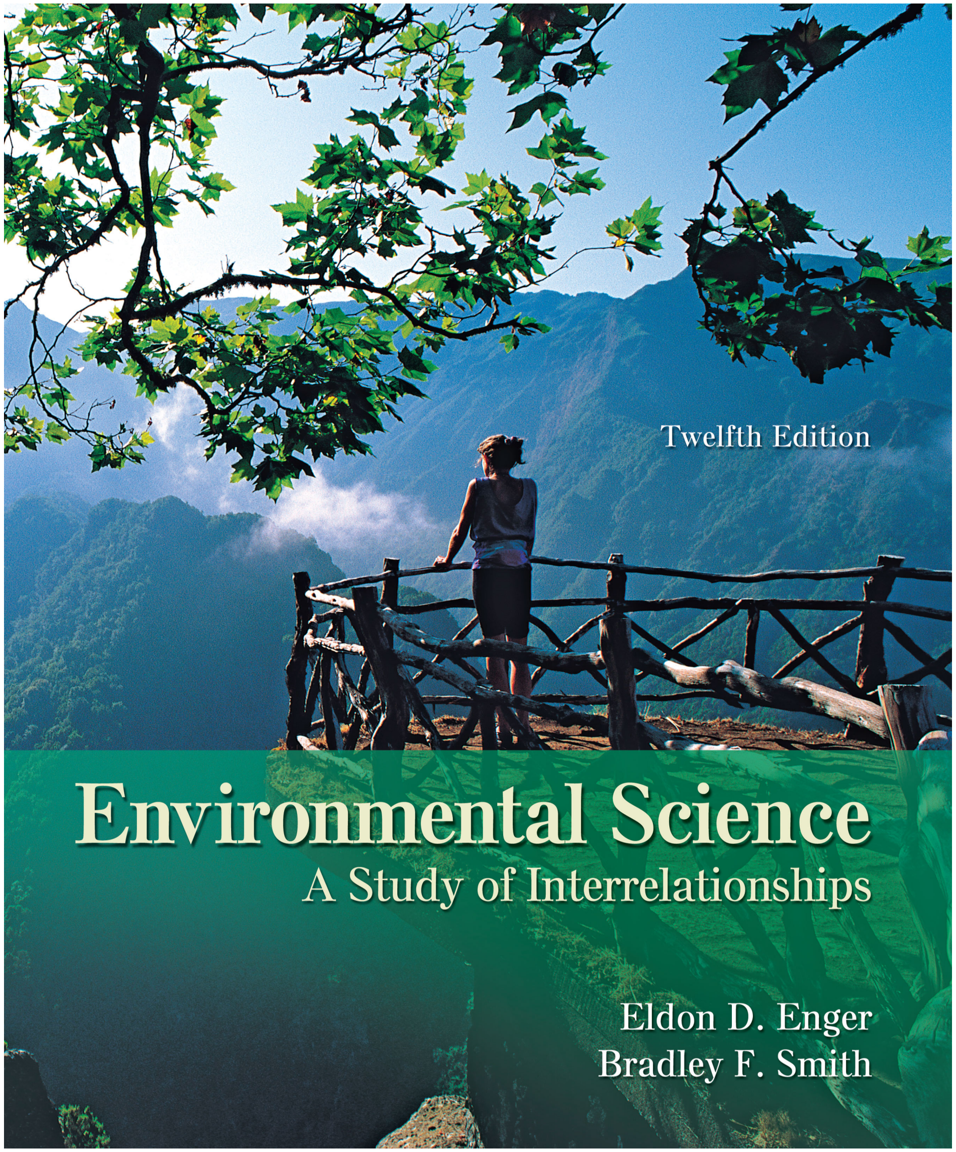
The McGraw-Hill Companies

# Chapter 10 Image Slides




Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Chapter opener 10

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

© Getty RF

Figure 10_01

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

U.S. Air Force

(a) Bomb blast

© Corbis RF

(b) Nuclear power plant


© SIU/Visuals Unlimited

(c) Nuclear medicine

Table 10_01

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

## TABLE 10.1 Half-Lives and Significance of Some Radioactive Isotopes

| Radioactive Isotope | Half-Life | Significance |
|---|---|---|
| Uranium-235 | 700 million years | Fuel in nuclear power plants |
| Plutonium-239 | 24,110 years | Nuclear weapons<br>Fuel in some nuclear power plants |
| Carbon-14 | 5730 years | Establish age of certain fossils |
| Americium-241 | 432.2 years | Used in smoke detectors |
| Cesium-137 | 30.17 years | Treat prostate cancer<br>Used to measure thickness of objects in industry |
| Cobalt-60 | 5.27 years | Sterilize food by irradiation<br>Cancer therapy<br>Inspect welding seams |
| Strontium-90 | 29.1 years | Power source in space vehicles<br>Treat bone tumors |
| Iridium-192 | 73.82 days | Inspect welding seams<br>Treat certain cancers |
| Phosphorus-32 | 14.3 days | Radioactive tracer in biological studies |
| Iodine-131 | 8.06 days | Diagnose and treat thyroid cancer |
| Radon-222 | 3.8 days | Naturally occurs in atmosphere of some regions where it causes lung cancers |
| Radon-220 | 54.5 seconds | Naturally occurs in atmosphere of some regions where it causes lung cancers |

