

CHAPTER

8

Nutrients Involved in Antioxidant Function and In Depth

Third Canadian Edition

nutrition

a functional approach

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What Are Antioxidants?

Antioxidants: chemicals that protect cells from damage from oxidation, including

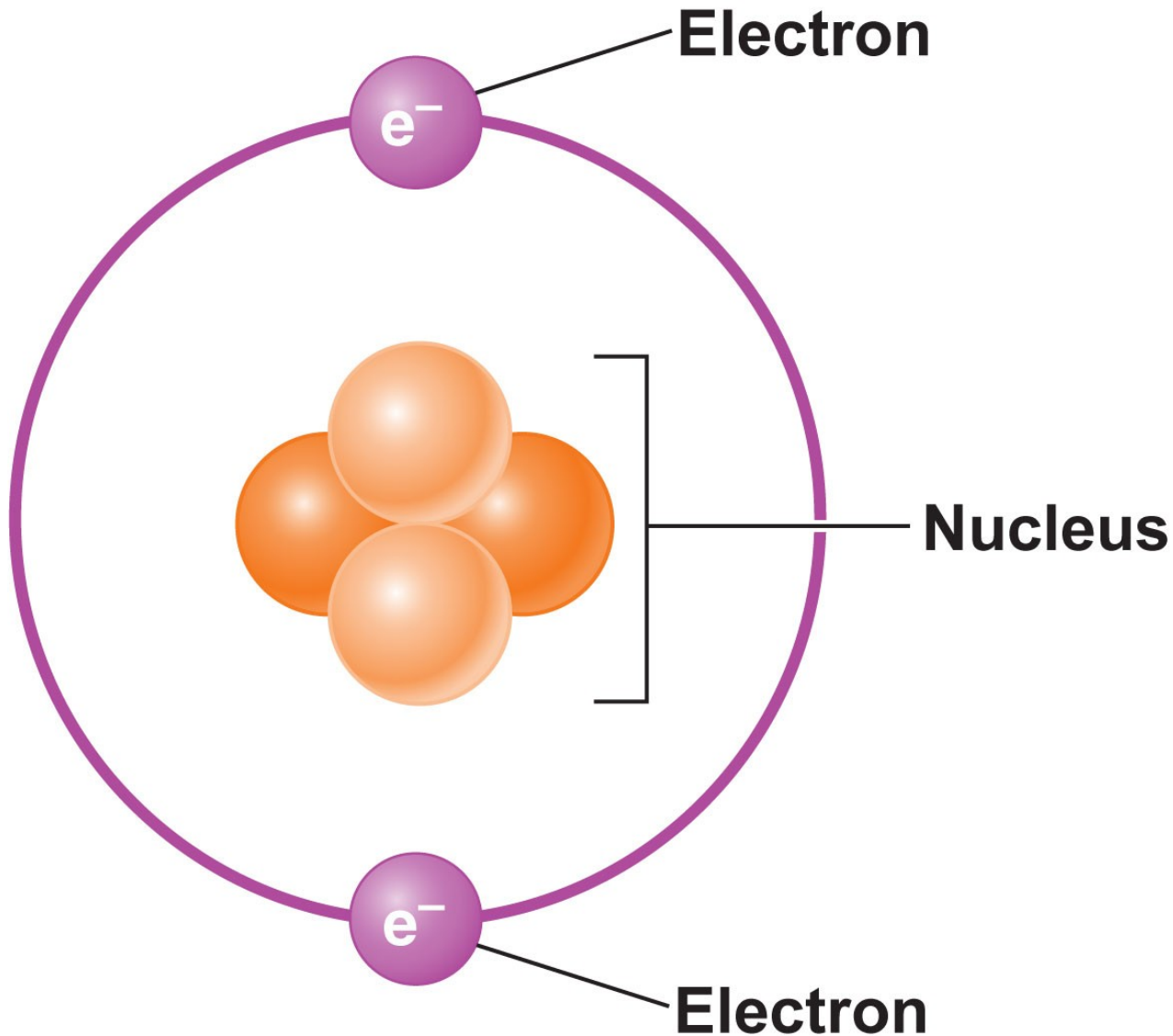
- Vitamin E
- Vitamin C
- Beta-carotene
- Vitamin A
- Selenium

Structure of Atoms

Atom: the smallest unit of matter

- Atoms are composed of particles
 - **Nucleus**—positively charged center portion of the atom
 - **Electrons**—negatively charged particles surrounding the nucleus

