# AP Environmental Science Summer Assignments

Monsignor Edward Pace High School

Mr. Mayo

E-mail: lmayo@pacehs.com

## *Introduction*:

Welcome to AP Environmental Science! This summer assignment will give you an overview of all the topics we will go over during the school year. This is intended to help you get accustomed to the content that I will be teaching you in this course. These assignments must be **handwritten** neatly and organized on paper, and you will be given a test grade for all your work. This will be the first grade that you will receive for the first quarter!

The following is a list of major topics that will be discussed in the AP Environmental Science course:

- The Living World: Ecosystems
- The Living World: Biodiversity
- Populations
- Earth Systems and Resources
- Land and Water Use
- Energy Resources and Consumption
- Atmospheric Pollution
- Aquatic and Terrestrial Pollution
- Global Change

In addition, the following BIG IDEAS will serve as the foundation for the AP Environmental Science course:

- Energy Transfer
- Interactions between Earth Systems
- Interactions between Different Species and the Environment
- Sustainability

Furthermore, the following practices will be required for the AP Environmental Science curse:

- Concept Explanation
- Visual Representations
- Text Analysis
- Scientific Experiments
- Data Analysis
- Mathematical Routines
- Environmental Solutions

AP Environmental Science Exam Structure

- Section 1: Multiple Choice (80 Questions): 90 minutes, 60% of Exam Score
- Section 2: Free Response (3 Questions): 70 minutes, 40% of Exam Score

If you have any questions, feel free to E-mail me at the URL address listed above. If you are working with someone who is in the class, make sure that your answers are in your own words and not copied from a partner.

Additional Information:

**This assignment will be collected on the first day of class**. Because you have had all summer to work on this, no late summer assignments will be accepted for students who were listed on my roster in May. Also, you will be tested on each of these items during the first few weeks of class. Be sure to study the information that is presented in Pages 3 through 23.

## *Monsignor Edward Pace High School Honor Code*:

We, the members of the Monsignor Edward Pace community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at Monsignor Edward Pace High School, the following pledge is either required or implied:

"On my honor, I have neither given nor received unauthorized aid, in doing this assignment."

## *Prerequisite Environmental Science Knowledge and Skills*:

While taking the AP Environmental Science course, you will come across various diseases, events and incidents, legislative acts and treaties, people, organizations, scientific concepts, effects and laws, and terms. Over the summer, you should be familiar with these environmental science concepts and skills. Additionally, you should gain an understanding of these items and must read about them on the Internet. On a sheet of paper, I want to identify each of the following as they relate to environmental science:

### *A. Diseases*

1. atherosclerosis
2. bird flu
3. black lung disease
4. building-related illness
5. cholera
6. dengue fever
7. Ebola
8. hepatitis B
9. HIV/AIDS
10. influenza
11. lead poisoning
12. Lyme disease
13. marasmus
14. mercury poisoning

15. mesothelioma
16. Minamata disease
17. Not In My Backyard syndrome (NIMBY)
18. plasmodium
19. rabies
20. Rocky Mountain spotted fever
21. rotavirus
22. SARS
23. schistosomiasis
24. sick building syndrome
25. skin cancer
26. swine flu
27. typhoid fever
28. vibrio cholera
29. West Nile Virus

### *B. Events and Incidents*

1. Aral Sea disaster
2. Bhopal disaster
3. Chernobyl disaster
4. Deepwater Horizon oil spill (BP oil spill or Gulf of Mexico oil spill)
5. Earth Day
6. El Niño/La Niña-Southern Oscillation (ENSO) events
7. Exxon Valdez oil spill
8. Industrial Revolution
9. Love Canal disaster

10. Minamata, Japan
11. Three Gorges Dam, China
12. Three Mile Island accident
13. Yucca Mountain

### *C. Legislative Acts and Treaties*

1. Atomic Energy Act (AEA)
2. Clean Air Act (CAA) of 1970 and 1990
3. Clean Water Act (CWA) of 1972
4. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), 1980
5. Consumer Product Safety Act (CPSA)
6. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
7. Corporate Average Fuel Economy (CAFE)
8. Emergence Planning and Community Right-to-Know Act (EPCRA), or SARA Title III
9. Endangered Species Act (ESA) of 1973
10. Energy Policy and Conservation Act of 1975
11. Environmental Education Act of 1990
12. Environmental Policy Act of 1969
13. Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), 1947
14. Food Security Act (FSA) of 1985
15. Hardrock Mining and Reclamation Act (HMA)
16. Hazardous Material Transportation Act (HAZMAT)
17. Hazardous and Solid Waste Amendments (HSWA) of 1984
18. Homestead Act of 1862

19. International Environmental Protection Act of 1983
20. Kyoto Protocol
21. Lacey Act
22. Law of the Sea Convention (LOSC)
23. Magnuson Fishery Conservation and Management Act
24. Madrid Protocol
25. Marine Mammals Protection Act (MMPA) of 1972
26. Mineral Lands Act of 1866
27. Mining Act of 1872
28. Montreal Accord
29. Montreal Protocol
30. National Energy Act (NEA) of 1972
31. National Environmental Policy Act (NEPA) of 1969
32. Noise Control Act (NCA)
33. Nuclear Waste Policy Act (NWPA)
34. Occupational Safety and Health Act of 1979 (OSH Act)
35. Ocean Dumping Act (ODA)
36. Oil Spill Prevention and Liability Act
37. Pollution Prevention Act (PPA) of 1990
38. Resource Conservation and Recovery Act (RCRA) of 1976
39. Safe Drinking Water Act (SDWA) of 1974
40. Safe Waste Disposal Act (SWDA) of 1965
41. Soil Conservation Act of 1935
42. Stockholm Declaration
43. Superfund Amendments and Reauthorization Act (SARA), 1986

44. Toxic Substances Control Act (TSCA) of 1976
45. U.S. Noise Control Act
46. Wilderness Act of 1964

### *D. People*

1. Al Gore
2. Aldo Leopold
3. Franklin Roosevelt
4. Frederick Clements
5. Jane Goodall
6. John Muir
7. Garrett Hardin
8. George Perkins Marsh
9. Gifford Pinchot
10. Henry David Thoreau
11. Henry Gleason
12. M. King Hubbert
13. Mario Molina
14. Rachel Carson
15. Sherwood Rowland
16. Theodore Roosevelt
17. Thomas Malthus
18. Wangari Maathai

### *E. Organizations*

1. Center for Biological Diversity
2. Centers for Disease Control (CDC)

3. Chesapeake Bay Foundation
4. Clean Water Action
5. The Climate Reality Project
6. Earth System Governance Project
7. Energy Action Coalition
8. Environmental Protection Agency (EPA)
9. Food and Agriculture Organization (FAO)
10. Greenpeace
11. Intergovernmental Panel on Climate Change (IPCC)
12. The Nature Conservancy
13. National Council for Science and the Environment (NSCE)
14. National Audubon Society
15. National Geographic Society
16. National Wildlife Federation
17. Occupational Safety and Health Association (OSHA)
18. Sierra Club
19. United Nations Environmental Programme (UNEP)
20. United States Fish and Wildlife Service
21. World Conservation Union
22. World Health Organization (WHO)
23. World Trade Organization (WTO)
24. World Wildlife Fund

### *F. Scientific Concepts, Laws and Processes*

1. accuracy
2. ammonification

3. carbon cycle
4. Coriolis effect
5. ecological succession
6. El Niño
7. First Law of Thermodynamics
8. Gaia hypothesis
9. Gause's principle
10. Green Revolution
11. Greenhouse Effect
12. Hubbert peak (peak oil)
13. hydrologic cycle
14. La Niña
15. Law of Conservation of Matter
16. nitrification
17. nitrogen cycle
18. nitrogen fixation
19. phosphorous cycle
20. precision
21. salinization
22. Second Law of Thermodynamics

## *G. Terms*

1. acid rain
2. active solar heating system
3. adaptive radiation
4. aeration

5. affluenza
6. agroforestry
7. air pollution
8. alley cropping
9. aquaculture
10. athenosphere
11. barrier island
12. biodiesel fuels
13. biological oxygen demand (BOD)
14. biomass
15. biomes
16. bitumen
17. carbon emissions
18. carbon sinks
19. catalytic converter
20. chlorofluorocarbons (CFCs)
21. closed-loop recycling
22. coal gasification
23. coal liquefaction
24. competitive exclusion principle
25. compost
26. crude oil
27. dead zones
28. debt-for-nature-swap
29. desalinization

30. developing country
31. dew point
32. dichlorodiphenyltrichloroethane (DDT)
33. dioxins
34. doldrums
35. dredging
36. ecotone
37. electronic waste (e-waste)
38. estuary
39. evapotranspiration
40. exponential growth
41. feedback loop
42. flyway
43. Freon
44. gangue
45. genetically modified organisms (GMO)
46. geothermal energy
47. gray smog (industrial smog)
48. habitat loss
49. Hadley cell
50. herbicide
51. humus
52. hydrochlorofluorocarbons (HCFCs)
53. hydroelectric power
54. industrial smog

55. industrialized agriculture
56. infiltration
57. insecticide
58. integrated pest management
59. intercropping
60. kerogen
61. landfill
62. leaching
63. liquefied natural gas (LNF)
64. liquefied petroleum gas (LNG)
65. loams
66. monoculture
67. mutualism
68. negative feedback loop
69. nitrous oxide ($N_2O$)
70. non-point source pollution
71. nuclear energy
72. nuclear fission
73. nuclear fusion
74. ocean dredging
75. oil shale
76. open-loop recycling
77. ore
78. oxygen demanding wastes
79. PANs

80. parasitism
81. percolation
82. pesticide
83. petrochemicals
84. phosphorous cycle
85. photochemical smog
86. photovoltaic cell
87. point source pollution
88. polychlorinated biphenyls (PCBs)
89. polyculture
90. porosity
91. positive feedback loop
92. primary pollutants
93. relative humidity
94. riparian zones
95. runoff
96. scrubbers
97. secondary pollutants
98. slash and burn
99. sludge
100. soil erosion
101. solar power
102. spoils
103. subduction
104. subsidence

105. suburban sprawl or urbanization
106. sulfur monoxide (SO)
107. sulfur dioxide ($SO_2$)
108. sustainability
109. stratospheric ozone
110. symbiosis
111. synfuels
112. synthetic natural gas (SNG)
113. tailings
114. tar sand
115. terracing
116. thermocline
117. transform faults
118. upwelling
119. urban sprawl
120. volatile organic compounds (VOCs)
121. wastewater
122. water pollution
123. wave energy
124. wilderness
125. wind power
126. windbreak
127. wind turbines
128. zone of saturation

## *Prerequisite Basic Mathematical Skills*:

During this course, you will need to use basic math skills in order to solve and understand environmental problems. I have given you some basic rules for the following math skills: percentages, rates, scientific notation, SI Units, scientific notation, dimensional analysis, and graphs. Using this information, you will be solving some problems.

### A. Percentage

1. Percent literally means divided by 100.
2. It is a measure of the part of the whole, or a part divided by the whole.
3. Examples:
   a. 17% = 17/100 = 0.17
   b. 15 million is what percentage of the US population? 15 million/300 million = 0.05% = 5%
   c. What is 20% of this $15 bill so that I can give a good tip? $15 x 0.20 = $15 x 20/100 = $3 tip!

### B. Rates

1. Rates are calculating how much an amount changes in a given amount of time.
2. Often will be written using the word "per" followed by a unit of time, such as cases per year, grams per minute, or mile per hour. The word per means to divide, so miles per gallon is actually the number miles driven divided by one gallon.
3. *Examples*:
   a. Rise/Run
   b. $Y_2 - Y_1 / X_2 - X_1$
   c. Slope
   d. change/time
   e. $y = mx + b$
   f. $dX/dt$
4. All of the above are different ways of looking at rates. The second equation (b) is the easiest way to calculate a rate, especially from looking at a graph.

## C. SI Units

1. SI Units are based on multiples of tens.
2. Calculations are made by multiplying or dividing.
3. To change quantities, you move a decimal point.
4. *The Basic SI Units*:

| Measure | Name of Unit | Symbol |
|---|---|---|
| Length | Meter | m |
| Mass | Kilogram | kg |
| Time | Second | s |

5. *SI Prefixes*:

| Measurement | Unit | Symbol |
|---|---|---|
| Kilo | 1,000 | k |
| Hector | 100 | h |
| Deca | 10 | da |
| Deci | 1/10 | d |
| Centi | 1/100 | c |
| Milli | 1/1000 | m |
| Micro | 1/1000000 or $10^{-6}$ | µ |
| Nano | $10^{-9}$ | n |

6. *Other Measurements*:

a. **Gram** - 1 gram is equal to 1/1000 kg; it is a measure of mass. **Mass** is the amount of matter that an object contains.
b. **Liter (L)** – 1 L = 1000 mL; it is a measure of volume; **Volume** is the amount of space that something occupies. The SI unit of volume is the **cubic meter**, **$m^3$**.
c. **Kelvin**, **Celsius**, and **Fahrenheit** – all measure temperature.

## D. Scientific Notation

1. When using large numbers, scientific notation is often the easiest method used to manipulate numbers.
2. For big numbers, you move the decimal place from the right to the left.
3. For small numbers, you move from the left to the right.
4. When adding or subtracting, exponents must be the same. Add the numbers in front of the ten and keep the exponents the same.
5. When multiplying or dividing, multiply or divide the number in front of the ten and add the exponents if multiplying or subtract the exponents if dividing.
6. *Examples*:
   a. 40000 can be written as $4 \times 10^4$
   b. 0.000002 can be written as $2 \times 10^{-6}$
   c. The US population is 300 million people and can be written using scientific notation as $300 \times 10^6$ or $3 \times 10^8$
   d. $9 \times 10^6 / 3 \times 10^2 = (9/3) \times 10^{(6-2)} = 3 \times 10^4$

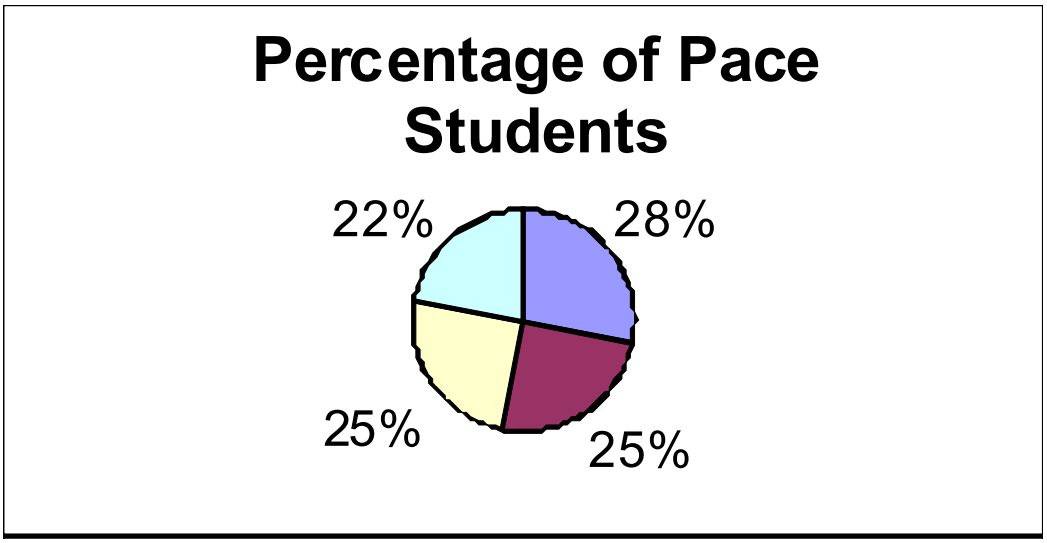
## E. Dimensional Analysis

1. Dimensional analysis is a method used to keep track of units when converting.
2. By using the converting factor, one is able to convert a measurement into one another.
3. *Example*:
   a. How many kilometers are there in 123 m?
   b. Solve: $125 \not{m} \times 1 \text{ km} / 1000 \not{m} = 0.125 \text{ km}$
4. For additional help, use these online tutorials:
   a. http://chemprofessor.com/dimension_text.htm
   b. http://chem.tamu.edu/class/fyp/mathrev/mr-da.html

## F. Graphs

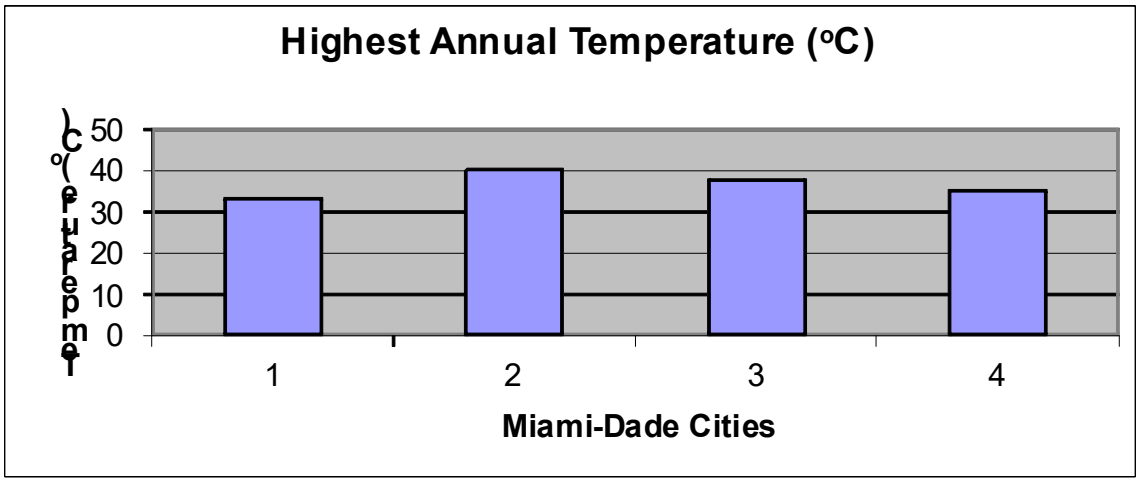
1. A graph is a visual presentation of data.
2. They show numerical data in diagram form.
3. *Examples*:

### Circle Graphs



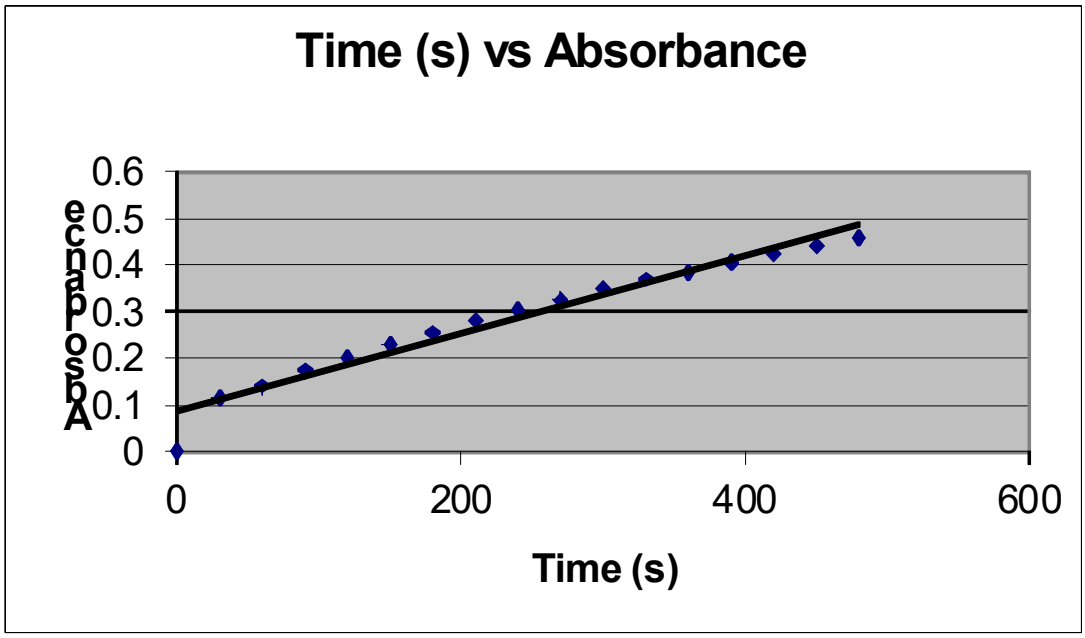

1. It is circle divided into parts (just think of it as a slice of pie).
2. It shows fractions, percentages, shares, or proportions of the whole.
3. Basically, the data that is presented are a proportion of a whole.

### Bar Graphs



1. They are used to compare measurements, such as weight, height, and length, about groups or individual items.
2. They also compare quantities and change over time.

## Line Graphs




1. They are used to compare sets of numerical data
2. They show change and patterns.
3. Horizontal line is the x-axis, while the vertical line is the y-axis.
4. Remember the formula for a line: $y = mx + b$.

## *Math Problems*:

Answer the questions on a sheet of paper. Make sure to show all work.

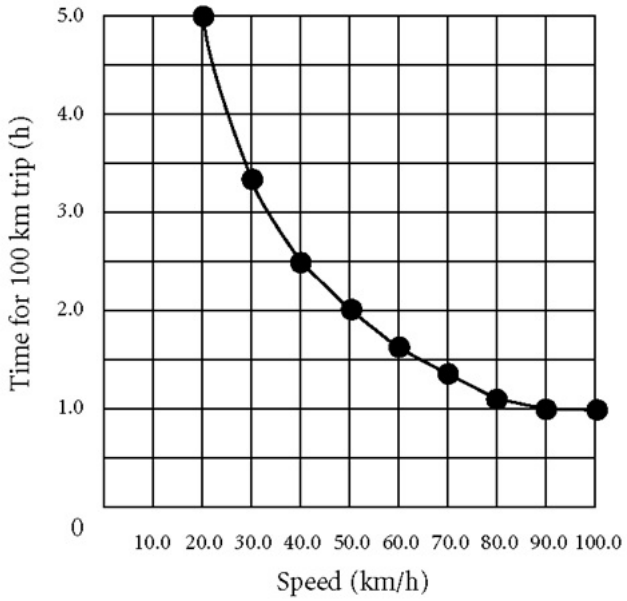
1. What is one million times one thousand? Show your work in scientific notation. Give the answer in scientific notation and in words.