Figure 10_02

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

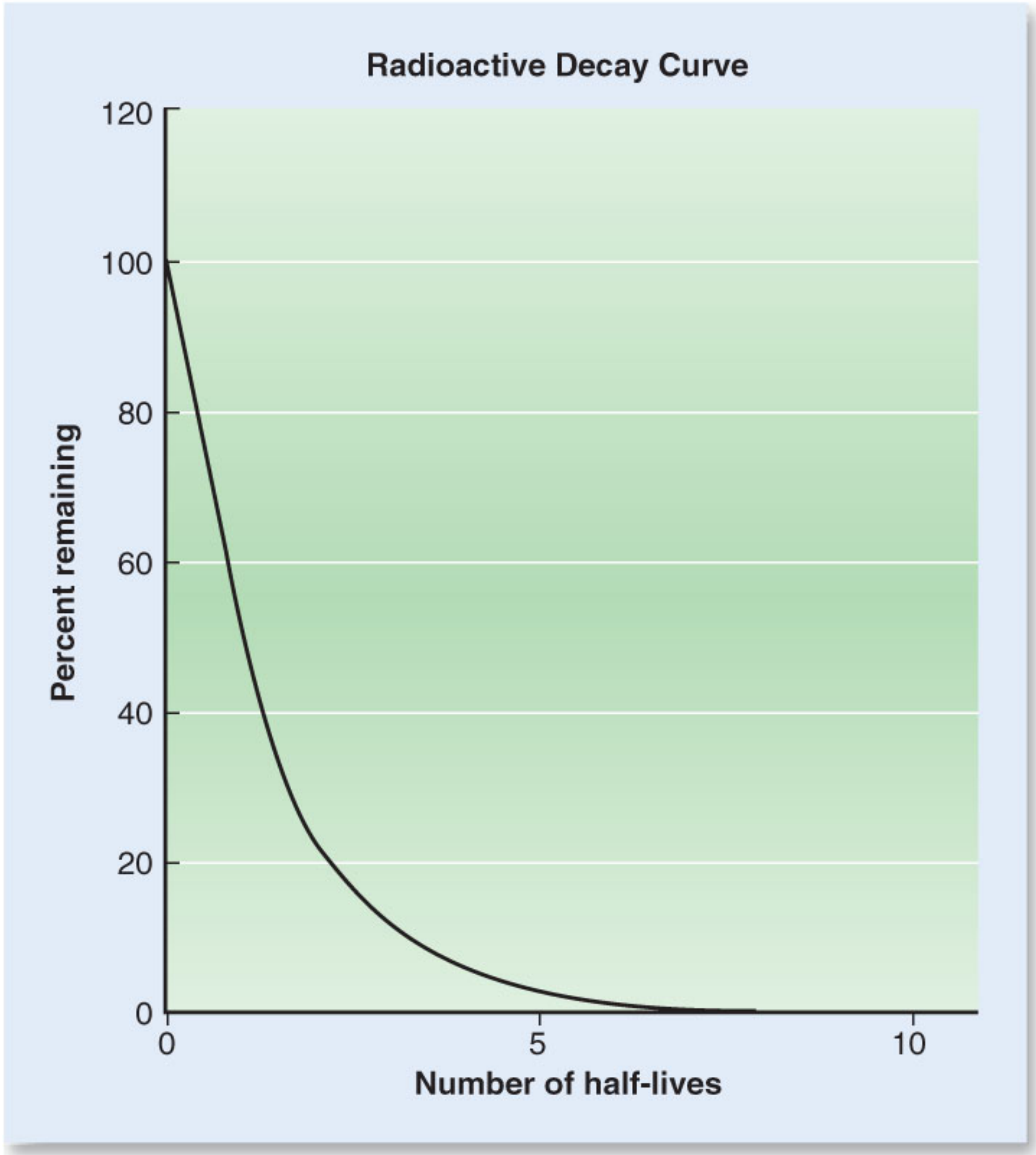


Figure 10_03

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

| Isotope of Element | Type of Radiation | Half-Life |
|---|---|---|
| Uranium-238 (U-238)<br>Protons = 92<br>Neutrons = 146 | | 4.5 billion years |
| | Alpha<br>(2 protons and 2 neutrons) | |
| Thorium-234 (Th-234)<br>Protons = 90<br>Neutrons = 144 | | 24.5 days |
| | Beta (electron) | |
| Protactinium-234 (Pa-234)<br>Protons = 91<br>Neutrons = 143 | | 1.14 minutes |
| | Beta (electron) | |
| Uranium-234 (U-234)<br>Protons = 92<br>Neutrons = 142 | | 233,000 years |
| | Alpha<br>(2 protons and 2 neutrons) | |
| Thorium-230 (Th-230)<br>Protons = 90<br>Neutrons = 140 | | 83,000 years |
| | Alpha<br>(2 protons and 2 neutrons) | |
| Radium-226 (Ra-226)<br>Protons = 88<br>Neutrons = 138 | | 1590 years |
| | Alpha<br>(2 protons and 2 neutrons) | |
| Radon-222 (Rn-222)<br>Protons = 86<br>Neutrons = 136 | | 3.825 days |
| | Alpha<br>(2 protons and 2 neutrons) | |
| Polonium-218 (Po-218)<br>Protons = 84<br>Neutrons = 134 | | 3.05 minutes |
| | Alpha<br>(2 protons and 2 neutrons) | |
| Lead-214 (Pb-214)<br>Protons = 82<br>Neutrons = 132 | | 26.8 minutes |
| | Beta (electron) | |
| Bismuth-214 (Bi-214)<br>Protons = 83<br>Neutrons = 131 | | 19.7 minutes |
| | Beta (electron) | |
| Polonium-214 (Po-214)<br>Protons = 84<br>Neutrons =130 | | 0.00015 seconds |
| | Alpha<br>(2 protons and 2 neutrons) | |
| Lead-210 (Pb-210)<br>Protons = 82<br>Neutrons = 128 | | 22 years |
| | Beta (electron) | |
| Bismuth-210 (Bi-210)<br>Protons = 83<br>Neutrons = 127 | | 5 days |
| | Beta (electron) | |
| Polonium-210 (Po-210)<br>Protons = 84<br>Neutrons = 126 | | 140 days |
| | Alpha<br>(2 protons and 2 neutrons) | |
| Lead-206(Pb-206)<br>Protons = 82<br>Neutrons = 124 | | Stable |

Table 10_02

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

## TABLE 10.2 Radiation Measurement Units

| What Is Measured | International Scientific Units | U.S. Commonly Used Units | Application |
|---|---|---|---|
| *Number of nuclear disintegrations* | **becquerel (Bq)**<br>1 Bq = 1 disintegration/second | **curie (Ci)**<br>1 Ci = 37 billion disintegration/second<br>*1 Ci = 37 billion Bq* | Quantify the strength of a radiation source |
| *Absorbed dose* | **gray (Gy)**<br>1 Gy = 1 joule/kilogram of matter | **rad**<br>1 rad = 0.01 joule/kilogram of matter<br>*1 rad = 0.01 Gy* | Quantify the amount of energy absorbed |
| *Dose equivalent* | **sievert (Sv)**<br>1 Sv = Gy *X* quality factor* | **rem**<br>1 rem = rad *X* quality factor*<br>*1 rem = 0.01 Sv* | Quantify the potential biological effect of a dose |

*For beta and gamma radiation, the quality factor = 1. For alpha radiation, the quality factor = 20.

