Chapter 8

8.1 Regulating Metabolism

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

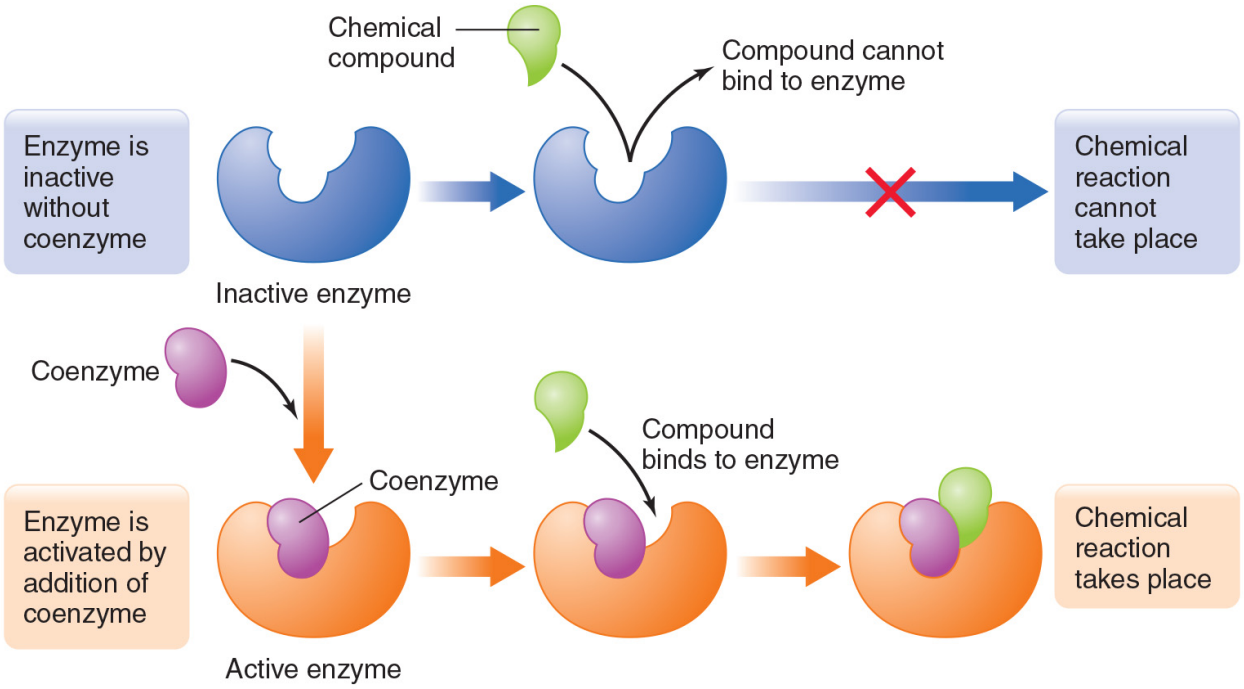

Figure 8.1: Enzymes

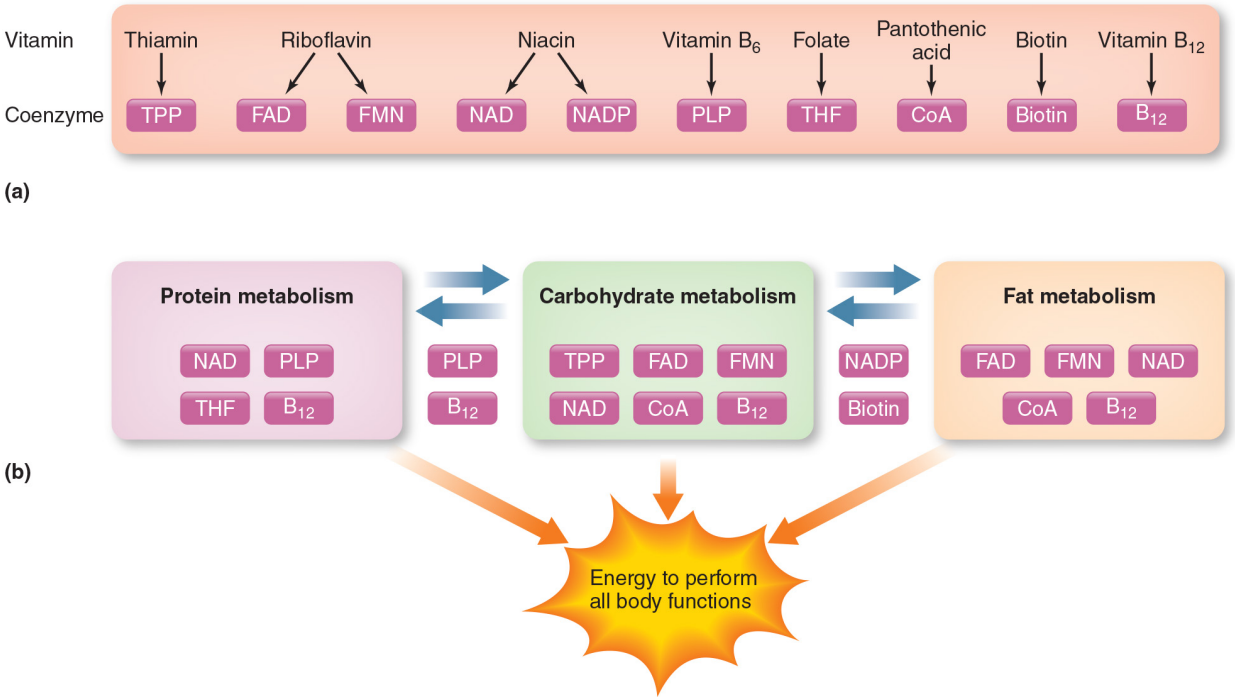

Figure 8.2: Enzymes

Table 8.1: Nutrient and Energy Metabolism

Nutrient	Recommended Intake
Thiamin (vitamin B1)	RDA for 19 years of age and older: Women = 1.1 mg/day Men = 1.2 mg/day
Riboflavin (vitamin B2)	RDA for 19 years of age and older: Women 1.1 mg/day Men 1.3 mg/day
Niacin (nicotinamide and nicotinic acid)	RDA for 19 years of age and older: Women 14 mg/day Men 16 mg/day
Vitamin B6 (pyridoxine)	RDA for 19 to 50 years of age: 1.3 mg/day RDA for 51 years of age and older: Women = 1.5 mg/day Men 1.7 mg/day
Folate (folic acid)	RDA for 19 years of age and older 400 μg/day
Vitamin B12 (cobalamin)	RDA for 19 years of age and older: 2.4 μg/day
Pantothenic acid	Al for 19 years of age and older: 5 mg/day
Biotin	Al for 19 years of age and older: 30 μg/day
Choline	Al for 19 years of age and older: Women 425 mg/day Men 550 mg/day
Iodine	RDA for 19 years of age and older: 150 μg/day
Chromium	RDA for 51 years of age and older: Women 20 μg/day Men 30 μg/day RDA for 19 to 50 years of age: Women 25 μg/day Men 35 μg/day
Manganese	Al for 19 years of age and older: Women 1.8 mg/day 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.

