

Chapter 8

8.1 Regulating Metabolism

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

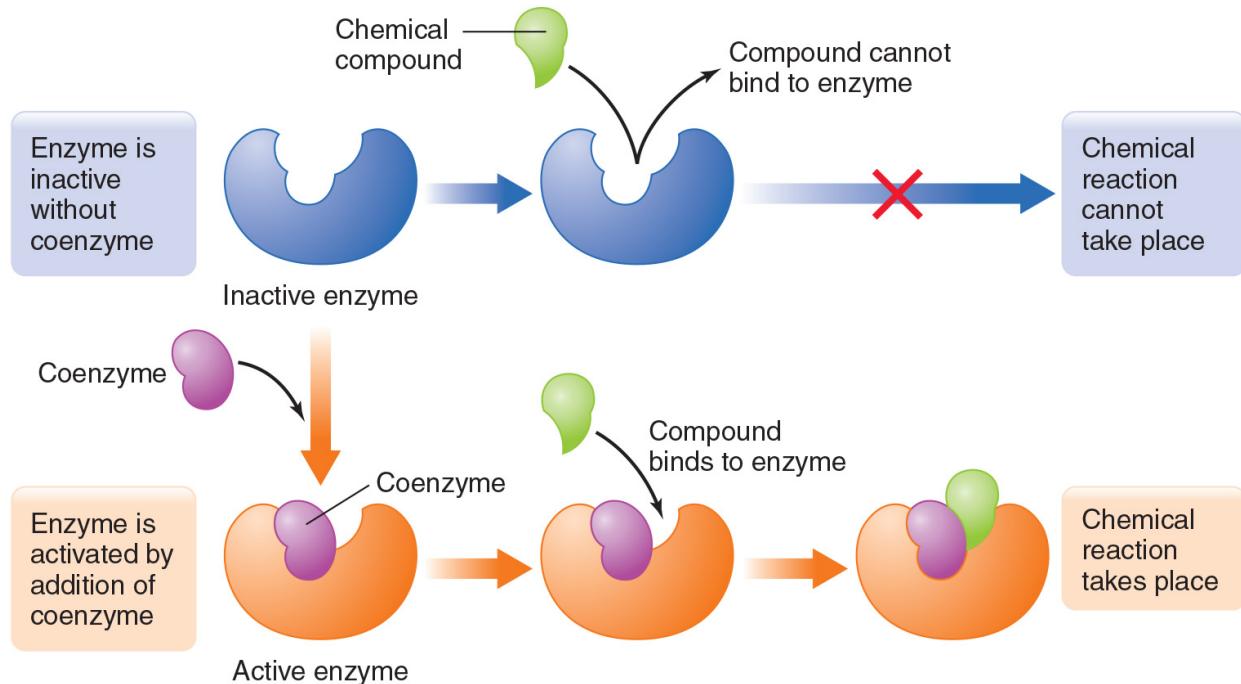


Figure 8.1: Enzymes

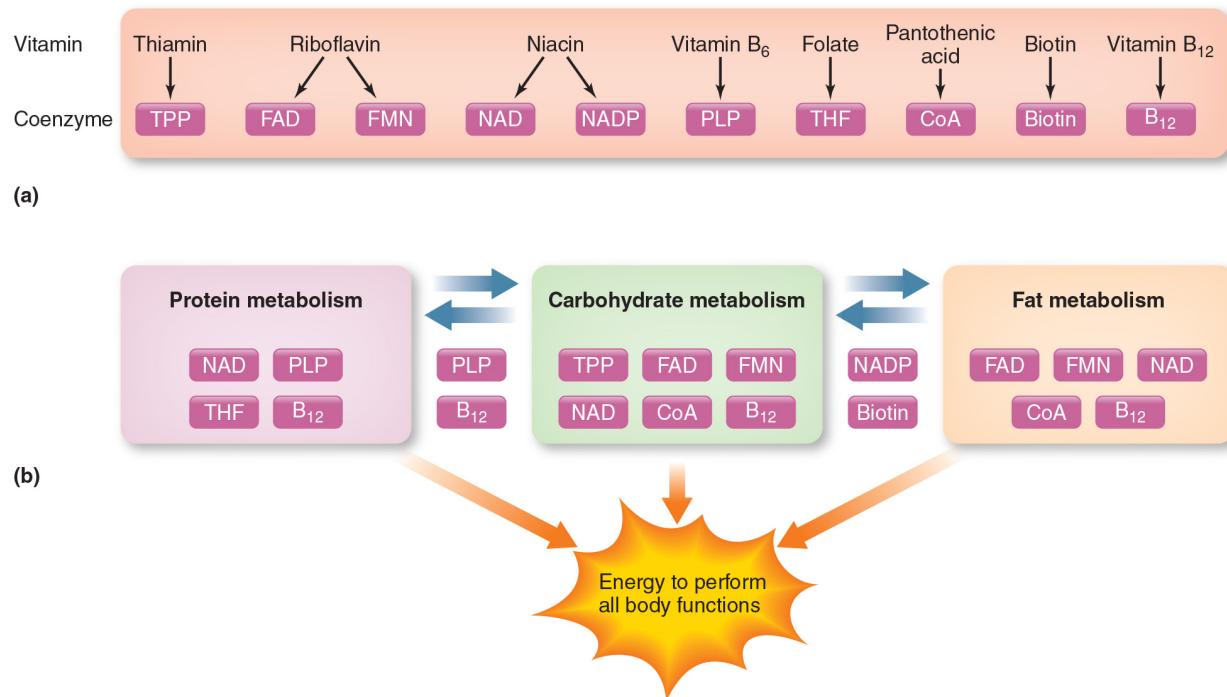


Figure 8.2: Enzymes

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 μ g/day
Vitamin B12 (cobalamin)	RDA for 19 years of age and older: 2.4 μ g/day
Pantothenic acid	AI for 19 years of age and older: 5 mg/day
Biotin	AI for 19 years of age and older: 30 μ g/day
Choline	AI 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 μ g/day
Chromium	RDA for 51 years of age and older: Women 20 μ g/day Men 30 μ g/day RDA for 19 to 50 years of age: Women 25 μ g/day Men 35 μ g/day
Manganese	AI 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 (B₁)

- 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.