Table 10_03

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

## TABLE 10.3 Radiation Effects

| Source or Benchmark | Dose | Biological Effects |
|---|---|---|
| *Nuclear bomb blast or accidental exposure in a nuclear facility* | 100,000 rems/incident | Immediate death |
| *Nuclear accident or accidental exposure to X rays* | 10,000 rems/incident | Coma, death in 1–2 days |
| | 1000 rems/incident | Death in 2–3 weeks |
| | 800 rems/incident | 100% death eventually |
| | 500 rems/incident | 50% survival with good medical care |
| | 100 rems/incident | Increased probability of leukemia |
| | 50 rems/incident | Changes in numbers of blood cells observed |
| | 10 rems/incident | Early embryos may show abnormalities |
| *X ray of intestine* | 1 rem/procedure | Damage or effects difficult to demonstrate |
| *Upper limit for occupationally exposed persons* | 5 rems/year | |
| *Upper limit for release from nuclear facilities that are not nuclear power plants* | 0.5 rem/year | |
| *Natural background radiation* | 0.2–0.3 rem/year | |
| *Upper limit for exposure of general public to radiation above background* | 0.1 rem/year | |
| *Upper limit for release from nuclear power plants* | 0.005 rem/year | |

Figure 10_04

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

© Getty RF

Figure 10_05

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Table 10_04

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

## TABLE 10.4 Nuclear Reactor Statistics (2008)

| Region | Reactors Operating | Reactors Under Construction | Reactors Planned |
|---|---|---|---|
| *World* | *439* | *36* | *93* |
| United States | 104 | 0 | 12 |
| France | 59 | 1 | 0 |
| Japan | 55 | 2 | 11 |
| Russia | 31 | 7 | 10 |
| South Korea | 20 | 3 | 5 |
| United Kingdom | 19 | 0 | 0 |
| Canada | 18 | 2 | 3 |
| Germany | 17 | 0 | 0 |
| Ukraine | 15 | 0 | 2 |
| India | 15 | 6 | 10 |
| China | 11 | 7 | 24 |
| Sweden | 10 | 0 | 0 |
| Spain | 8 | 0 | 0 |
| Rest of World | 57 | 8 | 16 |

Source: Data from World Nuclear Association.

