly during intense, prolonged exercise, the extracellular fluid becomes diluted. This results in the concentration of electrolytes being greater inside the cells, which causes water to enter the cells, making them swell. Drinking moderate amounts of water or sports drinks more slowly will replace lost fluids and restore fluid balance.

**STRENUOUS EXERCISE WITH INADEQUATE FLUID INTAKE**
If a person does not consume adequate amounts of fluid during strenuous exercise of long duration, the concentration of electrolytes becomes greater outside the cells, drawing water away from the inside of the cells and making them shrink. Consuming sports drinks will replace lost fluids and electrolytes.
How Much Water Do You Need and What Are the Best Sources?

- Daily water needs depend on physical activity, environmental factors, diet
- Recommendations based on reported total water intake of healthy Americans
- Men: 16 cups/day (about 13 cups of beverages)
- Women: 12 cups/day (about 9 cups of beverages)
  - About 80 percent from beverages, 20 percent from foods
  - Physical activity increases needs
Water Content of Foods

Figure 8.8
The Best Way to Meet Your Daily Water Needs

**Figure 8.9**

- **Water**: 2–6 servings (0 calories)
- **Unsweetened coffee or tea**: 0–5 servings (0 calories)
- **Milk, soy milk**: 0–2 servings (100 calories)
- **Soft drinks, fruit drinks**: 0–1 serving (110–115 calories)
- **Diet drinks**: 0–4 servings (0 calories)
- **100% fruit juices, sports drinks**: 0–1 serving (110 calories)

**Total**: 12 cups, 96 fluid ounces (200–300 calories)

1. Includes diet soft drinks and tea or coffee with sugar substitutes.
2. Includes fat-free or 1% milk and unsweetened fortified soy milk.

© 2017 Pearson Education, Inc.
Tap Water or Bottled Water: Is Bottled Better?

- False assumption: bottled water is purer than tap water
- Tap water is perfectly safe
  - Monitored by Environmental Protection Agency (EPA)
  - Provides fluoride, helps prevent dental caries
- Bottled water is very popular
  - Most products conform to FDA requirements
  - May actually be tap water
  - High cost
  - Various "designer" waters on the market
## A Well of Sources for Bottled Water

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral water</td>
<td>Water derived from an underground source that contains a specific amount of naturally occurring minerals and trace elements. The minerals and elements cannot be added to the water after bottling.</td>
</tr>
<tr>
<td>Spring water</td>
<td>Water that is obtained from underground water that flows naturally to the surface. The water is collected at the spring or at the site of the well purposefully drilled to obtain this water.</td>
</tr>
<tr>
<td>Sparkling water</td>
<td>Spring water that has carbon dioxide gas added to supply “bubbles” before bottling. Also sold as seltzer water or club soda. <em>Note:</em> This is technically considered a soft drink and does not have to adhere to FDA bottled water regulations.</td>
</tr>
<tr>
<td>Distilled water</td>
<td>Water that has been boiled and processed to remove most, but not all, contaminants.</td>
</tr>
<tr>
<td>Flavored water</td>
<td>Water that has a flavor such as lemon or lime added. It may also contain added sugars and calories.</td>
</tr>
<tr>
<td>Vitamin or enhanced waters</td>
<td>Water that has vitamins, protein, herbs, and/or caffeine added to it. Such water may also contain added sugars and calories.</td>
</tr>
</tbody>
</table>

Water can be classified according to its source or how it is treated prior to bottling.

# Bottled vs. Tap Water: A Summary

<table>
<thead>
<tr>
<th>Bottled Water</th>
<th>Tap Water</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost to Consumers</strong></td>
<td><strong>Cost to Consumers</strong></td>
</tr>
<tr>
<td>• About $1.00-$4.00 per gallon (plain water)</td>
<td>• About $0.003 per gallon</td>
</tr>
<tr>
<td>• Designer waters can cost more than $10 per gallon and may contain added sugar and calories</td>
<td></td>
</tr>
<tr>
<td><strong>Safety and Sustainability</strong></td>
<td><strong>Safety and Sustainability</strong></td>
</tr>
<tr>
<td>• Generally safe</td>
<td>• Municipal water is regulated by EPA, state, and local regulations</td>
</tr>
<tr>
<td>• Regulated by the FDA.</td>
<td>• EPA guidelines require that the public have access to water quality reports and be notified if water quality is outside established bounds</td>
</tr>
<tr>
<td>• May not contain fluoride.</td>
<td></td>
</tr>
<tr>
<td>• If not recycled, end up as garbage in landfills.</td>
<td></td>
</tr>
<tr>
<td><strong>Benefits to Consumers</strong></td>
<td><strong>Benefits to Consumers</strong></td>
</tr>
<tr>
<td>• Packaging of bottled water may make it more convenient than tap water</td>
<td>• Available at the faucet</td>
</tr>
<tr>
<td>• May taste better than tap water</td>
<td>• Often contains fluoride, which helps to prevent tooth decay</td>
</tr>
<tr>
<td></td>
<td>• Doesn’t contain any added sugar or calories</td>
</tr>
</tbody>
</table>
Practical Nutrition Tips Video: Enhanced Water

Are Enhanced Waters Necessary?

with Joan Salge Blake and student Michael Halpern
ABC News Video: Sports Drink Science: Is It Hype?