2. A population of deer had 200 individuals. If the population grows by 15% in one year, how many deer will there be the next year?

3. One year I had 40 Ecology students and the next year I had 50. What percentage did the population of Ecology grow by?

4. How many cm are there in 0.090 m?

5. How many grams are there in 1,300,000 micrograms?




6. The time required to make a trip of 100.0 km is measured at various speeds. From the graph above, what speed will allow the trip to be made in 2 hours?

| Hour | Temperature (°C) |
|---|---|
| 1:00 | 30.0 |
| 2:00 | 29.0 |
| 3:00 | 28.0 |
| 4:00 | 27.5 |
| 5:00 | 27.0 |
| 6:00 | 25.0 |

7. A weather balloon records the temperature every hour. From the table above, explain what is occurring to the temperature as each hour goes by.

## *Textbook Materials*

***Instructions***:

I have sent you the **PowerPoint Slides** and **Instructor's Notes** for **Chapters 1 & 2** from your textbook. For these chapters, you must **read** and **study** the materials I have sent you, as well as answer questions that are listed on pages 21-23.

NOTES:

- Make sure to be familiar with all the terms and concepts presented in each of the chapters!
- The questions and their answers must be handwritten on a loose leaf sheet of paper! Make sure to read and study the materials before answering the questions.
- You will be tested on these chapters in the first week of school (not the first day of class).
- Do not assume that you will only be tested on the questions listed below. You will be tested on all materials presented in Chapters 1 and 2, so make sure to **read** and **study** the **PowerPoint Notes** and **Instructor's Notes**!

- ***Questions for Chapter 1 – Environmental Problem, Their Causes, and Sustainability***

1. List three ways in which you could apply Concepts 1-5A and 1-6 to making your lifestyle more environmentally sustainable.

2. Describe two environmentally beneficial forms of exponential growth.

3. Explain why you agree or disagree with the following propositions:
   a. Stabilizing population is not desirable because without more consumers, economic growth would stop.

   b. The world will never run out of resources because we can use technology to find substitutes and to help to help us reduce resource waste.

4. Suppose the world's population stopped growing today. What environmental problems might this help solve? What environmental problems would remain? What economic problems might population stabilization make worse?

5. How do you feel when you read that: **(a)** the average American consumes about 30 times more resources than the average Indian citizen, and **(b)** human activities are projected to make the earth's climate warmer? Are you skeptical, indifferent, sad, helpless, guilty, concerned, or outraged? Which of these feelings help perpetuate such problems, and which can help alleviate them?

6. For each of the following actions, state one or more of the four scientific principles of sustainability that are involved: **(a)** recycling soda cans; **(b)** using a rake instead of a leaf blower; **(c)** choosing to have no more than one child; **(d)** walking to class instead of driving; **(e)** taking your own reusable bags to the grocery store to carry things home in; **(f)** volunteering in a prairie restoration project; and **(g)** lobbying elected officials to require that 20% of your country's electricity be produced by renewable wind power by 2020.

7. Explain why you agree or disagree with each of the following statements: **(a)** humans are superior to other forms of life, **(b)** humans are in charge of the earth, **(c)** all economic growth is good, **(d)** the value of other species depends only on whether they are useful to us, **(e)** because all species eventually become extinct we should not worry about whether our activities cause the premature extinction of a species, **(f)** all species have an inherent right to exist, **(g)** nature has an almost unlimited storehouse of resources for human use, **(h)** technology can solve our environmental problems, **(i)** I do not believe I have any obligation to future generations, and **(j)** I do not believe I have any obligation to other species.

8. What are the basic beliefs of your environmental worldview? Record your answer. Are your environmental actions consistent with your environmental worldviews?

- ***Questions for Chapter 2 – Science, Matter, Energy, and Systems***

1. What ecological lesson can we learn from the controlled experiment on the clearing of forests described in the Core Case Study that opened the chapter?

2. Think of an area you have seen where some significant change has occurred to a natural system. What is a question you might ask in order to start a scientific process to evaluate the effects of this change, similar to the process described in the Core Case Study?

3. Describe a way in which you have applied the scientific process described in this chapter in your own life, and state the conclusion you drew from this process. Describe a new problem that you would like to solve using this process.

4. Respond to the following statements:

    a. Scientists have not absolutely proven that anyone has ever died from smoking cigarettes.

    b. The natural greenhouse theory – that certain gases (such as water vapor and carbon dioxide) warm the lower atmosphere – is not a reliable idea because it is just a scientific theory.

5. A tree grows and increases its mass. Explain why this phenomenon is not a violation of the law of conservation of matter.

6. If there is no way where organisms can get rid of their wastes, why is the world not filled with waste matter?

7. Someone wants you to invest money in an automobile engine, claiming that it will produce more energy than the energy in the fuel used to run it. What is your response? Explain.

8. Use the second law of thermodynamics to explain why a barrel of oil can be used only once as a fuel, or in other words, why we cannot recycle high-quality energy?

9. Imagine you have the power to revoke the law of conservation of matter for one day. What are three things you would do with this power?

10. Imagine you have the power to violate the first law of thermodynamics for one day. What are three things you would do with this power?

11. Distinguish between a positive feedback loop and a negative feedback loop in a system, and give an example of each.

12. Distinguish between a time delay and a synergistic interaction in a system and give an example of each.

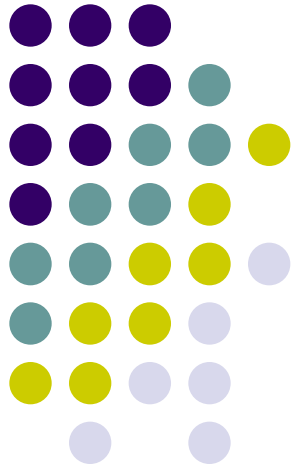
13. What is a tipping point?

ADDITIONAL INFORMATION ON THE NEXT PAGE!

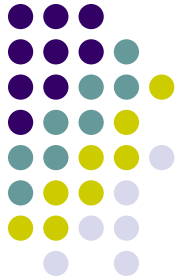
## *Additional Notes and Reminders*:

- All answers must be handwritten on loose leaf paper.
- Refer to Internet sources for answers and solutions. Keep in mind that your answers must be written in your own words! NO PLAGIARISM!
- Refer to the Studying Science PowerPoint notes for additional explanations on basic math skills.
- Refer to this website: http://www.bozemanscience.com for help on this packet. I will be using some of the podcasts posted on this website for many of our class lectures. There are also a few AP Environmental Science videos posted on YouTube if you need a visual presentation of a particular topic. You just need to do a search on YouTube to find them!
- Make sure to purchase the most updated edition of an AP Environmental Science prep book; I suggest *"The Princeton Review"* and "*Barron's*" prep books. Also, make sure that you start reading and working on problems from these prep books.
- This assignment will be due the first day of class; late work is not acceptable!
- You will be tested on all the materials presented in this packet during the first few weeks of school. Make sure that you review all the items presented in this packet!
- If you have any questions, feel free to E-mail me at **lmayo@pacehs.com**.
- I look forward working with you and ensuring your success on the AP Environmental Science exam!

# Studying Science



# What is Science?



- **Science** is a way to gather and organize information about the natural world
- It is a collection of facts and theories about the world around you

# Science Skills

- **Data** (information) is obtained by using the following science skills:

A. Observe
B. Infer
C. Estimate
D. Measure

# Science Skills

E. Predict
F. Classify
G. Hypothesize
H. Record and Organize
I. Analyze

# Experiments

- Need to be carefully designed to:

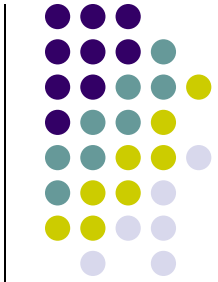
1. Observe how something behaves
2. Investigate an observation
3. Test an idea, prediction, or hypothesis
4. Get answers to a question

# Experiments

- Most experiments are **controlled experiments**
- ***Definition***: an experiment with two test groups

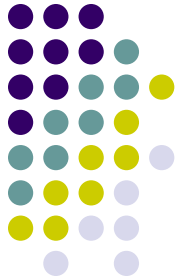
1. experimental group
2. control group

# Experiments



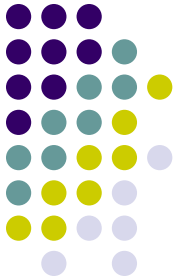
1. **control group** – a standard by which any change can be measured
2. **experimental group** – all the factors except one are the same as those in the control group

# Experiments



- The factors that are kept the same are known as **constants**
- The factor that is changed is known as the **variable**

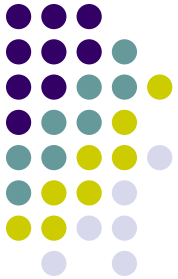
# The Scientific Method



- ***Definition***: a method that tests ideas, predictions and hypotheses
- The steps of the scientific method are as follows:

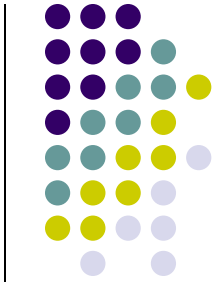
1. State the Problem – what do you want to find out?
2. State the Hypothesis – an educated guess about the problem

# The Scientific Method



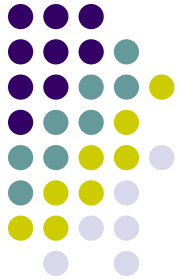
3. Plan your Experiment – to design an experiment
4. Make a Prediction about your Experiment
5. Gather and Organize Data
6. Analyze Data
7. State the Conclusion

# The Scientific Method



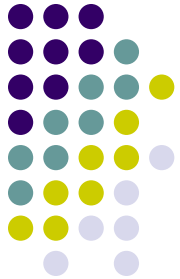
- If the experiment works, and several trials of the experiment prove that the hypothesis is indeed true, then the experiment will be considered either a law or theory

# The Scientific Method



- **Law**:  a formal statement in which a set of natural phenomena occur under certain conditions
- **Theory**:  an integrated group of fundamental principles underlying practical applications

# Measuring with Scientific Units



- The system of measurements used throughout most of the world today is the SI Unit, also known as the metric system

1. based on multiples of 10
2. calculations made by multiplying or dividing
3. to change quantities, you move a decimal point

# Prefixes Used in SI

| Measurement | Unit | Symbol |
|---|---|---|
| kilo | 1,000 | k |
| hecto- | 100 | h |
| deca- | 10 | da |
| deci- | 1/10 | d |
| centi- | 1/100 | c |
| milli- | 1/1,000 | m |
| micro- | 1/1,000,000 or $10^{-6}$ | μ |
| nano- | $10^{-9}$ | n |

# The Basic SI Units

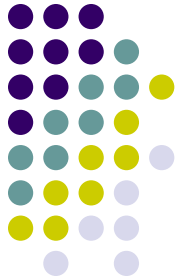
| Measure | Name of Unit | Symbol |
|---|---|---|
| Length | Meter | m |
| Mass | Kilogram | kg |
| Time | Second | s |

# Other Measurements

- **Gram** - 1 gram is equal to 1/1000 kg

1. it is a measure of mass
2. **mass** is the amount of matter that an object contains

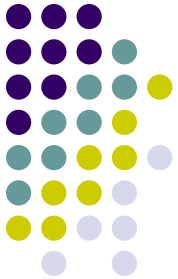
# Other Measurements



- **Density**: how much matter is packed into a given volume

1. Unit: grams of matter per cubic centimeter ($g/cm^3$)
2. can be used to identify a substance
3. can determine whether something will float or sink

# Other Measurements



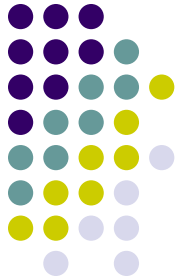
- **Liter (L)** – 1 L = 1000 mL

1. it is a measure of volume
2. **volume** is the amount of space that something occupies
3. the SI unit of volume is the **cubic meter**, $\mathbf{m^3}$

# Other Measurements

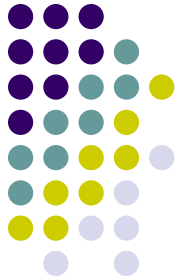
- **Kelvin**, **Celsius**, and **Fahrenheit** – all measure temperature
- **Time**:  SI unit is the second (s)

# Scientific Notation



- A shorthanded form of writing numbers
- Written as the product of two numbers; the first is a number between 1 and 10, the other number is 10 and has a small number called an exponent written above it

# Scientific Notation

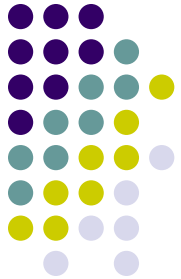


- For example:

  40000 can be written as $4 \times 10^4$

  For big numbers, you move the decimal place from the right to the left

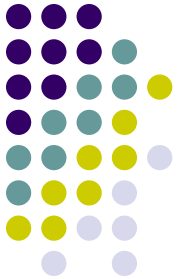
# Scientific Notation



0.000002 can be written as $2 \times 10^{-6}$

For small numbers, you move from the left to the right

# Dimensional Analysis



- A method of keeping track of units when converting
- By using the conversion factor, one is able to convert a measurement into another one.

# Dimensional Analysis

- For example:

  How many kilometers are there in 125 meters?

  125 $\cancel{m}$ x 1 km/1000 $\cancel{m}$ = 0.125 km

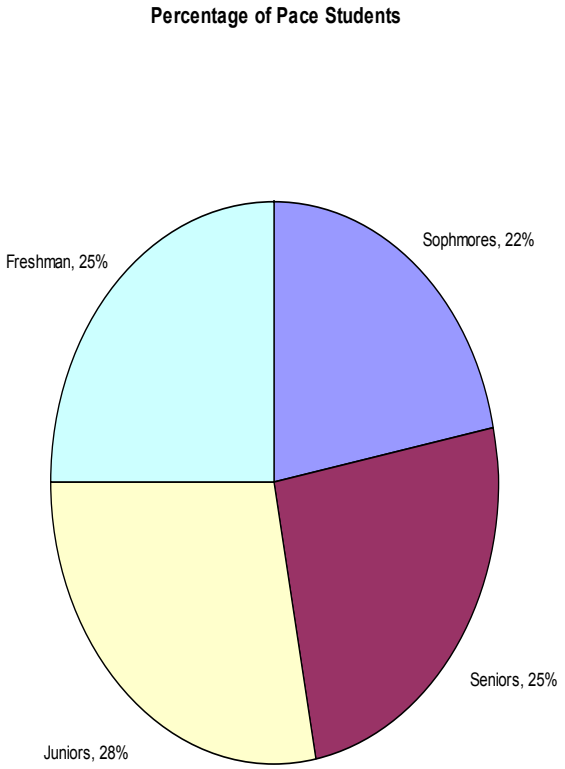
# Graphing

- A graph is a visual presentation of data
- They show numerical data in diagram form
- There are many different types of graphs, but for this course, we will only know three:

A. circle graphs
B. bar graphs
C. line graphs

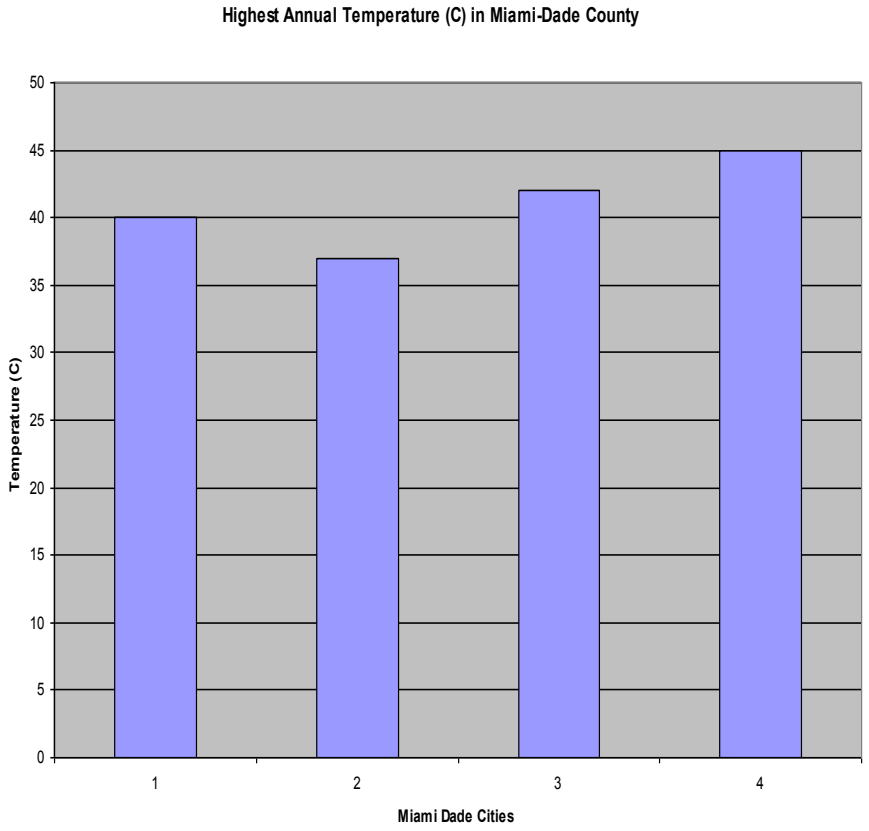
# Circle Graph

- It is circle divided into parts (just think of it as a slice of pie).
- It shows fractions, percentages, shares, or proportions of the whole
- Basically, the data that is presented are a proportion of a whole



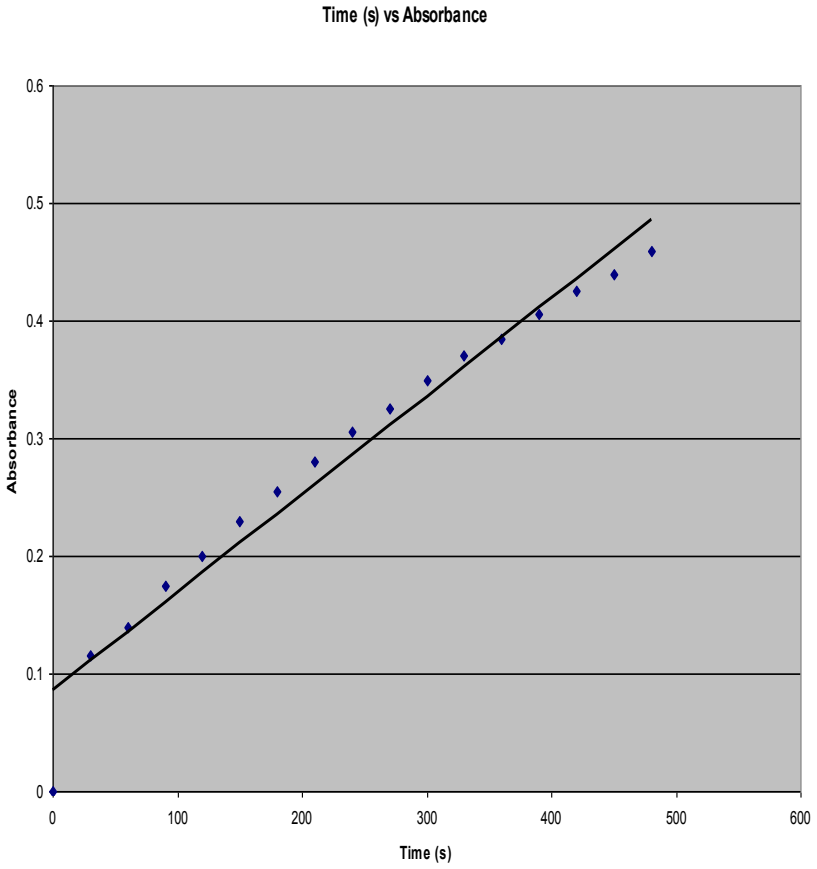
# Bar/Column Graph

- They are used to compare measurements, such as weight, height, and length, about groups or individual items
- They also compare quantities and change over time



# Line Graph

- They are used to compare sets of numerical data
- They show change and patterns
- Horizontal line is the x-axis, while the vertical line is the y-axis
- Remember the formula for a line:  y = mx + b