Structure of Atoms



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Figure 8.1

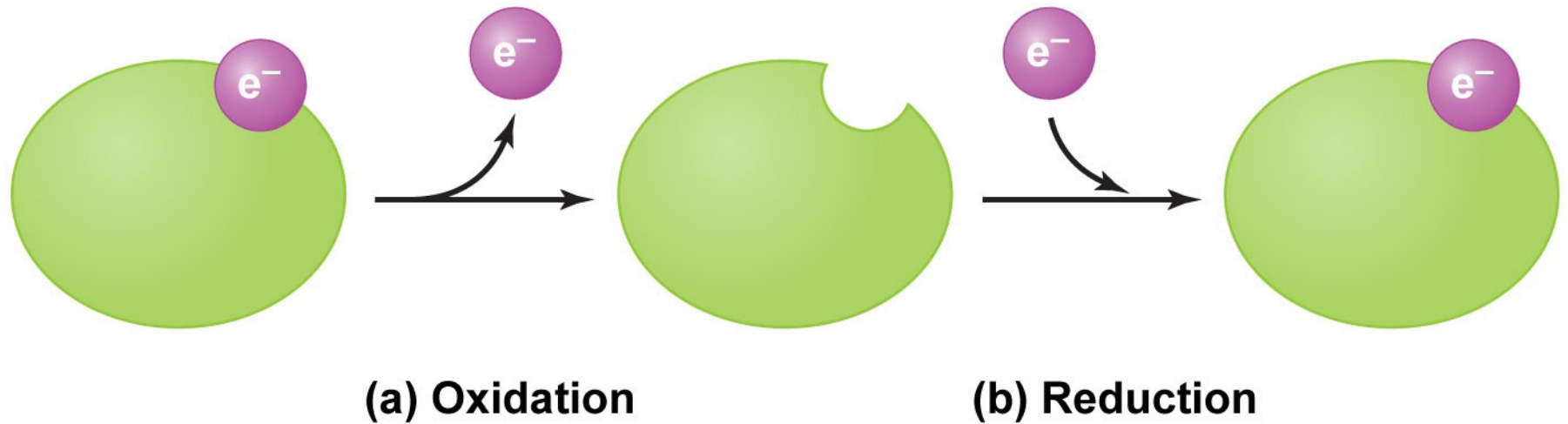
Oxidation

Molecules are composed of atoms

During metabolic reactions, electrons can be transferred

- *From* the atoms of one molecule
- *To* the atoms of another molecule

Oxidation: The Exchange Function



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Figure 8.2

Oxidation

Oxidation: the loss of electrons from a molecule

Reduction: the gain of electrons by a molecule

Oxidation and reduction usually occur together as an **exchange reaction**

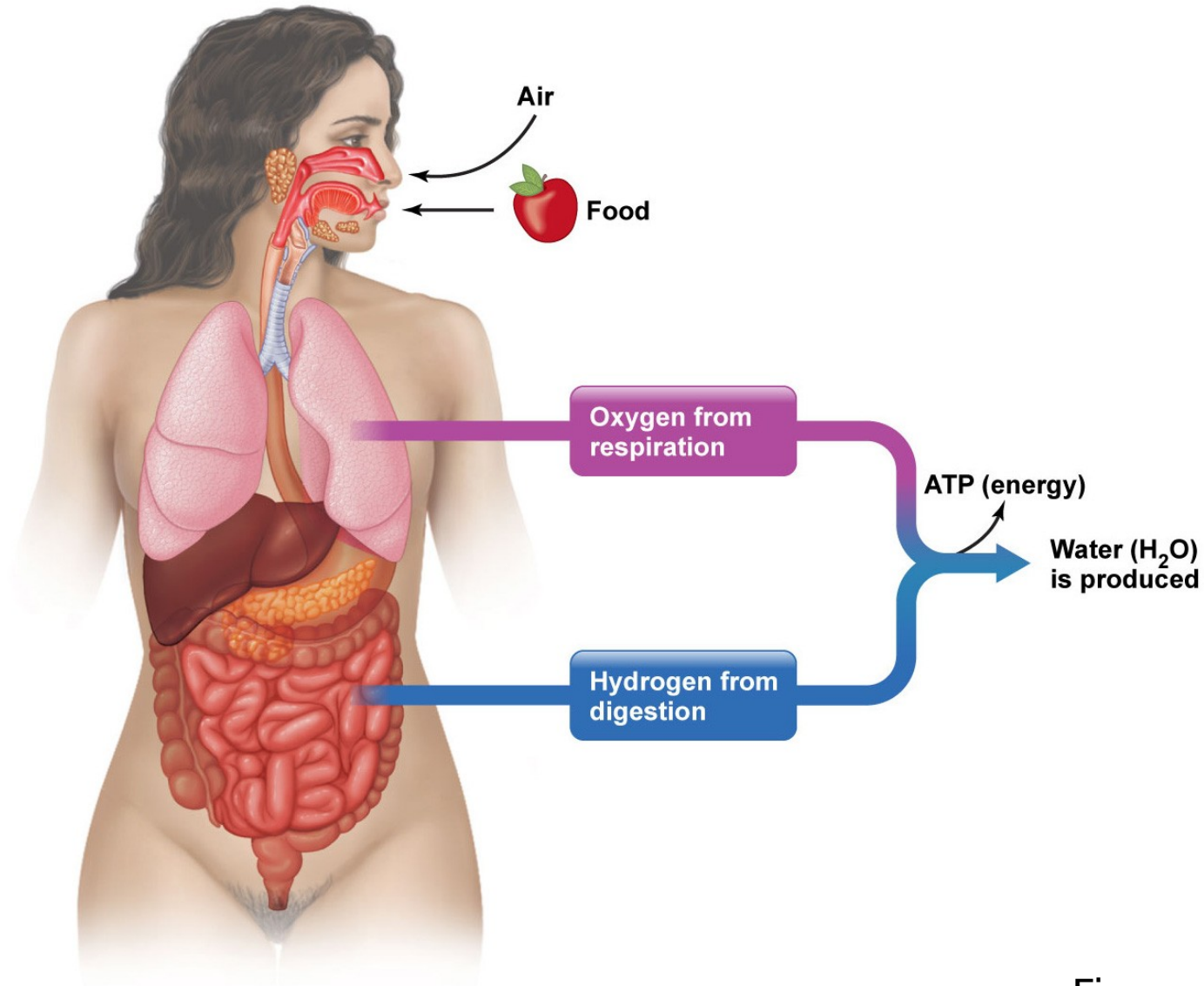
Oxidation

Stable atoms contain an even number of paired electrons

Free radical: an atom that has lost an electron and is left with an unpaired electron

- Free radicals are highly reactive and can cause damage to molecules in the cell