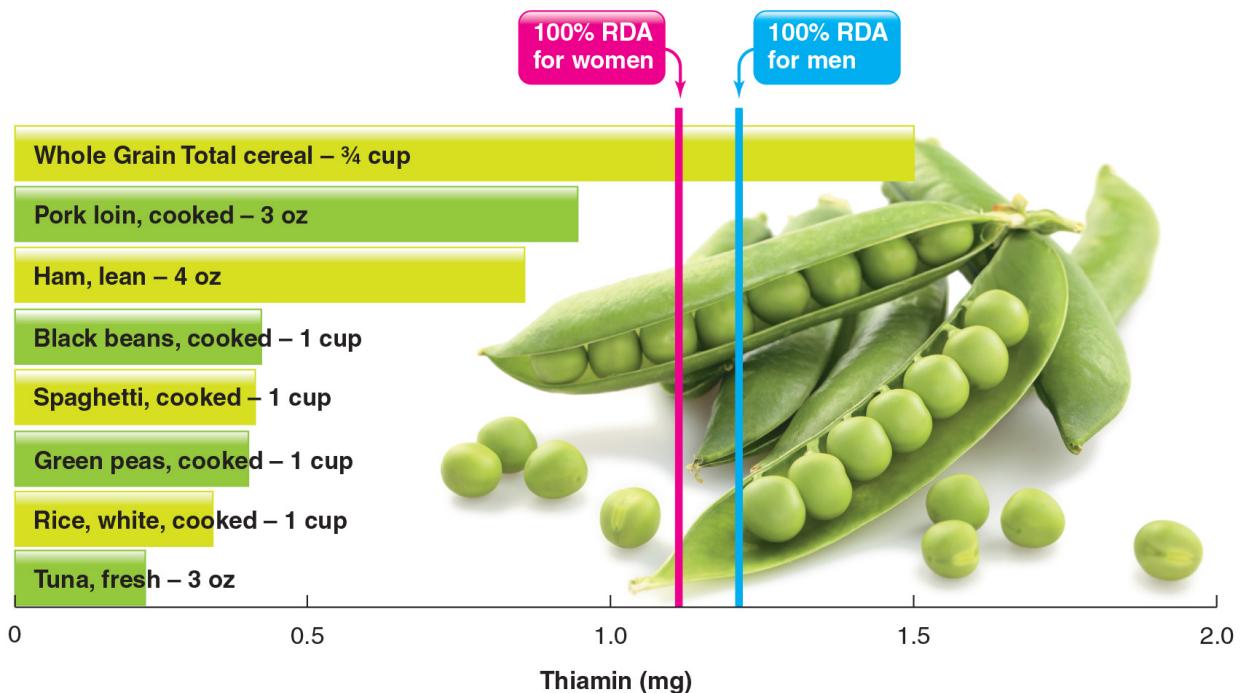


Figure 8.3: Thiamin

8.3 Riboflavin (B₂)

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

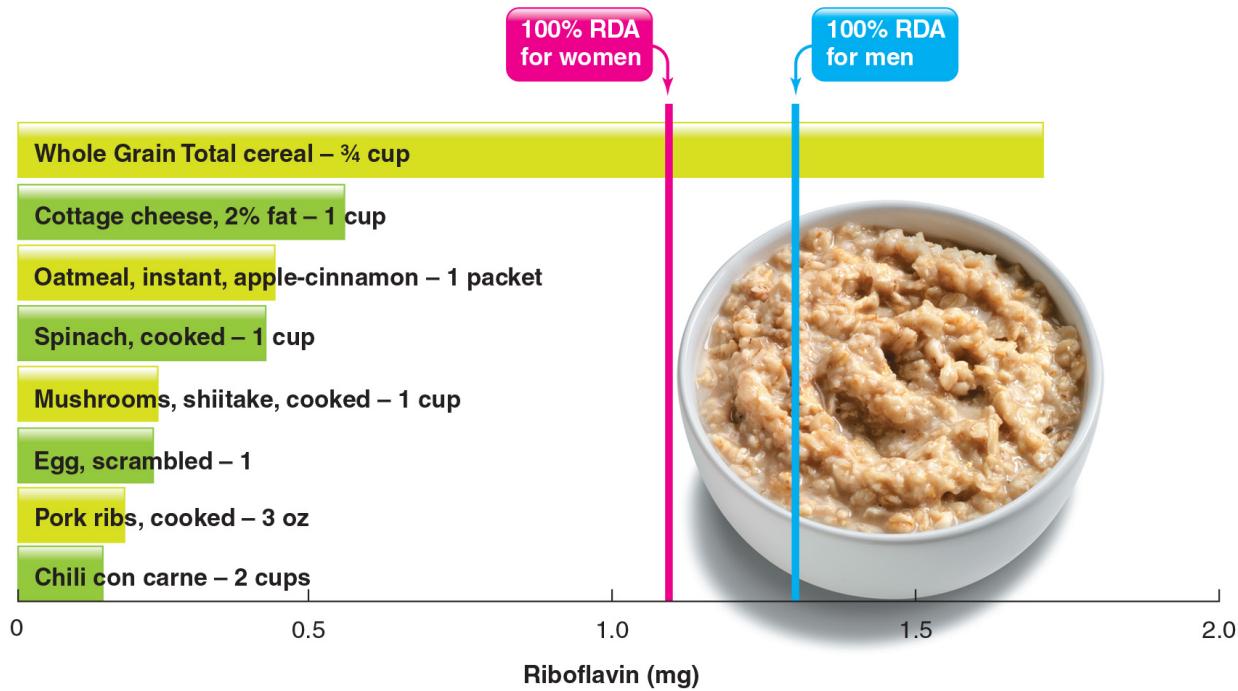


Figure 8.4: Riboflavin

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 (B₆)