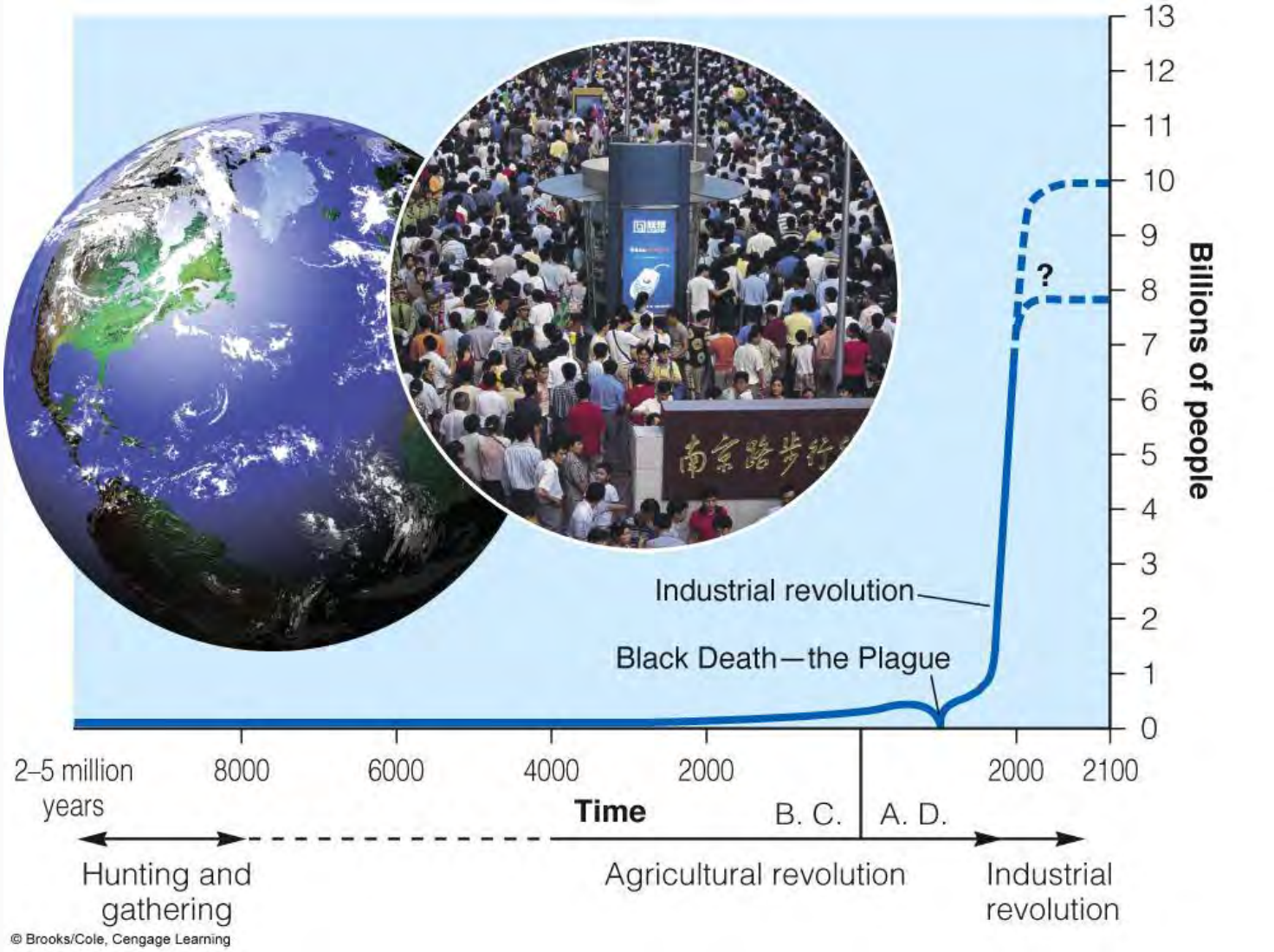
# Environmental Problems, Their Causes, and Sustainability

## Chapter 1

# Core Case Study: Living in an Exponential Age

- Impact of human exponential growth on
  - Loss of animal and plant species
  - Loss of resources

# Exponential Growth



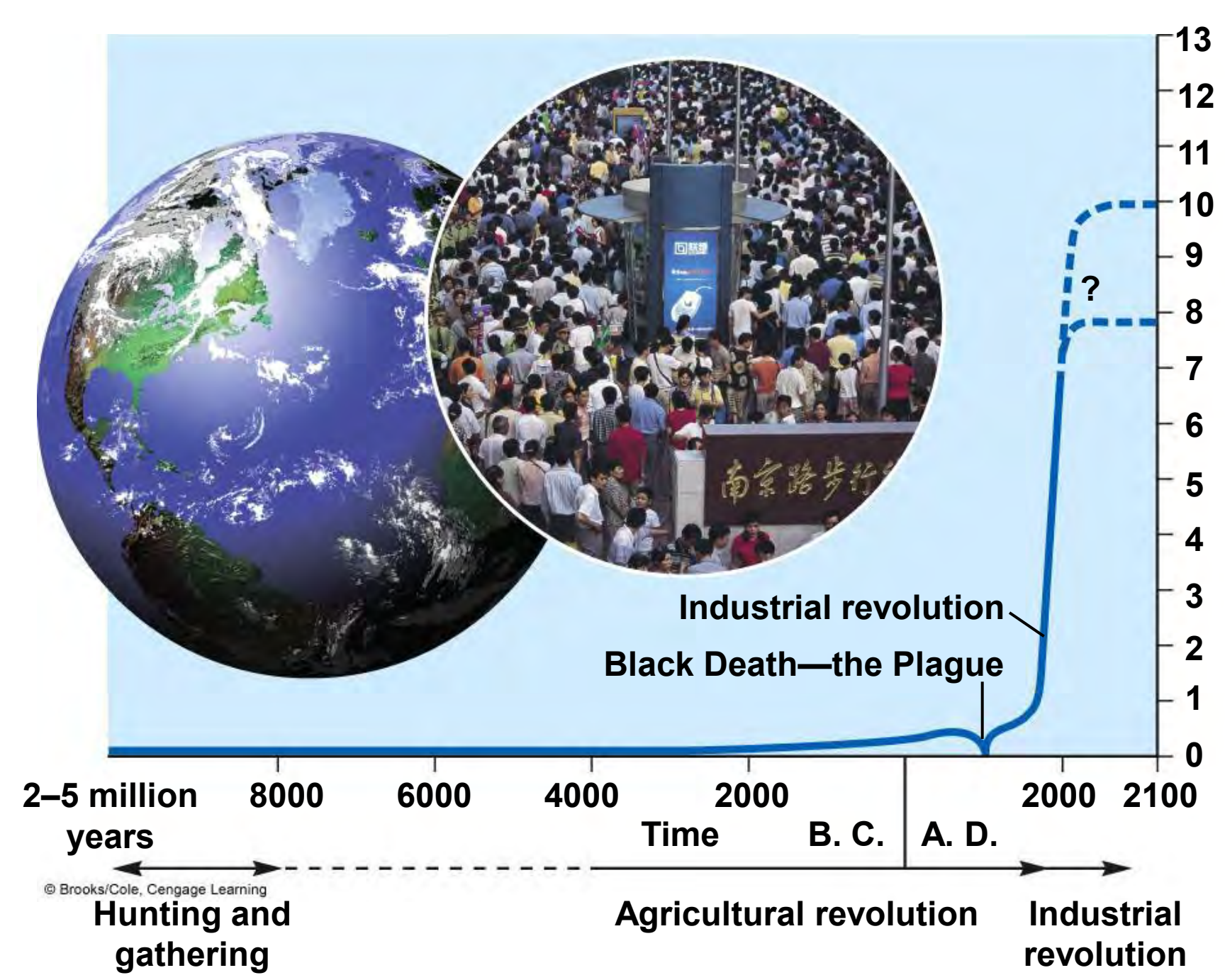

13
12
11
10
9
8
7
6
5
4
3
2
1
0
Billions of people
?
Industrial revolution
Black Death—the Plague
2–5 million years
8000
6000
4000
2000
2000
2100
Time
B. C.
A. D.
© Brooks/Cole, Cengage Learning
Hunting and gathering
Agricultural revolution
Industrial revolution

Fig. 1-1, p. 5

# *1-1 What Is an Environmentally Sustainable Society?*

- ***Concept 1-1A*** *Our lives and economies depend on energy from the sun (solar capital) and on natural resources and natural services (natural capital) provided by the earth.*

- ***Concept 1-1B*** *Living sustainability means living off the earth's natural income without depleting or degrading the natural capital that supplies it.*

# Environmental Science Is a Study of Connections in Nature (1)

- Interdisciplinary science connecting information and ideas from
  - Natural sciences, with an emphasis on ecology
  - Social sciences
  - Humanities

# Environmental Science Is a Study of Connections in Nature (2)

- How nature works
- How the environment affects us
- How we affect the environment
- How to deal with environmental problems
- How to live more sustainably

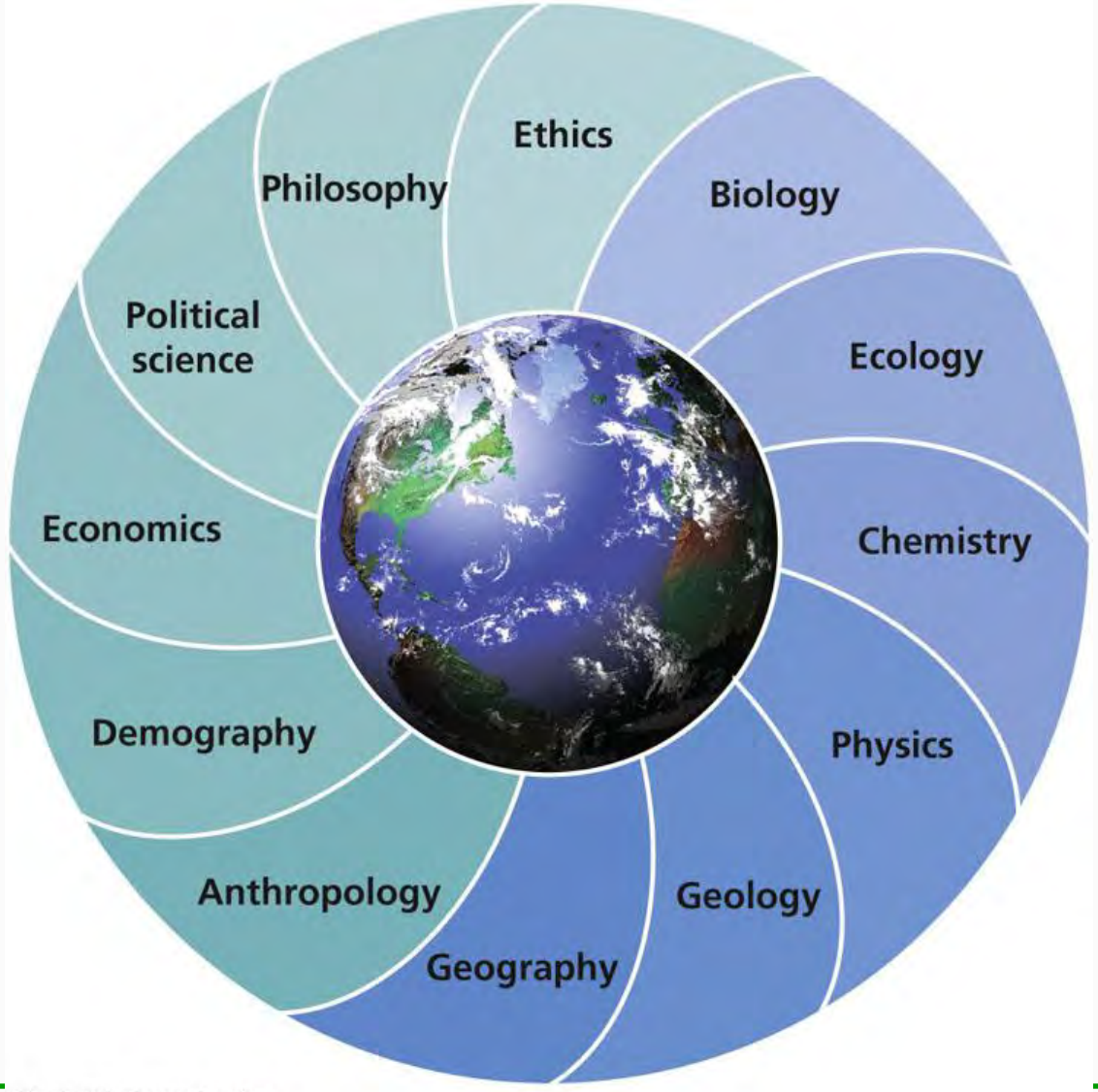
# Major Fields of Study Related to Environmental Science

**Table 1-1**

**Major Fields of Study Related to Environmental Science**

| Major Fields | Subfields |
|---|---|
| **Biology:** study of living things (organisms) | **Ecology:** study of how organisms interact with one another and with their nonliving environment |
| | **Botany:** study of plants |
| | **Zoology:** study of animals |
| **Chemistry:** study of chemicals and their interactions | **Biochemistry:** study of the chemistry of living things |
| **Earth science:** study of the planet as a whole and its nonliving systems | **Climatology:** study of the earth's atmosphere and climate |
| | **Geology:** study of the earth's origin, history, surface, and interior processes |
| | **Hydrology:** study of the earth's water resources |
| | **Paleontology:** study of fossils and ancient life |
| **Social sciences:** studies of human society | **Anthropology:** study of human cultures |
| | **Demography:** study of the characteristics of human populations |
| | **Geography:** study of the relationships between human populations and the earth's surface features |
| | **Economics:** study of the production, distribution, and consumption of goods and services |
| | **Political Science:** study of the principles, processes, and structure of government and political institutions |
| **Humanities:** study of the aspects of the human condition not covered by the physical and social sciences | **History:** study of information and ideas about humanity's past |
| | **Ethics:** study of moral values and concepts concerning right and wrong human behavior and responsibilities |
| | **Philosophy:** study of knowledge and wisdom about the nature of reality, values, and human conduct |

# Environmental Science Is an Interdisciplinary Study



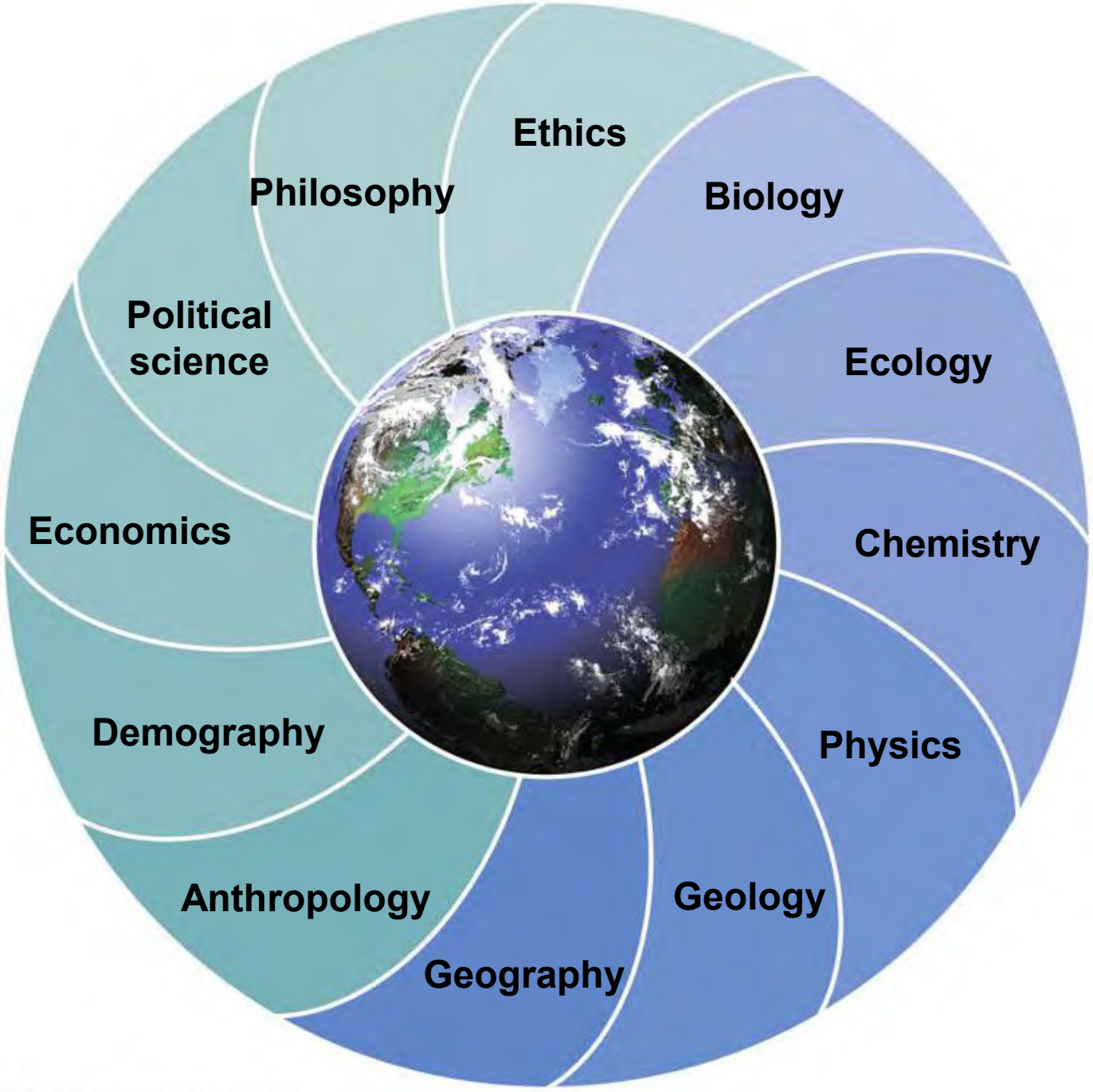


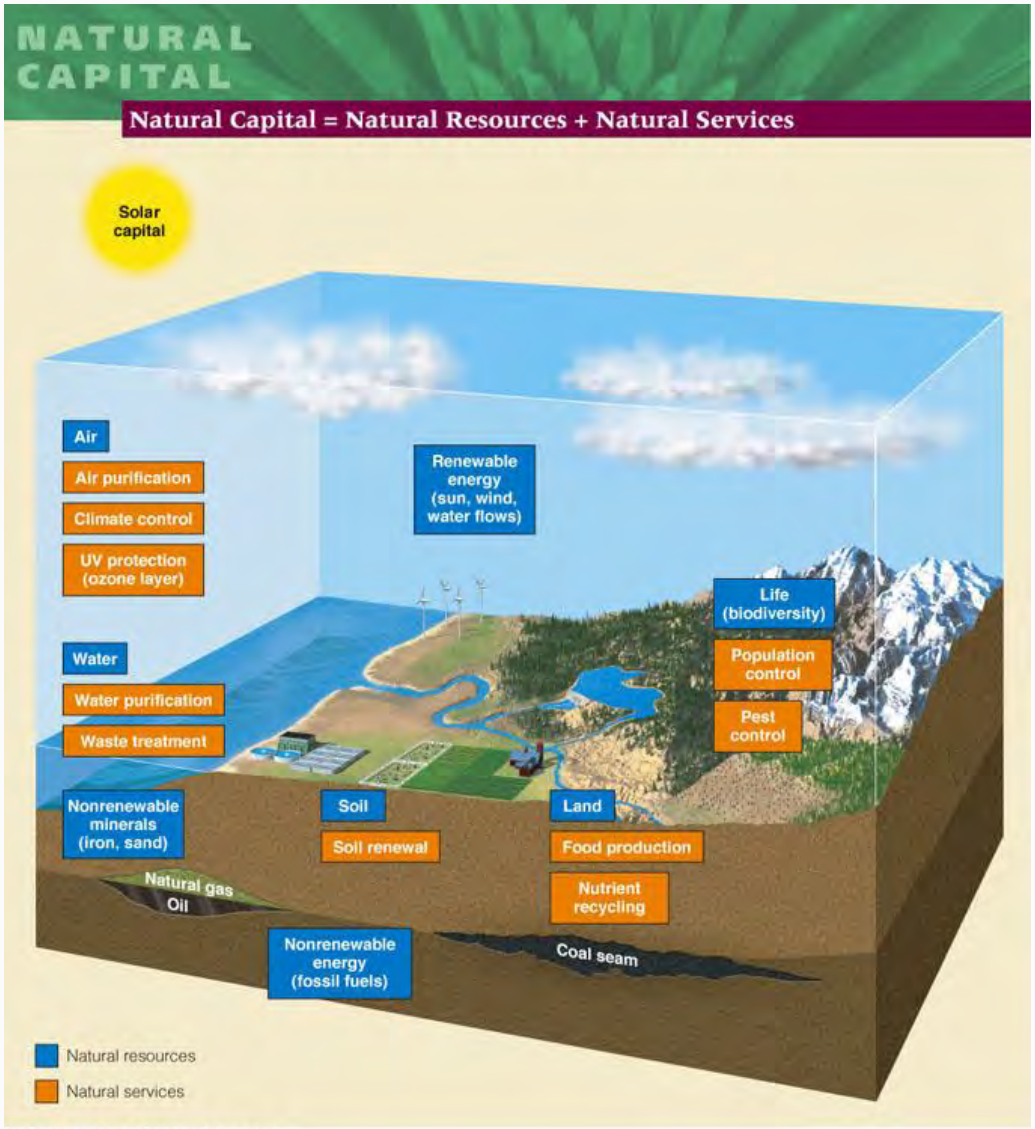



Fig. 1-2, p. 7

# Sustainability Is the Central Theme of This Book

- Natural capital: supported by solar capital
  - Natural resources
  - Natural services
    - E.g., nutrient cycling
- Degradation of natural capital through human activities
- Scientific solutions