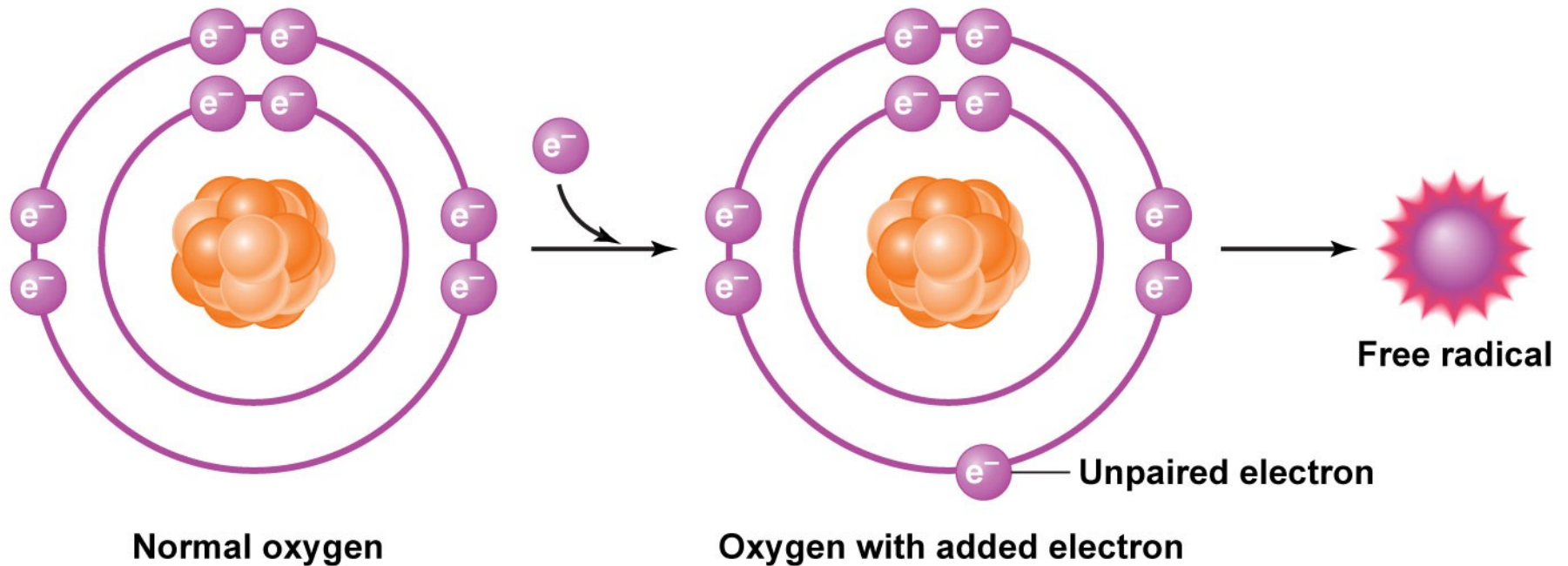
Oxidation



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Figure 8.3

Formation of Free Radicals



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Figure 8.4

Formation of Free Radicals

Many metabolic processes involve oxidation reactions and can produce free radicals

- Free radicals are also produced by
 - Pollution
 - Ultraviolet light and radiation
 - Toxic substances

Impact of Free Radicals

Free radicals cause damage to

- Cell membranes
- Low-density lipoproteins (LDLs)
- Proteins in the cell
- Genetic material (DNA)

Diseases Linked to Free Radicals

- Cancer
- Heart disease
- Type 2 diabetes
- Arthritis
- Cataracts
- Kidney disease
- Alzheimer's disease
- Parkinson's disease

Antioxidants

Antioxidants can function in different ways

- Some vitamins donate their electrons to free radicals to stabilize them
- Other compounds (e.g., beta-carotene and other phytochemicals) help stabilize free radicals and prevent damage to cells and tissues
- Some minerals act with complex enzyme systems to destroy free radicals
 - Superoxide dismutase
 - Catalase
 - Glutathione peroxidase

Antioxidants

TABLE 8.1 Nutrients Involved in Antioxidant Function

To see the full profile of nutrients involved in energy metabolism, turn to **In Depth**, Vitamins and Minerals: Micronutrients with Macro Powers, pages 216–225.

Nutrient	Recommended Intake
Vitamin E (fat soluble)	RDA: Women and men = 15 mg alpha-tocopherol
Vitamin C (water soluble)	RDA: Women = 75 mg Men = 90 mg Smokers = 35 mg more per day than RDA
Beta-carotene (fat-soluble provitamin for vitamin A)	None at this time
Vitamin A (fat soluble)	RDA: Women: 700 µg Men: 900 µg
Selenium (trace mineral)	RDA: Women and men = 55 µg

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Table 8.1

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)

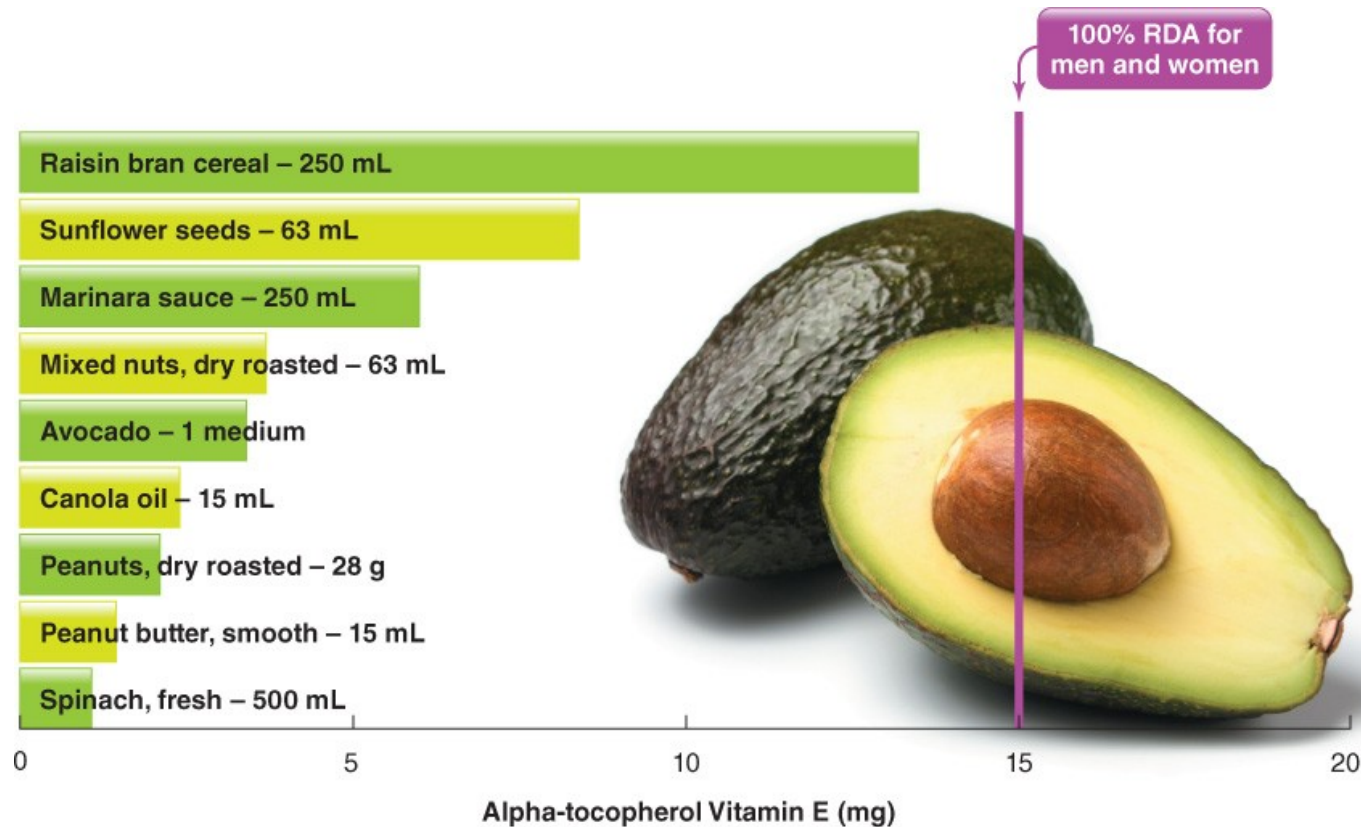
Vitamin E

- RDA is 15 mg alpha-tocopherol/day
- UL is 1000 mg per day

Sources of Vitamin E

- Vegetable oils, nuts, seeds, and soybeans
- Animal and dairy products are poor sources