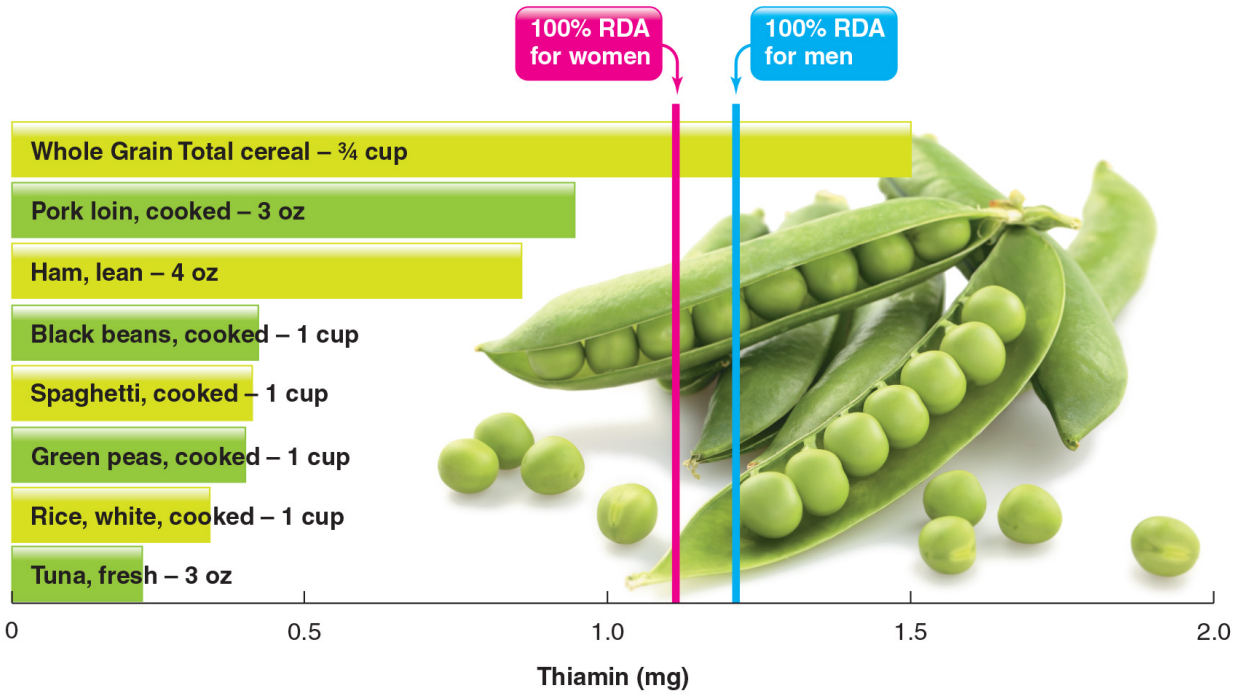

Figure 8.3: Thiamin

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

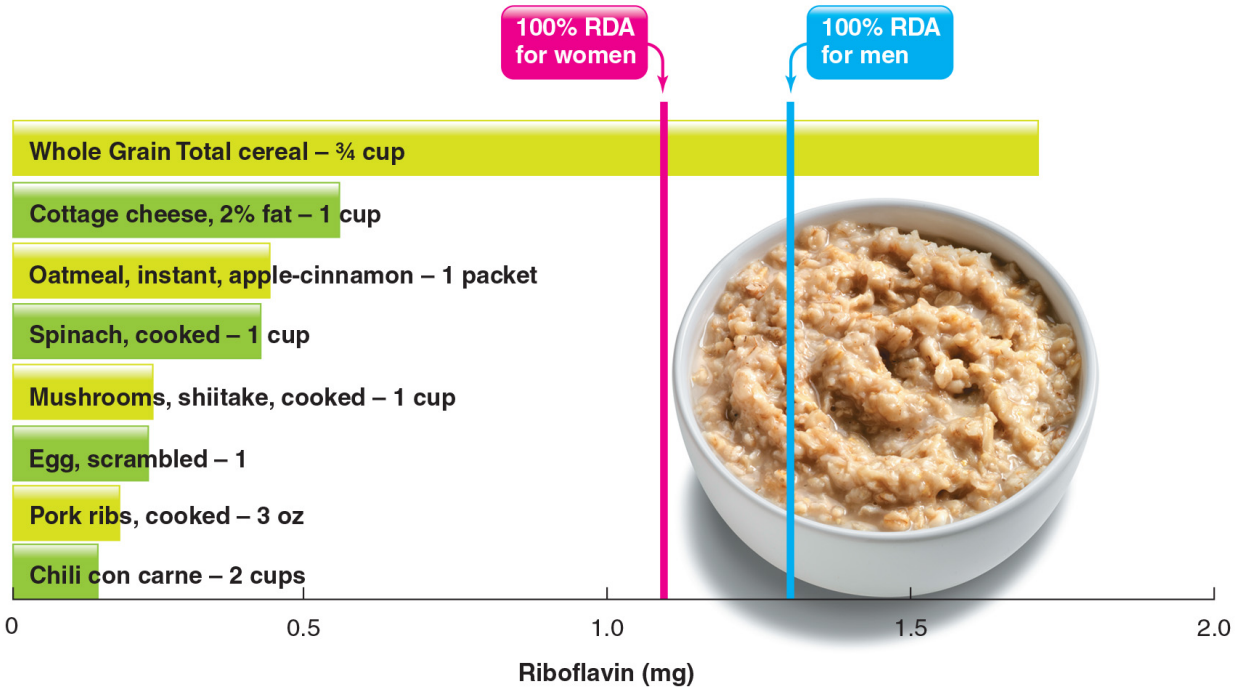

Figure 8.4: Riboflavin

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

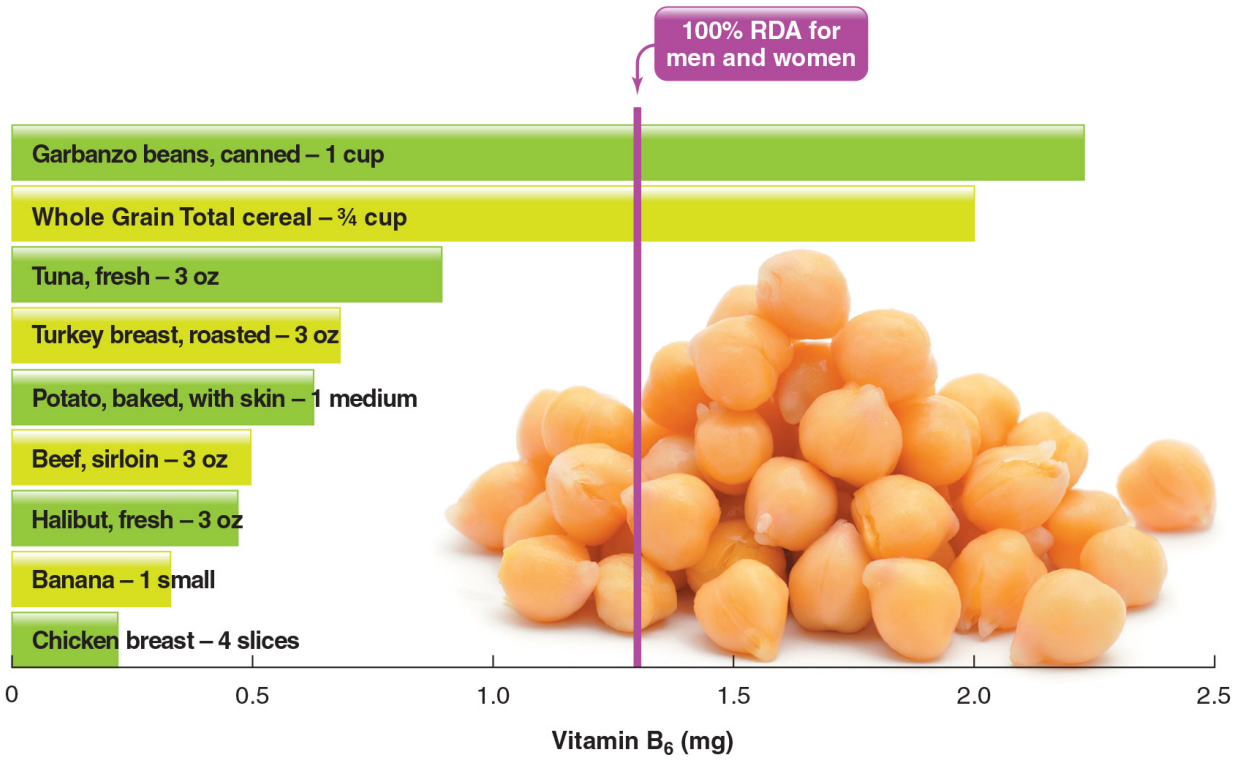

Figure 8.5: Pyrodoxine

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