# Natural Capital = Natural Resources + Natural Services



# NATURAL CAPITAL

## Natural Capital = Natural Resources + Natural Services

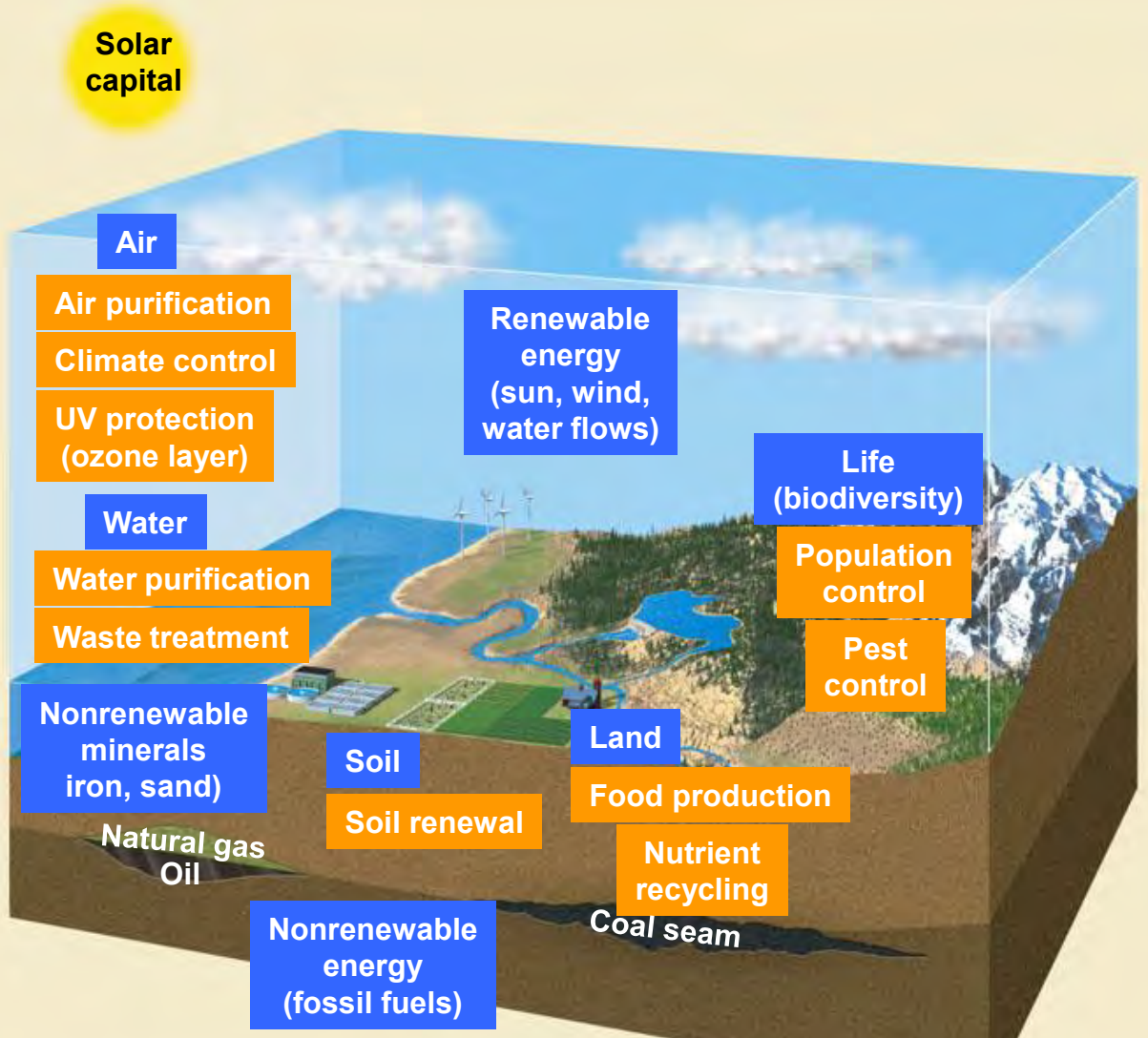
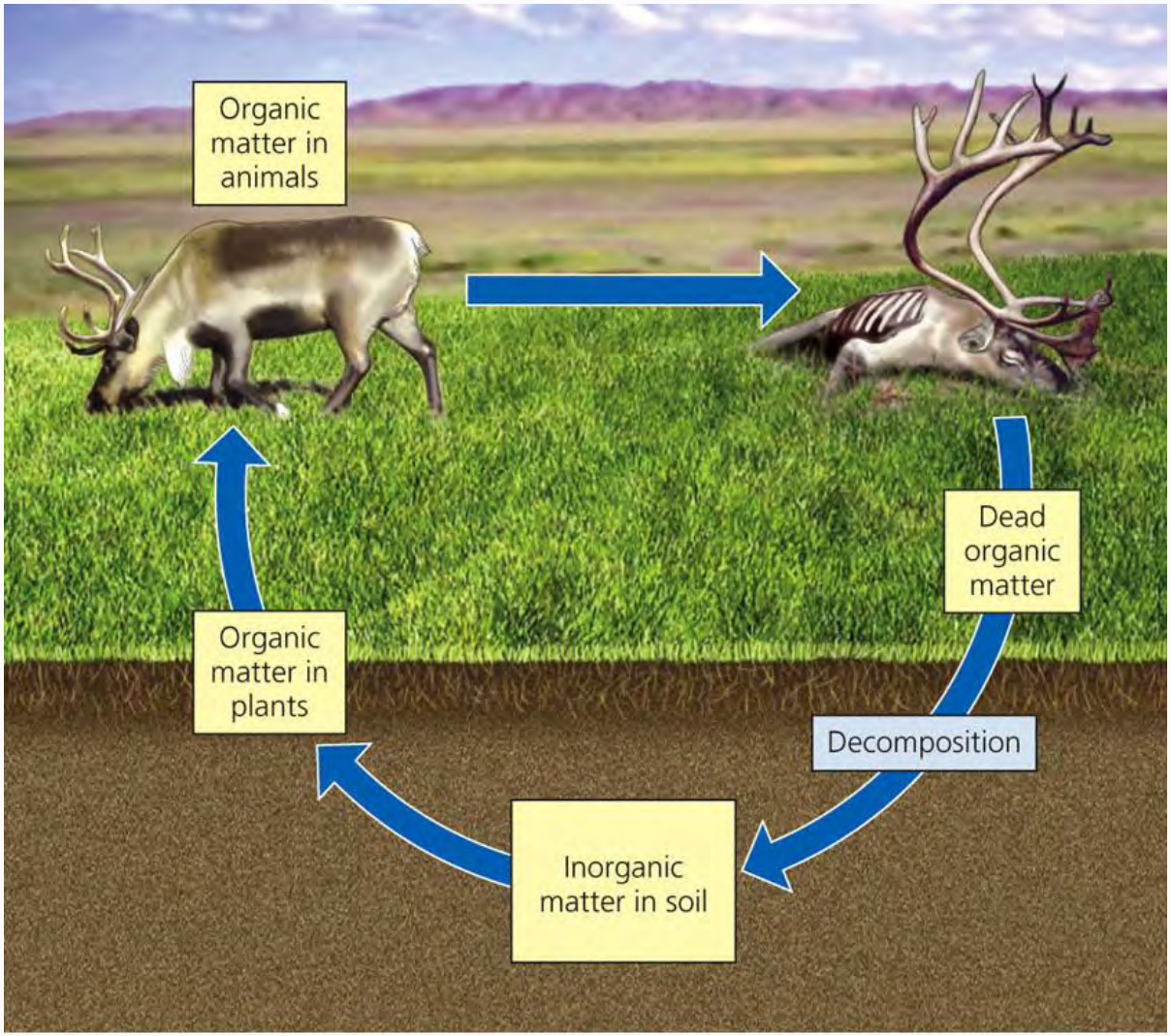





Fig. 1-3, p. 8

# Nutrient Cycling



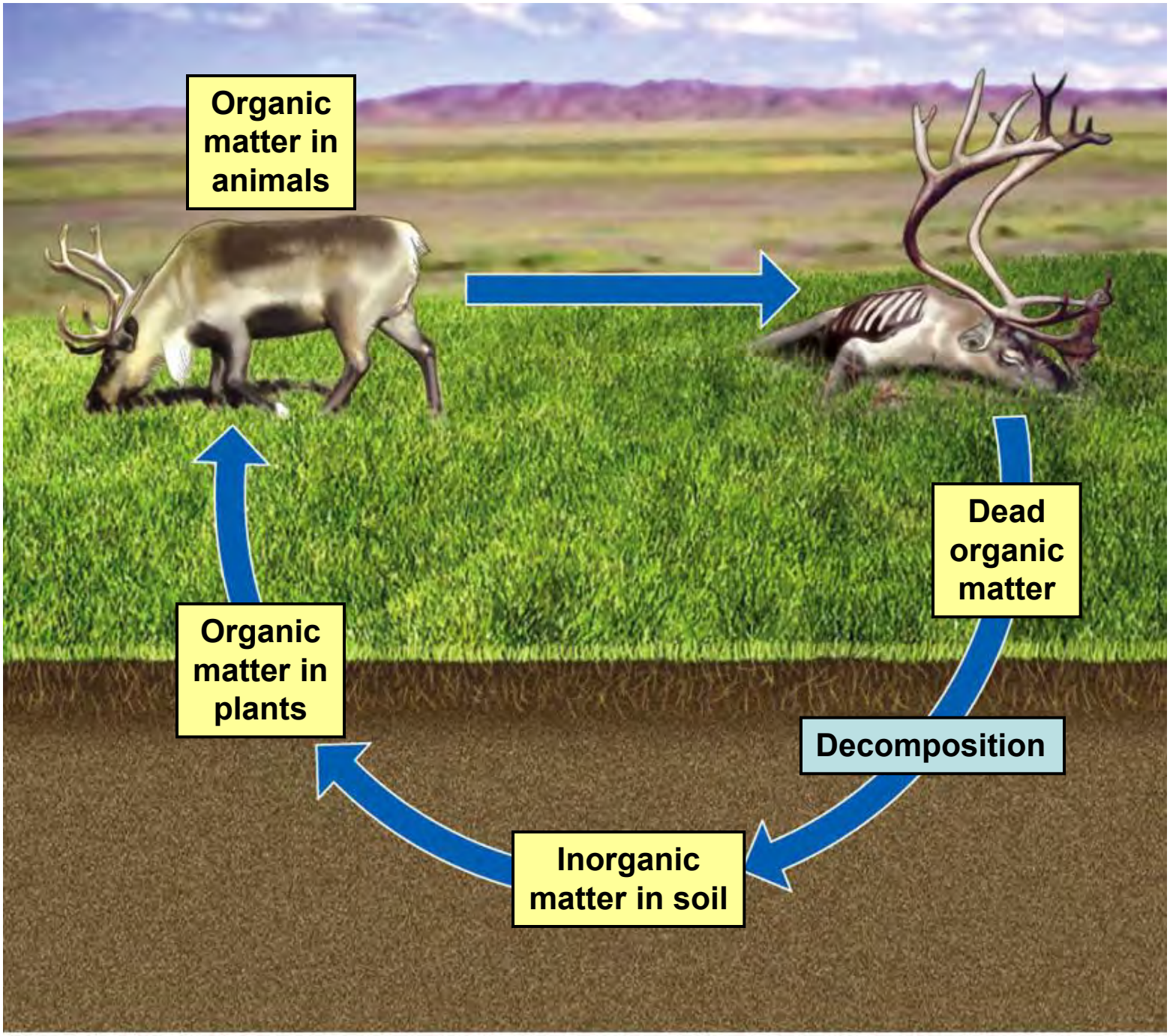





Fig. 1-4, p. 9

# Environmentally Sustainable Societies Protect Natural Capital and Live off Its Income

- Live off natural income
- Human activity and its affect on the earth's natural capital

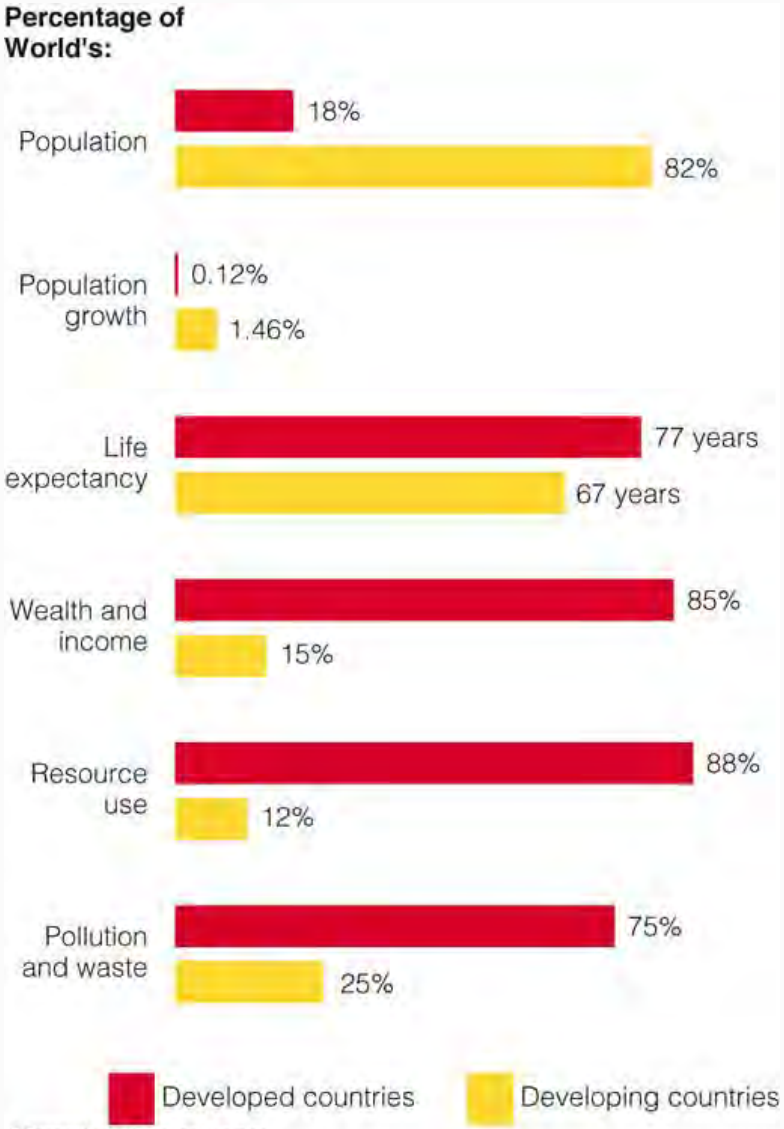
# *1-2 How Can Environmentally Sustainable Societies Grow Economically?*

- ***Concept 1-2*** *Societies can become more environmentally sustainable through economic development dedicated to improving the quality of life for everyone without degrading the earth's life support systems.*

# There Is a Wide Economic Gap between Rich and Poor Countries

- Country's economic growth: measured by **gross domestic product (GDP)**
- Changes in economic growth: measured by **per capita GDP**
- Purchasing power parity (PPP) plus GDP are combined for **per capita GDP PPP**
- Compare developed with developing countries

# Comparison of Developed and Developing Countries, 2008



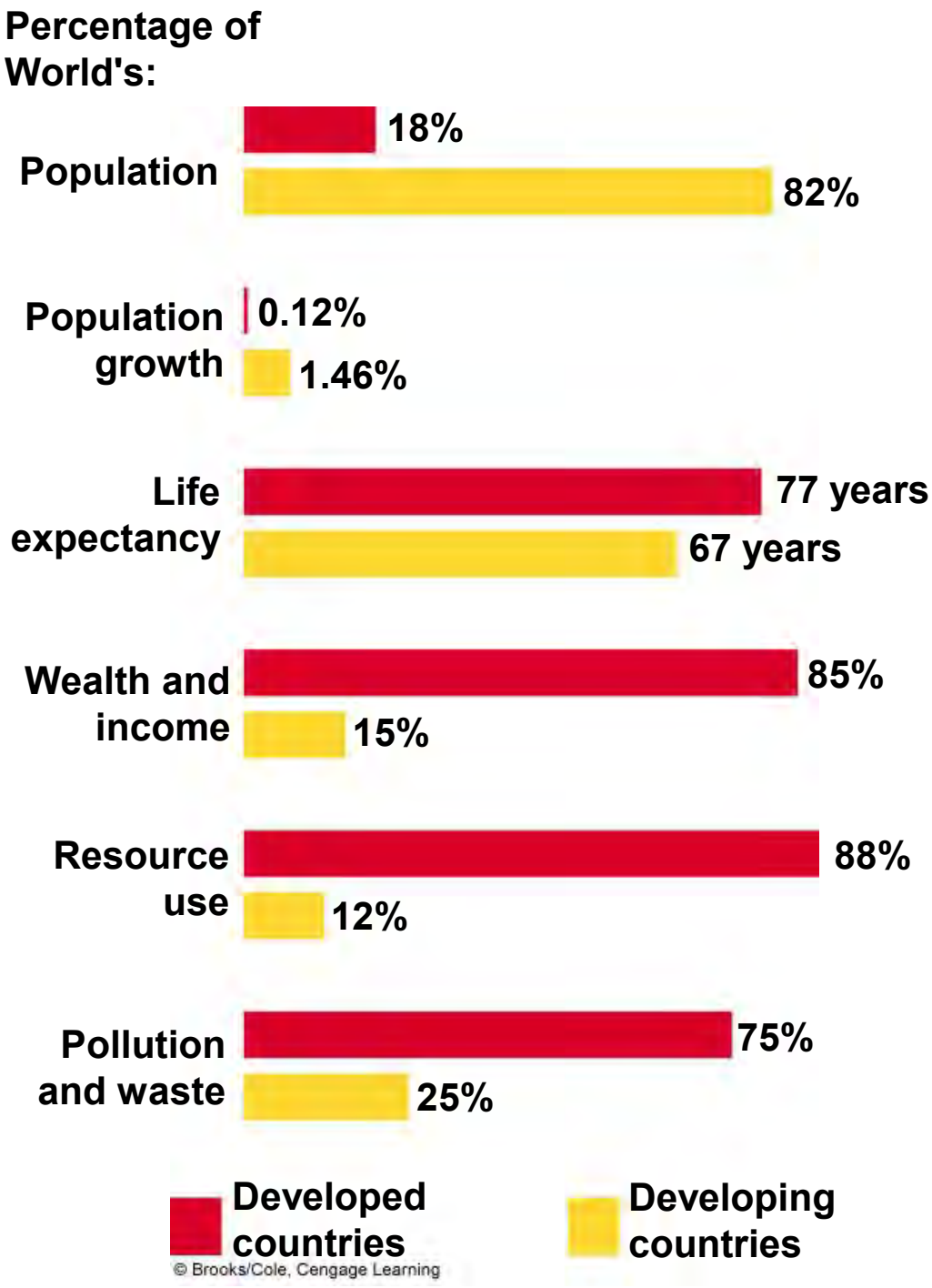

Percentage of World's:
Population
18%
82%
Population growth
0.12%
1.46%
Life expectancy
77 years
67 years
Wealth and income
85%
15%
Resource use
88%
12%
Pollution and waste
75%
25%
Developed countries
Developing countries
© Brooks/Cole, Cengage Learning

Fig. 1-5, p. 11

# Extreme Poverty in a Developing Country

# 1-3 *How Are Our Ecological Footprints Affecting the Earth?*

- ***Concept 1-3*** *As our ecological footprints grow, we are depleting and degrading more of the earth's natural capital.*

# Some Sources Are Renewable (1)

- **Resource**
  - Directly available for use
  - Not directly available for use
- **Perpetual resource**
  - Solar energy

# Some Sources Are Renewable (2)

- **Renewable resource**
  - E.g., forests, grasslands, fresh air, fertile soil
- **Sustainable yield**
- **Environmental degradation**

# Degradation of Normally Renewable Natural Resources and Services

# Overexploiting Shared Renewable Resources: Tragedy of the Commons

- Three types of property or resource rights
  - **Private property**
  - **Common property**
  - **Open access renewable resources**

- Tragedy of the commons
  - Solutions

# Some Resources Are Not Renewable

- **Nonrenewable resources**
  - Energy resources
  - Metallic mineral resources
  - Nonmetallic mineral resources
- **Reuse**
- **Recycle**

# Reuse

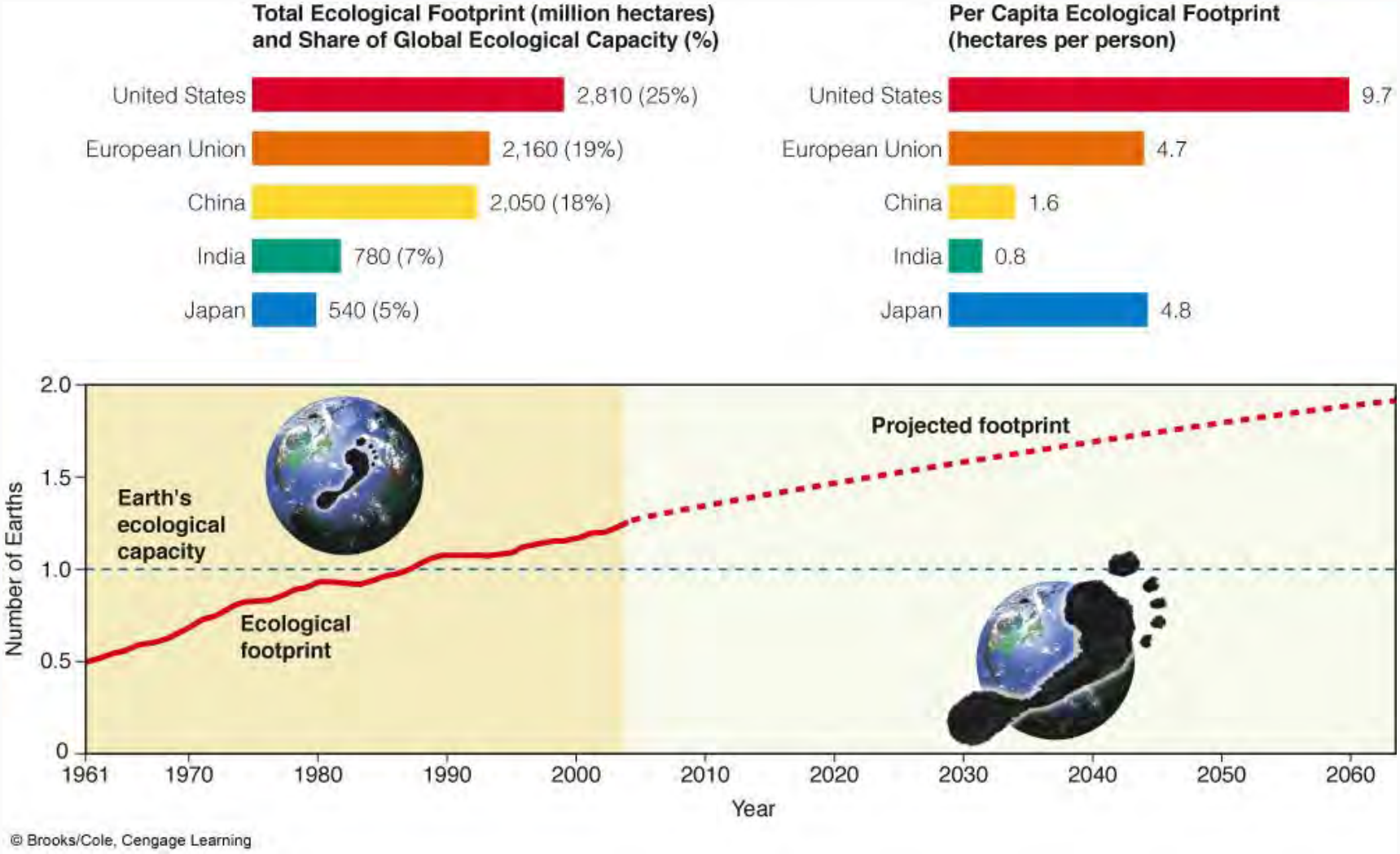
# Consumption of Natural Resources

# Consumption of Natural Resources

# Our Ecological Footprints Are Growing

- **Ecological footprint** concept
  - Biological capacity
  - Ecological footprint