Vitamin E



▶ **Figure 8.6** Common food sources of vitamin E. The RDA for vitamin E is 15 mg alpha-tocopherol per day for men and women.

Data from U.S. Department of Agriculture, Agricultural Research Service, 2009. USDA Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory Home Page, www.ars.usda.gov/ba/bhnrc/ndl.

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Figure 8.6

Vitamin E

What if you consume too much vitamin E?

- Some studies suggest possible links to vascular disease, diabetes, or heart failure at high doses over long periods; results are still unconfirmed
- Common side effects such as nausea and diarrhea
- Vitamin E can interfere with anticoagulant medications

Vitamin E

What if you don't consume enough vitamin E?

- Vitamin E deficiencies are uncommon
- Can result in fragile red blood cells (erythrocyte hemolysis)

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
- Enhances the absorption of iron

Vitamin C

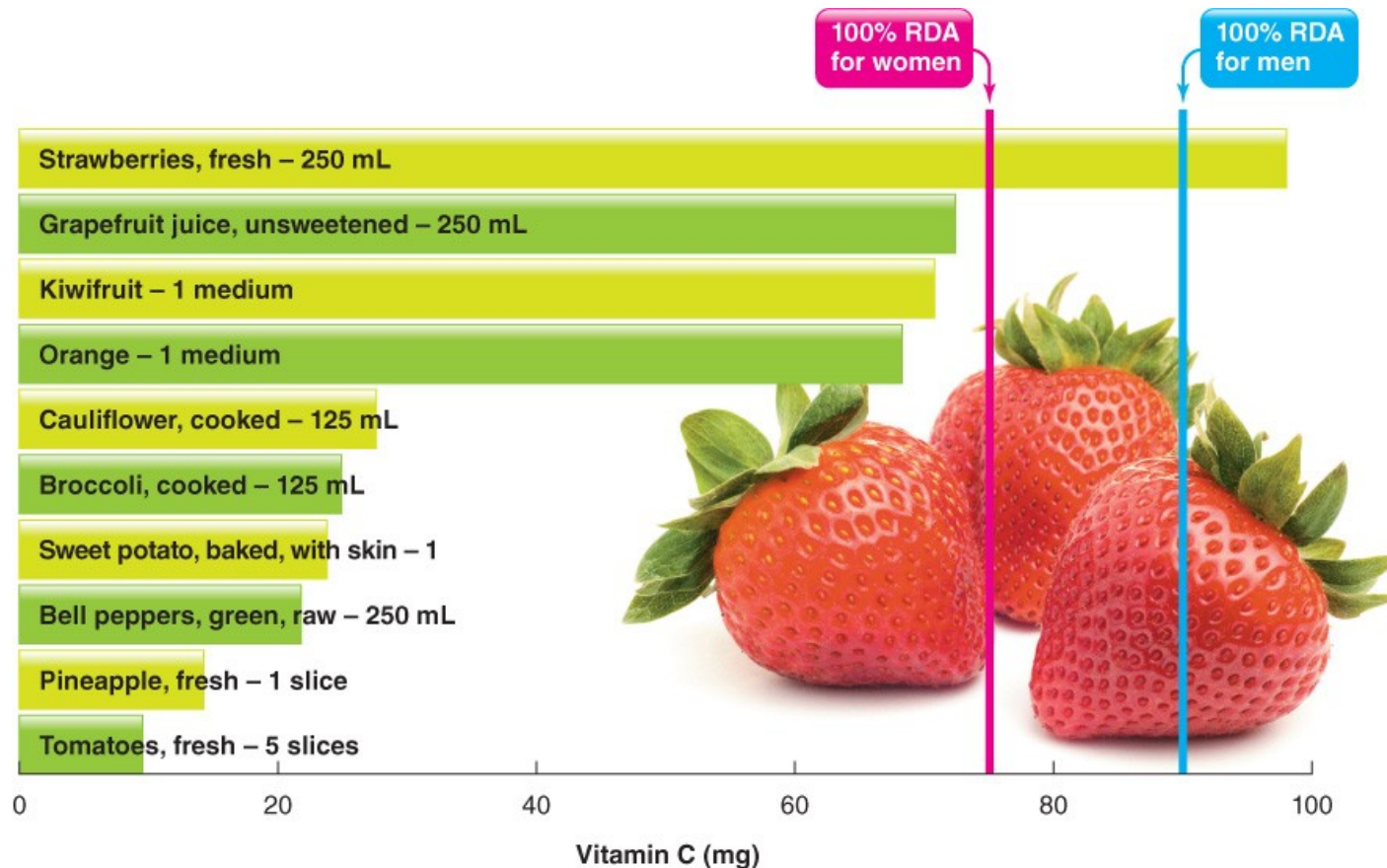
Recommended intake

- 90 mg/day for men; 75 mg/day for women
- Smokers need an extra 35 mg/day
- UL is 2000 mg/day for adults

Sources of vitamin C

- Fresh fruits and vegetables
- Heat destroys vitamin C
- Cooking foods lowers vitamin C content

Vitamin C



➤ **Figure 8.8** Common food sources of vitamin C. The RDA for vitamin C is 90 mg/day for men and 75 mg/day for women.

Data from U.S. Department of Agriculture, Agricultural Research Service, 2009. USDA Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory Home Page, www.ars.usda.gov/ba/bhnrc/ndl.

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Figure 8.8

Vitamin C

What if you consume too much vitamin C?

- Megadoses (10 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

Vitamin C

What if you don't consume enough vitamin C?