involved in

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

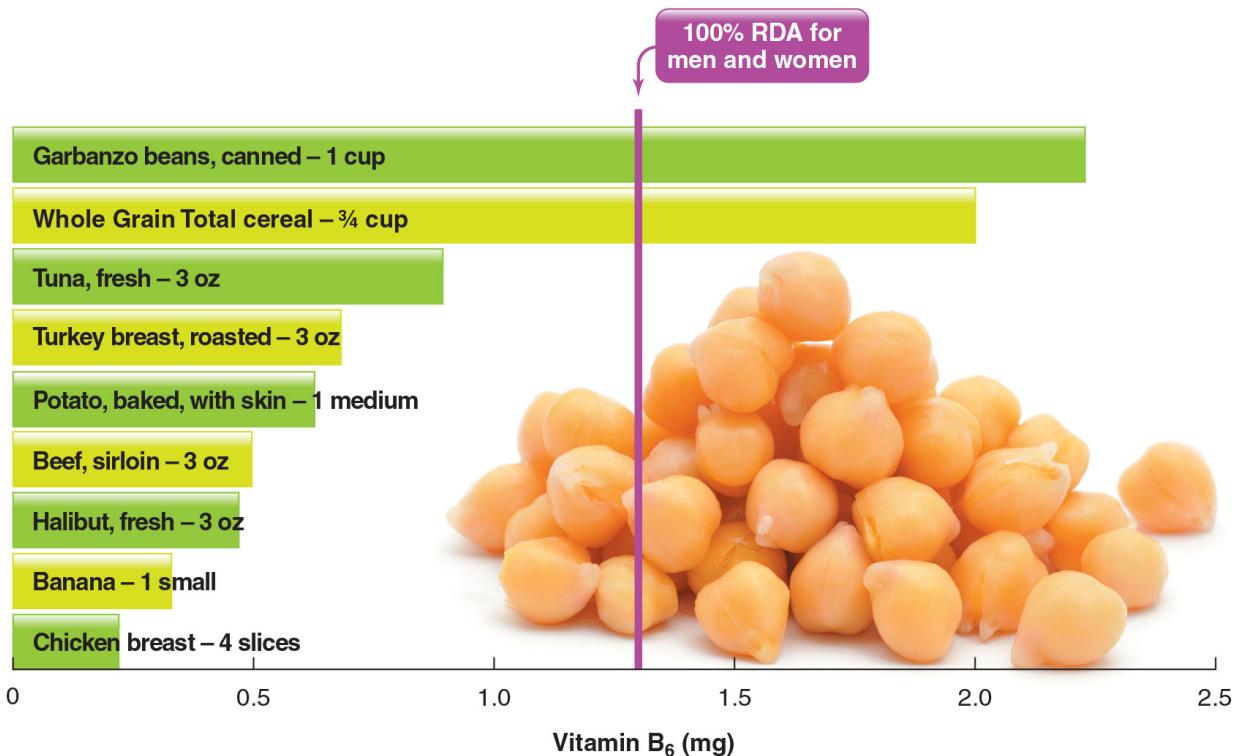


Figure 8.5: Pyrodoxine

8.7 Folate (B₉)

- 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

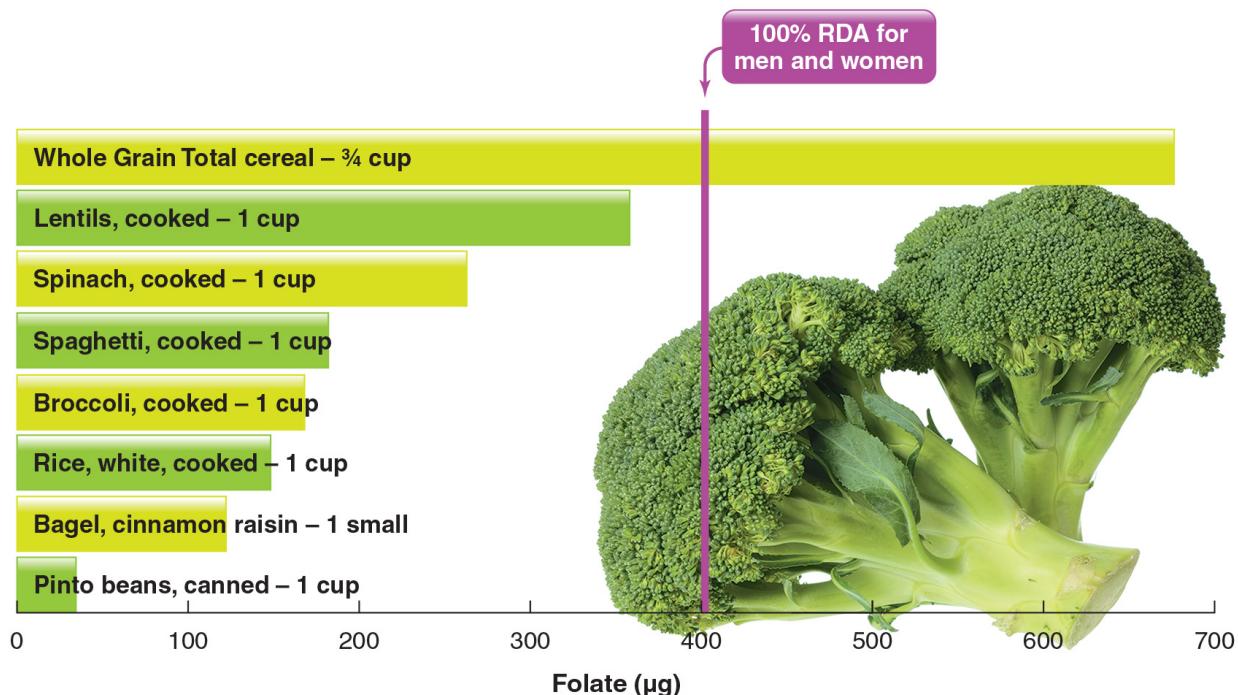
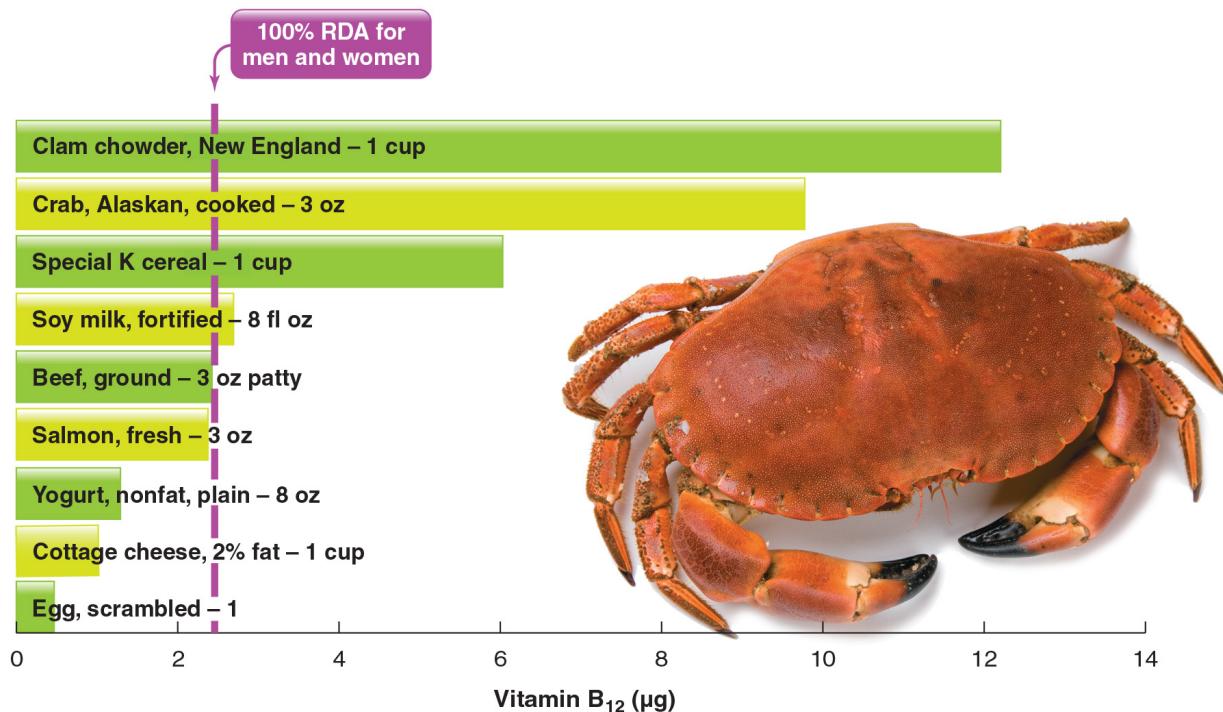