# Natural Capital Use and Degradation



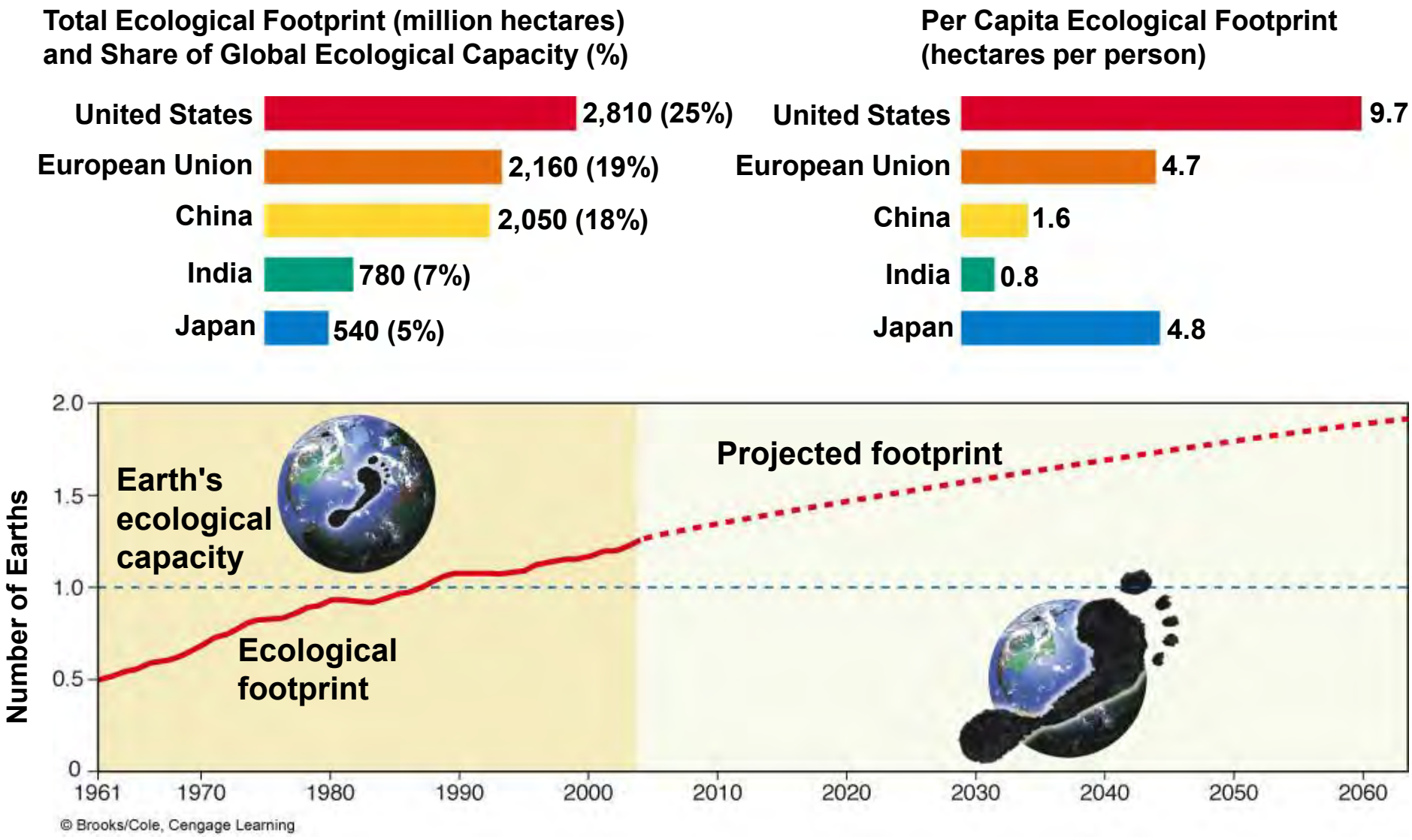

Total Ecological Footprint (million hectares) and Share of Global Ecological Capacity (%)
United States
2,810 (25%)
European Union
2,160 (19%)
China
2,050 (18%)
India
780 (7%)
Japan
540 (5%)
Per Capita Ecological Footprint (hectares per person)
United States
9.7
European Union
4.7
China
1.6
India
0.8
Japan
4.8
Number of Earths
2.0
1.5
1.0
0.5
0
Earth's ecological capacity
Projected footprint
Ecological footprint
1961
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
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Fig. 1-10, p. 15

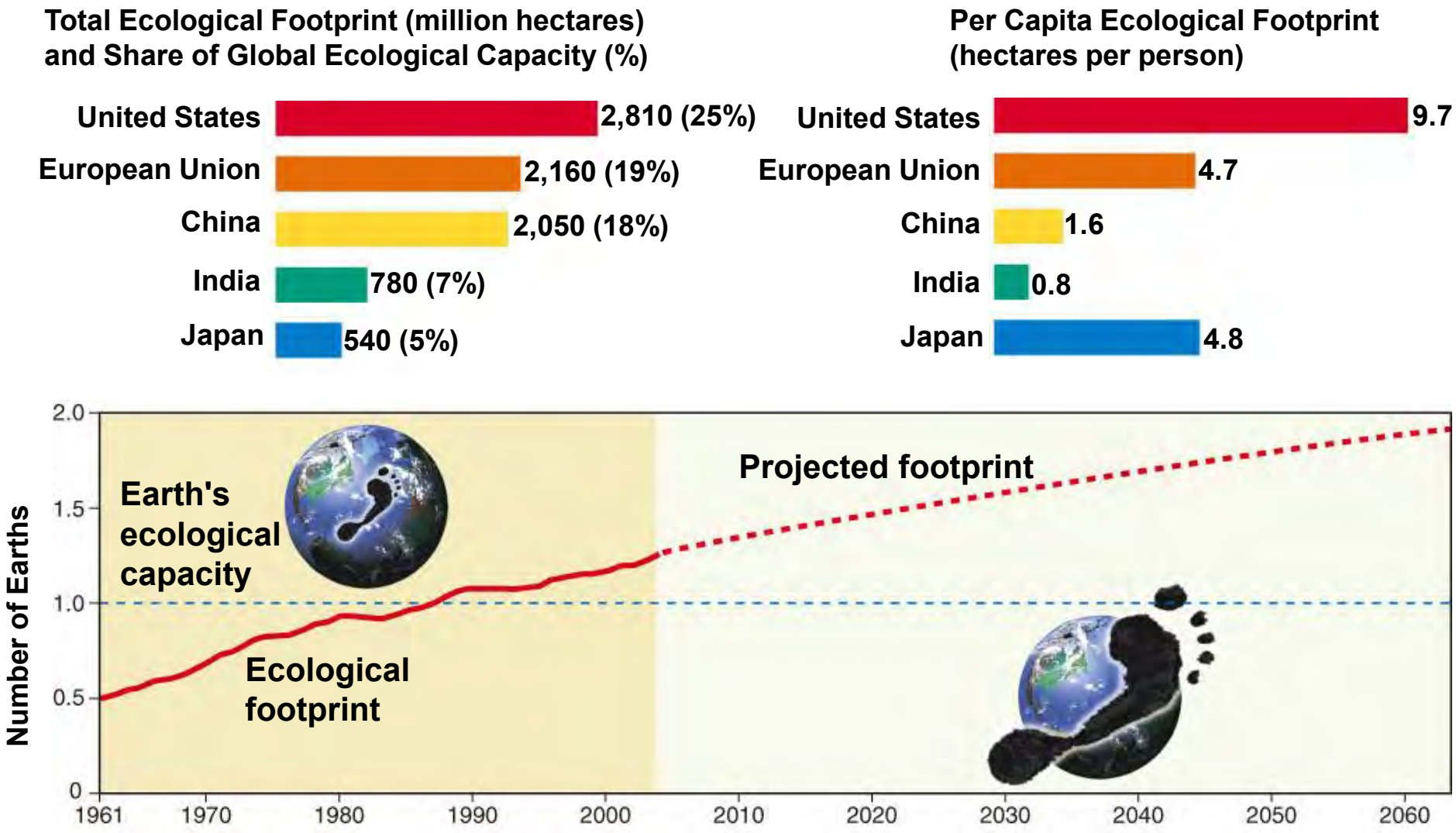


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Fig. 1-10, p. 15

# Case Study: China's New Affluent Consumers (1)

- Leading consumer of various foods and goods
  - Wheat, rice, and meat
  - Coal, fertilizers, steel, and cement
- Second largest consumer of oil

# Case Study: China's New Affluent Consumers (2)

- Two-thirds of the most polluted cities are in China

- Projections, by 2020
  - Largest consumer and producer of cars
  - World's leading economy in terms of GDP PPP

# Cultural Changes Have Increased Our Ecological Footprints

- 12,000 years ago: hunters and gatherers

- Three major cultural events
  - Agricultural revolution
  - Industrial-medical revolution
  - Information-globalization revolution

# *1-4 What Is Pollution and What Can We Do about It?*

- ***Concept 1-4*** *Preventing pollution is more effective and less costly than cleaning up pollution.*

# Pollution Comes from a Number of Sources

- Sources of pollution
  - **Point**
    - E.g., smokestack
  - **Nonpoint**
    - E.g., pesticides blown into the air
- Main type of pollutants
  - **Biodegradable**
  - **Nondegradable**
- Unwanted effects of pollution

# Point-Source Air Pollution

# We Can Clean Up Pollution or Prevent It

- Pollution cleanup (**output pollution control**)
- Pollution prevention (**input pollution control**)

# *1-5 Why Do We Have Environmental Problems? (1)*

- ***Concept 1-5A*** *Major causes of environmental problems are population growth, wasteful and unsustainable resource use, poverty, exclusion of environmental costs of resource use from the market prices of goods and services, and attempts to manage nature with insufficient knowledge.*

# *1-5 Why Do We Have Environmental Problems? (2)*

- ***Concept 1-5B*** *People with different environmental worldviews often disagree about the seriousness of environmental problems and what we should do about them.*

# Experts Have Identified Five Basic Causes of Environmental Problems

- Population growth
- Wasteful and unsustainable resource use
- Poverty
- Failure to include the harmful environmental costs of goods and services in their market prices
- Insufficient knowledge of how nature works

# Causes of Environmental Problems

## Causes of Environmental Problems

Population growth

Unsustainable resource use

Poverty

Excluding environmental costs from market prices

Trying to manage nature without knowing enough about it

## Causes of Environmental Problems

Population growth

Unsustainable resource use

Poverty

Excluding environmental costs from market prices

Trying to manage nature without knowing enough about it



Fig. 1-12, p. 18

# Causes of Environmental Problems



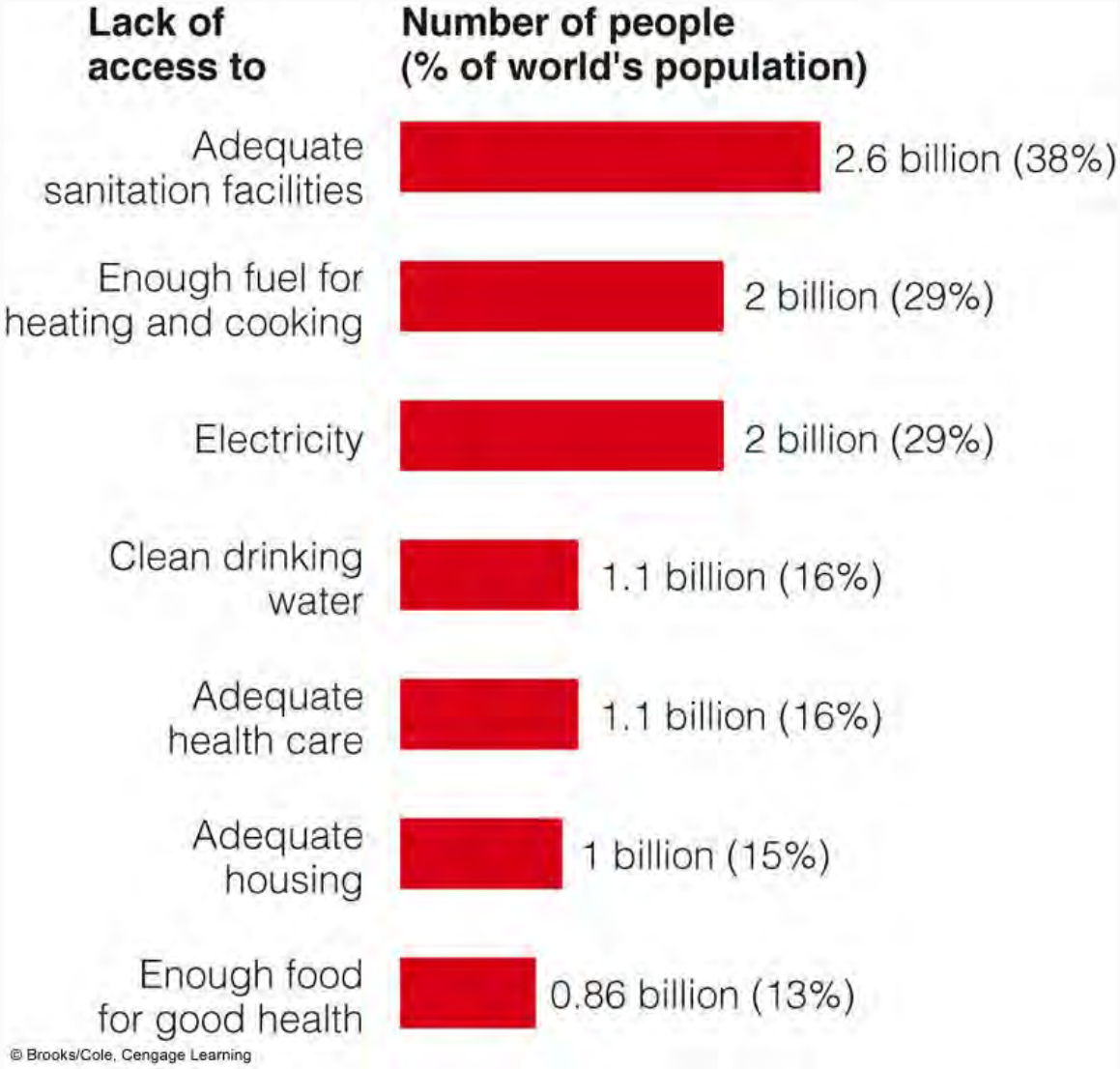
Stepped Art

Fig. 1-12, p. 18

# Poverty Has Harmful Environmental and Health Effects

- Population growth affected
- Malnutrition
- Premature death
- Limited access to adequate sanitation facilities and clean water

# Some Harmful Results of Poverty



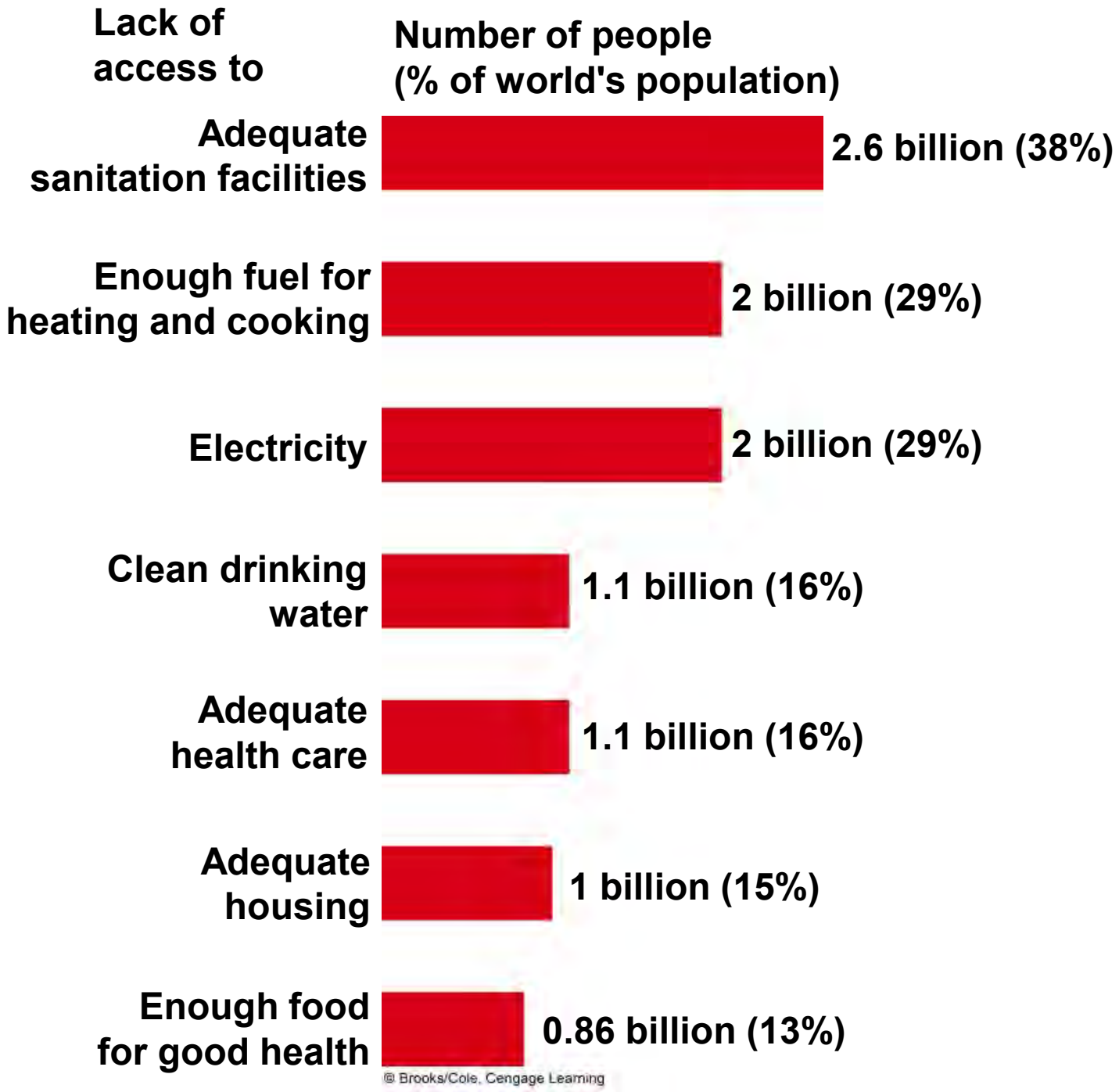

Lack of access to
Number of people (% of world's population)
Adequate sanitation facilities
2.6 billion (38%)
Enough fuel for heating and cooking
2 billion (29%)
Electricity
2 billion (29%)
Clean drinking water
1.1 billion (16%)
Adequate health care
1.1 billion (16%)
Adequate housing
1 billion (15%)
Enough food for good health
0.86 billion (13%)
© Brooks/Cole, Cengage Learning

Fig. 1-13, p. 18

# Global Outlook on Malnutrition

# Affluence Has Harmful and Beneficial Environmental Effects

- Harmful environmental impact due to
  - High levels of consumption
  - Unnecessary waste of resources

- Affluence can provide funding for
  - Developing technologies to reduce
    - Pollution
    - Environmental degradation
    - Resource waste

# Prices Do Not Include the Value of Natural Capital

- Companies do not pay the environmental cost of resource use
- Goods and services do not include the harmful environmental costs
- Companies receive tax breaks and subsidies
- Economy may be stimulated but there may be a degradation of natural capital