- **Scurvy**: the most common vitamin C deficiency disease
- Bleeding gums, loose teeth, weakness
- Can occur after one month of a diet deficient in vitamin C
- Anemia can also result

Beta-Carotene

Beta-carotene is

- 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**

Beta-Carotene

Functions of beta-carotene

- A 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

Beta-Carotene

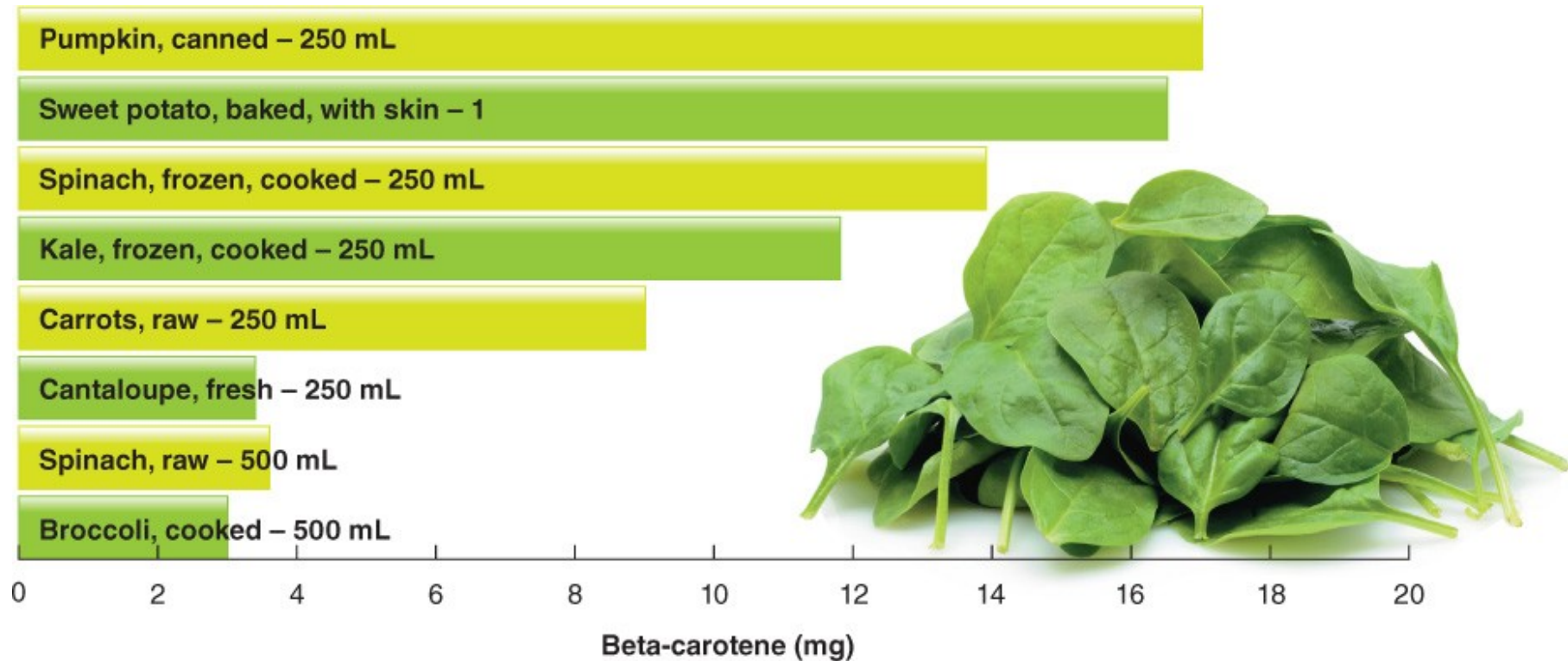
Recommended intake

- Beta-carotene is not considered an essential nutrient
- No DRI or RDA has been established

Sources of beta-carotene

- Fruits and vegetables that are red, orange, yellow, and deep green

Beta-Carotene



➤ **Figure 8.10** Common food sources of beta-carotene. There is no RDA for beta-carotene.

Data from U.S. Department of Agriculture, Agricultural Research Service. USDA—NCC Carotenoid Database for U.S. Foods, 2009. USDA Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory Home Page, www.ars.usda.gov/ba/bhnrc/ndl.

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Figure 8.10

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?

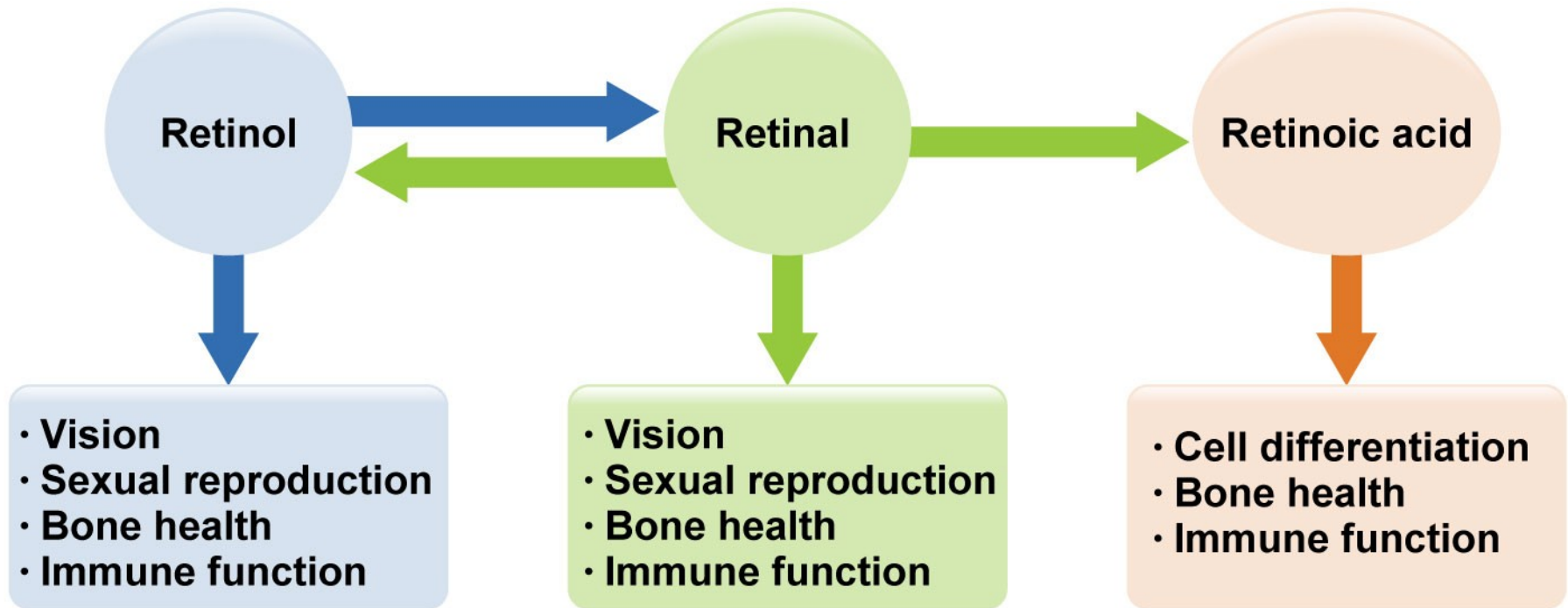
- There are no known deficiency symptoms