World News Tonight
August 6, 2012

>> Just in time for the London Olympics, we have new research tonight
ABC News Video: Sports Drink Science: Is It Hype?, Continued

Discussion Questions

1. How does the marketing of products, including product placement, impact sales?

2. Discuss the problems with the science behind the sports drinks. Discuss whether or not it is ethical for companies to pay for research on their own products.

3. Identify claims sports drink companies have published that may bend the truth.

4. Why might sports drinks be unhealthy for your weekend warrior or average gym goer?
What Are Minerals and Why Do You Need Them?

• Inorganic elements needed in relatively small amounts
• Mineral absorption depends on bioavailability
  • Some minerals compete for absorption: too much of one can decrease absorption of another
    • Example: excess zinc can reduce copper absorption
  • Some substances bind minerals, making them unavailable for absorption
    • Example: oxalates in spinach bind calcium
The Amounts of Different Minerals in Your Body

Figure 8.10

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Amount in the body in grams*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>1,000</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>780</td>
</tr>
<tr>
<td>Potassium</td>
<td>140</td>
</tr>
<tr>
<td>Sulfur</td>
<td>140</td>
</tr>
<tr>
<td>Sodium</td>
<td>100</td>
</tr>
<tr>
<td>Chloride</td>
<td>95</td>
</tr>
<tr>
<td>Magnesium</td>
<td>19</td>
</tr>
<tr>
<td>Iron</td>
<td>4.2</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.3</td>
</tr>
<tr>
<td>Copper</td>
<td>0.07</td>
</tr>
<tr>
<td>Iodine</td>
<td>0.02</td>
</tr>
</tbody>
</table>

* Based on a 154-pound person

© 2017 Pearson Education, Inc.
What Are Minerals and Why Do You Need Them?, Continued

• Major minerals (macrominerals): needed in amounts greater than 100 mg/day
• Trace minerals (microminerals): needed in amounts less than 20 mg/day
• You need major minerals in larger amounts
  • Sodium, chloride, potassium, magnesium, sulfur play key roles in fluid balance
  • Calcium, phosphorus, magnesium work together to strengthen bones and teeth
What Are Minerals and Why Do You Need Them?, Continued-1

• Trace minerals are needed in small amounts
  • Play essential roles as important as major minerals
  • Chromium and iodine help certain hormones
  • Iron maintains healthy red blood cells
  • Fluoride protects teeth
  • Iron, zinc, copper, manganese, and molybdenum are cofactors that work with enzymes in critical chemical reactions
What Are Minerals and Why Do You Need Them?, Continued-2

- Overconsumption of minerals can be toxic
  - Difference between recommended and excessive amount may be minimal
    - Example: magnesium, which can cause gastrointestinal problems
- Foods alone rarely provide excessive amounts
  - Problems usually arise with supplements
  - Another good reason to eat a varied diet
Minerals Are Found Widely in MyPlate

Vegetables
- Potassium
- Calcium
- Magnesium
- Chromium
- Manganese

Fruits
- Potassium
- Calcium (fortified juice)
- Manganese
- Boron

Grains
- Sodium
- Phosphorus
- Magnesium
- Iron
- Zinc
- Selenium
- Chromium
- Manganese

Protein
- Sodium
- Phosphorus
- Magnesium
- Iron
- Copper
- Zinc
- Selenium

Dairy
- Potassium
- Calcium
- Phosphorus

Figure 8.11
Exploring Sodium

• What are sodium and salt?
  • Sodium is an electrolyte (charged ion) in blood and in the fluid surrounding cells
  • About 90 percent of sodium consumed is in form of sodium chloride, table salt
• Functions: chief role is regulation of fluid balance
  • Also transports substances such as amino acids across cell membranes
Exploring Sodium, Continued

• Sodium balance in your body
  • Sodium level is maintained by the kidneys reducing or increasing sodium excretion as needed
• Smaller amounts lost in stool and sweat
• Daily needs: 1,500 mg/day for adults under 51
• Food sources: 75 percent of sodium consumed by Americans comes from processed foods
  • About 10 percent occurs naturally in foods; another 5-10 percent added during cooking and at table