Figure 8.6: Folate

8.8 Cobalamin (B₁₂)

- 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: B₁₂

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

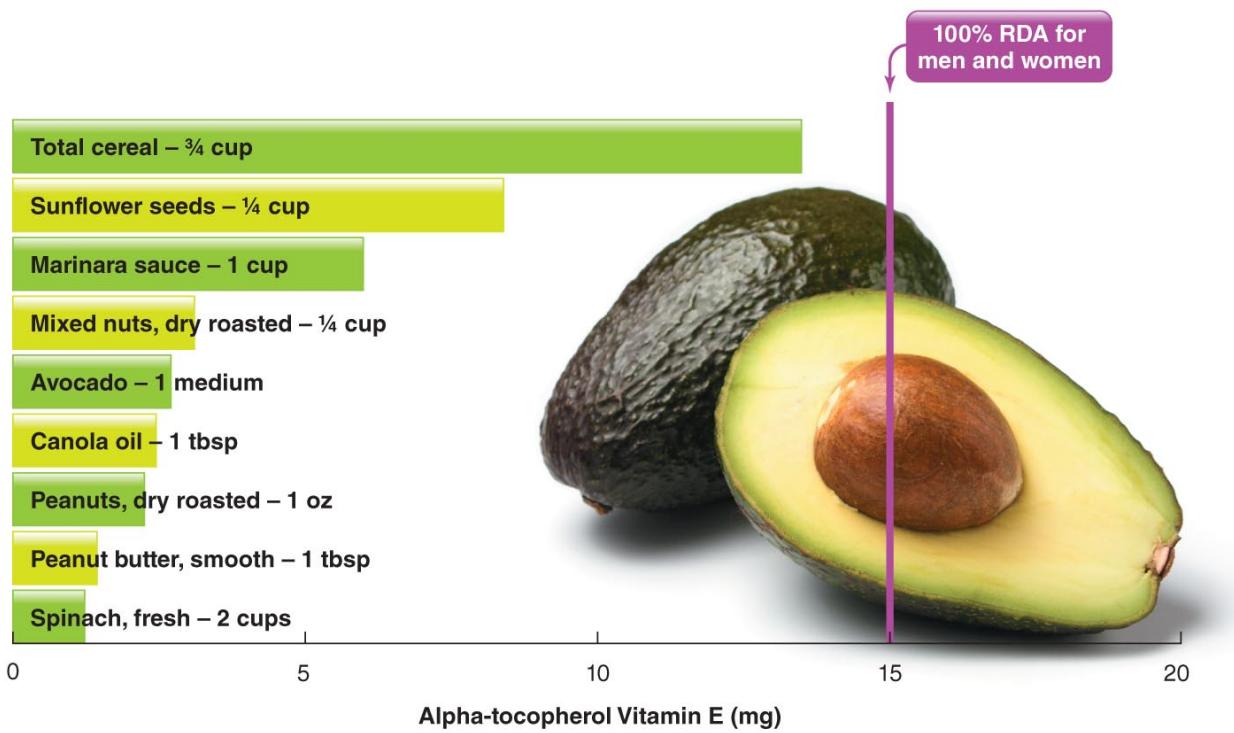


Figure 8.8: Common Food Sources of Vitamin E

- 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

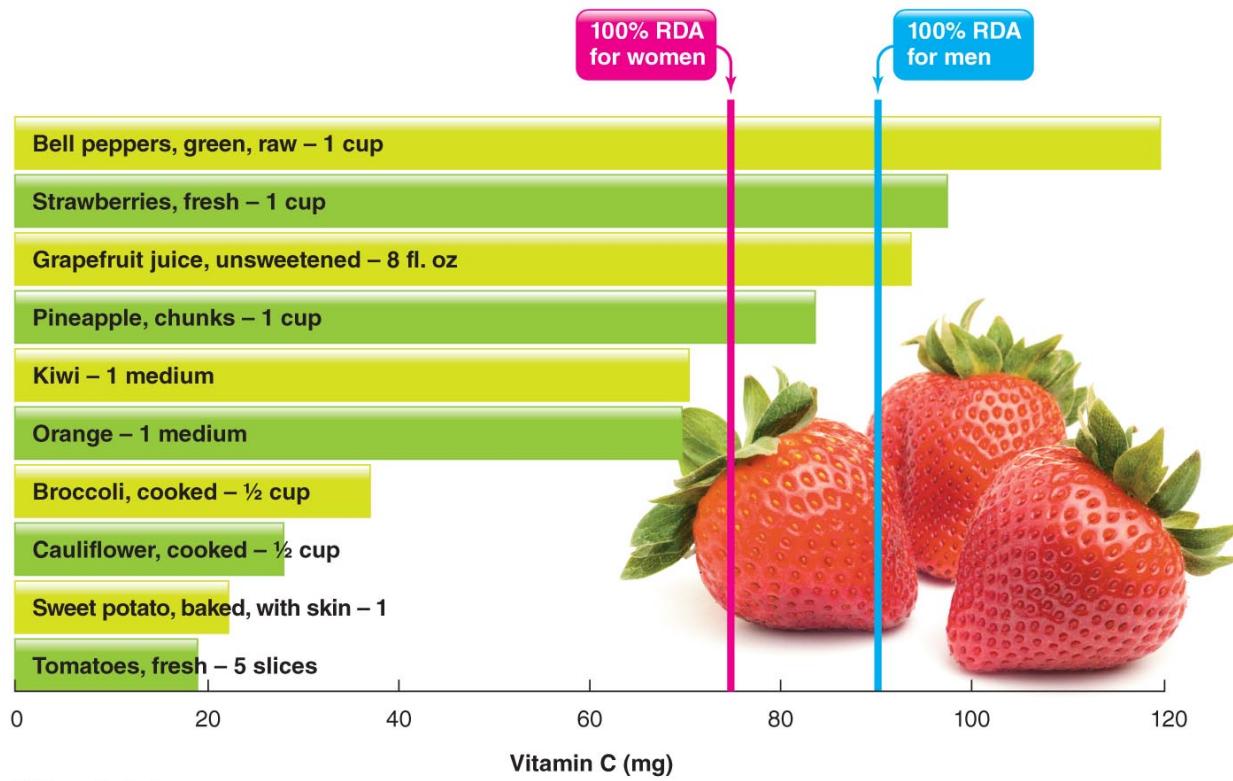


Figure 8.9: Common Food Sources of Vitamin C

- 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

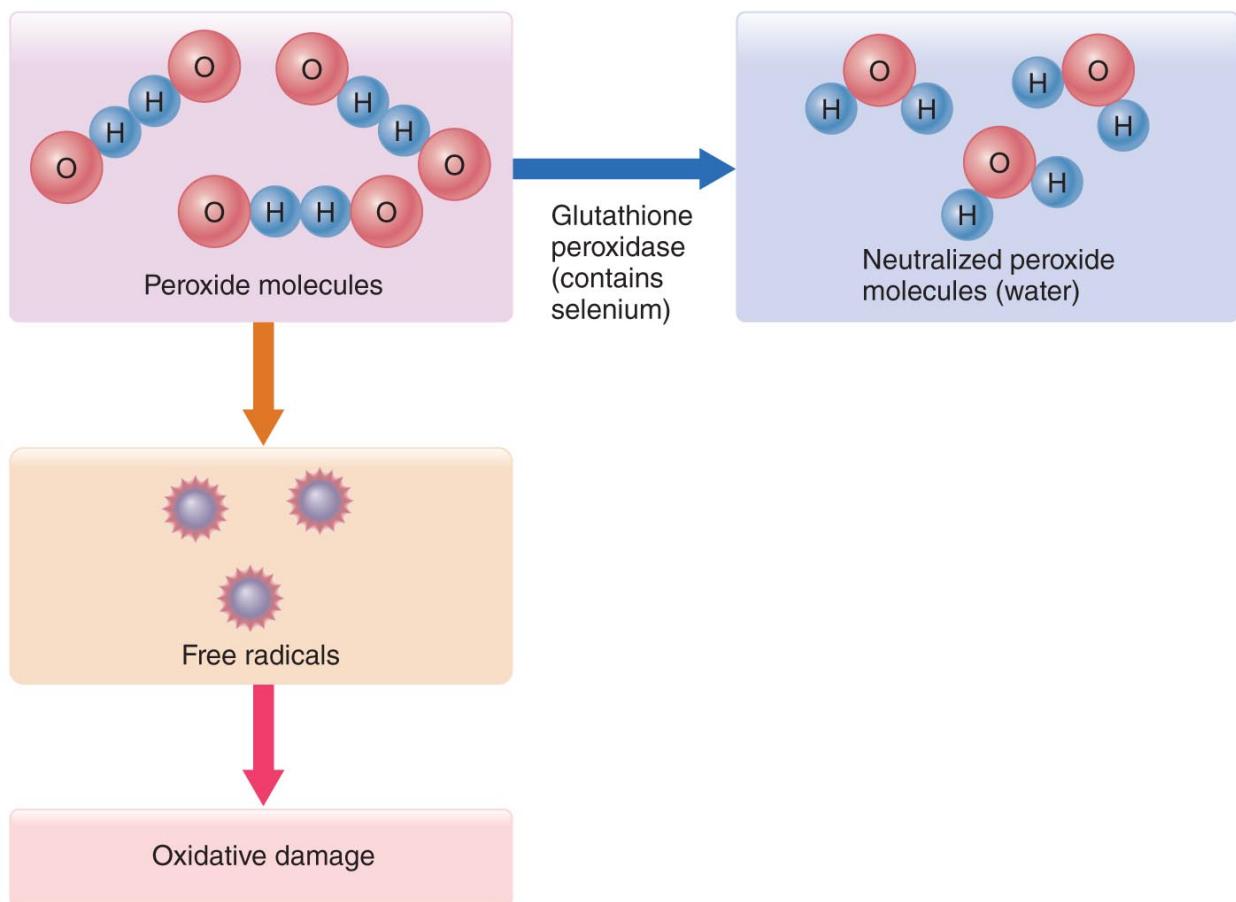


Figure 8.11: Neutralizing Peroxide Molecules

- 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

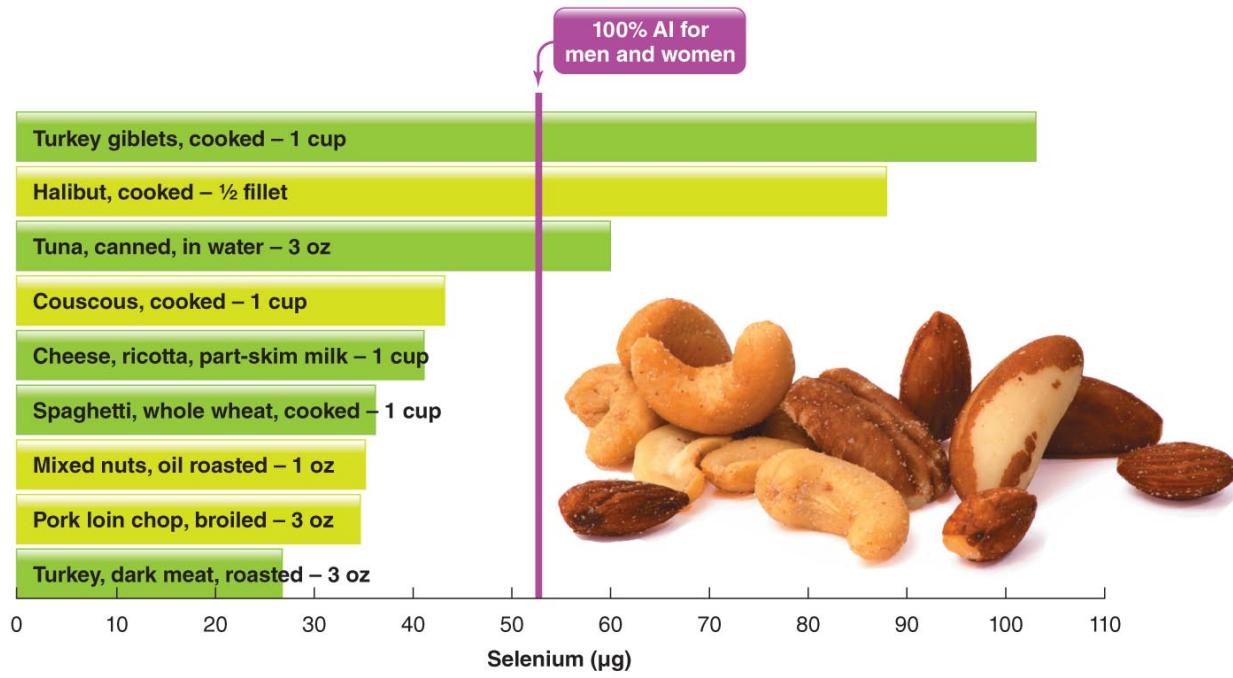


Figure 8.12: Common Food Sources of Selenium

- 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

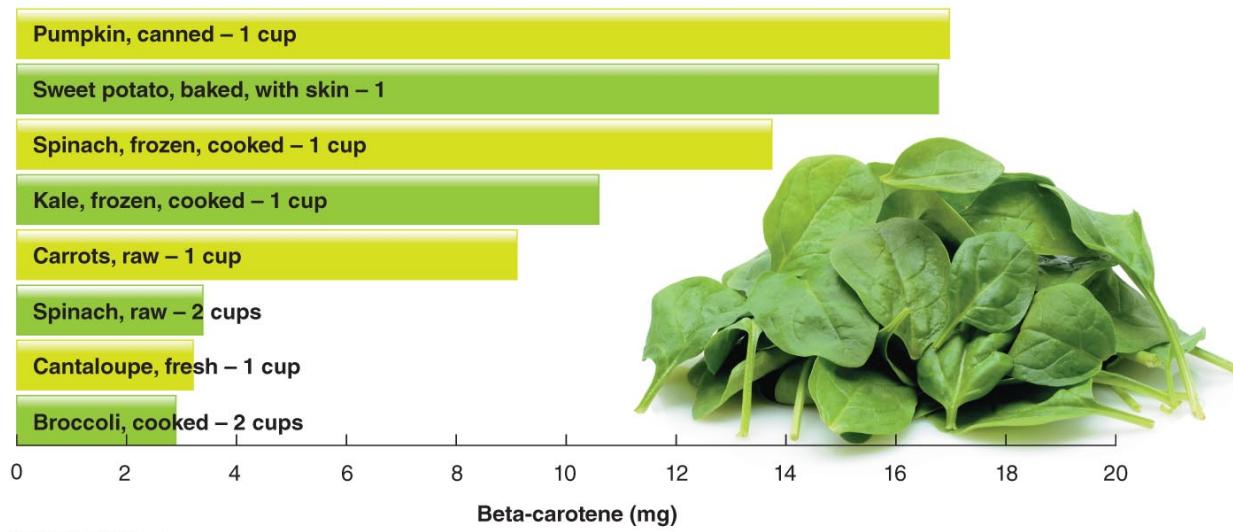


Figure 8.14: Common Food Sources of Beta-Carotene

- 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