Vitamin A

Vitamin A is a fat-soluble vitamin

- Excess vitamin A is stored in the liver, adipose tissue, kidneys, and lungs
- There are 3 active forms of vitamin A (collectively known as the **retinoids**)
 - **Retinol**
 - **Retinal**
 - **Retinoic acid**

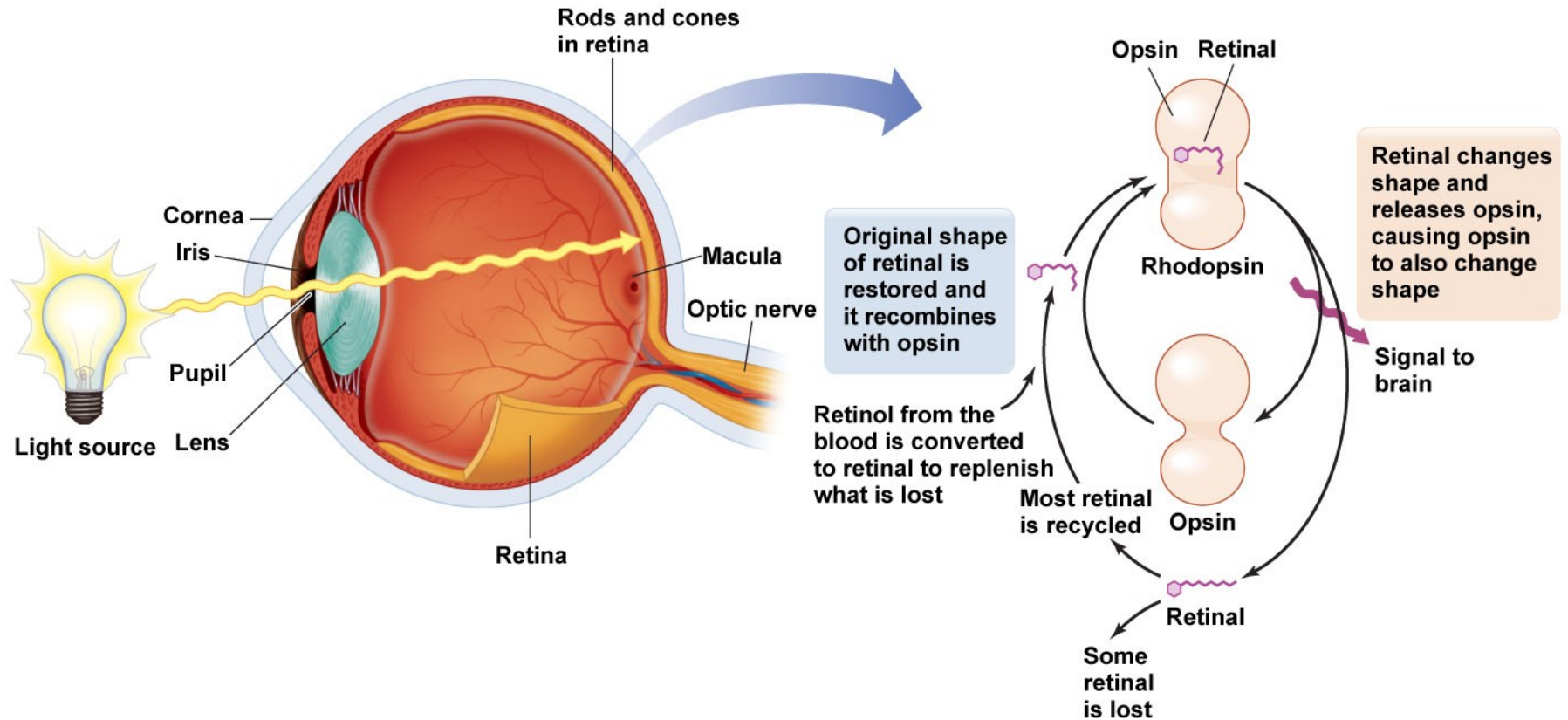
Vitamin A



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Figure 8.11

Vitamin A



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Figure 8.12

Vitamin A

Functions of Vitamin A

- Essential to proper vision
- Antioxidant, protecting LDL cholesterol
- Cell differentiation – the process by which cells mature and specialize
- Sperm production and fertilization
- Bone growth