© 2017 Pearson Education, Inc.
Recommended Intake of Sodium

- American adult daily consumption (> 3,400 mg)
- Adult upper level daily (2,300 mg)
- Adult recommended daily (1,500 mg)
- Adult needed daily (180 mg)

Figure 8.12
Practical Nutrition Tips Video: Sodium Needs

Sodium: What You Need Compared to What You Consume
Sodium Content of Selected Natural and Processed Foods

Figure 8.13

© 2017 Pearson Education, Inc.
Too much or too little:

- UL for adults is set at 2,300 mg/day to reduce the risk of hypertension (high blood pressure)
  - Cut back on processed foods and salt added to foods to lower sodium intake
- Sodium deficiency is rare in healthy individuals consuming a balanced diet
You and Your Blood Pressure

• Blood pressure: a measure of force that blood exerts on the walls of arteries
  • Expressed as systolic pressure (when heart beats) over diastolic pressure (when heart is at rest between beats)
    • <120/80 mm Hg is normal
    • Systolic >120 or diastolic >80 = prehypertension
    • ≥140/90 = hypertension
You and Your Blood Pressure, Continued

• Hypertension is a silent killer
  • No symptoms – have blood pressure checked regularly
  • Contributes to atherosclerosis, heart enlarges and weakens
  • Damages arteries leading to brain and kidneys, increasing risk of stroke and kidney disease

• To control hypertension:
  • Reduce weight, increase physical activity, eat a balanced diet
The DASH: (Dietary Approaches to Stop Hypertension)

Figure 8.14
## Table 8.4 Take Charge of Your Blood Pressure!

<table>
<thead>
<tr>
<th>If You</th>
<th>By</th>
<th>Your Systolic Blood Pressure* May Be Reduced by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce your sodium intake</td>
<td>Keeping dietary sodium consumption to less than 2,400 mg daily</td>
<td>8-14 mm Hg</td>
</tr>
<tr>
<td>Lose excess weight</td>
<td>Modifying your diet and exercise to reach and maintain a normal, healthy body weight</td>
<td>5-20 mm Hg for every 22 lbs of weight loss</td>
</tr>
<tr>
<td>Stay physically active</td>
<td>Partaking in 30 minutes of aerobic activity (e.g., brisk walking) on most days of the week</td>
<td>4-9 mm Hg</td>
</tr>
<tr>
<td>Drink alcohol only in moderation</td>
<td>Limiting consumption to no more than 2 drinks daily for men and 1 drink daily for women</td>
<td>2-4 mm Hg</td>
</tr>
<tr>
<td>Follow the DASH diet</td>
<td>Consuming this diet, which is abundant in fruits and vegetables and low-fat dairy products</td>
<td>8-14 mm Hg</td>
</tr>
</tbody>
</table>

*Controlling the systolic pressure is more difficult than controlling the diastolic pressure, especially for individuals 50 years of age and older. Therefore, it is the primary focus for lowering blood pressure. Typically, as systolic pressure goes down with diet and lifestyle changes, the diastolic pressure will follow.

Exploring Potassium

- Important mineral with many functions:
  - Fluid balance: electrolyte inside cells
  - A blood buffer: helps keep blood pH and acid-base balance correct
  - Muscle contraction and nerve impulse conduction
  - Can help lower high blood pressure
  - Aids in bone health: helps increase bone density
  - Reduces kidney stones by helping to excrete citrate (binds with calcium to form kidney stones)
Kidney Stone

Figure 8.15
Exploring Potassium, Continued

- Daily needs:
  - Adults: 4,700 mg/day
  - Adult females consume only about 2,400 mg/day and adult males only 3,170 mg/day, on average

- Food sources:
  - Fruits and vegetables
    - Minimum of 4½ cups/day will help meet potassium needs
  - Dairy foods, nuts, legumes also good sources
Potassium Content in Selected Foods

Figure 8.16
Too much or too little:

- Too much from supplements or salt substitutes can cause hyperkalemia in some individuals
  - Can cause irregular heartbeats, damage heart, and be life-threatening

- Too little can cause hypokalemia
  - Can cause muscle weakness, cramps, irregular heartbeats, and paralysis
  - Can occur as result of excessive vomiting and/or diarrhea, anorexia and/or bulimia eating disorders
Exploring Calcium

• Most abundant mineral in body
  • More than 99 percent located in bones and teeth
• Functions:
  • Helps build strong bones and teeth
  • Plays a role in muscles, nerves, and blood
  • May help lower high blood pressure
  • May fight colon cancer
  • May reduce risk of kidney stones (though supplements have opposite effect)
Calcium Metabolism
Exploring Calcium, Continued