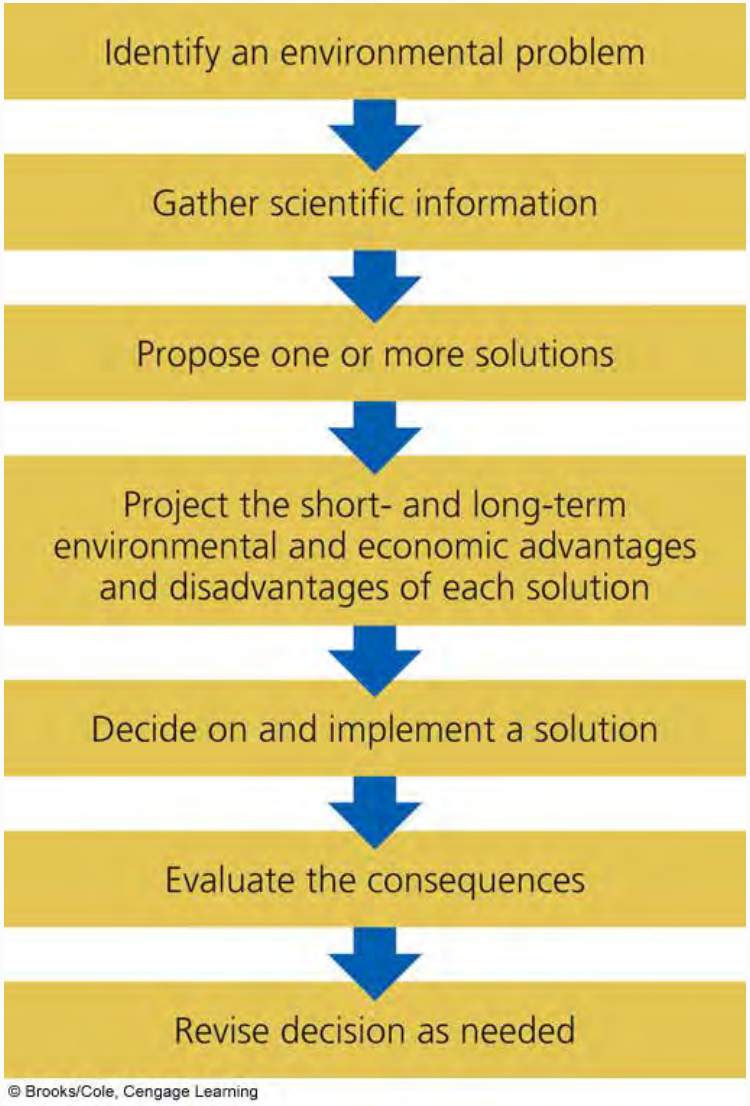
# Different Views about Environmental Problems and Their Solutions

- Environmental Worldview including environmental ethics
  - **Planetary management worldview**
  - **Stewardship worldview**
  - **Environmental wisdom worldview**

# We Can Learn to Make Informed Environmental Decisions

- Scientific research
- Identify problem and multiple solutions
- Consider human values

# Steps Involved in Making an Environmental Decision



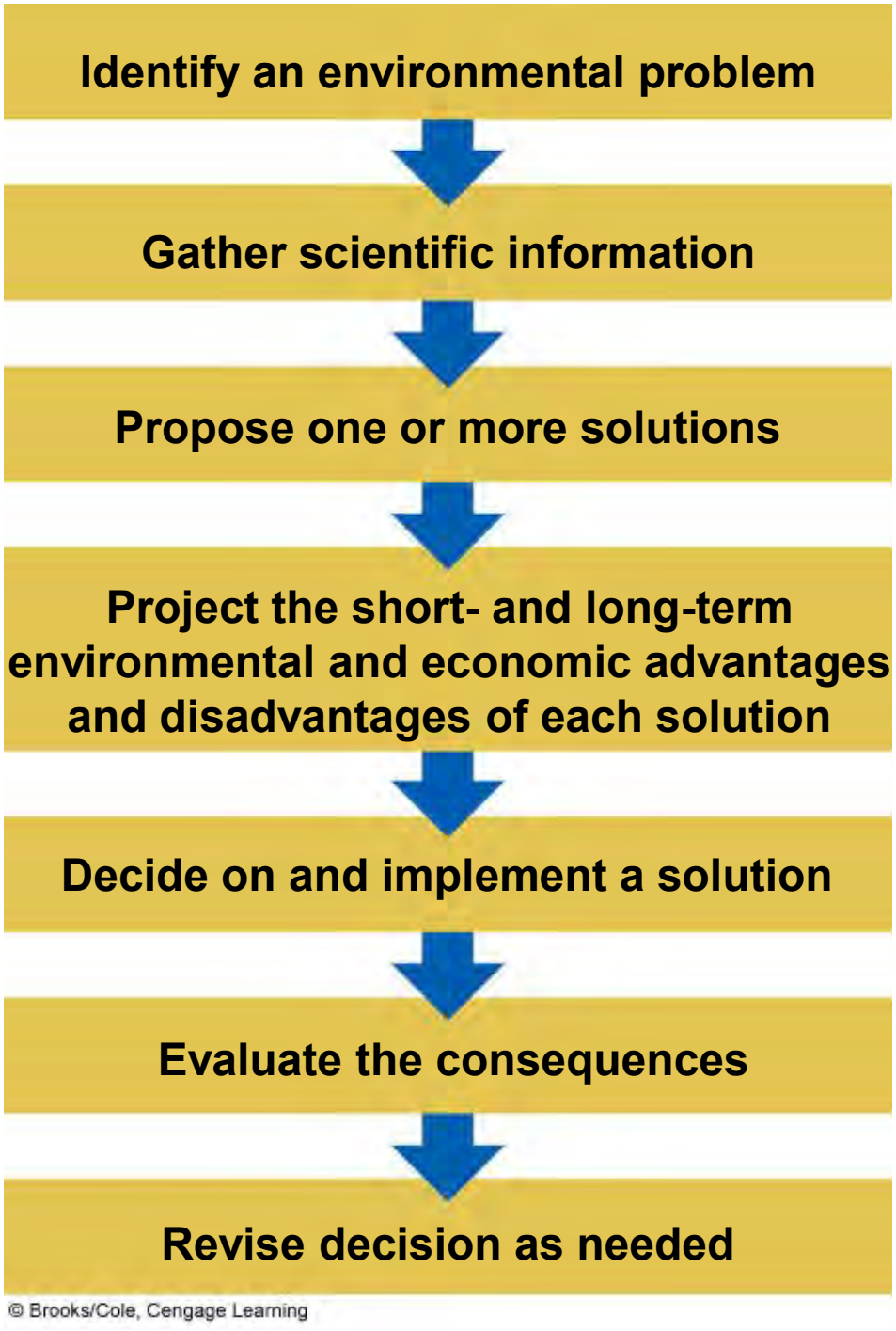




Fig. 1-15, p. 21

# We Can Work Together to Solve Environmental Problems

- **Social capital**
  - Encourages
    - Openness and communication
    - Cooperation
    - Hope
  - Discourages
    - Close-mindedness
    - Polarization
    - Confrontation and fear

# Case Study: The Environmental Transformation of Chattanooga, TN

- Environmental success story: example of building their social capital
- 1960: most polluted city in the U.S.
- 1984: *Vision 2000*
- 1995: most goals met
- 1993: *Revision 2000*

# Chattanooga, Tennessee

# Individuals Matter: Aldo Leopold

- 5–10% of the population can bring about major social change
- Anthropologist Margaret Mead
- Aldo Leopold: environmental ethics
  - A leader of the *conservation and environmental movements* of the 20th century
    - Land ethic
  - Wrote: *A Sand County Almanac*

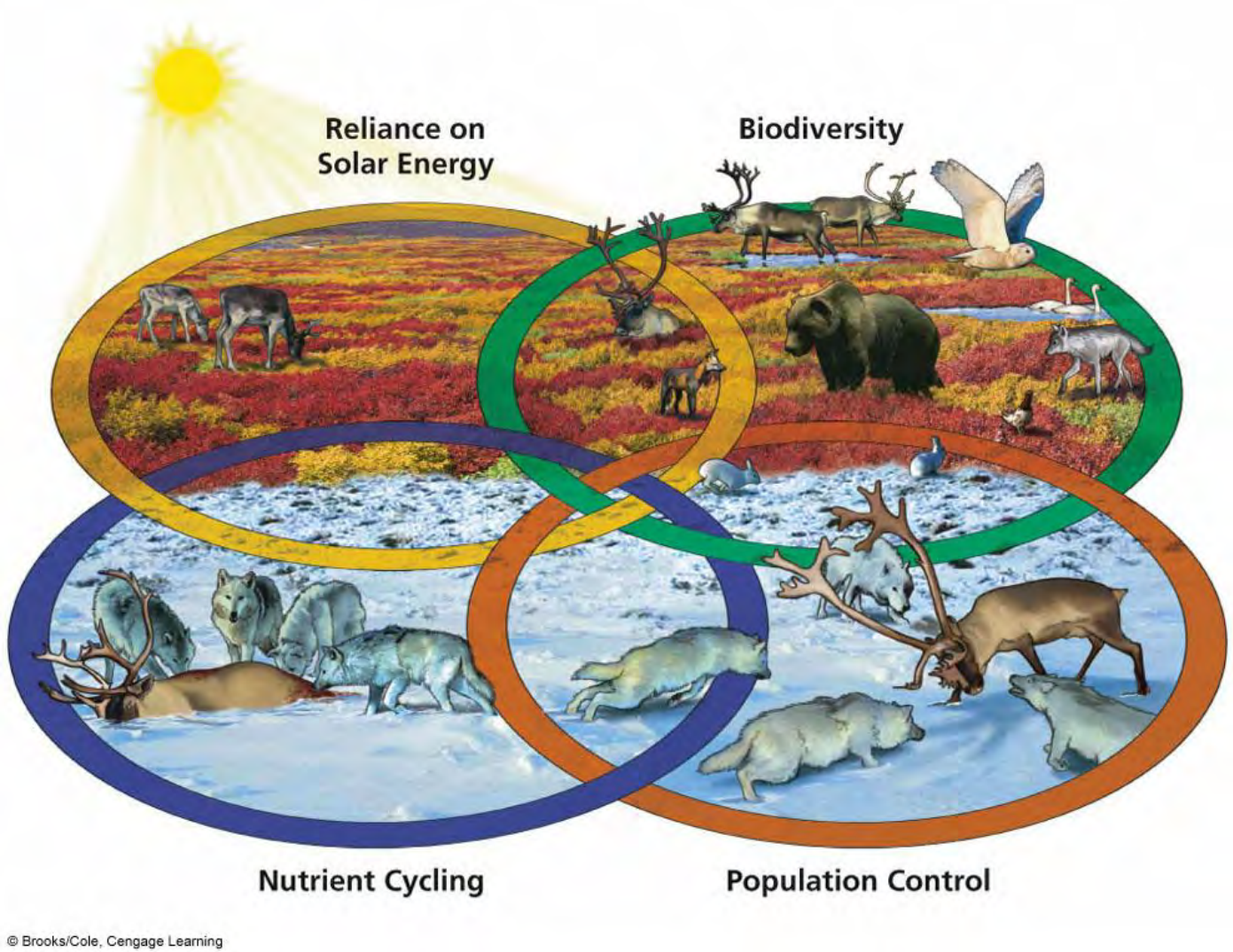
# *1-6 What Are Four Scientific Principles of Sustainability?*

- ***Concept 1- 6*** *Nature has sustained itself for billions of years by using solar energy, biodiversity, population control, and nutrient cycling—lessons from nature that we can apply to our lifestyles and economies.*

# Studying Nature Reveals Four Scientific Principles of Sustainability

- Reliance on solar energy
- Biodiversity
- Population control
- Nutrient cycling

# Four Scientific Principles of Sustainability



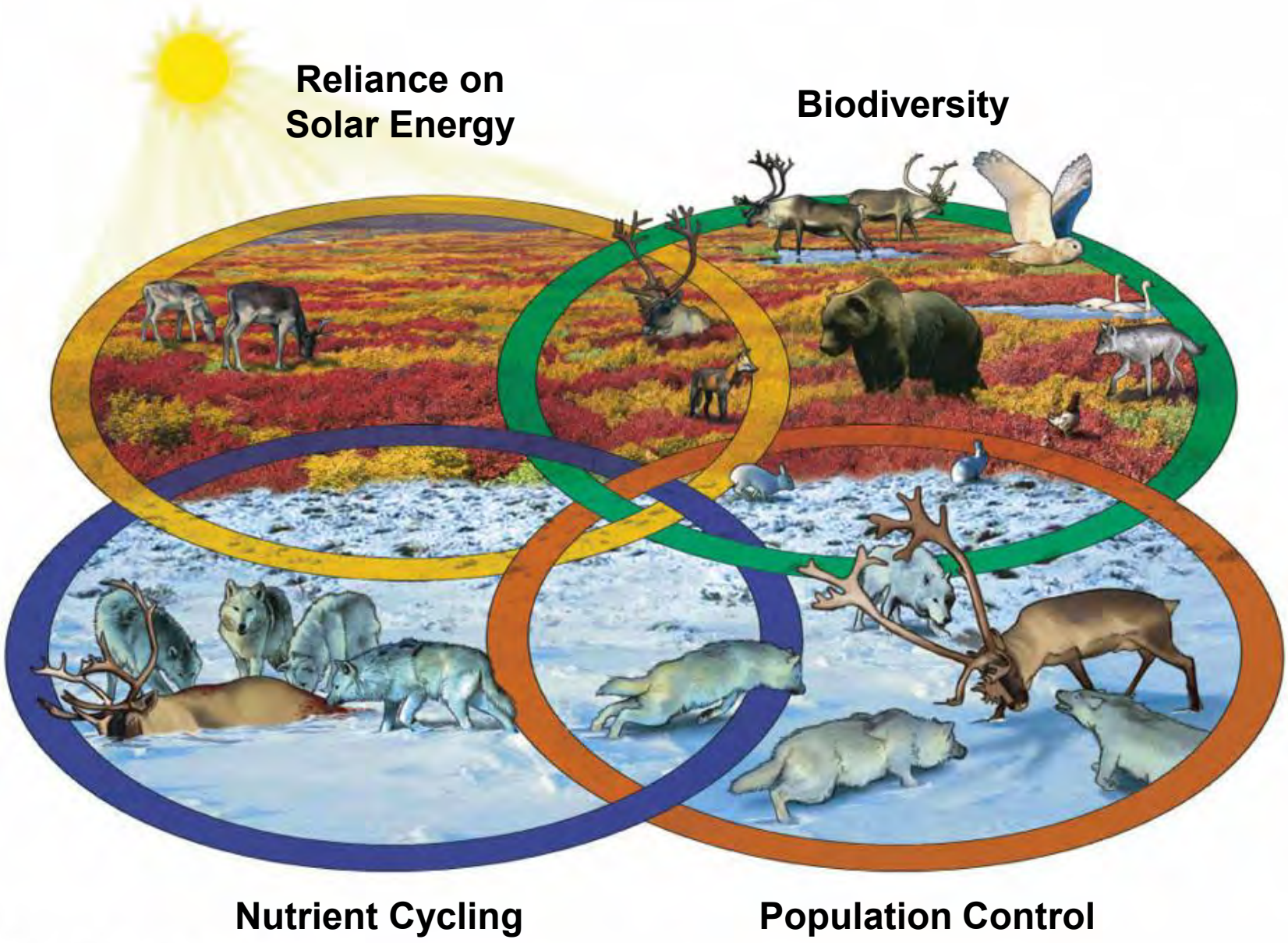





Fig. 1-17, p. 23

# Solutions For Environmental or Sustainability Revolution


Current Emphasis
Sustainability Emphasis
Pollution cleanup
Pollution prevention
Waste disposal (bury or burn)
Waste prevention
Protecting species
Protecting habitat
Environmental degradation
Environmental restoration
Increasing resource use
Less resource waste
Population growth
Population stabilization
Depleting and degrading natural capital
Protecting natural capital
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Fig. 1-18, p. 24

HUMANS AND SUSTAINABILITY: AN OVERVIEW

# Chapter 1

# Environmental Problems, Their Causes, and Sustainability

## Summary


1. All life depends on energy from the sun, solar capital, and the resources and ecological services of the earth, natural capital, to survive. An environmentally sustainable society provides for the current needs of its people without undermining the ability of future generations to do the same.

2. The world's population is growing about 1.2% per year, which adds about 77 million people per year. Economic growth increases a country's capacity to provide goods and services to its people. Economic development uses economic growth to improve standards of living. Globalization is a process of increasingly interconnecting people through social, economic, and environmental global changes.

3. The earth's main resources are perpetual resources like solar energy, renewable resources like forests and fresh water, and nonrenewable resources like oil and gas. The resources can be depleted or degraded by overuse, by waste, by pollution, and by man's increasing "ecological footprint."

4. The principle types of pollution are air, water, soil, and food pollutants. We can prevent pollution or clean up pollution. Prevention is far preferable because cleaning up pollution often causes additional pollutants in another part of the environment.

5. The basic causes of today's environmental problems are population growth, wasteful use of resources, the tragedy of the commons, poverty, poor environment accounting, and ecological ignorance. They are interconnected because of political and economic practices that are not equitable for various populations, in resource consumption and in technological applications.

6. The world's current course is not sustainable. Environmental sustainable development encourages environmentally beneficial forms of economic growth and discourages environmentally harmful growth.


## Key Questions and Concepts

### 1-1 What is an environmentally sustainable society?

**CORE CASE STUDY**. The human population is growing exponentially, consuming vast amounts of resources. It is uncertain how many people the earth can sustain, particularly in light of the pollution they create.

A. Environmental science studies how the earth works, our interaction with the earth, and the methods/procedures we use to deal with environmental problems.
B. Environmental science considers everything that affects a living organism.
C. Ecology studies relationships between living organisms and their environment.
D. Environmentalism is a social movement dedicated to protecting life support systems for all species.
E. A path toward sustainability includes five subthemes that are addressed throughout the text:
    1. Natural capital—natural resources and services that keep us and other species alive.
    2. Natural capital degradation—when human activities use renewable resources unsustainably.
    3. Solutions—are sought to degradation of natural resources.
    4. Trade-offs—or compromises are made to resolve conflicts.
    5. Individuals matter—to search for solutions to environmental problems.
F. Life and economies depend on solar capital (energy from the sun) and natural capital.

**1-2 How can environmentally sustainable societies grow economically?**

A. Economic growth provides people with the goods and services needed.
   1. Gross domestic product (GDP) is the market value for goods and services produced within the country.
   2. Standard of living is the GDP divided by total population at midyear.

B. Economic development is improving living standards through growth. Most developed countries have high industrialization and high per capita income. Developing countries have moderate to low income.
   1. Economic developments reflect good and bad economic news.
      a. Poverty produces harmful environmental effects.
   2. Developed countries enjoy a higher standard of living.
      a. Longer life expectancy.
      b. Decrease in infant mortality.
   3. Environmentally sustainable development rewards sustainable activities and discourages harmful activities.

**1-3 How are our ecological footprints affecting the earth?**

A. Natural capital/natural resources are those in the environment or those obtained from the environment: food, water, air, shelter petroleum, etc.

B. Material resources we get from the environment are classified as perpetual, renewable, or nonrenewable.
   1. A perpetual resource is renewed continuously, like solar energy.
   2. Sustainable yield is the highest rate of use on an indefinite scale without degradation or depletion.
   3. Environmental degradation occurs when use of resources exceeds rate of replacement.

C. The Tragedy of the Commons describes the overuse or degradation of freely available resources such as ocean pollution, abuse of national parks, air pollution, etc. No one individual owns these free-access resources.

D. What is our ecological footprint, our impact on the environment?
   1. The per capita ecological footprint is the biologically productive land and water needed to supply renewable resources and absorb waste for each individual.
   2. Humanity's ecological footprint exceeds by about 39% the earth's ecological capacity (or biocapacity) to replenish its renewable resources and absorb the resulting waste products and pollution.

E. What are nonrenewable resources?
   1. Nonrenewable resources are those that exist in fixed quantity or stock in the earth's crust. The resource is economically depleted when it costs too much to obtain what is left.
   2. These resources include energy resources (oil, coal, natural gas), metallic mineral resources (copper, iron, aluminum, etc.), and nonmetallic minerals like salt, clay, sand, and phosphates.
   3. There are solutions for an economically depleted resource.
      a. Try to find more of the resource.
      b. Recycle the resource.
      c. Waste less.
      d. Use less.
      e. Try to develop a substitute for the resource.

**CASE STUDY**: The number of affluent consumers will soon double, as people in underdeveloped countries attain a middleclass lifestyle. China is already a leading consumer of many resources, and its economy and population are continuing to grow at a rapid rate. Thus, its ecological footprint and overall level of resource consumption are expected to continue to grow.

**1-4 What is pollution and what can we do about it?**

A. Pollutants are chemicals at high enough levels in the environment to harm people or other living organisms.
   1. Pollutants may enter the environment naturally (e.g., volcanic eruptions) or through human activities.
   2. Point sources of pollutants are single, identifiable sources.
   3. Non-point sources are dispersed.
   4. Three unwanted effects of pollutants are:
      a. They can disrupt or degrade life-support systems of any organism.
      b. They damage human health, wildlife, and property
      c. They can produce nuisances in the form of noise, smells, tastes, and sights.

B. Solutions: What can we do about pollution?
   1. We use two basic approaches to deal with pollution.

a. Pollution prevention/input pollution control reduces or eliminates production of pollutants.
b. Pollution cleanup/output pollution control cleans up or dilutes pollutants after they have been produced.
c. Problems with pollution clean up include:
    1) Temporary bandage without long-term pollution control technology, like the catalytic converter.
    2) Pollutant is removed but causes pollution in another place: burning garbage/burying it.
    3) Expensive to reduce pollution to an acceptable level. Prevention is less expensive.

**1-5 Why do we have environmental problems?**

A. Five major causes of environmental problems are:
    1. Population growth.
    2. Wasteful Resource use.
    3. Poverty.
    4. Poor environmental accounting.
    5. Ecological ignorance.
B. Affluence is the addiction to over-consumption of material goods.
    1. Symptoms: high debt level, declining health, increased stress, more bankruptcies.
    2. Solutions: admit the problem, shop less, avoid malls and other shopping addicts.
    3. Toynbee's law of progressive simplification: transfer energy and attention to the nonmaterial side of life.
C. Affluence of developed countries can lead to environmental improvements.
    1. Money is available for technological improvements.
    2. Since 1970, air and water are cleaner than previously.
    3. Money was spent on environmental improvements.
D. Environmental worldviews and ethics determine the way people view the seriousness of environmental problems.
    1. Your environmental worldview is your assumptions and values about the world and your role.
        a. The planetary management worldview holds that nature exists to meet our needs.
        b. The stewardship worldview holds that we mange the earth, but we have an ethical responsibility to be stewards of the earth.
        c. The environmental worldview holds that we are connected to nature and that nature exists for all species equally.