Figure 10_06

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

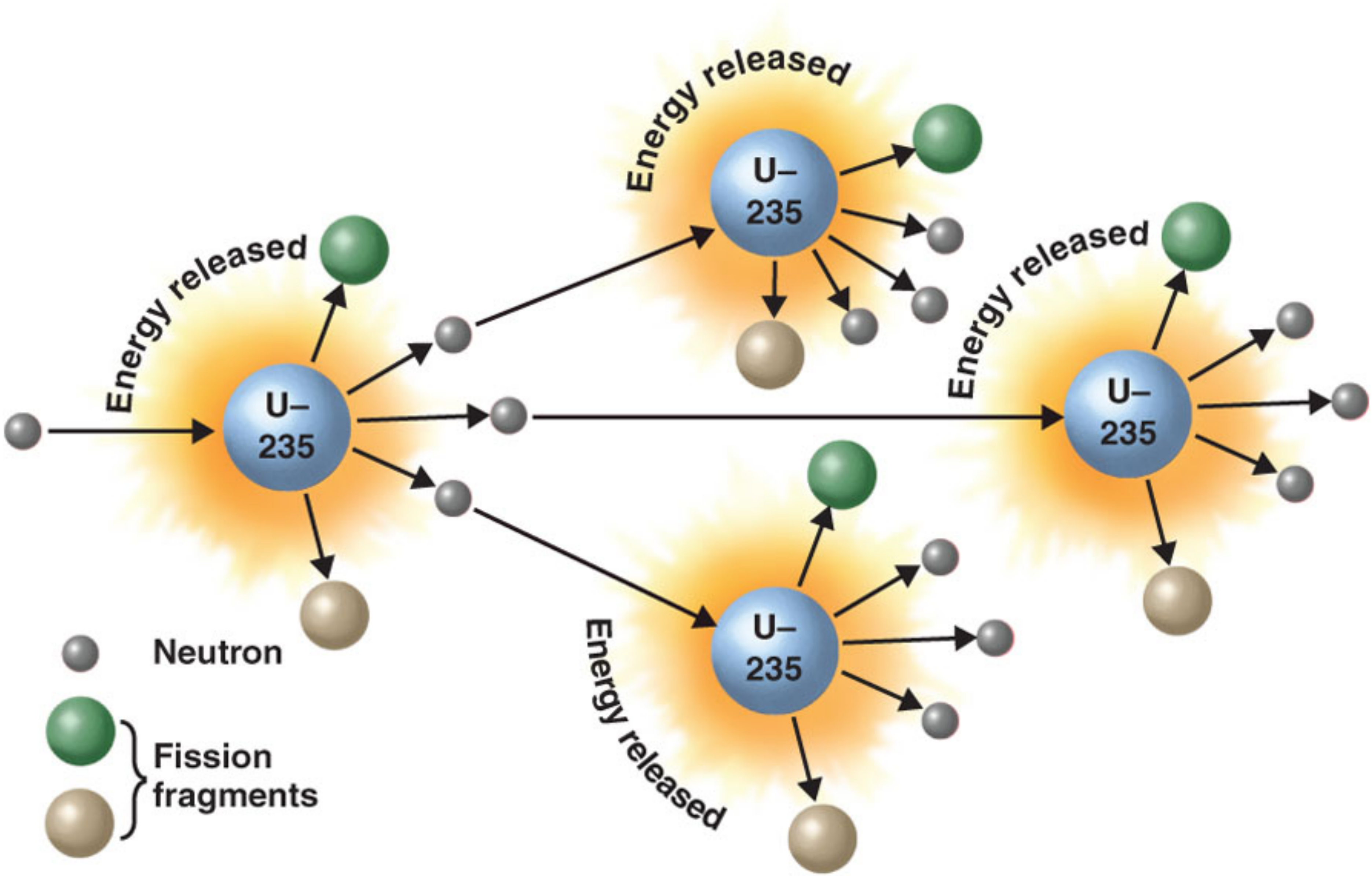


Figure 10_07

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