- Daily needs:
  - 1,000 to 1,200 mg/day, depending on age
- Food sources:
  - Milk, yogurt, cheese, broccoli, kale, canned salmon (with bones), tofu processed with calcium, calcium-fortified juices and cereals
Calcium Content in Selected Foods

Figure 8.17

[Bar chart showing calcium content in various foods]
Bioavailability of Calcium

- **< 10%**
  - Spinach
  - Rhubarb
  - Okra

- **20–30%**
  - Milk
  - Cheese
  - Yogurt
  - Tofu
  - Soy milk
  - Salmon
  - OJ with calcium
  - Almonds
  - Beans

- **> 40%**
  - Kale
  - Broccoli
  - Chinese mustard greens
  - Turnip greens
  - Green cabbage

Figure 8.18
Exploring Calcium, Continued

- Too much or too little:
  - UL: 2,500 mg/day (ages 19-50); 2,000 mg (51+)
  - Too much calcium leads to hypercalcemia: impaired kidneys, calcium deposits in body
  - Too little can lead to less dense, weakened, brittle bones, and increased risk for osteoporosis

- Calcium supplements:
  - Consume in doses of 500 mg or less
  - Some sources (oyster shell, bone meal, dolomite) may contain lead, other toxic metals
  - May be inadvisable if consuming enough in foods
Healthy Bone (left) vs Weakened Bone (right)

Figure 8.19
Osteoporosis: Not Just Your Grandmother's Problem

- Bones are living tissue, constantly changing
- Peak bone mass occurs in early adulthood (20s)
  - Then slowly more bone is lost than added
  - As bones lose mass, they become more porous and prone to fractures, leading to osteoporosis
- Bone mineral density (BMD) test measures bone density
  - Low score = osteopenia (low bone mass)
  - Very low score = osteoporosis
Weakened Bones Cause the Spine to Collapse over Time
Osteoporosis: Not Just Your Grandmother's Problem, Continued

• Risk factors:
  • Gender (females at higher risk due to loss of estrogen after menopause)
  • Ethnicity (Caucasian and Asian-American at higher risk)
  • Age (over 30)
  • Body type (small-boned/petite women at higher risk)
  • Family history of fractures increases risk
  • Level of sex hormones (amenorrhea, menopause, or men with low levels of sex hormones)
Osteoporosis: Not Just Your Grandmother's Problem, Continued-1

- Risk factors (continued):
  - Medications: glucocorticoids, antiseizure medications, aluminum-containing antacids, high amounts of thyroid replacement hormones
  - Smoking
  - Low physical activity: 30 minutes per day recommended
  - Alcohol (more than one drink for women, two for men)
  - Inadequate calcium and vitamin D (less than three cups/day of vitamin D-fortified milk or yogurt)
Exploring Phosphorus

- Second most abundant mineral in body
  - 85 percent in bones; rest in cells and fluids outside cells, including blood

- Functions:
  - Needed for bones and teeth
  - Important component of cell membranes
  - Needed for energy metabolism and stores
  - Acts as a blood buffer
  - Part of DNA and RNA
Phosphorus in Phospholipids

Phosphorus in phospholipid head

Outside of cell

Cell membrane

Inside of cell

Figure 8.22
Exploring Phosphorus, Continued

- Daily needs:
  - Adults: 700 mg/day

- Food sources:
  - Meat, fish, poultry, dairy
  - Abundant in diet

- Too much or too little:
  - UL set at 4,000 mg/day for adults 19 to 50 to prevent hyperphosphatemia, which can lead to calcification of tissues; 3,000 mg for those aged 51 or older
  - Too little can result in muscle weakness, bone pain, rickets, confusion, death; would need to be in state of near starvation to experience deficiency
Phosphorus Content of Selected Foods

Figure 8.23
Exploring Magnesium

• Another abundant mineral in body
  • About half in bones; most of rest inside cells
• Functions:
  • Helps more than 300 enzymes, including energy metabolism
  • Used in synthesis of protein
  • Helps muscles and nerves function properly
  • Maintains healthy bones and regular heartbeat
  • May help lower high blood pressure and reduce risk of type 2 diabetes
Exploring Magnesium, Continued

- Daily needs:
  - 19 to 30 years: males, 400 mg/day; females, 310 mg/day
  - >30 years: males, 420 mg/day; females, 320 mg/day
  - Many Americans fall short (80 to 85 percent of needs)

- Food sources:
  - Whole grains, vegetables, nuts, fruits; also milk, yogurt, meat, eggs

- Too much or too little:
  - UL from supplements (not foods) = 350 mg/day to avoid diarrhea
  - Deficiencies are rare, but diuretics and some antibiotics can inhibit absorption
Figure 8.24
Exploring Chloride