    **CASE STUDY**: Chattanooga, Tennessee, was once one of the most polluted cities in the United States. In the mid-1980s civic leaders gathered together community members to identify problems and brainstorm solutions. After years of encouraging zero-emission industries, implementing recycling programs, and renovating much of the city, Chattanooga is an example of what can be accomplished when cities build their social capital.

**1-6 What are four scientific principles of sustainability?**

A. There are four major components of earth's natural sustainability
    1. Reliance on solar energy.
    2. Reserve biodiversity.
    3. Population control.
    4. Nutrient recycling.

# Science, Matter, Energy, and Systems

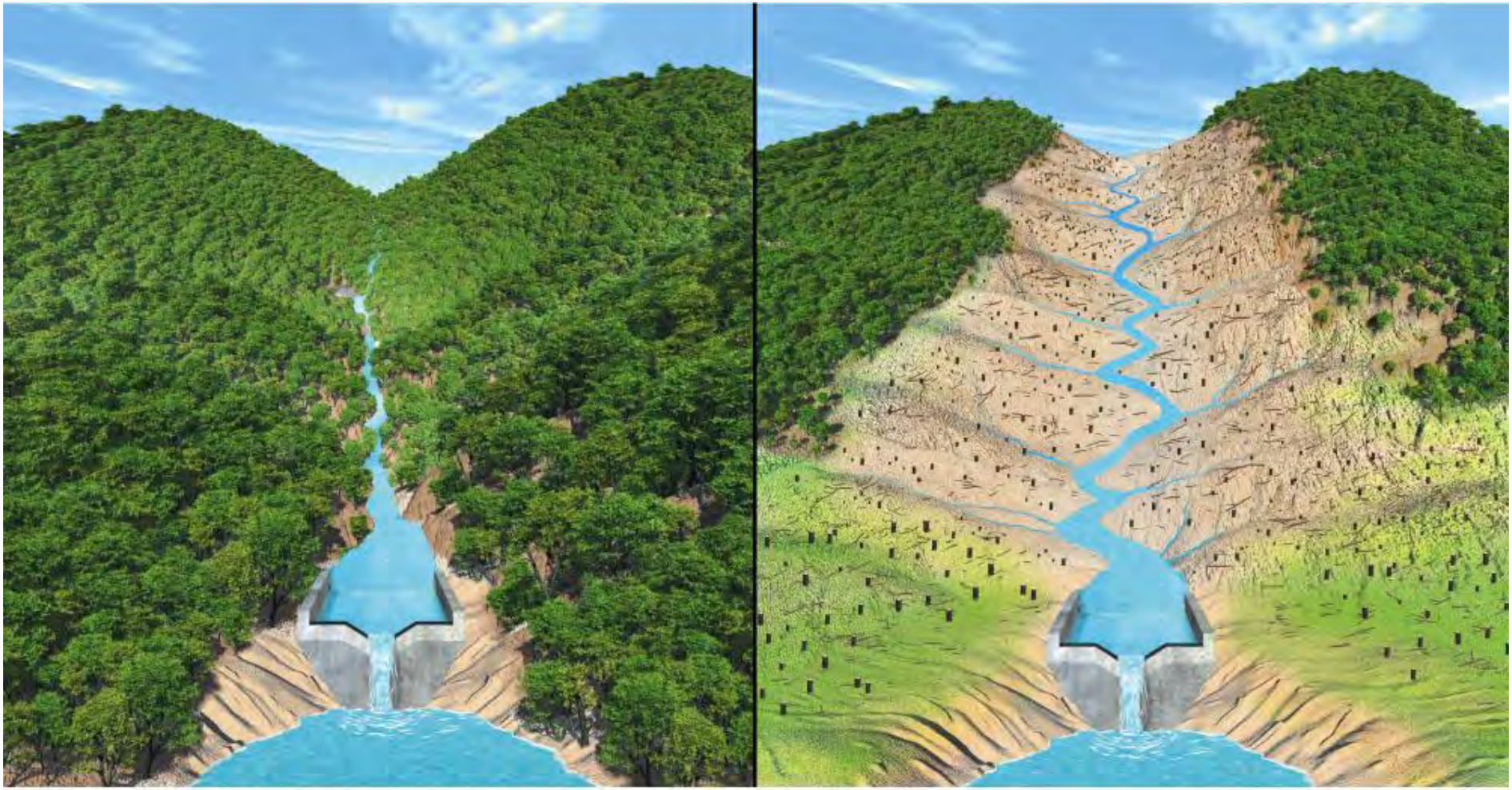
## Chapter 2

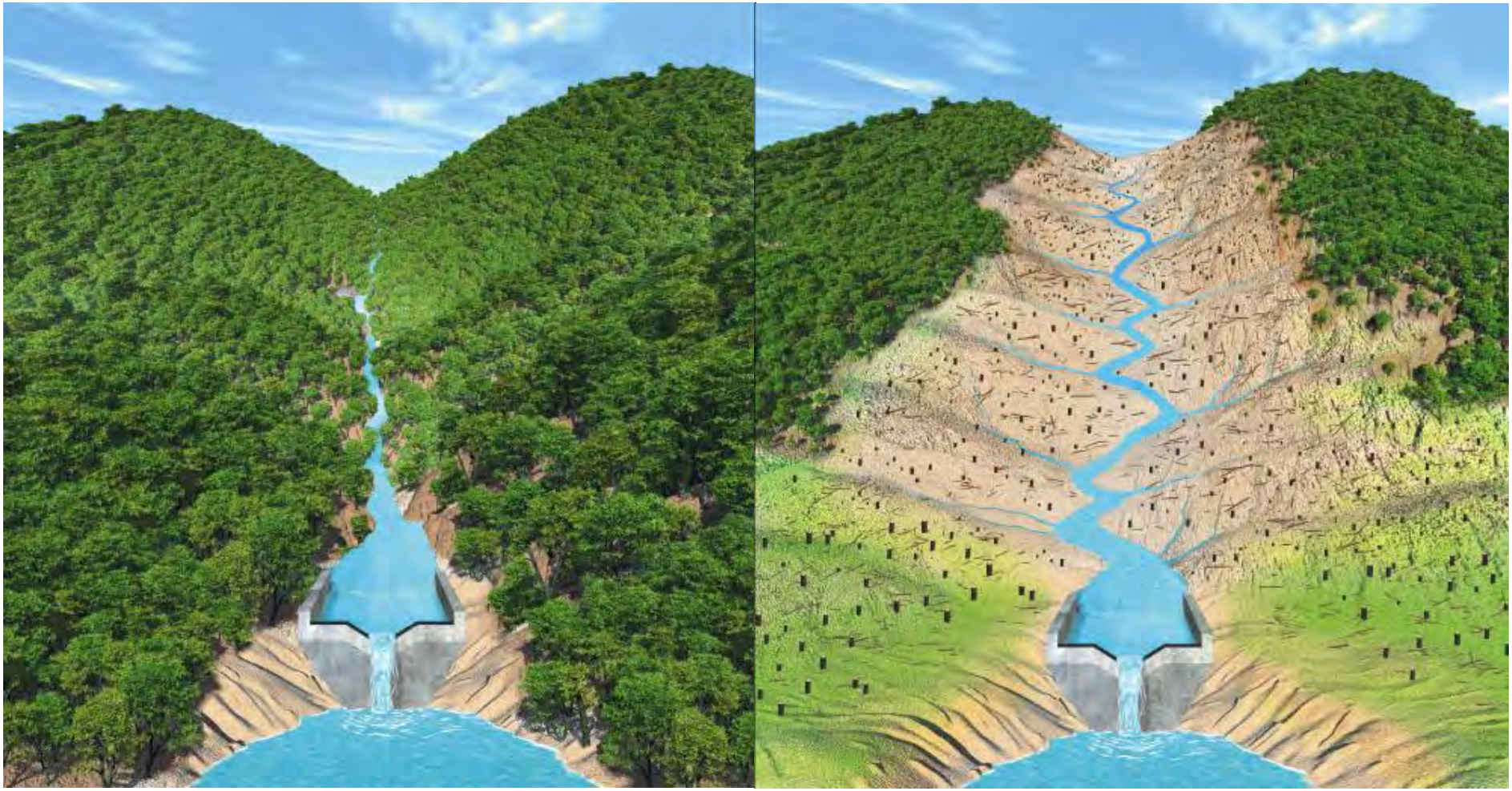
# Core Case Study: Carrying Out a Controlled Scientific Experiment

- F. Herbert Bormann, Gene Likens, *et al.:* Hubbard Brook Experimental Forest in NH (U.S.)

- Compared the loss of water and nutrients from an uncut forest (control site) with one that had been stripped (experimental site)

# The Effects of Deforestation on the Loss of Water and Soil Nutrients





Stepped Art

Fig. 2-1, p. 28

# *2-1 What Is Science?*

- ***Concept 2-1*** *Scientists collect data and develop theories, models, and laws about how nature works.*

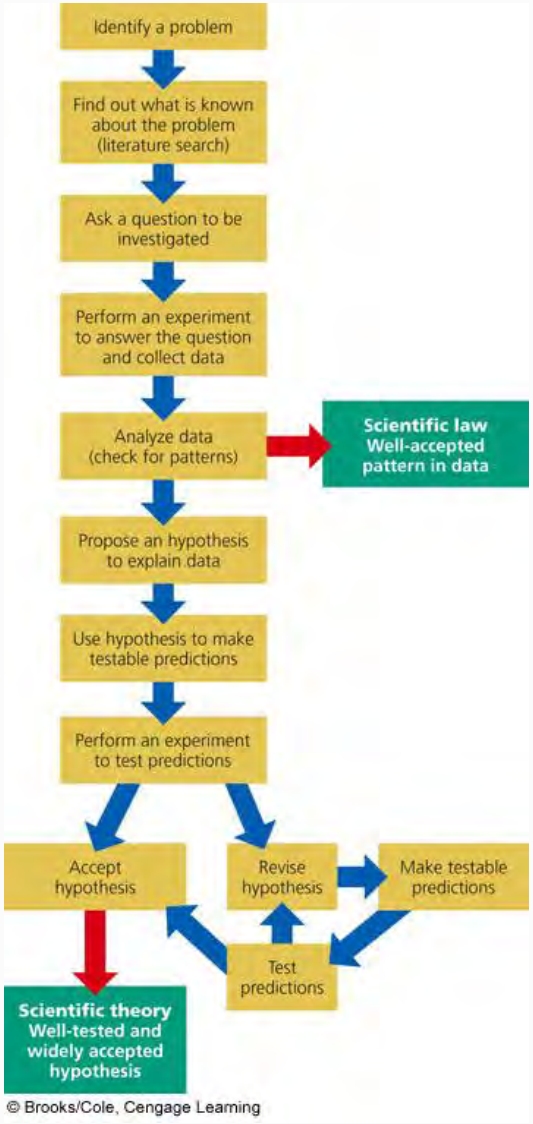
# Science Is a Search for Order in Nature (1)

- Identify a problem
- Find out what is known about the problem
- Ask a question to be investigated
- Gather data
- Hypothesize
- Make testable predictions
- Keep testing and making observations
- Accept or reject the hypothesis

# Science Is a Search for Order in Nature (2)

- Important features of the scientific process
  - Curiosity
  - Skepticism
  - Peer review
  - Reproducibility
  - Openness to new ideas

# The Scientific Process



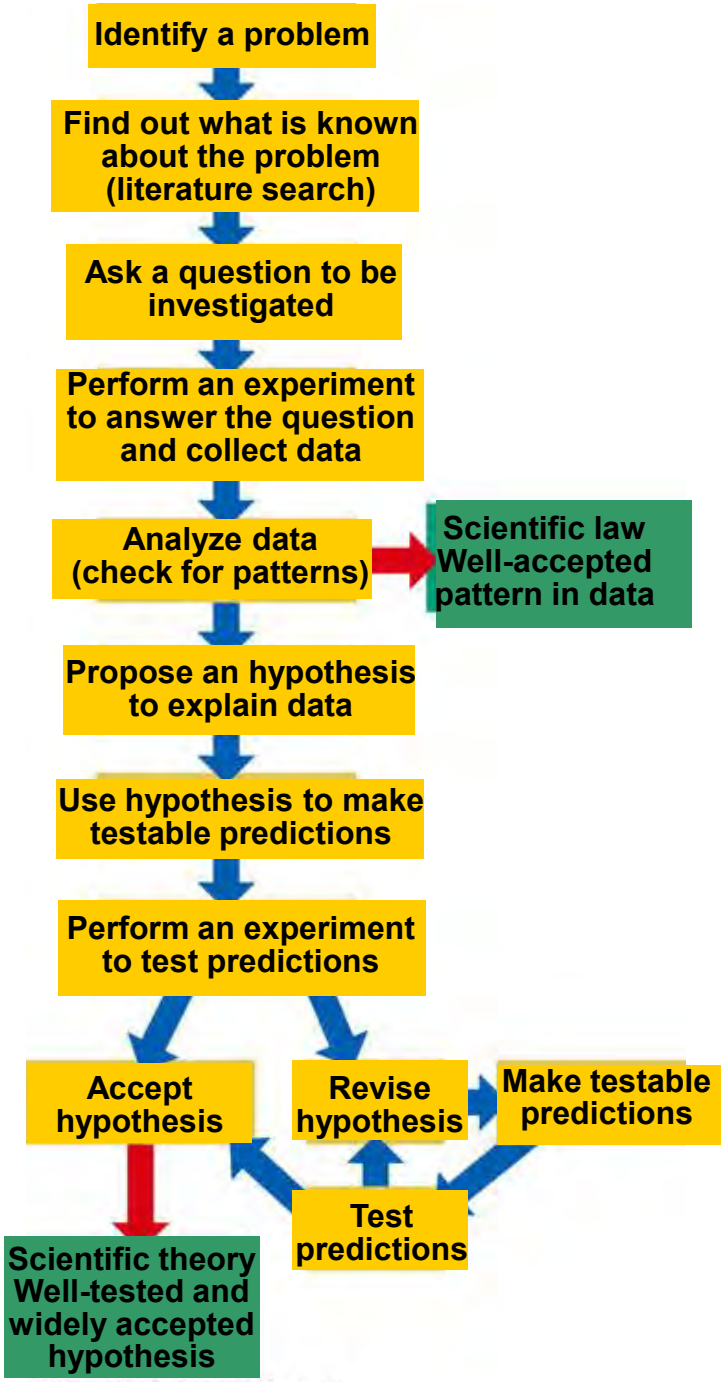





Fig. 2-2, p. 30

# Science Focus: Easter Island: Revisions to a Popular Environmental Story

- Some revisions in a popular environmental story
  - Polynesians arrived about 800 years ago
  - Population may have reached 3000
  - Used trees in an unsustainable manner, **but** rats may have multiplied and eaten the seeds of the trees

# Scientists Use Reasoning, Imagination, and Creativity to Learn How Nature Works

- Important scientific tools
  - **Inductive reasoning**
  - **Deductive reasoning**

- Scientists also use
  - Intuition
  - Imagination
  - Creativity

# Scientific Theories and Laws Are the Most Important Results of Science

- **Scientific theory**
  - Widely tested
  - Supported by extensive evidence
  - Accepted by most scientists in a particular area
- **Scientific law, law of nature**
- **Paradigm shift**

# Science Focus: The Scientific Consensus over Global Warming

- How much has the earth's atmosphere warmed during the last 50 years?
- How much of this warming is due to human activity?
- How much is the atmosphere likely to warm in the future?
- Will this affect climate?
- 1988: Intergovernmental Panel on Climate Change (IPCC)

# The Results of Science Can Be Tentative, Reliable, or Unreliable

- Tentative science, frontier science
- Reliable science
- Unreliable science

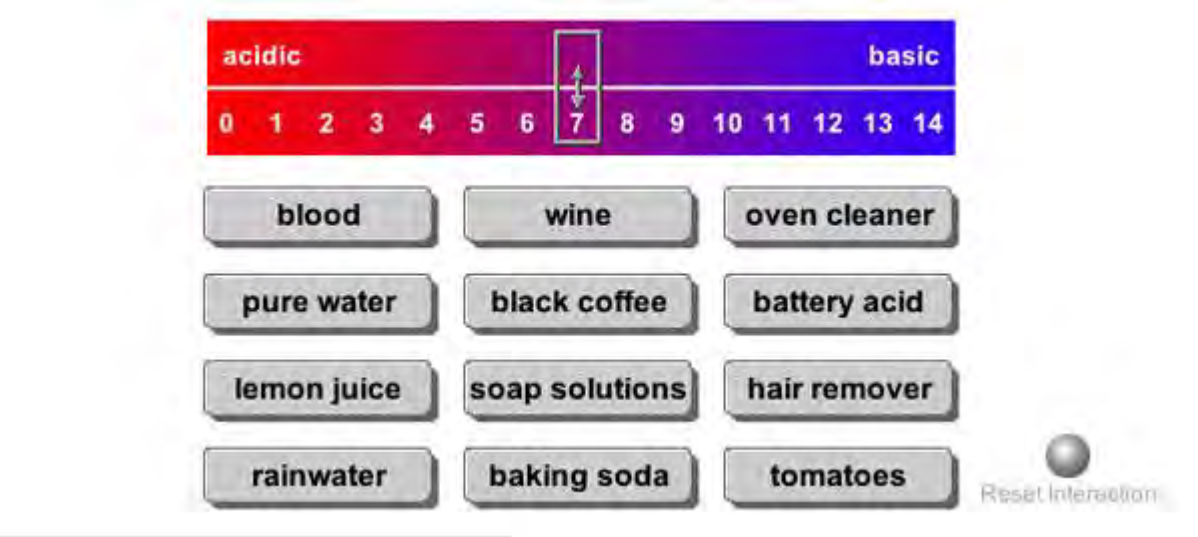
# Environmental Science Has Some Limitations

- Particular hypotheses, theories, or laws have a high probability of being true while not being absolute
- Bias can be minimized by scientists
- Statistical methods may be used to estimate very large or very small numbers
- Environmental phenomena involve interacting variables and complex interactions
- Scientific process is limited to the natural world

# Science Focus: Statistics and Probability

- **Statistics**
  - Collect, organize, and interpret numerical data
- **Probability**
  - The chance that something will happen or be valid

# Animation: pH scale



# Video: ABC News: Easter Island

# *2-2 What Is Matter?*

- ***Concept 2-2*** *Matter consists of elements and compounds, which are in turn made up of atoms, ions, or molecules.*

# Matter Consists of Elements and Compounds

- **Matter**
  - Has mass and takes up space
- **Elements**
  - Unique properties
  - Cannot be broken down chemically into other substances
- **Compounds**
  - Two or more different elements bonded together in fixed proportions

# Elements Important to the Study of Environmental Science

## Table 2-1

### Elements Important to the Study of Environmental Science

| Element | Symbol | Element | Symbol |
|---|---|---|---|
| Hydrogen | H | Bromine | Br |
| Carbon | C | Sodium | Na |
| Oxygen | O | Calcium | Ca |
| Nitrogen | N | Lead | Pb |
| Phosphorus | P | Mercury | Hg |
| Sulfur | S | Arsenic | As |
| Chlorine | Cl | Uranium | U |
| Fluorine | F | | |

# Atoms, Ions, and Molecules Are the Building Blocks of Matter (1)

- **Atomic theory**
- **Subatomic particles**
  - Protons (p) with positive charge and neutrons (0) with no charge in nucleus
  - Negatively charged electrons (e) orbit the nucleus
- **Mass number**
  - Protons plus neutrons
- **Isotopes**