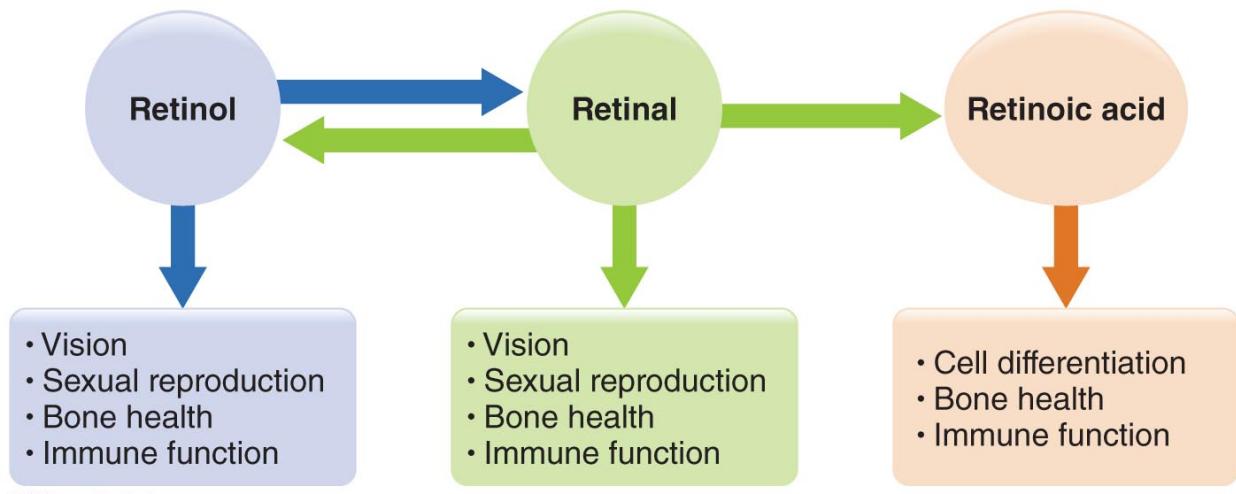
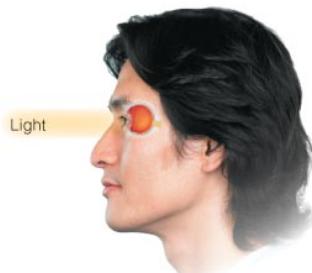


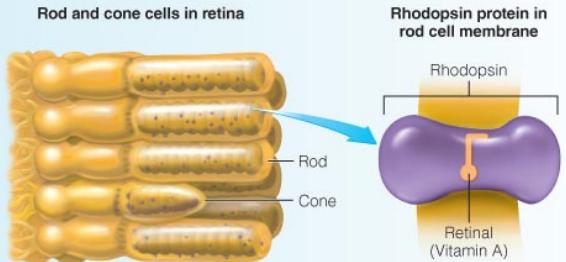
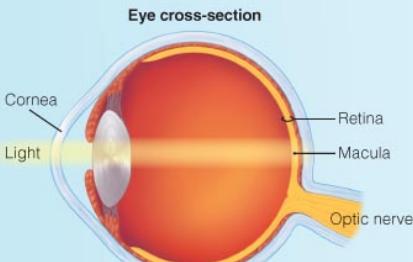
Figure 8.15: The Three Active Forms of Vitamin A

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



Vitamin A is a component of two light-sensitive proteins, rhodopsin and iodopsin, that are essential for vision. Here we examine rhodopsin's role in vision. Although the breakdown of iodopsin is similar, rhodopsin is more sensitive to light than iodopsin and is more likely to become bleached.

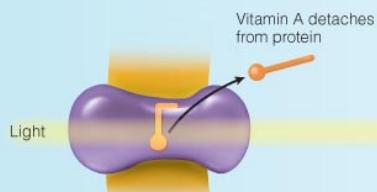
EYE STRUCTURE



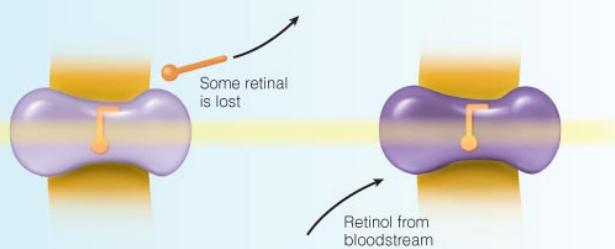
1 After light enters your eye through the cornea, it travels to the back of your eye to the macula, which is located in the retina. The macula allows you to see fine details and things that are straight in front of you.

2 Inside the retina are two types of light-absorbing cells, rods and cones. Rods contain the protein rhodopsin, while cones contain the protein iodopsin.

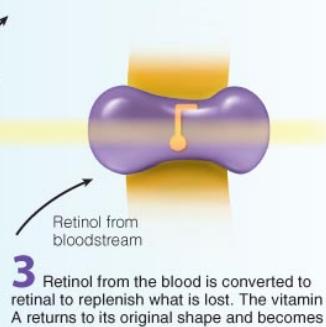
EFFECT OF LIGHT ON RHODOPSIN



1 As rhodopsin absorbs incoming light, the shape of vitamin A is altered, and it detaches from the rhodopsin.



2 This process, called bleaching, causes a cascade of events that transmits visual messages through your optic nerve to your brain. After bleaching, some retinal is lost.



3 Retinol from the blood is converted to retinal to replenish what is lost. The vitamin A returns to its original shape and becomes part of rhodopsin again, regenerating the eye's light-absorbing capabilities. This regeneration can take a few moments.

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Figure 8.16: Vitamin A Is Essential to Sight