- Chloride is part of hydrochloric acid in the stomach, which enhances protein digestion

- Functions:
  - Sodium and chloride are major electrolytes outside cells and in blood to help maintain fluid balance
  - Acts as buffer to keep blood at normal pH

- Daily needs: adults: 2,300 mg/day

- Food sources: salt (NaCl) is main source

- Too much or too little: deficiencies are rare
  - UL 3,600 mg/day to match sodium UL
Table Salt Is Composed of Sodium and Chloride

Figure 8.25
Exploring Sulfur

• Component of other compounds in body, including the vitamins thiamin, biotin, pantothenic acid
• Functions:
  • Helps give proteins 3-D shape as part of amino acids methionine, cystine, and cysteine
  • Sulfites used as food preservative
• Food sources: meat, poultry, fish, eggs, legumes, dairy, fruits, vegetables
• Too much or too little: no known toxicity or deficiency symptoms
Exploring Iron

- Most abundant mineral on earth and main trace mineral in body
- Two forms: heme and nonheme iron
  - Heme iron from animal sources is part of hemoglobin and myoglobin and easily absorbed
  - Nonheme iron in plant foods is not as easily absorbed, due to phytates and other substances
- Body absorbs only 10 to 15 percent of iron consumed
- Absorption increases if body stores are low
- Not excreted in urine or stool; once absorbed, very little leaves body (95 percent recycled, reused)
Hemoglobin Contains Heme Iron

Figure 8.26

Heme
Exploring Iron, Continued

• Functions:
  • Hemoglobin in red blood cells transports oxygen from lungs to tissues and picks up carbon dioxide waste from cells
  • Myoglobin transports and stores oxygen in muscle cells
  • Aids brain function by helping enzymes that make neurotransmitters
• Daily needs:
  • Men and women >50: 8 mg/day
  • Women 19 to 50: 18 mg/day: higher due to iron lost during menstruation
• Food sources:
  • Iron-enriched bread and grain products; heme iron in meats, fish, and poultry
Iron Content of Selected Foods

Figure 8.27

[Diagram showing iron content in milligrams (mg) for different food groups, including vegetables, fruits, grains, and protein.]

© 2017 Pearson Education, Inc.
Exploring Iron, Continued

- Too much or too little:
  - Too much iron from supplements can cause constipation, nausea, vomiting, diarrhea
  - In United States, a leading cause of accidental poisoning deaths in children under 6 years
  - Iron overload can damage heart, kidneys, liver, nervous system
  - Hemochromatosis, a genetic disorder, can cause iron overload
  - Iron deficiency: most common nutritional disorder in world
  - Iron-deficiency anemia occurs when iron stores are depleted and hemoglobin levels decrease
Normal and Anemic Blood Cells

(a) Normal red blood cells

(b) Red blood cells affected by anemia
Exploring Copper

• Functions:
  • Part of many enzymes and proteins
  • Important for iron absorption and transfer, synthesis of hemoglobin and red blood cells
  • Helps generate energy in cells, synthesize melanin, link the proteins collagen and elastin together in connective tissues
  • Helps enzymes protect cells from free radicals
  • Role in blood clotting and maintaining healthy immune system
Exploring Copper, Continued

- **Daily needs:**
  - Adults: 900 µg/day

- **Food sources:**
  - Organ meats, seafood, nuts, seeds, bran cereals, whole-grain products, cocoa

- **Too much or too little:**
  - UL: 10,000 µg/day
  - Excess can cause stomach cramps, nausea, diarrhea, vomiting, liver damage
  - Copper deficiency rare in United States
Copper Content of Selected Foods

Figure 8.29
Exploring Zinc

• Involved in function of more than 100 enzymes
• Functions:
  • DNA synthesis, growth, and development
  • Healthy immune system and wound healing
  • Taste acuity
  • Treatment for common cold
  • May reduce risk of age-related macular degeneration
• Daily needs:
  • Men: 11 mg/day; women: 8 mg/day
  • Vegetarians may need as much as 50 percent more
Exploring Zinc, Continued

• Food sources:
  • Red meat, some seafood, whole grains

• Too much or too little:
  • UL = 40 mg/day
  • As little as 50 mg can cause stomach pains, nausea, vomiting, diarrhea
  • 60 mg/day can inhibit copper absorption
  • Excessive amounts can suppress immune system, lower HDL cholesterol
  • Deficiency: hair loss, impaired taste, loss of appetite, diarrhea, delayed sexual maturation, impotence, skin rashes, impaired growth
Zinc Content of Selected Foods