Vitamin A

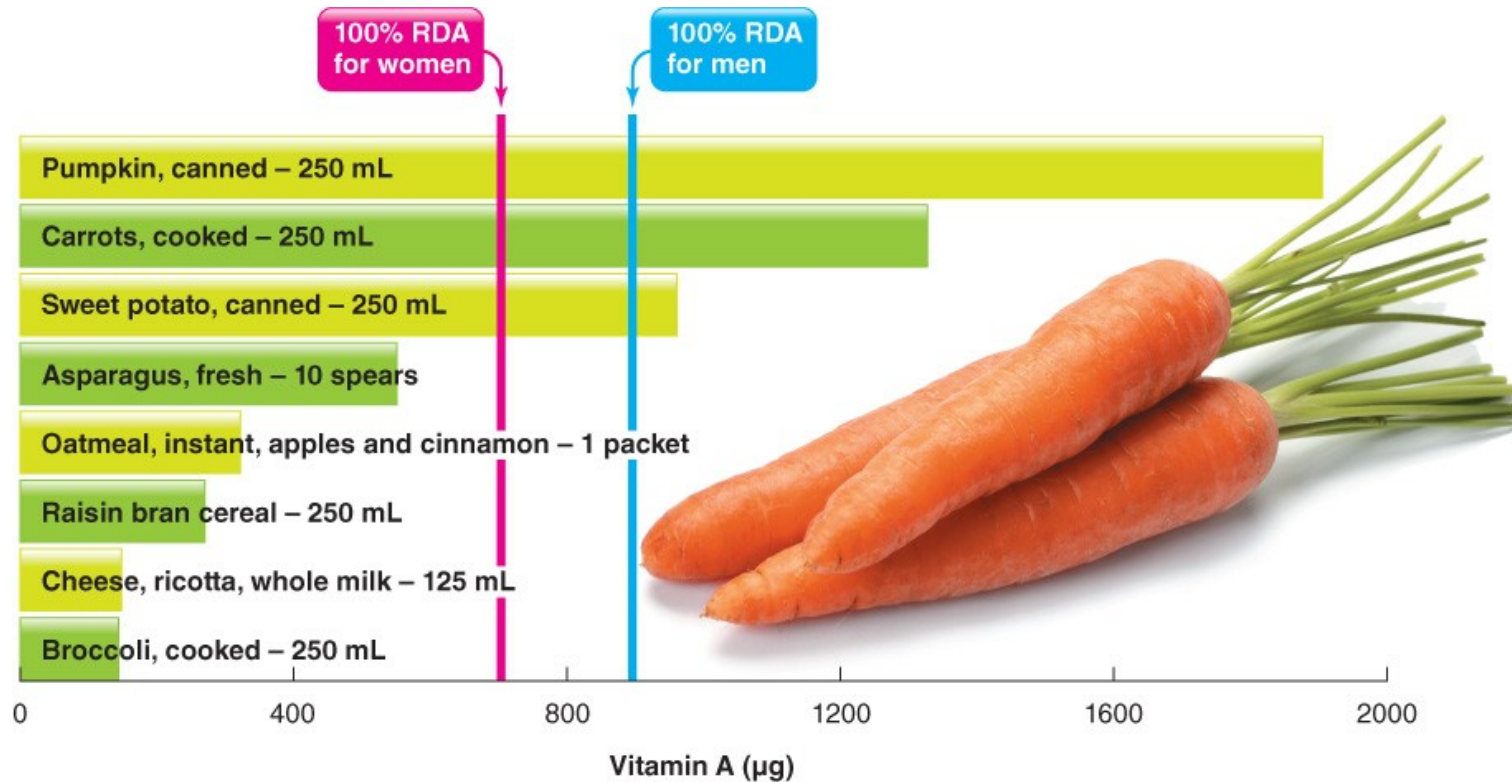
Recommended intake

- RDA is 900 mg/day for men; 700 mg/day for women

Sources of vitamin A

- Animal sources: liver, eggs, whole-fat dairy products
- Plant sources such as the provitamin carotenoids (dark-green, orange, and deep-yellow fruits and vegetables)

Vitamin A



➤ **Figure 8.13** Common food sources of vitamin A. The RDA for vitamin A is 900 µg/day for men and 700 µg/day for women.

Data from U.S. Department of Agriculture, Agricultural Research Service, 2009. USDA Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory Home Page, www.ars.usda.gov/ba/bhnrc/ndl.

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Figure 8.13

Vitamin A

What if you consume too much vitamin A?

- Vitamin A is highly toxic, especially from supplements
- Birth defects, spontaneous abortion, 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)