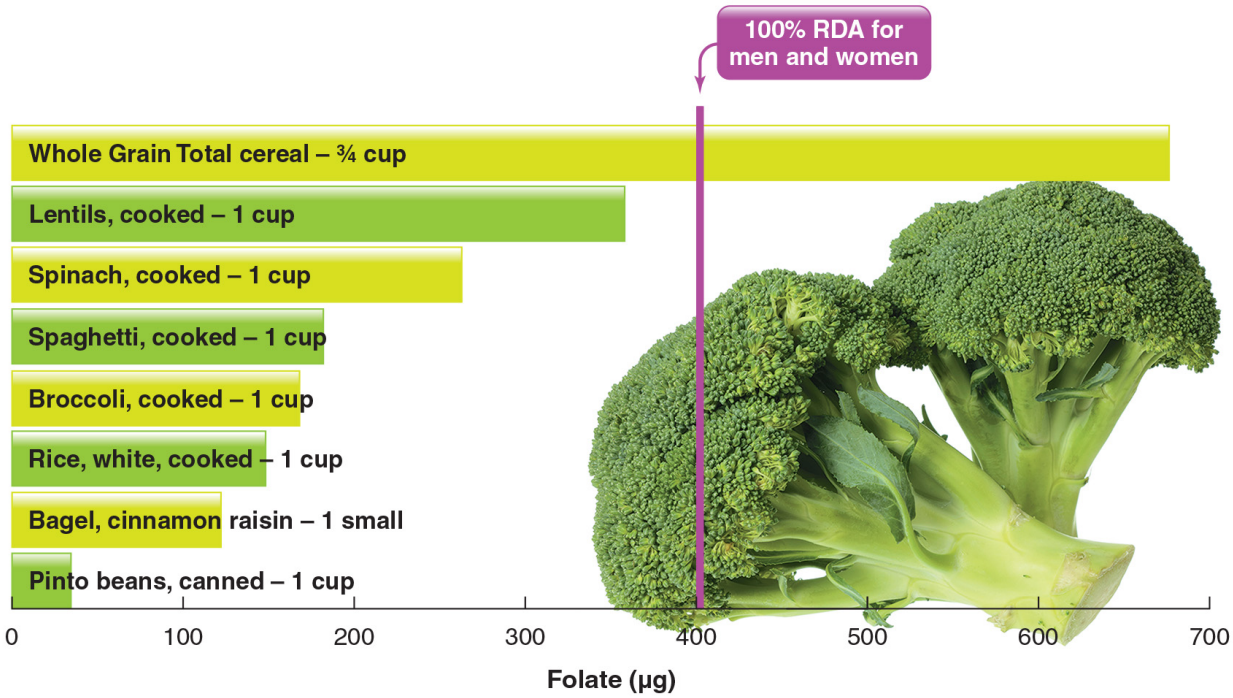

Figure 8.6: Folate

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

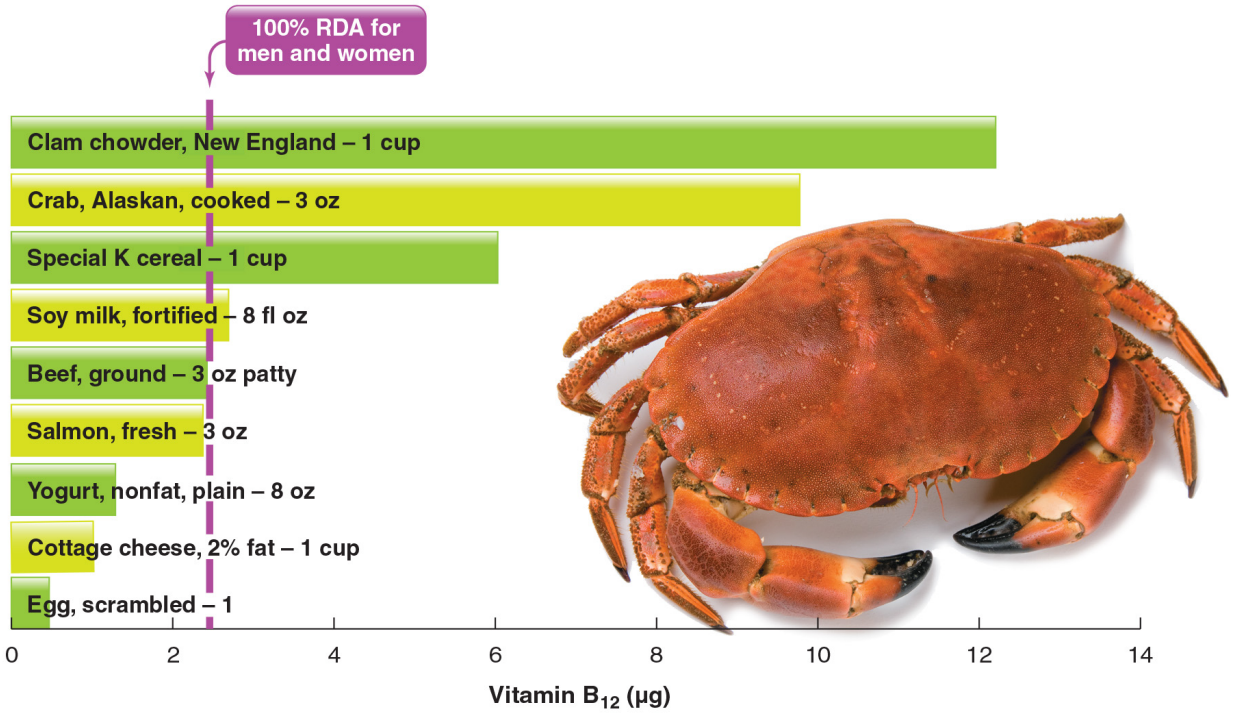

Figure 8.7: B_{12}

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

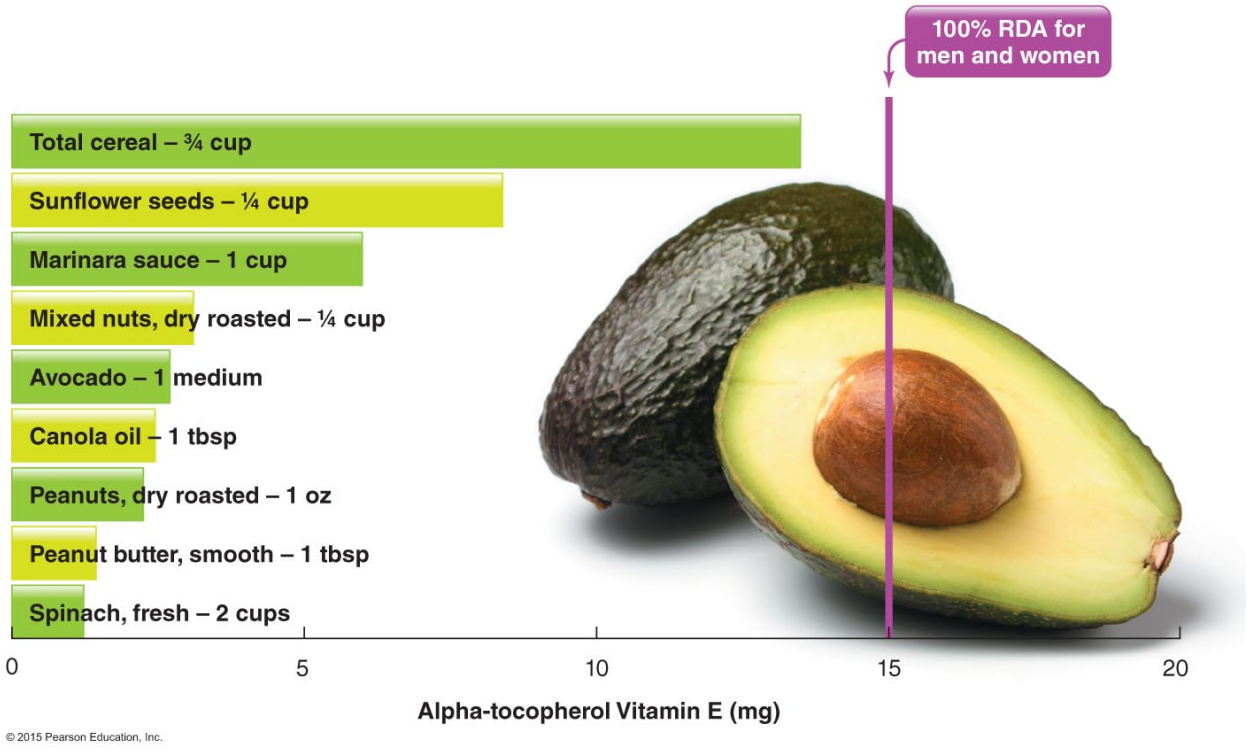

Figure 8.8: Common Food Sources of Vitamin E