Figure 8.30
Exploring Selenium

• Part of class of proteins called selenoproteins, many of which are enzymes
• Functions of selenoproteins:
  • Help regulate thyroid hormones
  • Act as antioxidants
  • May help fight cancer
• Daily needs: adults: 55 µg/day
• Food sources: meat, seafood, cereal, grains, dairy foods, fruits, vegetables
  • Amount varies depending on soil content
Too much or too little:
• UL = 400 µg/day
• Too much can cause toxic condition *selenosis*
  • Symptoms: brittleness and loss of nails and hair, stomach and intestinal discomfort, skin rash, garlicky breath, fatigue, nervous system damage
• Selenium deficiency is rare in United States
  • Deficiency can cause Keshan disease (heart damage): seen in children in rural areas that have selenium-poor soils
Selenium Content in Selected Foods

Figure 8.31

[Diagram showing the selenium content in various foods, with bars indicating the micrograms of selenium per serving.]
Exploring Fluoride

• Functions:
  • Protects against dental caries
    • Helps repair enamel eroded by acids from bacteria
    • Reduces amount of acid bacteria produce
    • Provides protective barrier
  • Fluoridated drinking water has reduced dental caries in United States

• Daily needs:
  • Men: 3.8 mg/day; women: 3.1 mg/day
Structure of a Tooth

Enamel

Gum

Bone

Figure 8.32
Percentage of Americans Living in Communities with Fluoridated Water Supply, by State, 2012
Exploring Fluoride, Continued

- Sources: foods are not a good source
  - Best source is fluoridated drinking water and beverages made with this water
- Too much or too little:
  - Too little increases risk of dental caries.
  - Too much can cause **fluorosis** (mottling/staining) when teeth are forming during infancy/childhood.
    - Fluorosis of bones can occur when >10 mg/day is consumed for 10 or more years.
  - UL: adults: 10 mg/day, much lower for infants and children
Exploring Chromium

• Functions:
  • Helps insulin in your body
    • Increases effectiveness in cells
  • May improve blood glucose control, but no large study confirms this theory
    • Small study suggests chromium supplement may reduce risk of insulin resistance
    • FDA allows a Qualified Health Claim on chromium supplements, but label must state that evidence is not certain
  • Does not help build muscle mass
Exploring Chromium, Continued

• Daily needs: men: 30 to 35 µg; women: 20 to 25 µg
• Food sources: grains, meat, fish, poultry, some fruits and vegetables
• Too much or too little:
  • No known risk from consuming too much
  • Deficiency is rare in United States
Chromium Content in Selected Foods

![Bar chart showing chromium content in selected foods.](image-url)

- Vegetables:
  - Green beans, 1 cup: 1.0 µg
  - Peas, 1 cup: 2.0 µg
  - Broccoli, 1 cup: 3.0 µg

- Fruits:
  - Apple with skin, 1 medium: 1.0 µg
  - Orange juice, 1 cup: 1.0 µg
  - Grape juice, 1 cup: 2.0 µg

- Grains:
  - Whole-wheat bread, 1 slice: 1.0 µg
  - English muffin, 1/2: 2.0 µg
  - Turkey breast, 3 oz: 0.2 µg
  - Chicken breast, 3 oz: 1.7 µg
  - Ham, 3 oz: 2.0 µg

- Protein:
  - Whole wheat, English muffin, 1/2: 1.0 µg
  - Turkey breast, 3 oz: 2.0 µg
  - Chicken breast, 3 oz: 3.6 µg

- Daily Needs:
  - Women 19-50 years: 35 µg
  - Men 19-50 years: 25 µg

© 2017 Pearson Education, Inc.

Figure 8.34
Exploring Iodine

• Functions: needed by thyroid to make essential hormones
  • Thyroid hormones regulate metabolic rate; help heart, nerves, muscle and intestines function properly
• Daily needs: adults: 150 µg/day
• Food sources: iodized salt (400 µg/tsp)
  • Amount in foods is low; depends on iodine content of soil, water, fertilizer
  • Salt-water fish have higher amounts
Location of Thyroid Gland
Iodine Content in Selected Foods

Figure 8.36
Exploring Iodine, Continued

• Too much or too little: UL = 1,100 µg/day
  • Excess iodine can impair thyroid function, decrease synthesis and release of thyroid hormones
• Early sign of deficiency = goiter (enlarged thyroid gland)
  • Mandatory iodization of salt has decreased iodine deficiency in United States but not in other parts of world
  • Iodine deficiency during early stages of fetal development can cause cretinism (congenital hypothyroidism)
Exploring Manganese

- Part of, or activates, many enzymes in body
- Functions:
  - Helps metabolize carbohydrates, fats, amino acids
  - Aids bone formation
- Daily needs: men: 2.3 mg/day; women: 1.8 mg/day
- Food sources: whole grains, nuts, legumes, tea, vegetables, pineapples, strawberries, bananas
- Too much or too little:
  - UL = 11 mg/day to avoid toxicity with Parkinson's disease-like symptoms
Manganese Content of Selected Foods