Selenium

Selenium is 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

Selenium

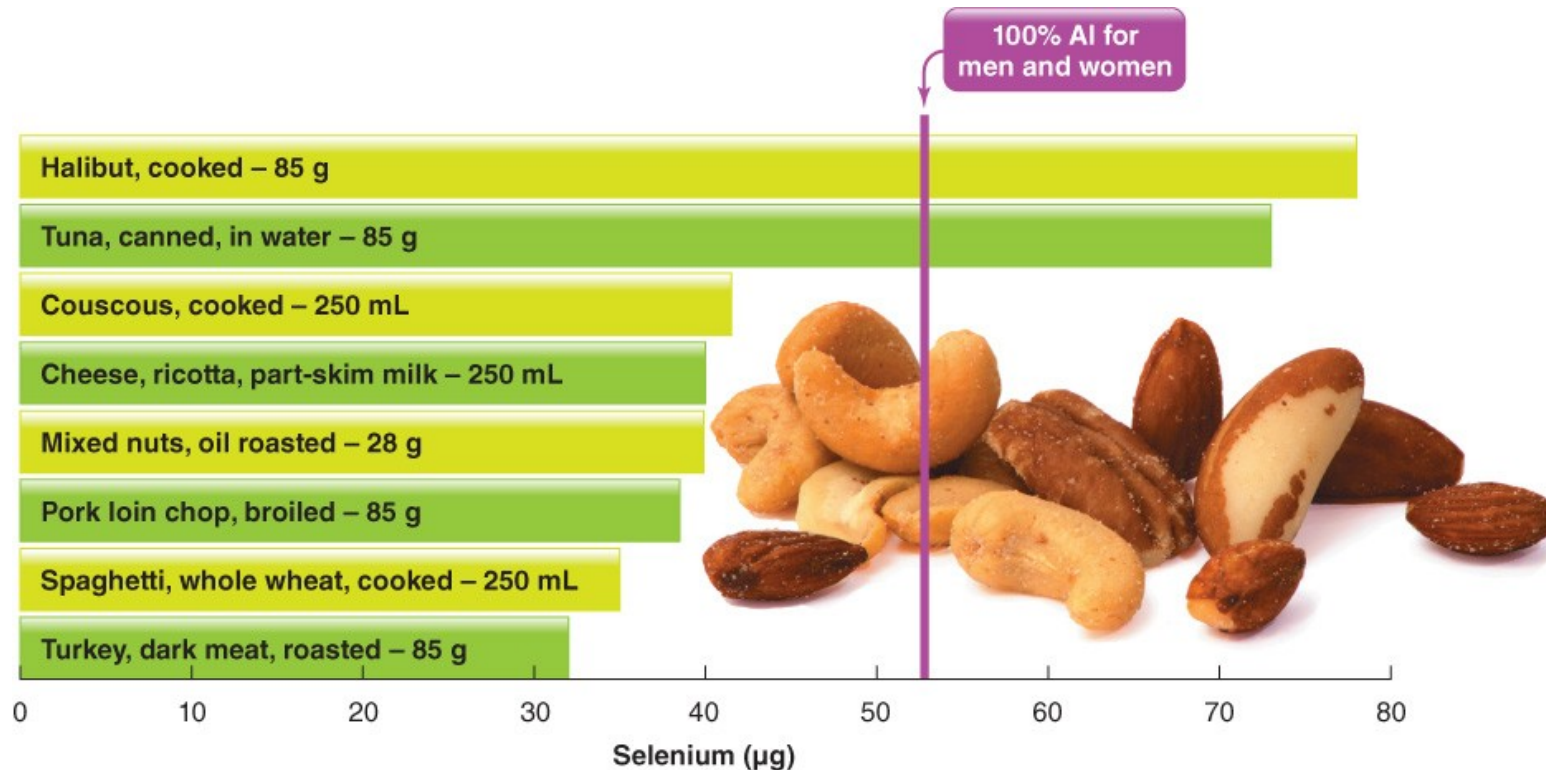
Recommended intake

- 55 µg/day for men and women
- UL is 400 µg/day

Sources of selenium

- Rich sources include organ meats, pork, and seafood
- Plant sources are dependent upon the amount of selenium in the soil

Selenium



➤ **Figure 8.15** Common food sources of selenium. The RDA for selenium is 55 µg/day.

Data from U.S. Department of Agriculture, Agricultural Research Service, 2009. USDA Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory Home Page, www.ars.usda.gov/ba/bhnrc/ndl.

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Figure 8.15

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

Additional Antioxidants

Cofactor: a compound needed for proper functioning of an enzyme

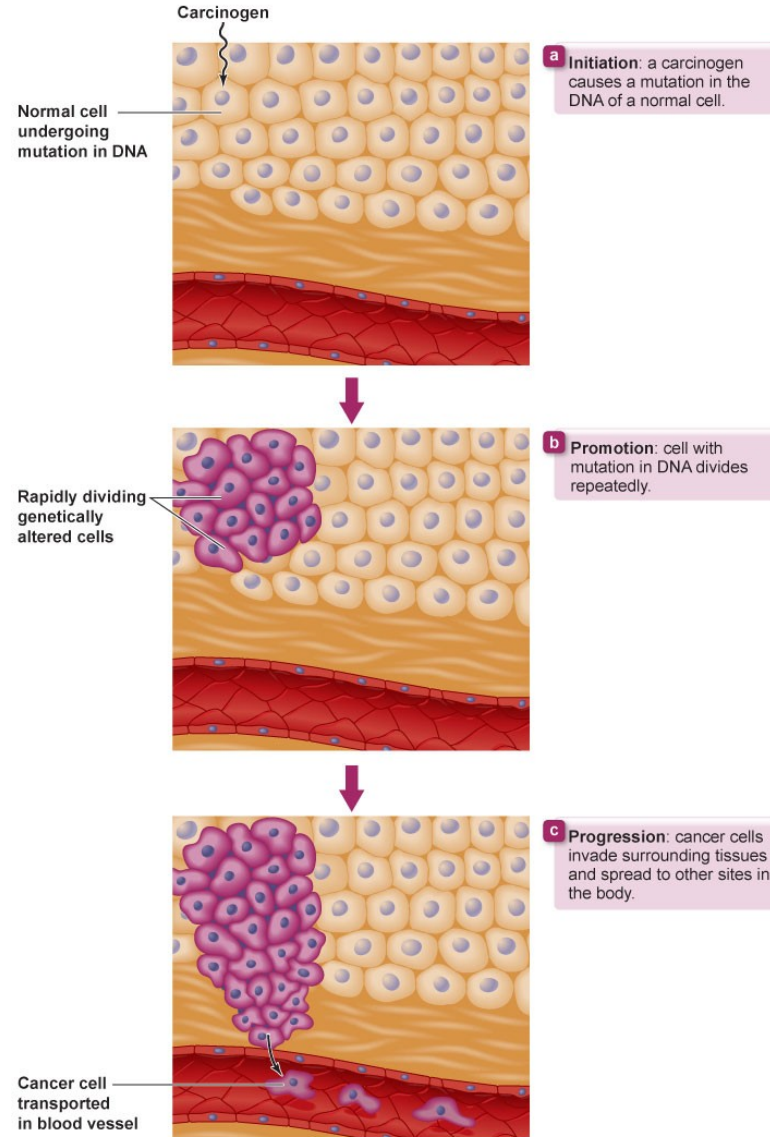
- **Copper, zinc, and manganese** are cofactors for the superoxide dismutase enzyme antioxidant system
- **Iron** is a cofactor for the catalase antioxidant system

In Depth: Cancer

Cancer: a group of related diseases characterized by cells growing out of control

- Composed of 3 steps
 - **Initiation**—a cell's DNA is mutated
 - **Promotion**—altered cell repeatedly divides
 - **Progression**—cells grow out of control

In Depth: Cancer



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Figure 1 In Depth

In Depth: Cancer

Factors that increase cancer risk include

- Tobacco use
- Heredity (but only 5% of all cancers are strongly hereditary)
- Weight, diet, and physical activity level
- Infectious agents (e.g., STDs)
- Sun exposure (ultraviolet radiation)
- Environmental/occupational exposure

Canadian Cancer Society's 5 Modifiable Risk Factors

1. Tobacco
2. Nutrition and fitness
3. Alcohol
4. UV radiation
5. Vitamin D

Signs and Symptoms of Cancer

- Unexplained weight loss
- Fever
- Extreme fatigue
- Aches and pains
- Skin changes

Signs and Symptoms of Cancer

- Changes in bowel or bladder function
- Indigestion or problems swallowing
- Unusual bleeding or discharge
- Skin thickenings or lumps
- Nagging cough or hoarseness

Cancer Treatments

- Depends on stage at which cancer is found
- 3 major types of treatments
 - Surgery
 - Radiation
 - Chemotherapy

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

Role of Antioxidants in Cancer

Antioxidants may contribute to reducing the risk of cancer

Antioxidants may **reduce** cancer risk by

- Enhancing the immune system
- Inhibiting the growth of cancer cells and tumours
- Preventing oxidation damage to cells