- 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

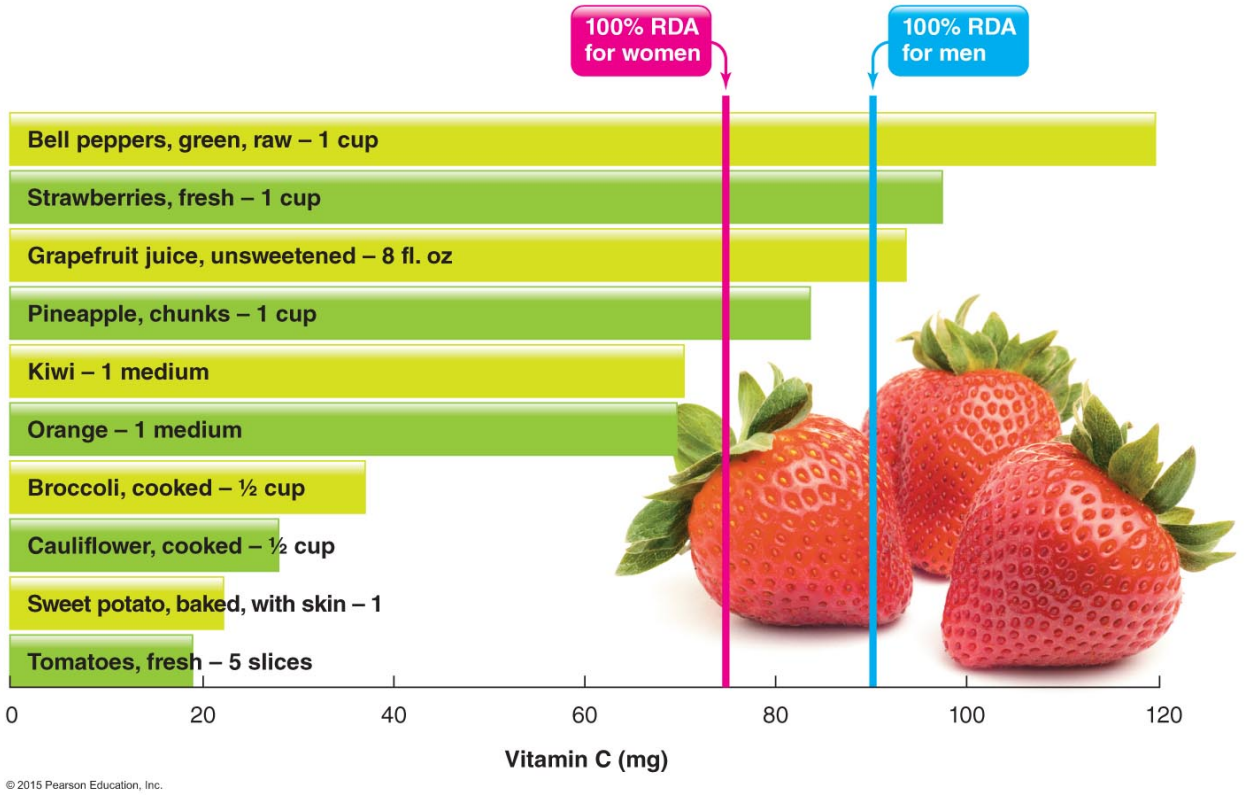

Figure 8.9: Common Food Sources of Vitamin C

- 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

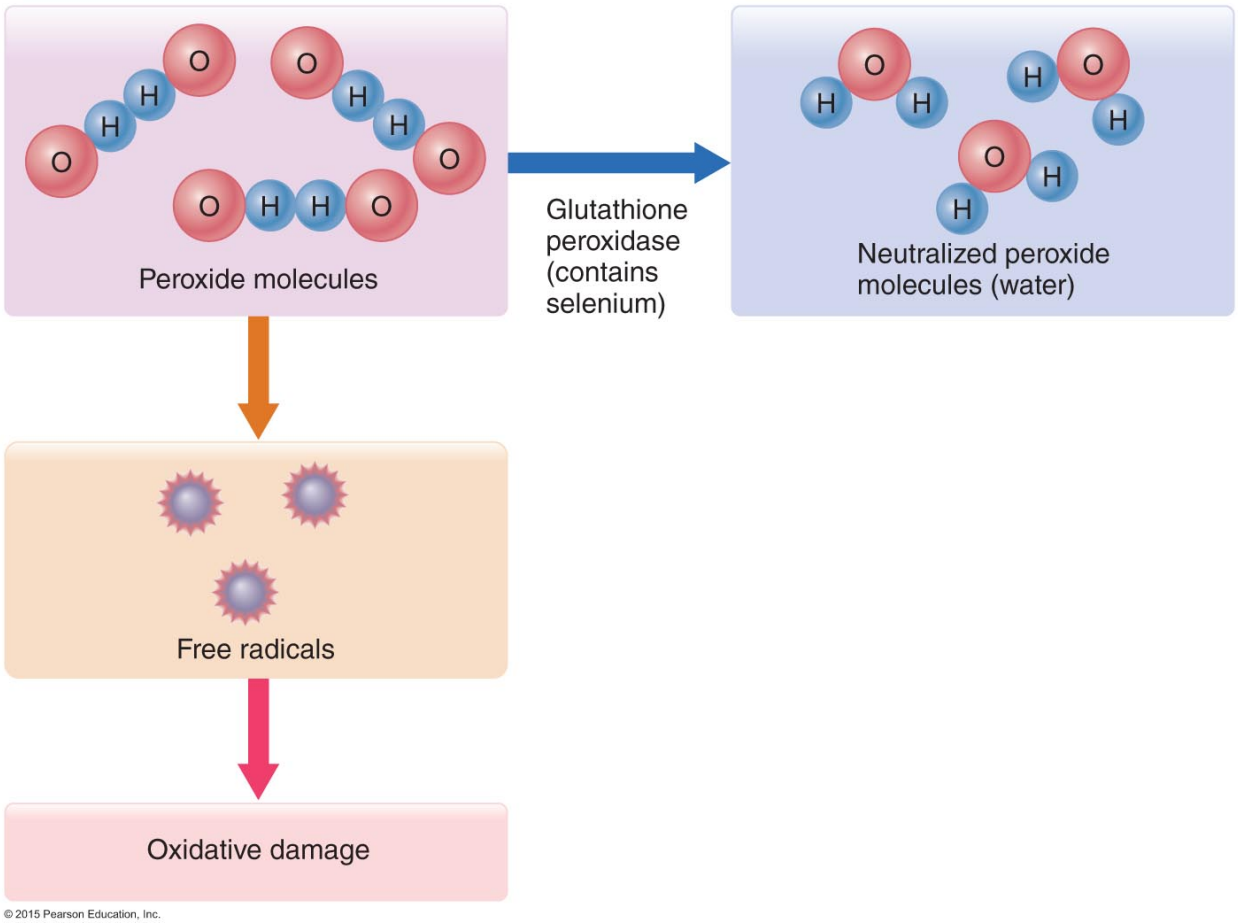

Figure 8.11: Neutralizing Peroxide Molecules

- 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