(a) Normal night vision

Poor night vision



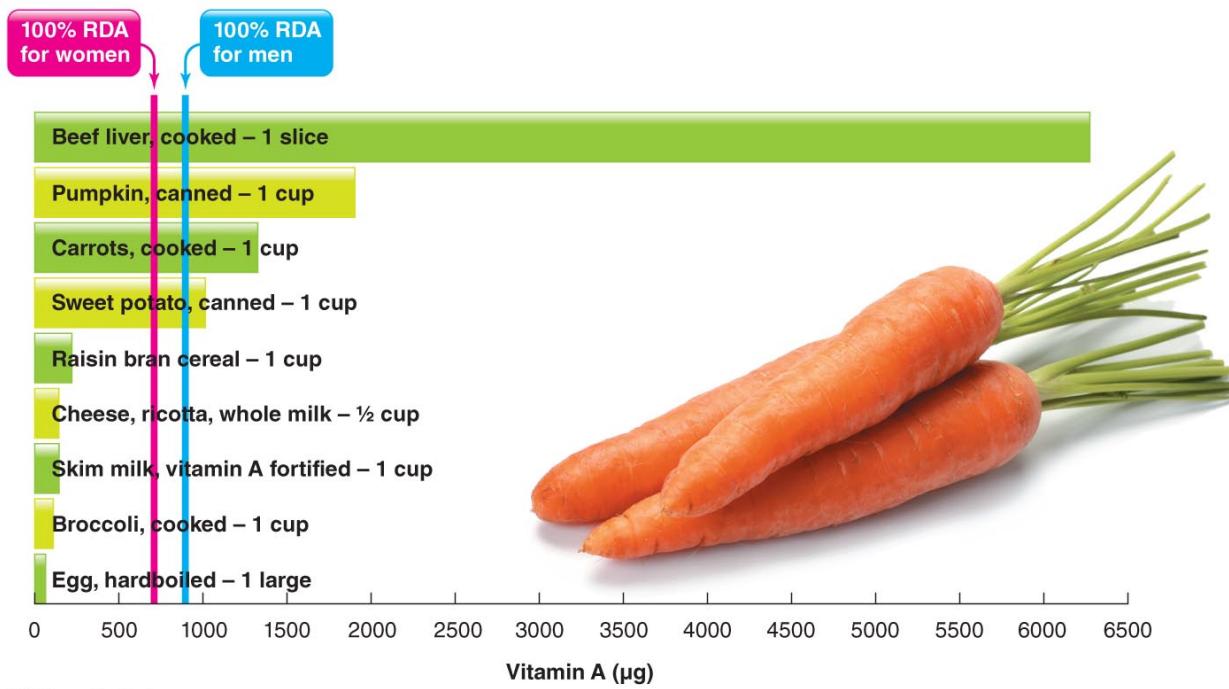
(b) Normal light adjustment

Slow light adjustment

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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)



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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

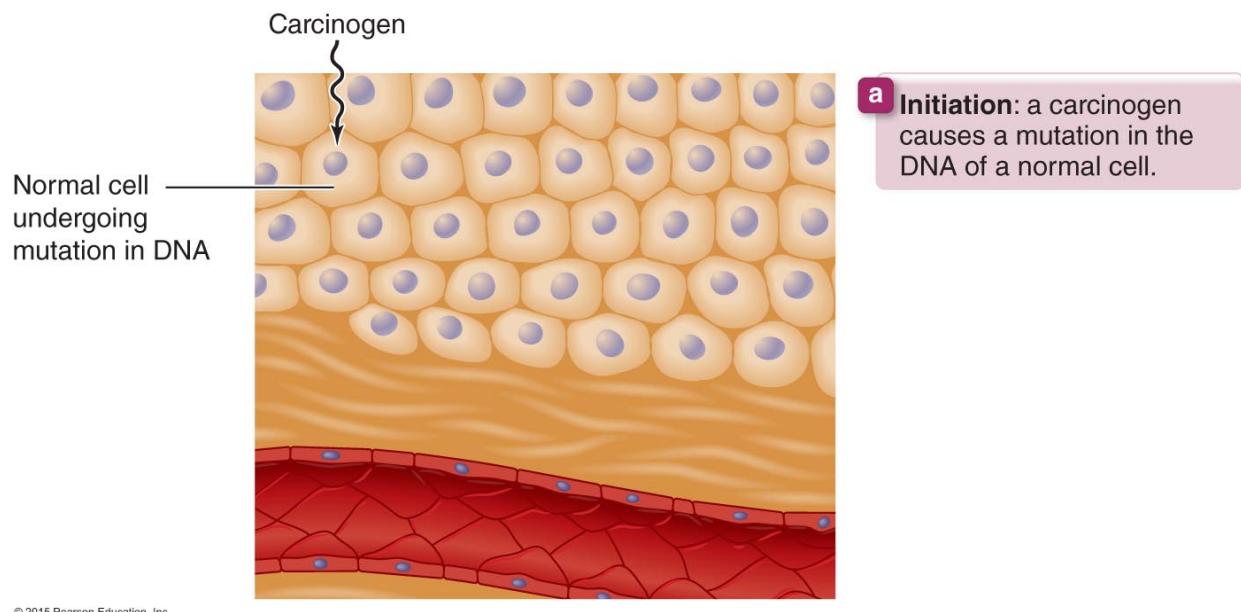


Figure 8.19: Cancer Initiation

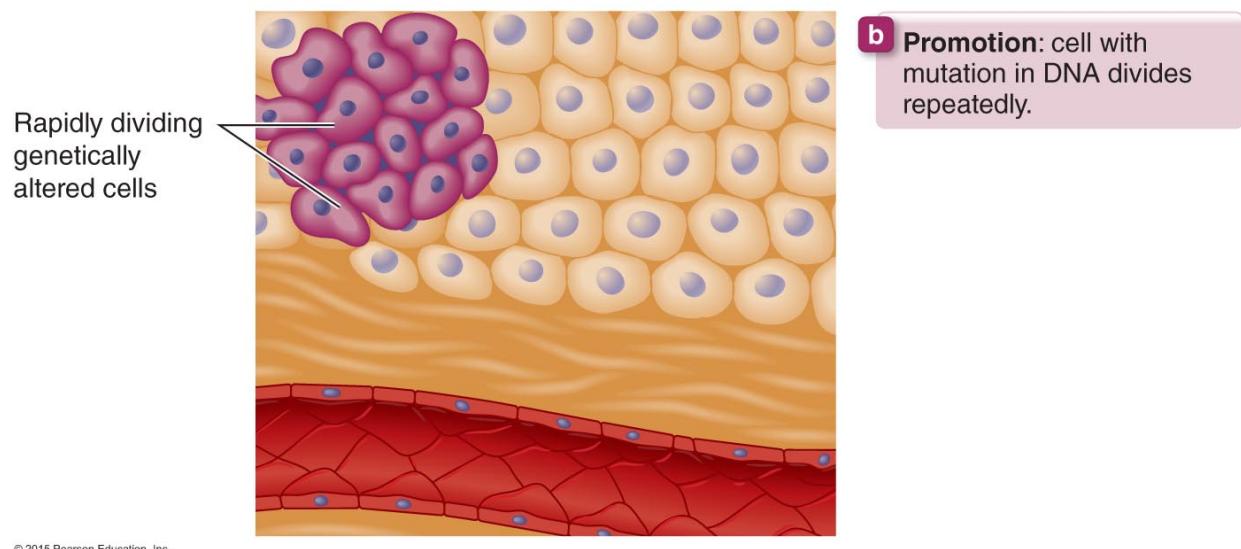
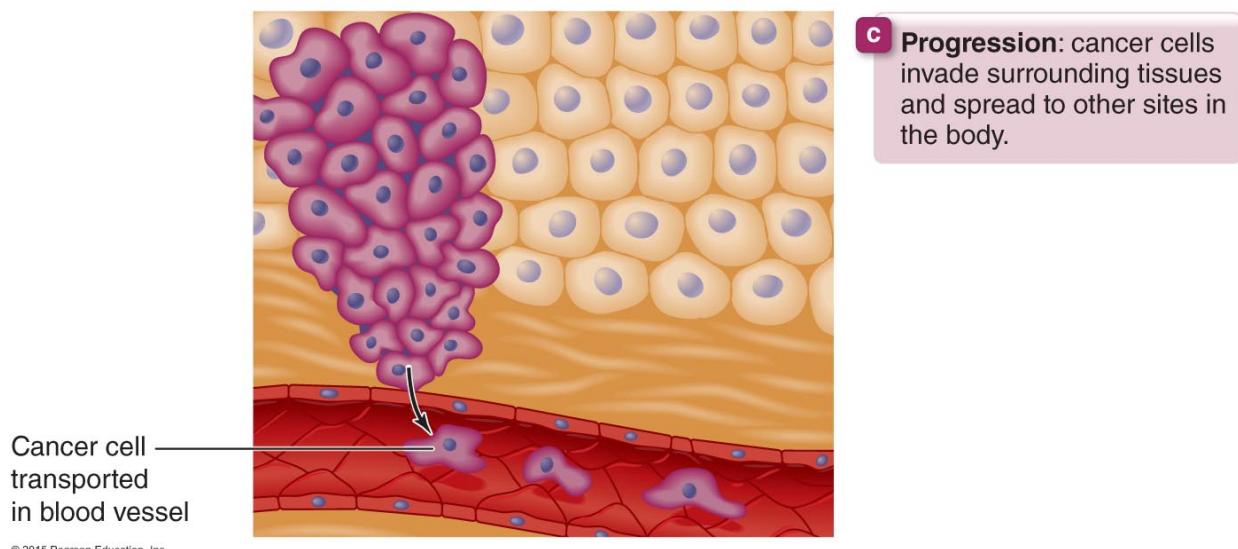