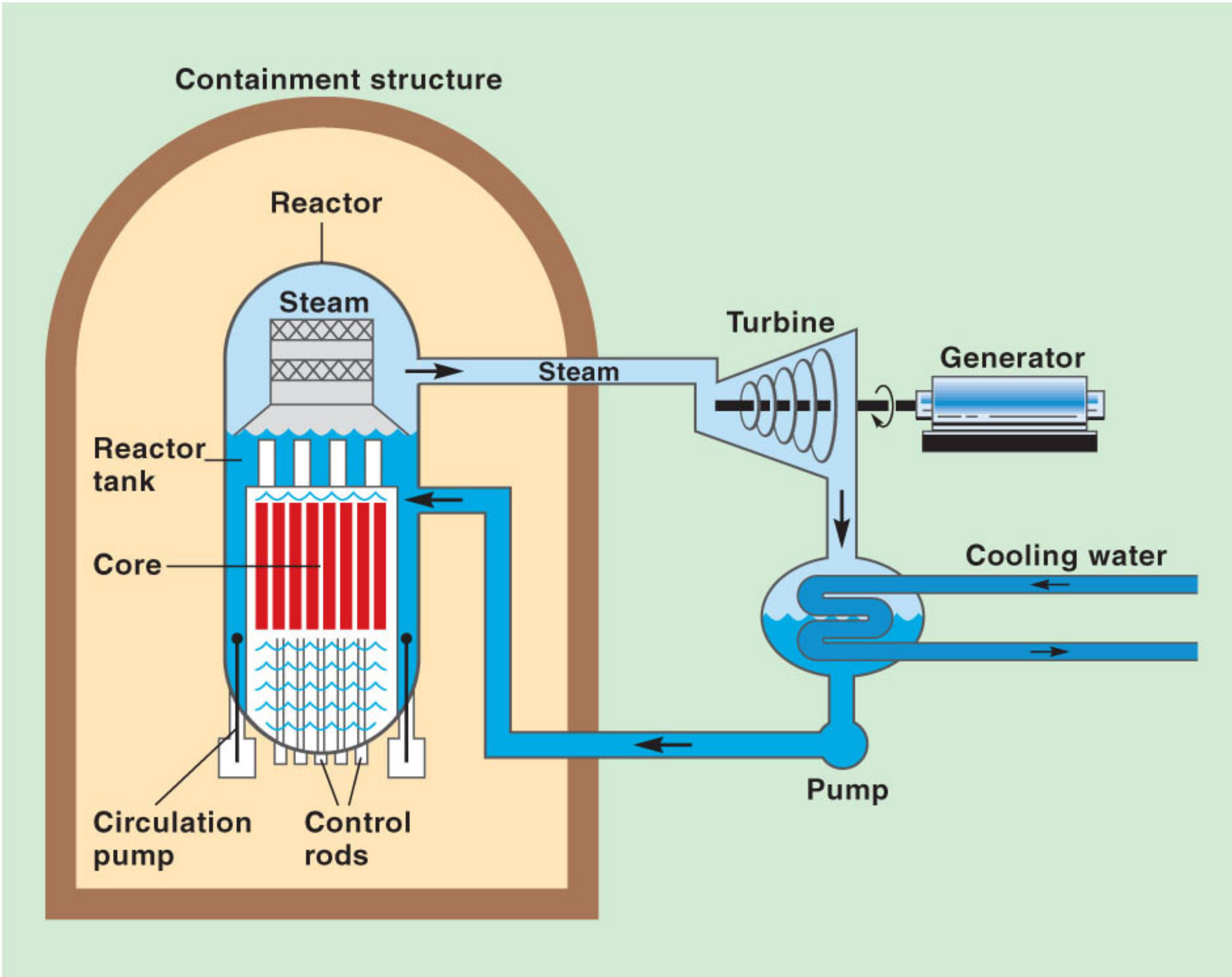


Figure 10_08

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

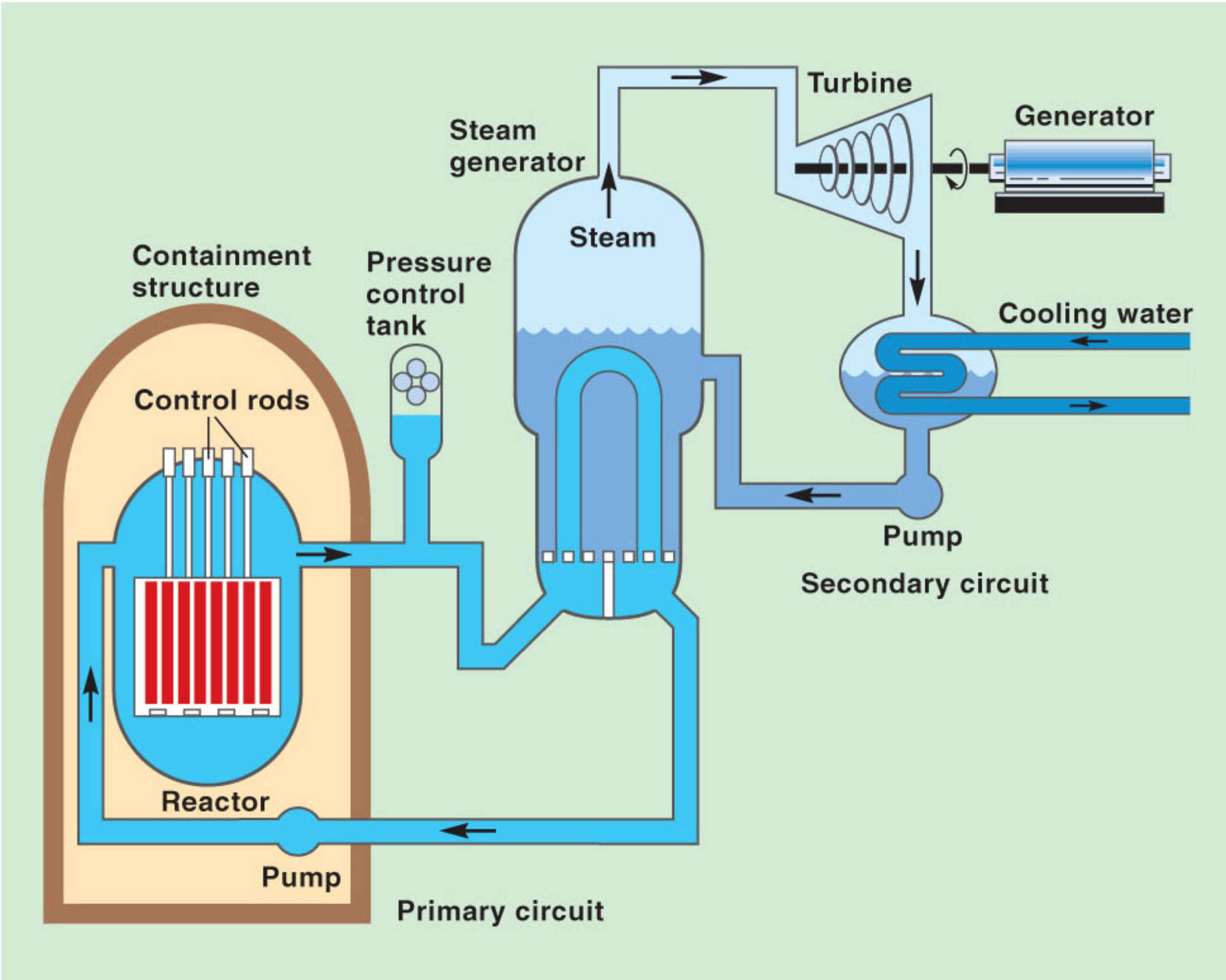