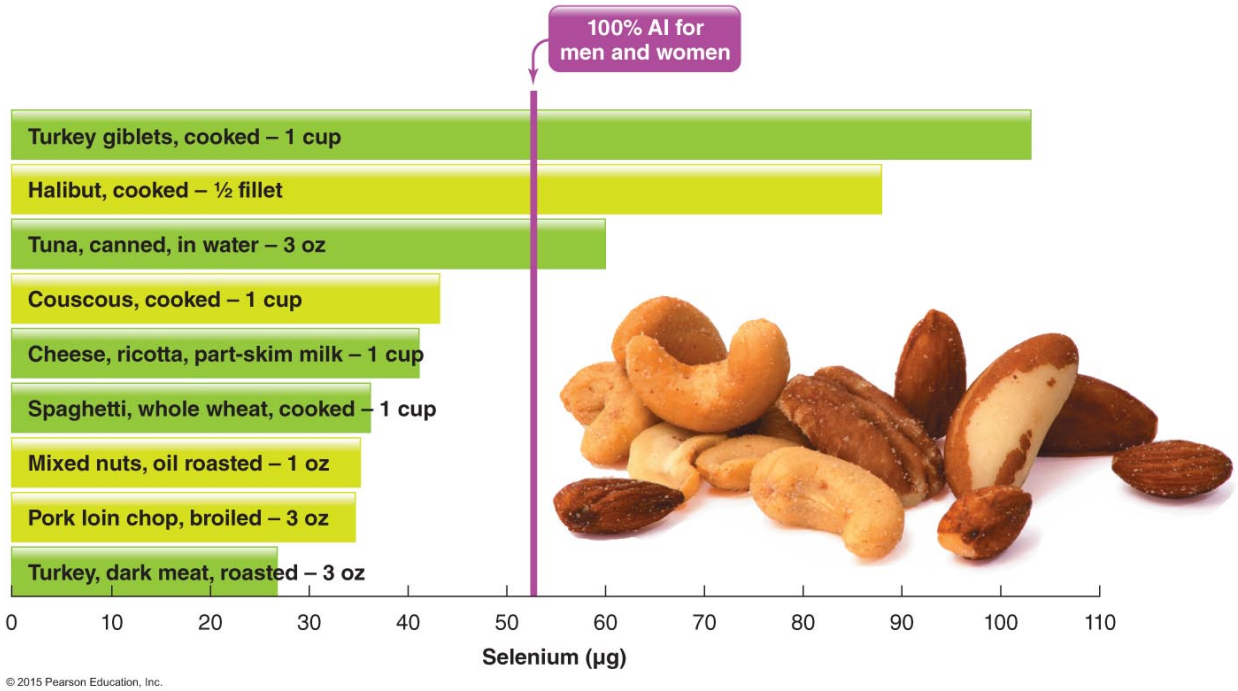

Figure 8.12: Common Food Sources of Selenium

- 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 metabolism

8.14 Beta

- 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

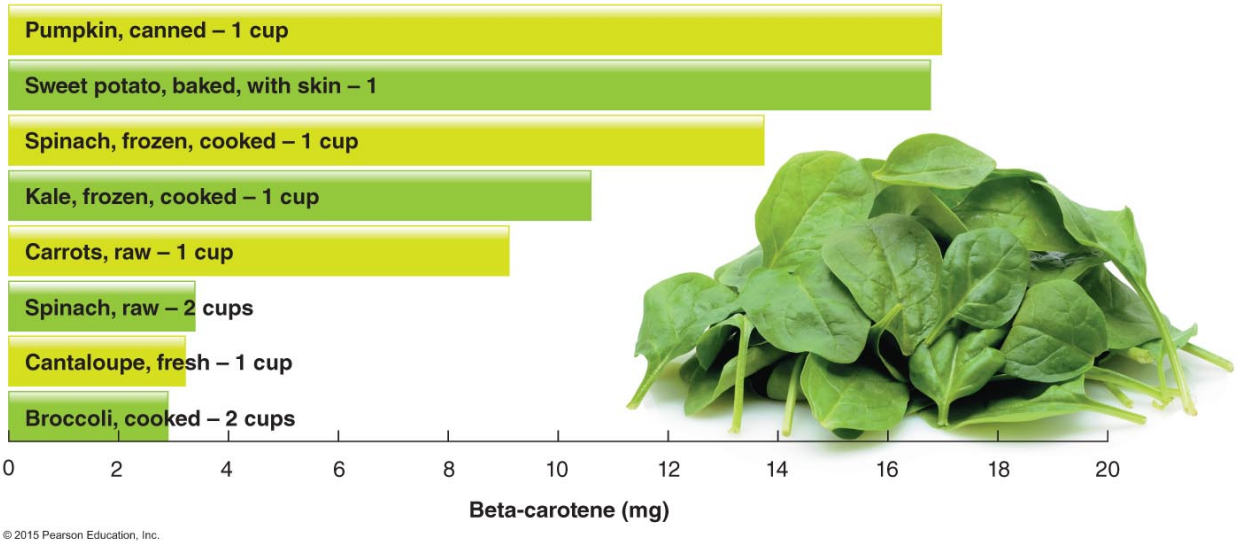

Figure 8.14: Common Food Sources of Beta-Carotene