Figure 8.20: Cancer Promotion



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Figure 8.21: Cancer Progression

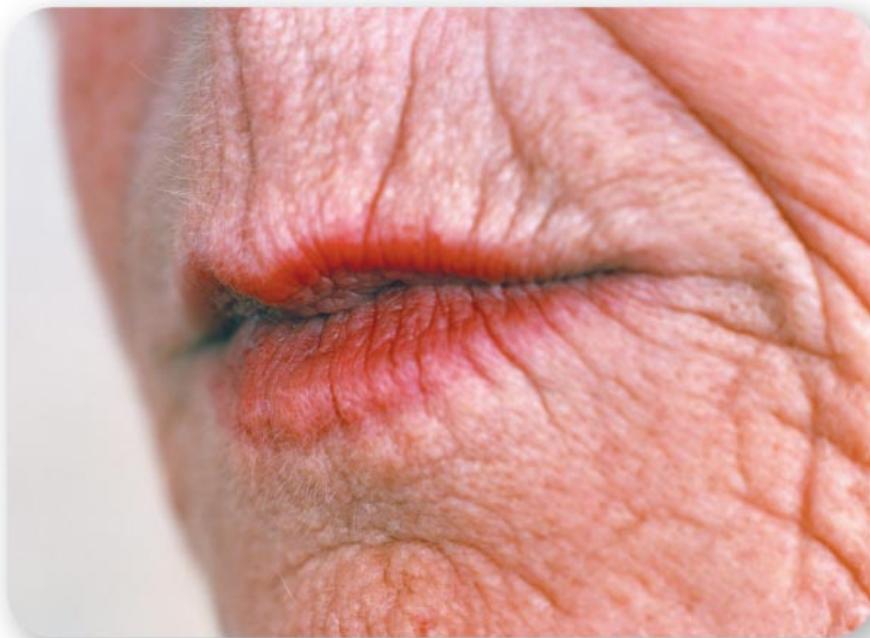
- Factors that increase cancer risk include
 - Family history of cancer
 - Tobacco use
 - Weight, poor diet, and sedentary lifestyle
 - Infectious agents (e.g., STDs)
 - Sun exposure (ultraviolet radiation)



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



(a)



(b)

Figure 8.23: Effects of Tobacco Use

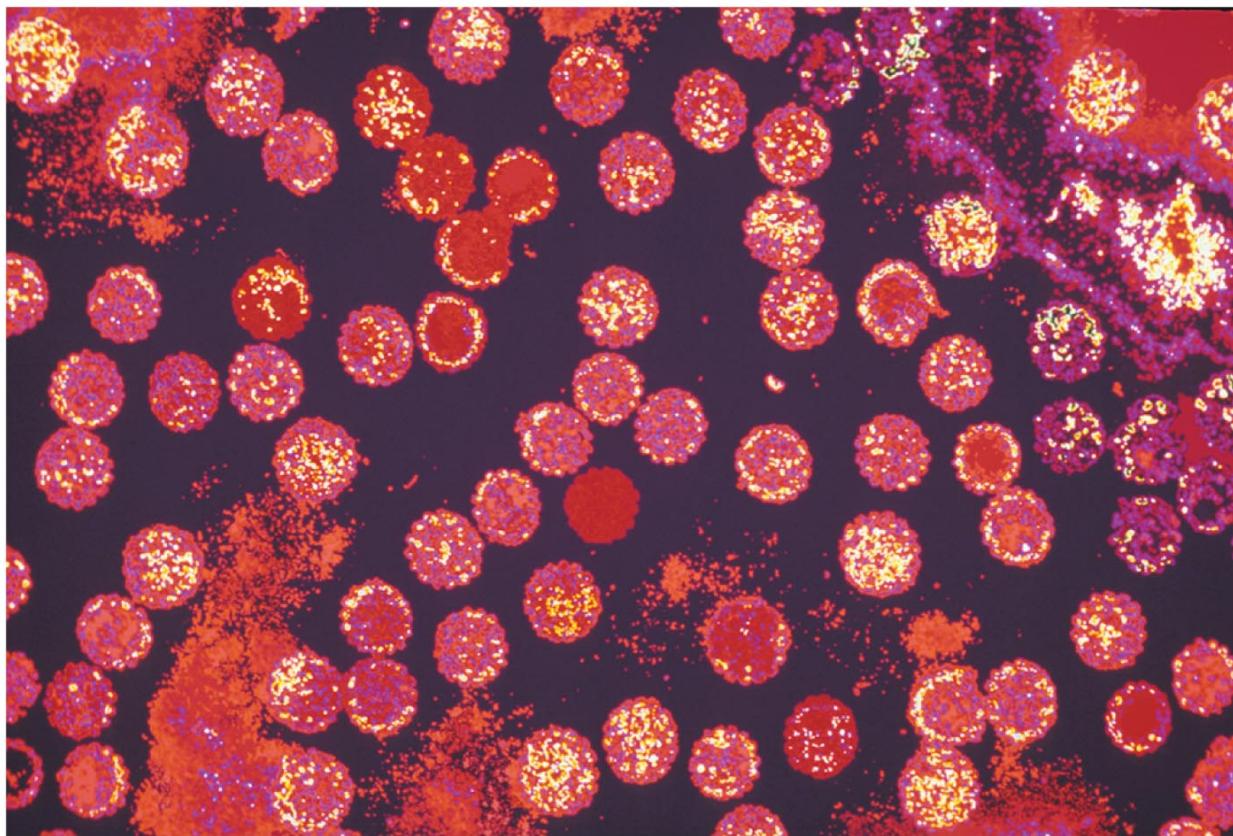


Figure 8.24: Human papillomavirus (HPV)



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)