Figure 10_09

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

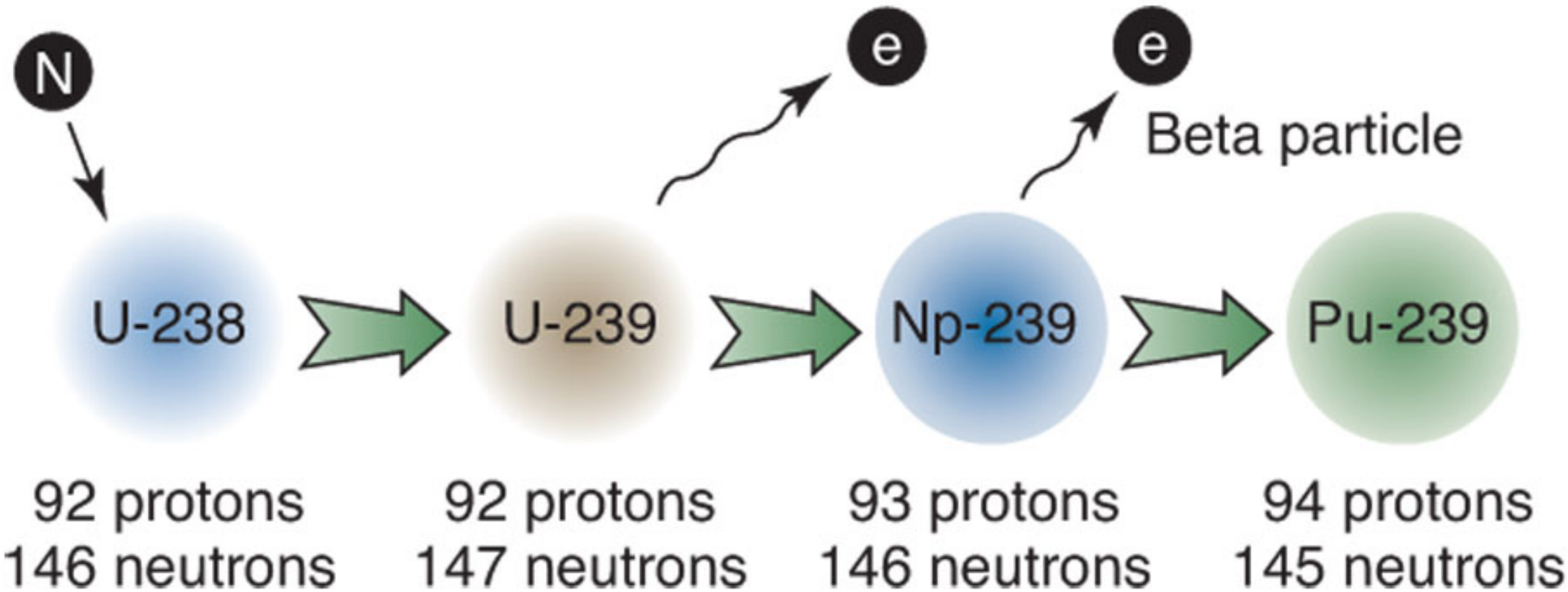
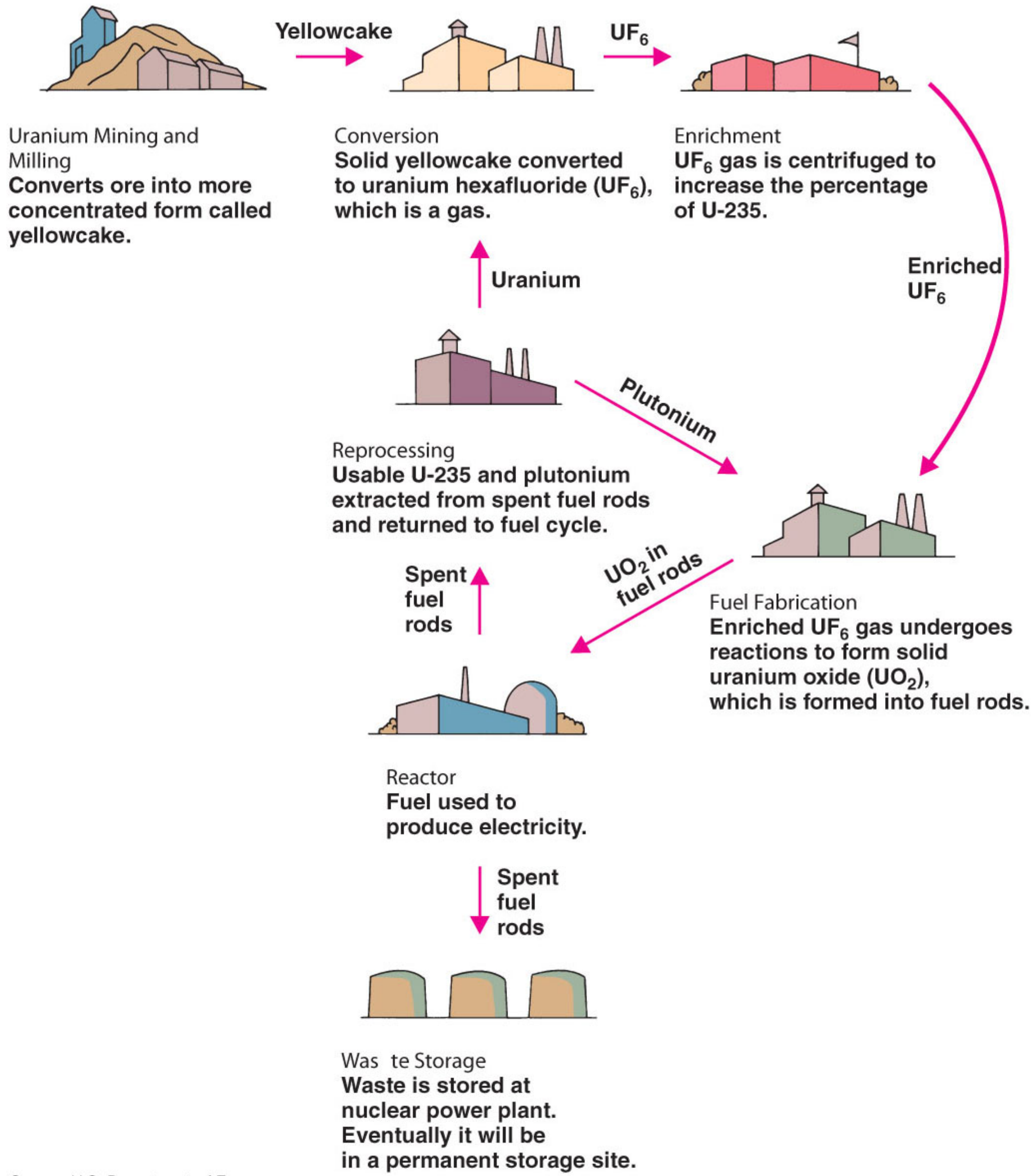