- 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

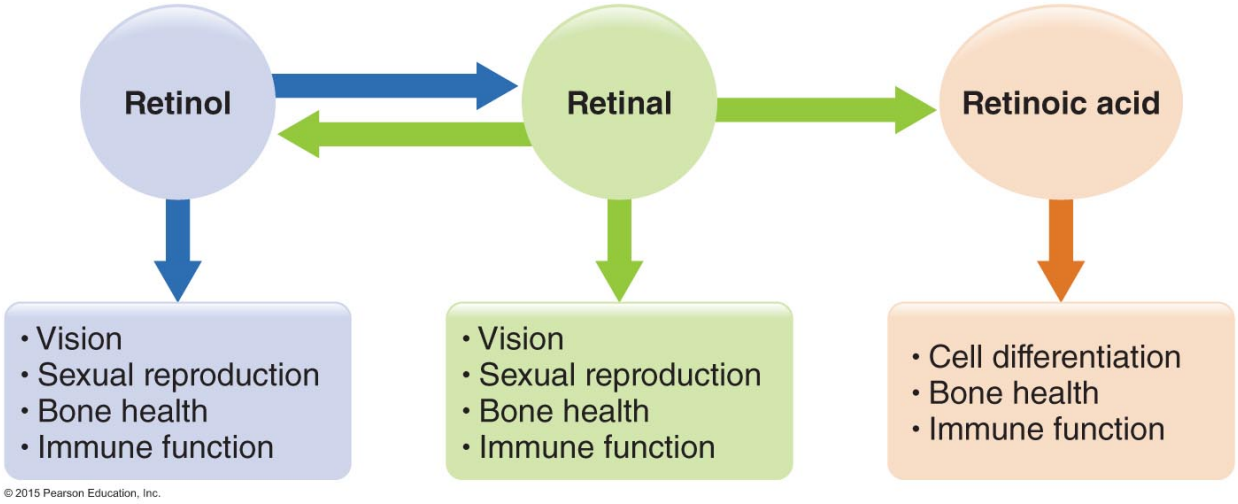

Figure 8.15: The Three Active Forms of Vitamin A

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

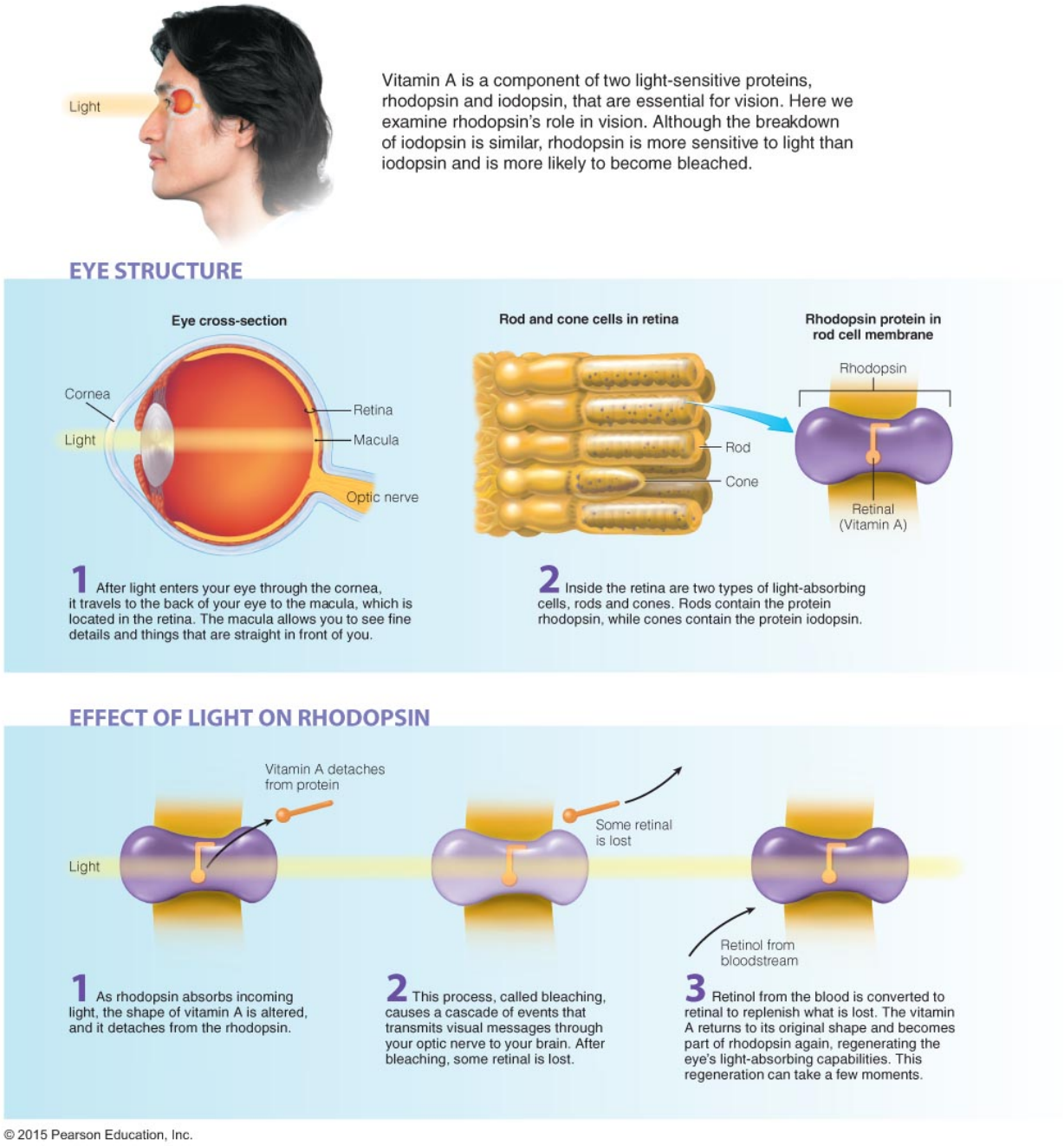

Figure 8.16: Vitamin A Is Essential to Sight

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)