- Vegetables: 0.5 mg
- Fruits: 1.7 mg
- Grains: 1.1 mg
- Protein: 0.9 mg
- Dairy: 0.3 mg

Daily Needs: 2.3 mg

© 2017 Pearson Education, Inc.
Exploring Molybdenum

- Functions: part of several enzymes involved in breakdown of certain amino acids and other compounds
- Daily needs: adults: 45 µg/day
- Food sources: legumes, grains, nuts
- Too much or too little:
  - UL = 2 µg/day, based on animal studies in which too much molybdenum caused reproductive problems
  - No cases seen in healthy individuals
Other Minerals

• Arsenic, boron, nickel, silicon, and vanadium
  • Exist in body but essential role in humans not established by research
  • May have function for some animals
  • Tolerable upper levels set for:
    • Boron: 20 mg/day (10 times more than average American consumes)
    • Nickel: 1 mg/day
    • Vanadium: 1.8 mg/day
Table 8.1 Minerals at a Glance: Major Minerals

<table>
<thead>
<tr>
<th>Major Minerals</th>
<th>Major Functions</th>
<th>Adult DRI, 19 to 50 years</th>
<th>Food Sources</th>
<th>Excessive/Toxicity Symptoms/UL</th>
<th>Deficiency Symptoms/Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>Major electrolyte outside the cell; helps regulate body water and blood pressure</td>
<td>1,500 mg/day</td>
<td>Processed foods, table salt, meat, seafood, milk, cheese, eggs</td>
<td>Hypertension UL: 2,300 mg/day</td>
<td>Rare in individuals consuming a healthy diet</td>
</tr>
<tr>
<td>Potassium</td>
<td>Major mineral inside the cell, needed for muscle contraction and nerve impulses; regulates body water and blood pressure</td>
<td>4,700 mg/day</td>
<td>Potatoes, melons, citrus fruits, most fruits and vegetables, meat, milk, legumes</td>
<td>Hyperkalemia</td>
<td>Hypokalemia</td>
</tr>
<tr>
<td>Calcium</td>
<td>Formation of bones and teeth, muscle contraction and relaxation, blood clotting, heart and nerve function</td>
<td>1,000 mg/day</td>
<td>Milk and dairy products, leafy greens, broccoli, salmon, sardines, tofu</td>
<td>Hypercalcemia UL: 2,500 mg/day</td>
<td>Osteoporosis</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Formation of bones and teeth</td>
<td>700 mg/day</td>
<td>Meat, fish, poultry, eggs, dairy, cereals</td>
<td>Hyperphosphatemia UL: 4,000 mg/day</td>
<td>Muscle weakness, bone pain, rickets, confusion, and death</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Participates in muscle contraction and nerve conduction</td>
<td>310 to 420 mg/day</td>
<td>Meat, seafood, nuts, legumes, dairy, whole grains</td>
<td>Large intakes from supplements can cause diarrhea, cramps, and nausea</td>
<td>Rare</td>
</tr>
<tr>
<td>Chloride</td>
<td>Helps maintain fluid and acid-base balance</td>
<td>2,300 mg/day</td>
<td>Found as sodium chloride in foods</td>
<td>UL: 3,600 mg/day</td>
<td>Rare</td>
</tr>
<tr>
<td>Sulfur</td>
<td>A part of other compounds in body; helps give some amino acids their three-dimensional shape</td>
<td>None</td>
<td>Meats, fish, poultry, eggs, dairy foods, fruits, vegetables</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
## Minerals at a Glance: Trace Minerals