Figure 10_10

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.




Source: U.S. Department of Energy.

Figure 10_11

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

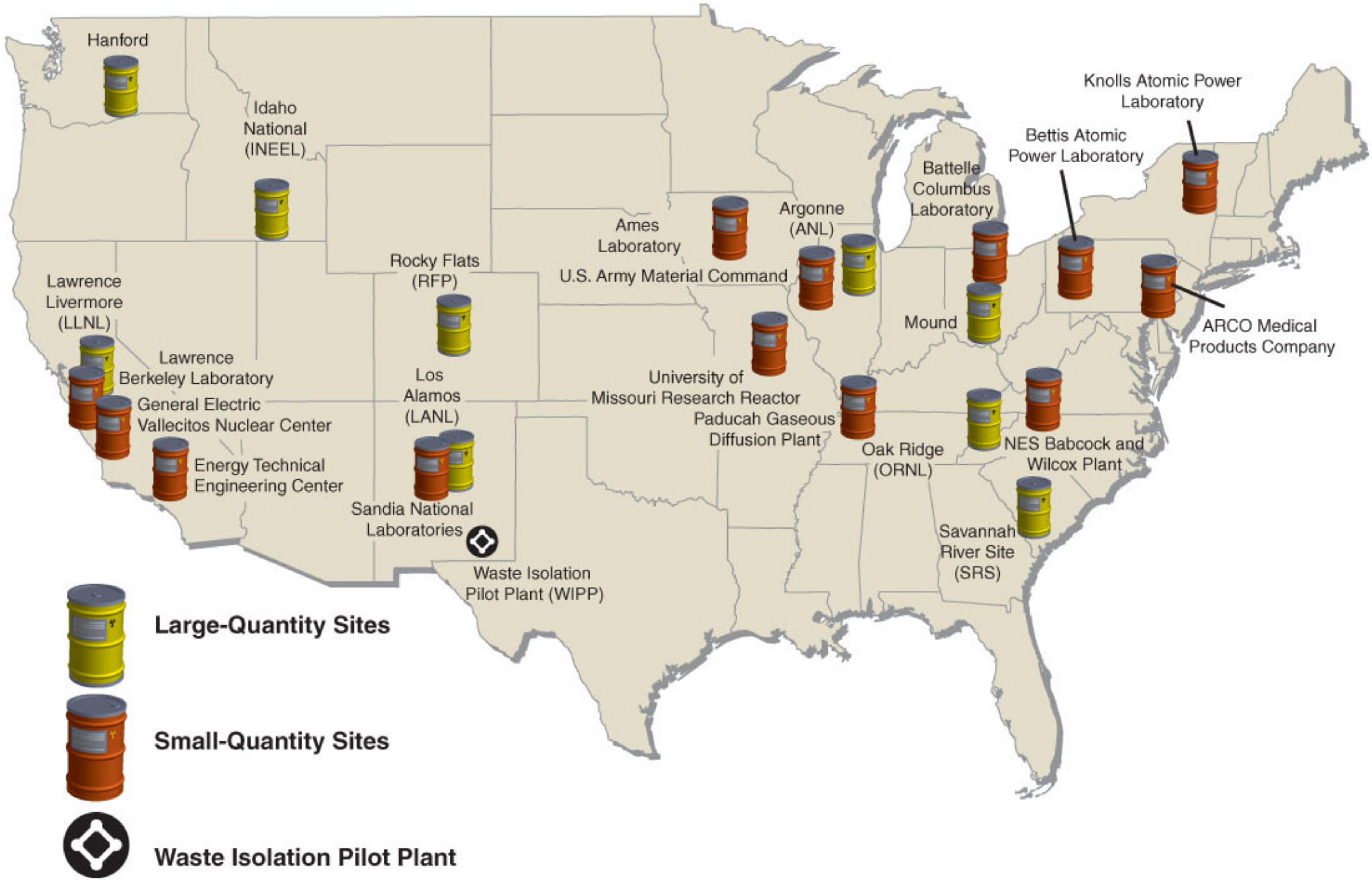
Figure 10_12

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

© TASS/Sovfoto/Eastfoto

Figure 10_13

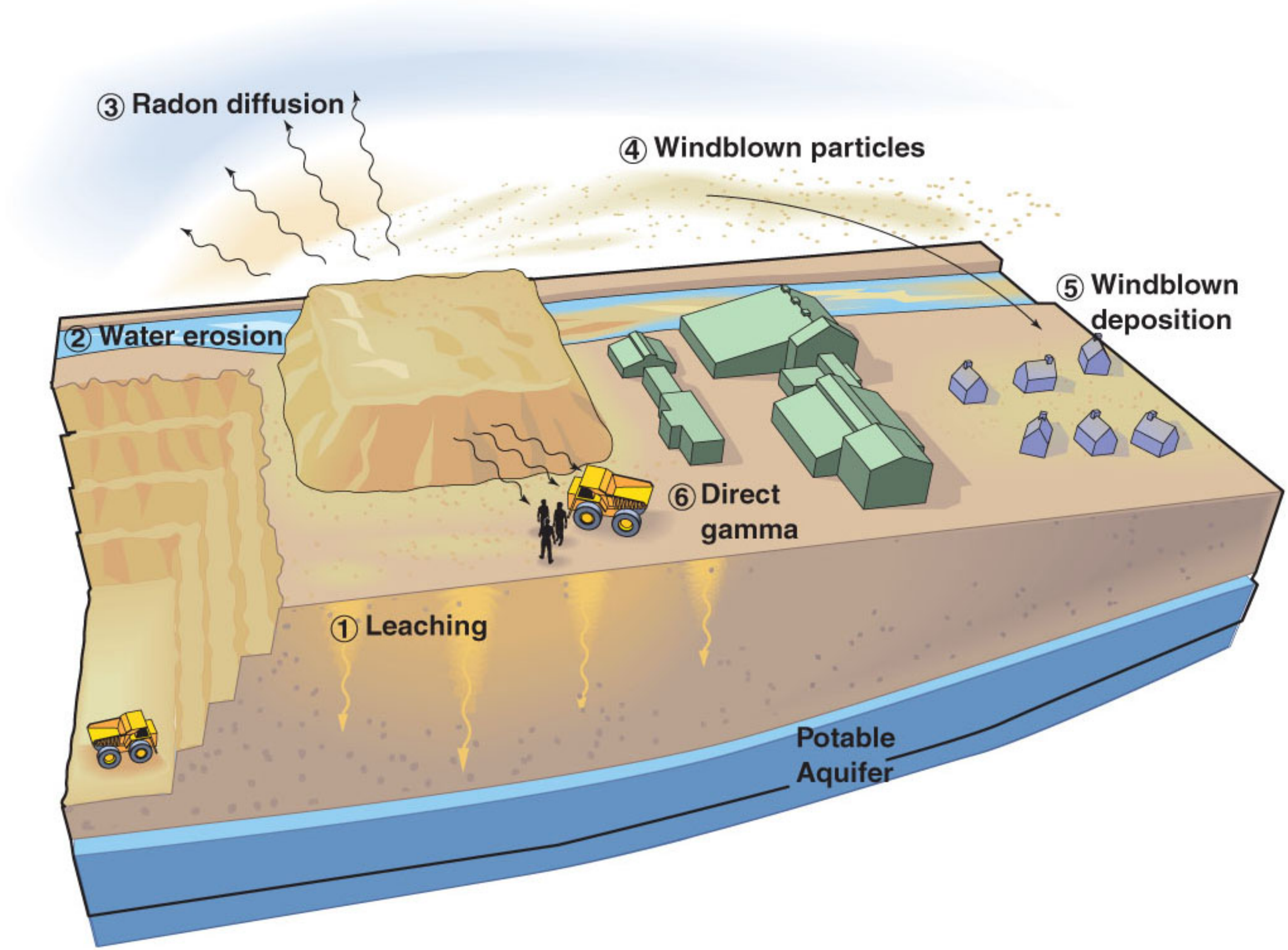
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.




Source: Nuclear Regulatory Commission.

Figure 10_14

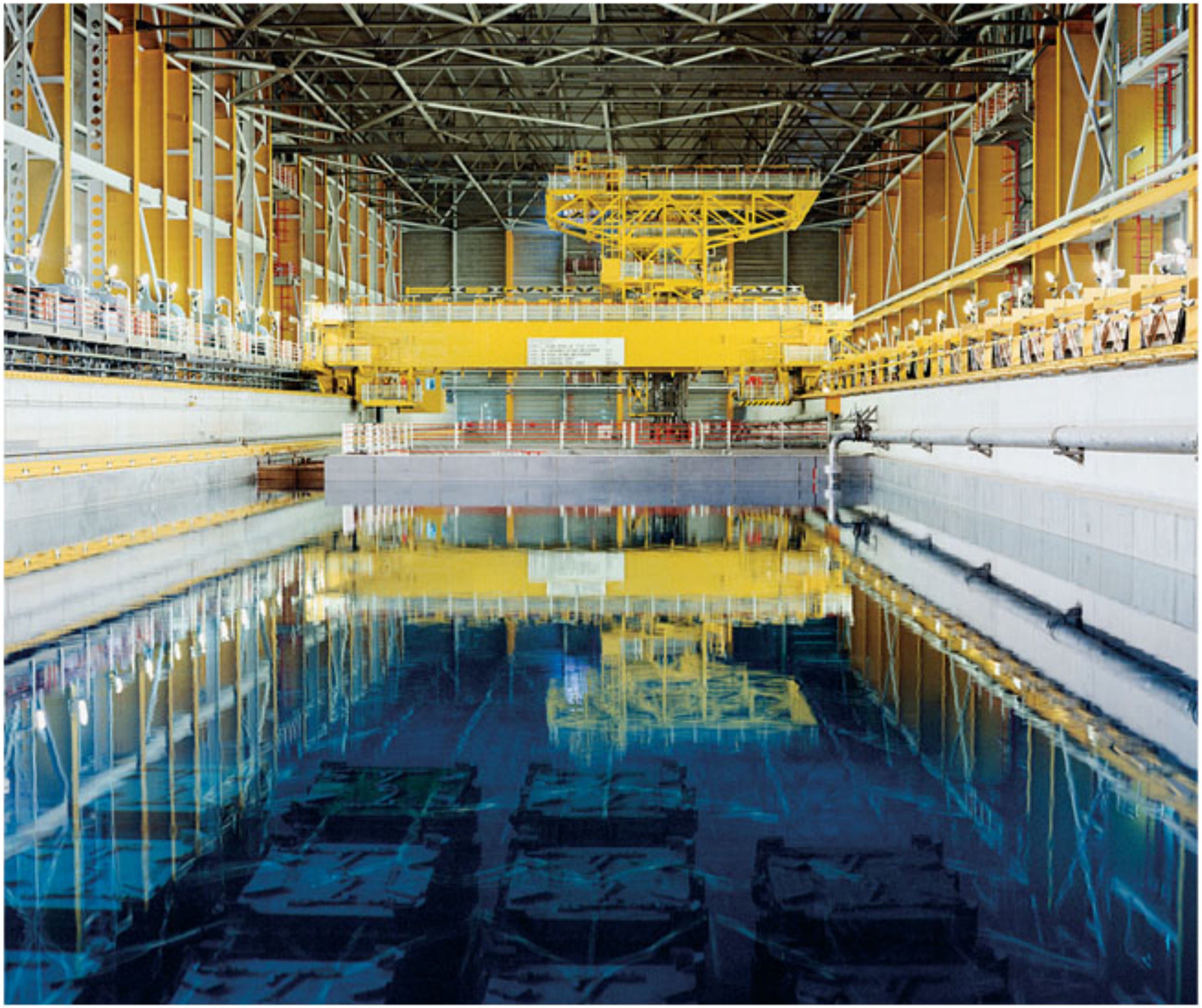
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.