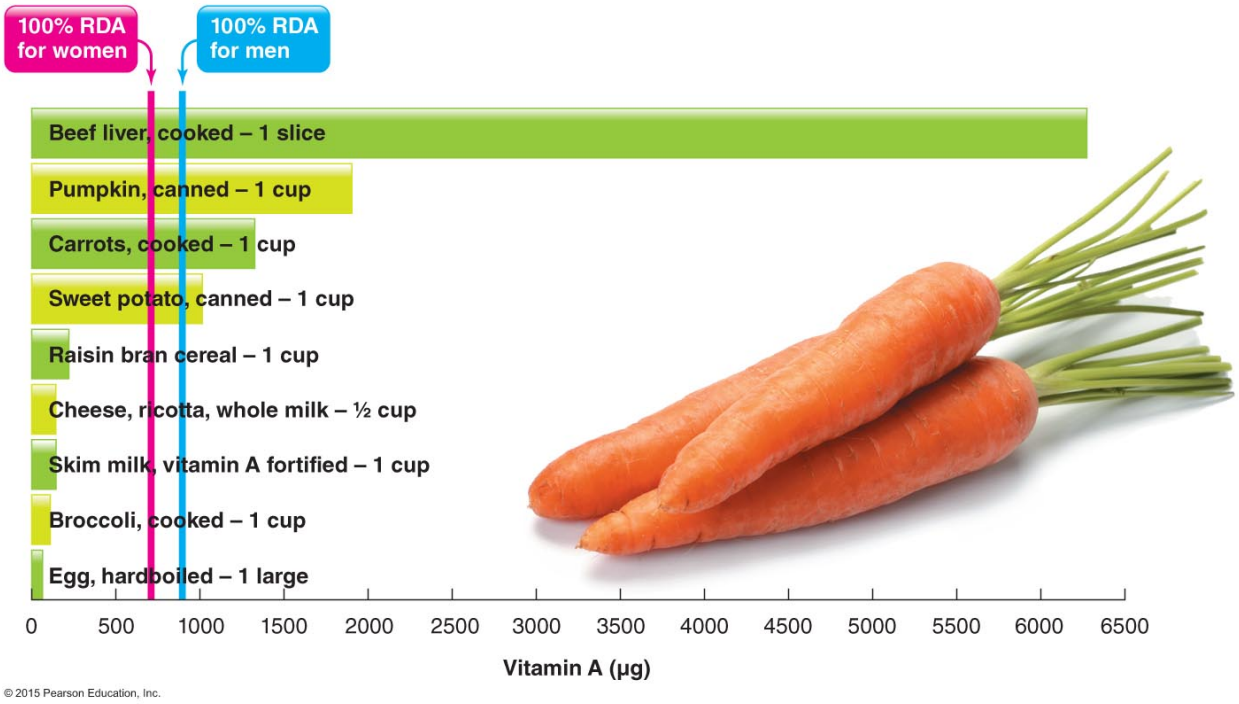

Figure 8.18: Common Food Sources of Vitamin A

- 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

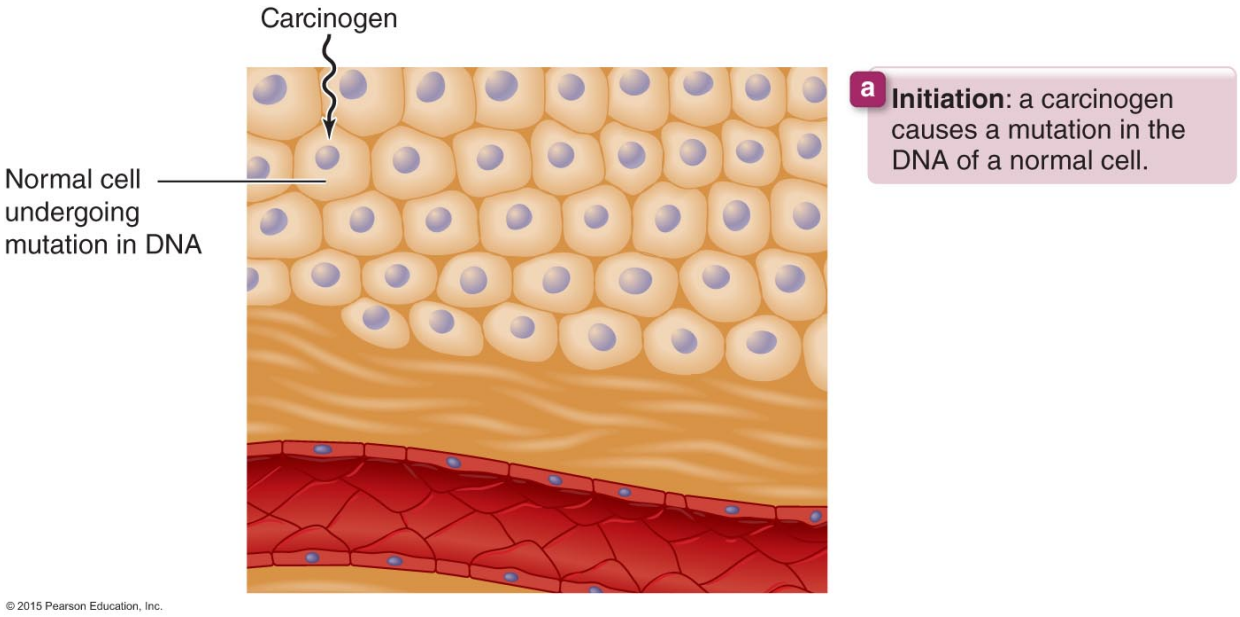

Figure 8.19: Cancer Initiation

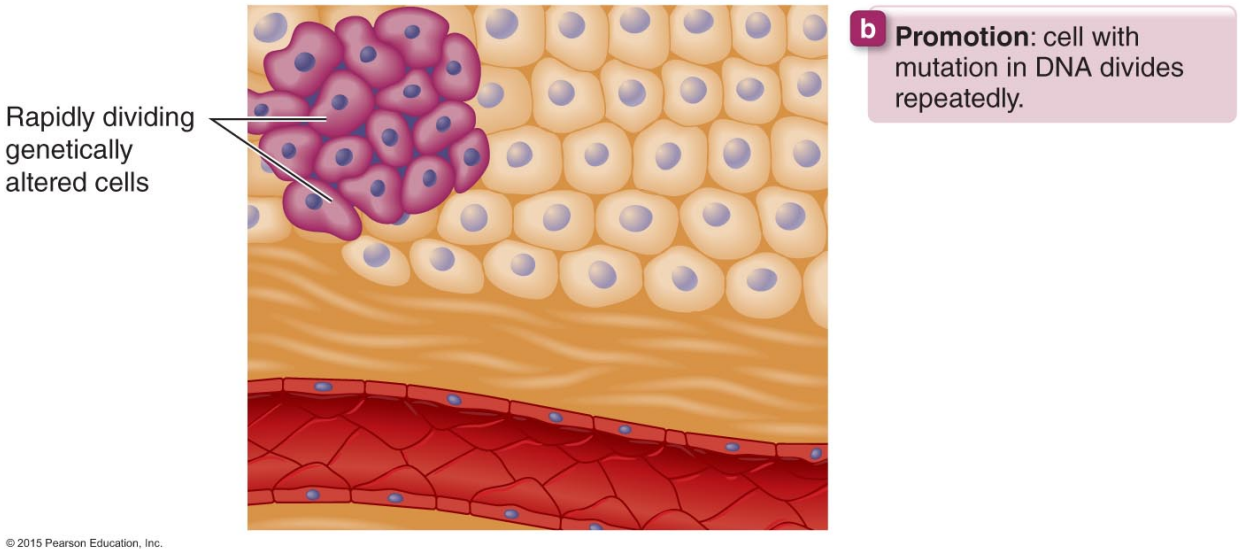

Figure 8.20: Cancer Promotion