<table>
<thead>
<tr>
<th>Trace Minerals</th>
<th>Major Functions</th>
<th>Adult DRI, 19 to 50 years</th>
<th>Food Sources</th>
<th>Excessive/Toxicity Symptoms/UL</th>
<th>Deficiency Symptoms/Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>As a major component of hemoglobin and myoglobin, helps transport oxygen throughout the body; enhances brain function</td>
<td>8 to 18 mg/day</td>
<td>Meat, fish, poultry, enriched and fortified breads and cereals</td>
<td>Vomiting, nausea, diarrhea, constipation, organ damage including the kidney and liver UL: 45 mg/day</td>
<td>Fatigue, iron-deficiency anemia, growth retardation in infants</td>
</tr>
<tr>
<td>Copper</td>
<td>A component of several enzymes; involved in iron transport; needed for healthy connective tissue enzymes; role in blood clotting and a healthy immune system</td>
<td>900 µg/day</td>
<td>Organ meats, nuts, seeds, cocoa, whole grains, legumes, and shellfish</td>
<td>Vomiting, abdominal pain, nausea, diarrhea, liver damage UL: 10,000 µg/day</td>
<td>Impaired growth and development</td>
</tr>
<tr>
<td>Zinc</td>
<td>Cofactor for several enzymes; DNA and RNA synthesis; needed for a healthy immune system, wound healing, and taste acuity</td>
<td>8 to 11 mg/day</td>
<td>Meat, poultry, seafood, whole grains</td>
<td>Nausea, vomiting, cramps, diarrhea, impaired immune function UL: 40 mg/day</td>
<td>Skin rash and hair loss, diarrhea, loss of taste and smell</td>
</tr>
<tr>
<td>Selenium</td>
<td>A component of enzymes; antioxidant</td>
<td>55 µg/day</td>
<td>Meat, seafood, fish, eggs, whole grains</td>
<td>Selenosis, brittle hair and nails, skin rash, garlic breath odor, fatigue UL: 400 µg/day</td>
<td>Keshan disease</td>
</tr>
<tr>
<td>Fluoride</td>
<td>Makes teeth stronger</td>
<td>3.1 to 3.8 mg/day</td>
<td>Fluoridated water, tea</td>
<td>Fluorosis in teeth and skeletal fluorosis UL: 10 mg/day</td>
<td>Increased susceptibility to dental caries</td>
</tr>
<tr>
<td>Chromium</td>
<td>Improves insulin response</td>
<td>20 to 35 µg/day</td>
<td>Pork, egg yolks, whole grains, nuts</td>
<td>Unconfirmed toxicity effects</td>
<td>Potential increase of insulin resistance</td>
</tr>
<tr>
<td>Iodine</td>
<td>Component of a thyroid hormone</td>
<td>150 µg/day</td>
<td>Iodized salt, seafood, dairy products</td>
<td>Impaired functioning of thyroid UL: 1,100 µg/day</td>
<td>Goiter, cretinism</td>
</tr>
<tr>
<td>Manganese</td>
<td>Cofactor involved in metabolism</td>
<td>1.8 to 2.3 mg/day</td>
<td>Beans, oats, nuts, tea</td>
<td>Abnormal central nervous system effects UL: 11 mg/day</td>
<td>Deficiency rare; rash and scaly skin</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Cofactor for a variety of enzymes</td>
<td>45 µg/day</td>
<td>Legumes, nuts, leafy vegetables, dairy, cereals</td>
<td>Unknown in humans UL: 2 mg/day</td>
<td>Unknown in humans</td>
</tr>
</tbody>
</table>
## Table 8.3 Additional Minerals

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Potential Role and Deficiency Symptoms</th>
<th>Food Sources</th>
<th>Potential Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>May be needed in the metabolism of a specific amino acid in rats. A deficiency may impair growth and reproduction in animals.</td>
<td>Dairy products, meat, poultry, fish, grains, and cereal products</td>
<td>No known adverse effect in humans from the organic form of arsenic found in foods. The inorganic form is poisonous to humans.</td>
</tr>
<tr>
<td>Boron</td>
<td>A deficiency may be associated with reproductive abnormalities in certain fish and frogs, which suggests a possible role in normal development in animals.</td>
<td>Grape juice, legumes, potatoes, pecans, peanut butter, apples, and milk</td>
<td>No known adverse effect from boron in food. Some research suggests that high amounts of boron may cause reproductive and developmental problems in animals. Because of this, the upper limit for human adults has been set at 20 mg daily, which is more than 10 times the amount American adults consume daily, on average.</td>
</tr>
<tr>
<td>Nickel</td>
<td>May be needed by specific enzymes in the body. It is considered an essential mineral in animals.</td>
<td>Grains and grain products, vegetables, legumes, nuts, and chocolate</td>
<td>No known toxicity of nickel in humans when consuming a normal diet. In rats, high exposure to nickel salts can cause toxicity, with symptoms such as lethargy, irregular breathing, and lower than normal weight gain. Because of this, the upper limit for adults is set at 1 mg daily for nickel salts.</td>
</tr>
<tr>
<td>Silicon</td>
<td>May be needed for bone formation in animals.</td>
<td>Grains, grain products, and vegetables</td>
<td>No known risk of silicon toxicity in humans from food sources.</td>
</tr>
<tr>
<td>Vanadium</td>
<td>In animals, vanadium has insulin-like actions and a deficiency increases the risk of abortion.</td>
<td>Mushrooms, shellfish, parsley, and black pepper</td>
<td>No known risk of toxicity in humans from vanadium in foods. Too much has been shown to cause kidney damage in animals. Vanadium can be purchased as supplements. Because of the known toxicity in animals, the upper limit for adults is set at 1.8 mg daily.</td>
</tr>
</tbody>
</table>