Source: U.S. Environmental Protection Agency.

Figure 10_15

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



© Getty RF

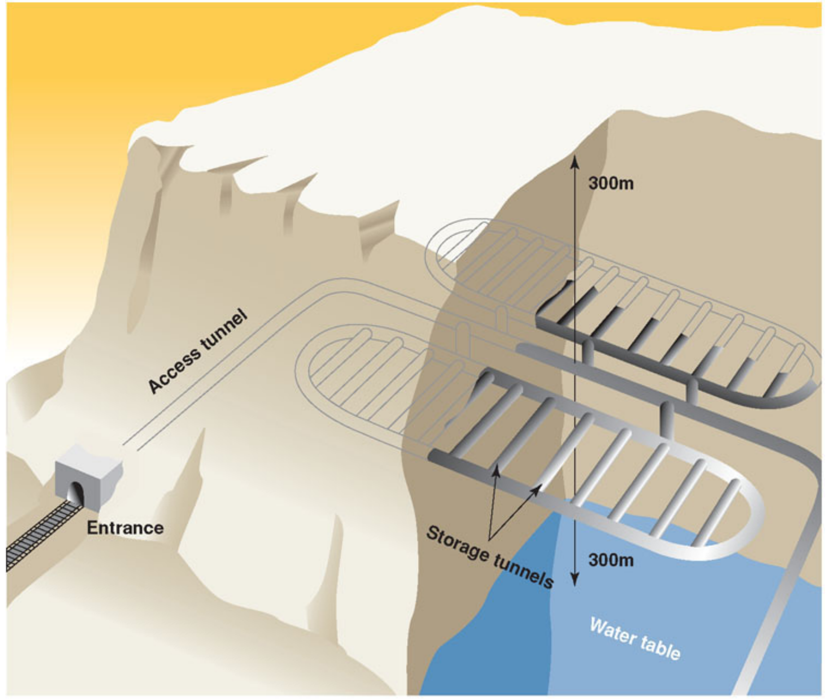
Figure 10_16

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

U.S. Department of Energy

Figure 10_17

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



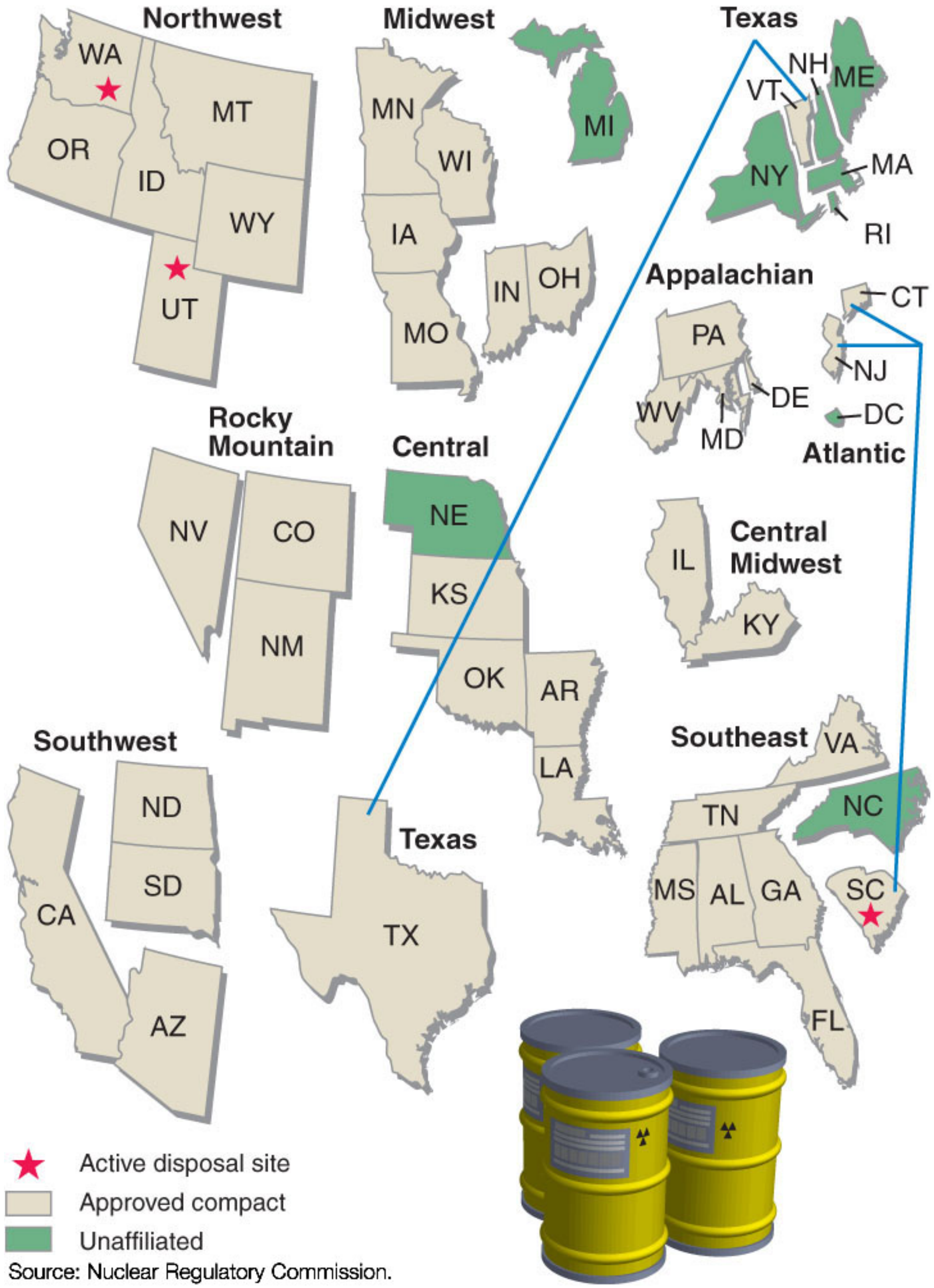

(a)


© AP Wide World Photos

(b)

Figure 10_18

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.




Source: Nuclear Regulatory Commission.

Figure 10_19

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

U.S. Department of Energy

Figure 10_20

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

© Arthur-Bertrand Peter Arnold, Inc.