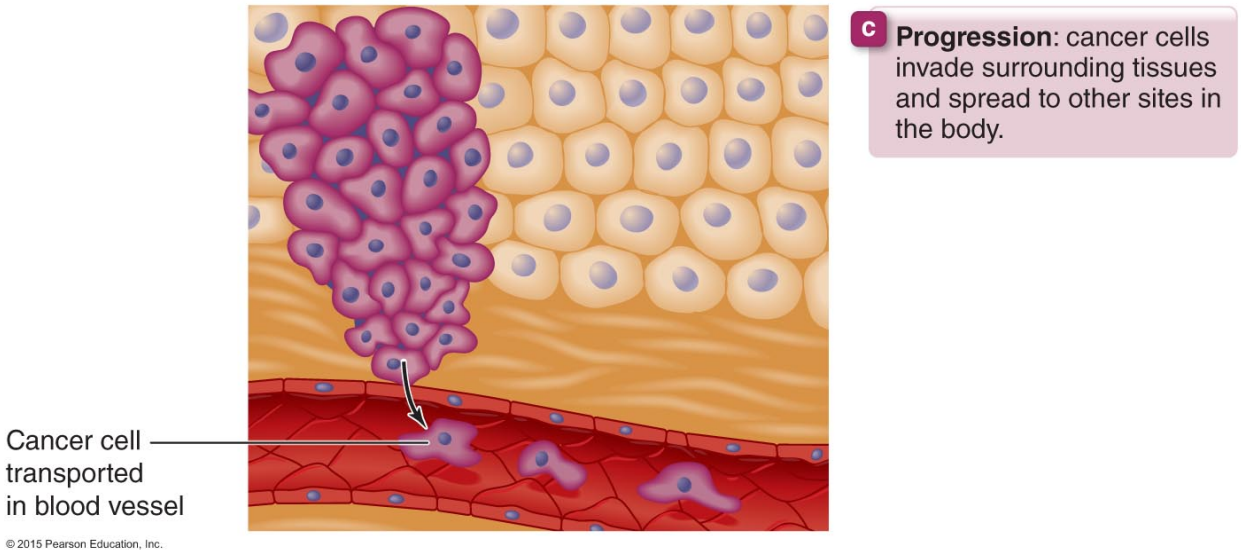

Figure 8.21: Cancer Progression

- 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

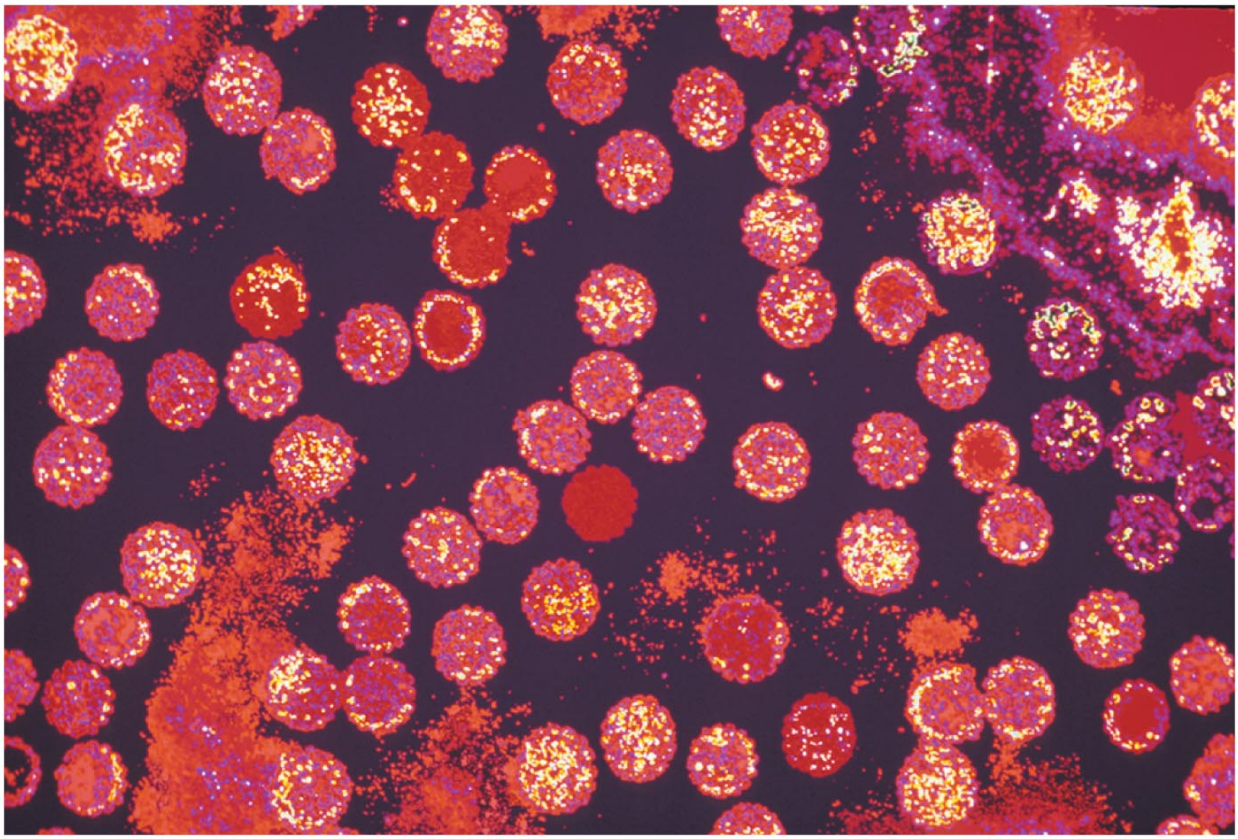

Figure 8.24: Human papillomavirus (HPV)

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)