# Atoms, Ions, and Molecules Are the Building Blocks of Matter (2)

- **Ions**
  - Gain or lose electrons
  - Form ionic compounds

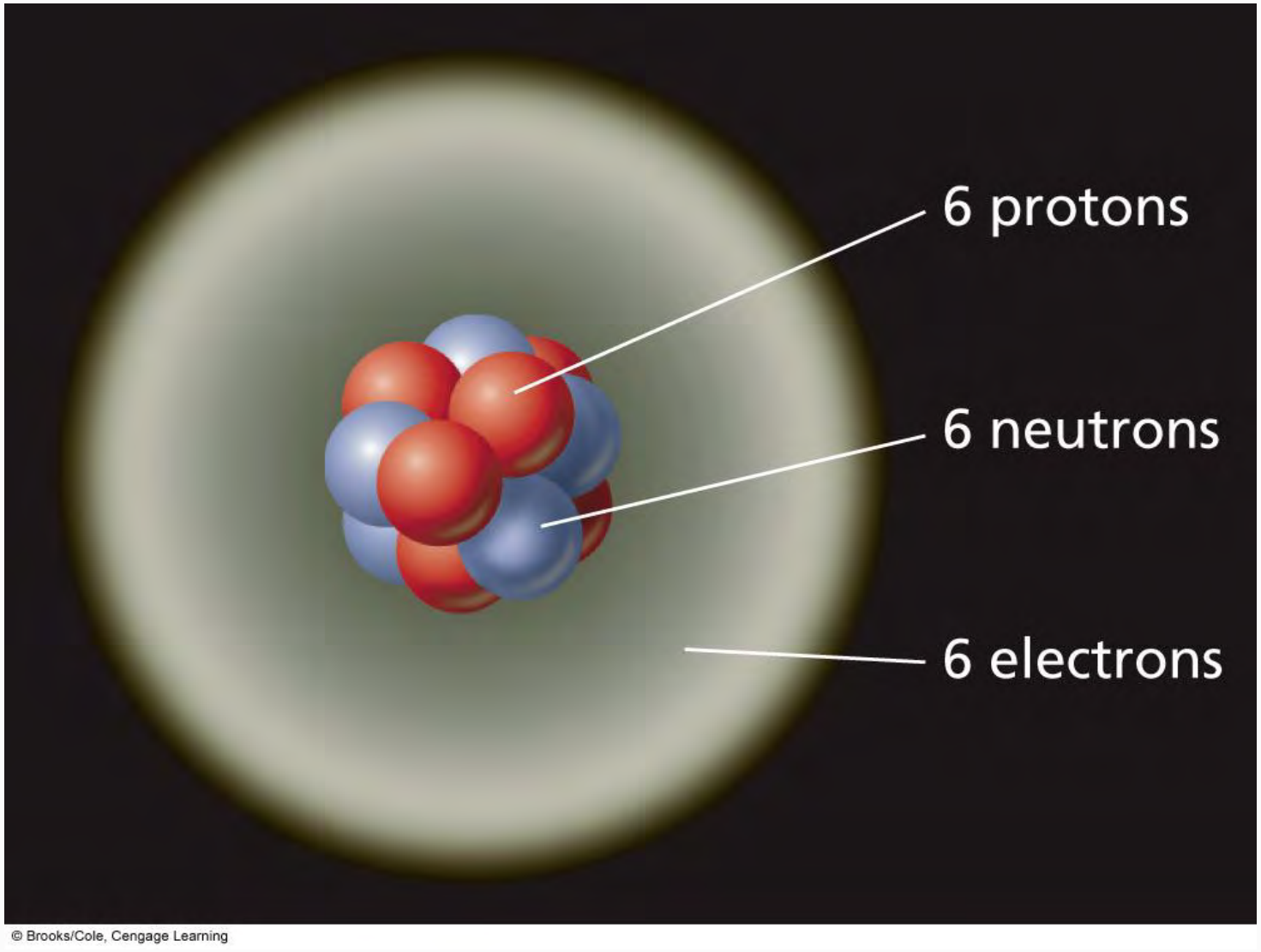
- **pH**
  - Measure of acidity
  - $H^+$ and $OH^-$

# Atoms, Ions, and Molecules Are the Building Blocks of Matter (3)

- **Molecule**
  - Two or more atoms of the same or different elements held together by chemical bonds

- **Chemical formula**

# Model of a Carbon-12 Atom



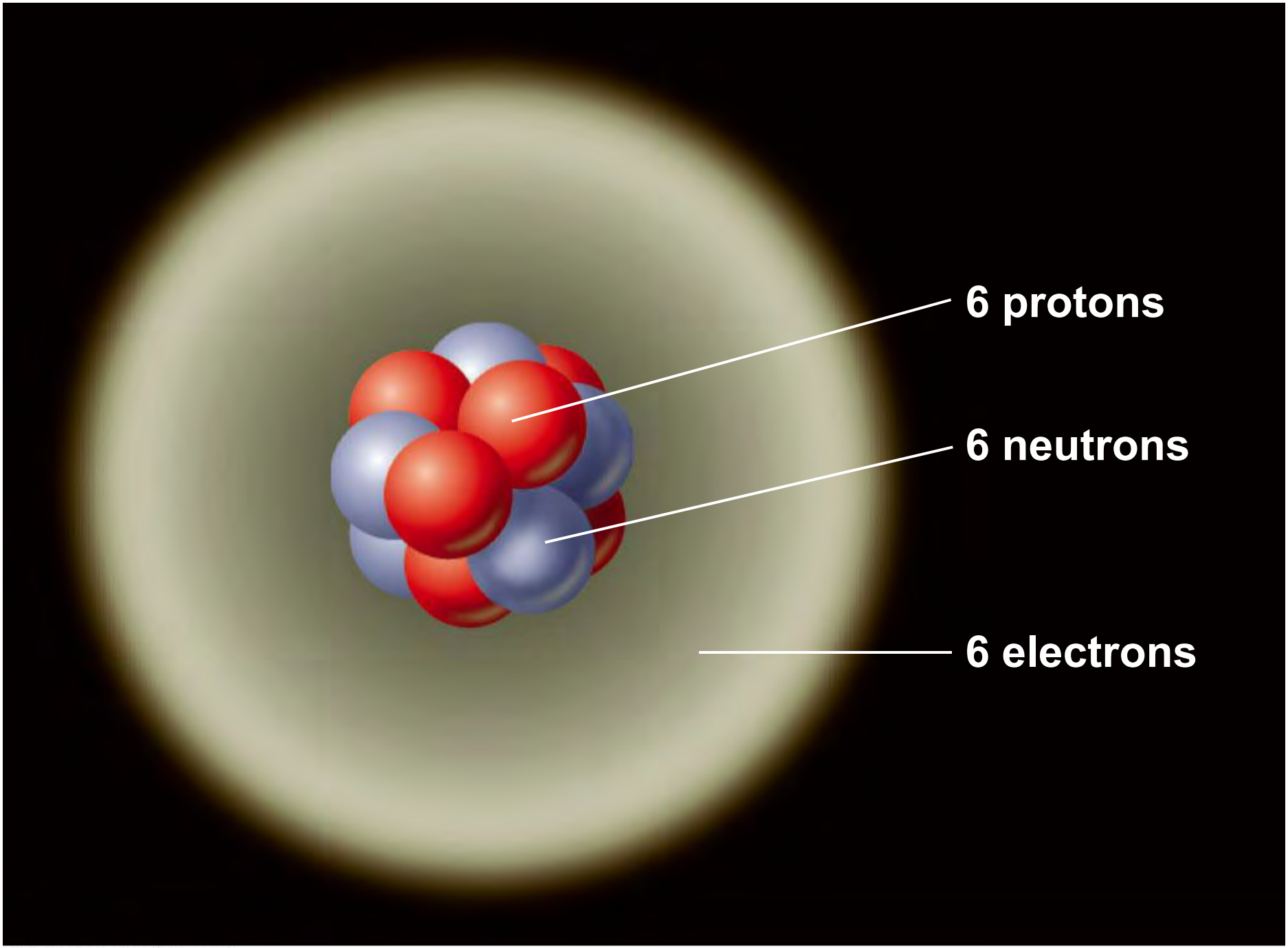





Fig. 2-3, p. 36

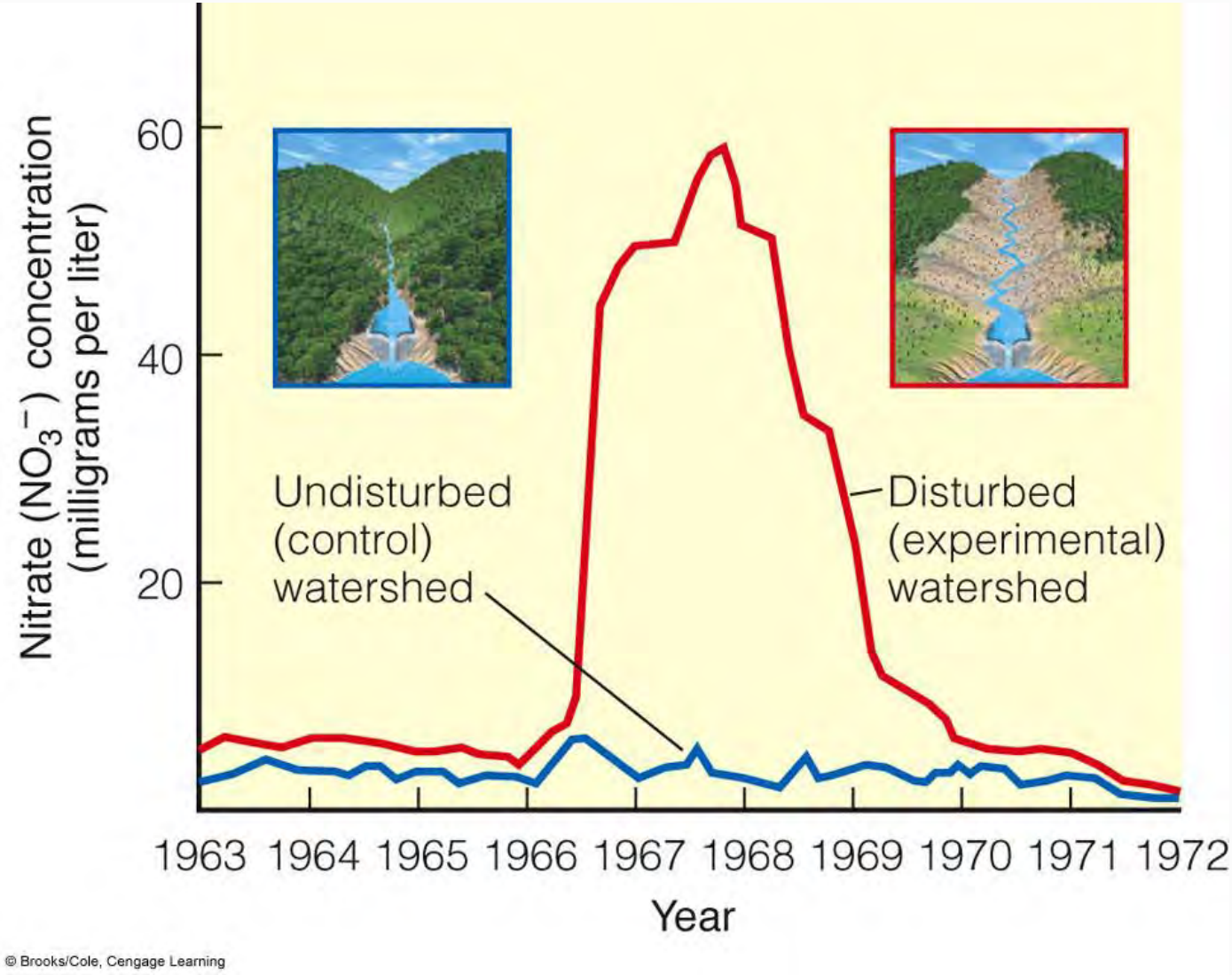
# Ions Important to the Study of Environmental Science

## Table 2-2

### Ions Important to the Study of Environmental Science

| Positive Ion | Symbol | Negative Ion | Symbol |
|---|---|---|---|
| hydrogen ion | $H^+$ | chloride ion | $Cl^-$ |
| sodium ion | $Na^+$ | hydroxide ion | $OH^-$ |
| calcium ion | $Ca^{2+}$ | nitrate ion | $NO_3^-$ |
| aluminum ion | $Al^{3+}$ | sulfate ion | $SO_4^{2-}$ |
| ammonium ion | $NH_4^+$ | phosphate ion | $PO_4^{3-}$ |

# Loss of $NO_3^-$ from a Deforested Watershed



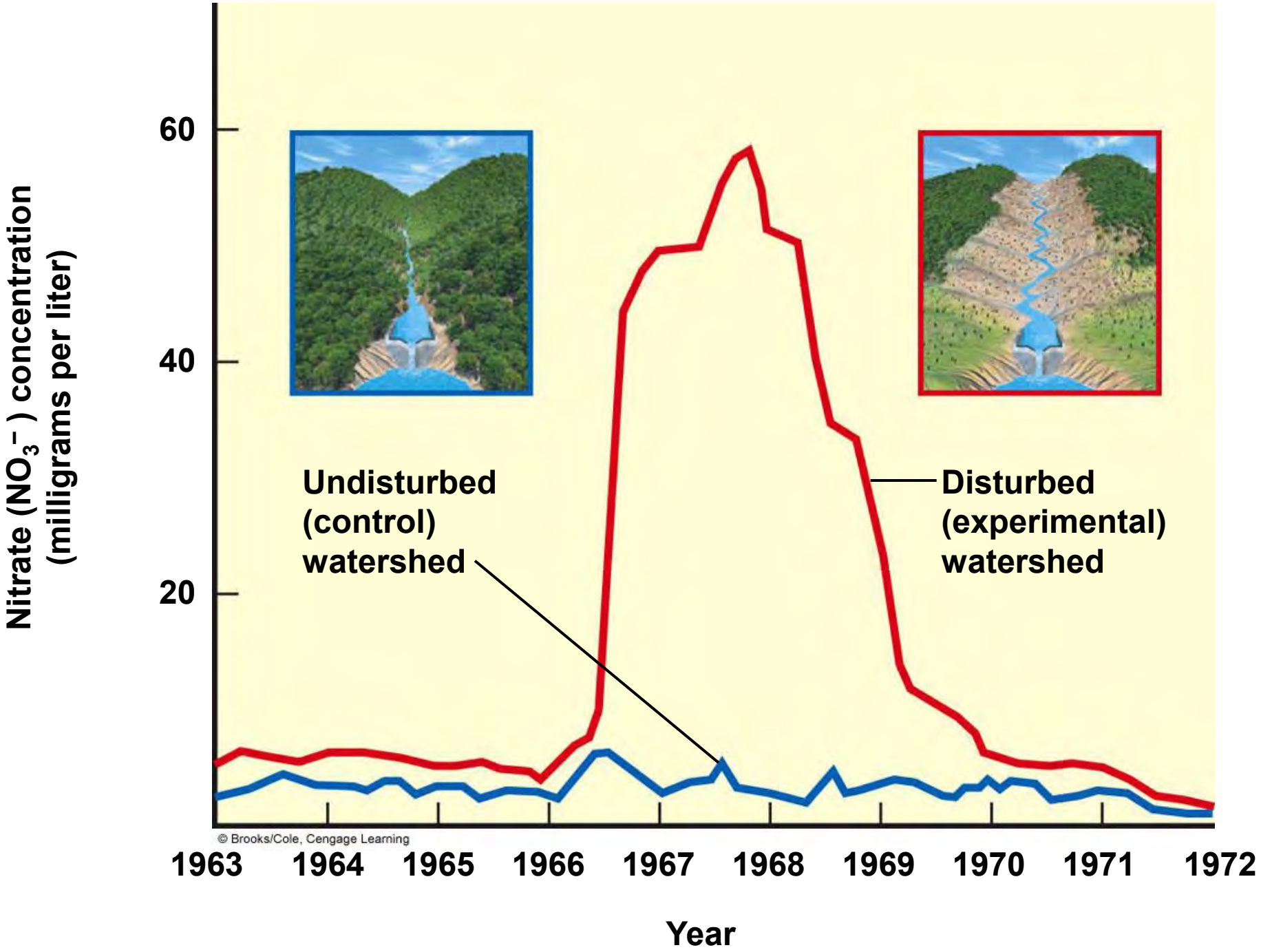

Nitrate ($NO_3^-$) concentration (milligrams per liter)
60
40
20
Undisturbed (control) watershed
Disturbed (experimental) watershed
© Brooks/Cole, Cengage Learning
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
Year

Fig. 2-4, p. 37

# Compounds Important to the Study of Environmental Science

## Table 2-3

### Compounds Important to the Study of Environmental Science

| Compound | Formula | Compound | Formula |
|---|---|---|---|
| sodium chloride | NaCl | methane | $CH_4$ |
| carbon monoxide | CO | glucose | $C_6H_{12}O_6$ |
| carbon dioxide | $CO_2$ | water | $H_2O$ |
| nitric oxide | NO | hydrogen sulfide | $H_2S$ |
| nitrogen dioxide | $NO_2$ | sulfur dioxide | $SO_2$ |
| nitrous oxide | $N_2O$ | sulfuric acid | $H_2SO_4$ |
| nitric acid | $HNO_3$ | ammonia | $NH_3$ |

# Organic Compounds Are the Chemicals of Life

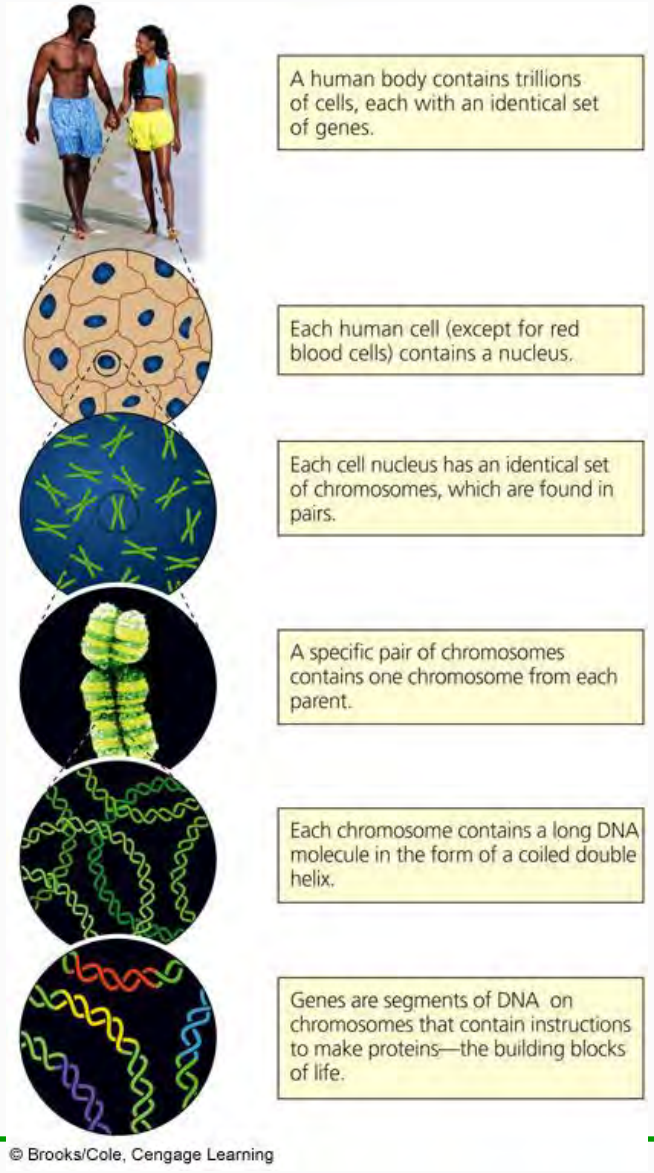
- **Inorganic compounds**

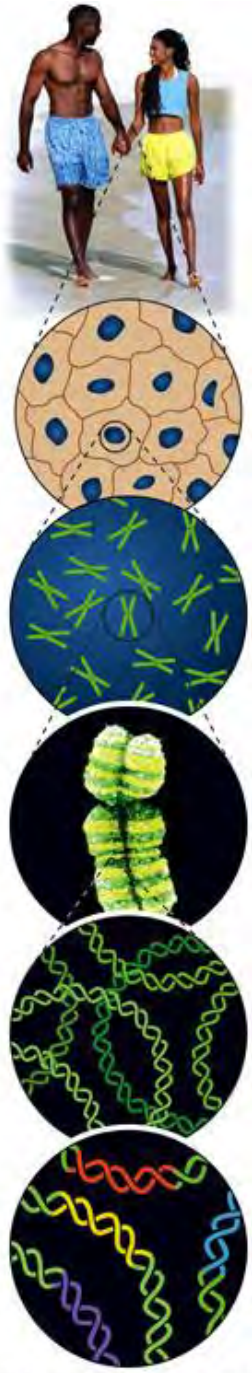
- **Organic compounds**
  - Hydrocarbons and chlorinated hydrocarbons
  - Simple carbohydrates
  - Macromolecules: complex organic molecules
    - Complex carbohydrates
    - Proteins
    - Nucleic acids
    - Lipids

# Matter Comes to Life through Genes, Chromosomes, and Cells

- **Cells:** fundamental units of life
- **Genes**: sequences of nucleotides within the DNA
- **Chromosomes**: composed of many genes

# Cells, Nuclei, Chromosomes, DNA, and Genes







A human body contains trillions of cells, each with an identical set of genes.

Each human cell (except for red blood cells) contains a nucleus.

Each cell nucleus has an identical set of chromosomes, which are found in pairs.

A specific pair of chromosomes contains one chromosome from each parent.

Each chromosome contains a long DNA molecule in the form of a coiled double helix.

Genes are segments of DNA on chromosomes that contain instructions to make proteins—the building blocks of life.

Fig. 2-5, p. 38

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Stepped Art

Fig. 2-5, p. 38

# Matter Occurs in Various Physical Forms

- Solid
- Liquid
- Gas

# Some Forms of Matter Are More Useful than Others

- High-quality matter
- Low-quality matter

# Examples of Differences in Matter Quality

**High Quality** **Low Quality**

**Solid**

**Gas**

**Salt**

**Solution of salt in water**

**Coal**

**Coal-fired power plant emissions**


**Gasoline**

**Automobile emissions**

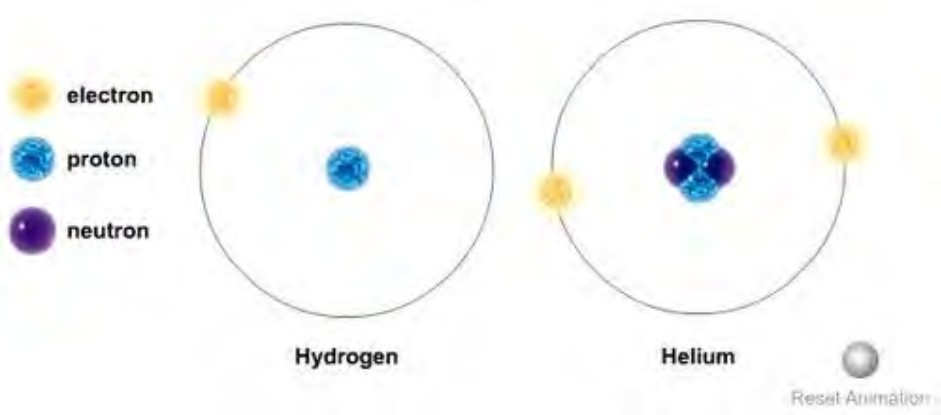

**Aluminum can**

**Aluminum ore**



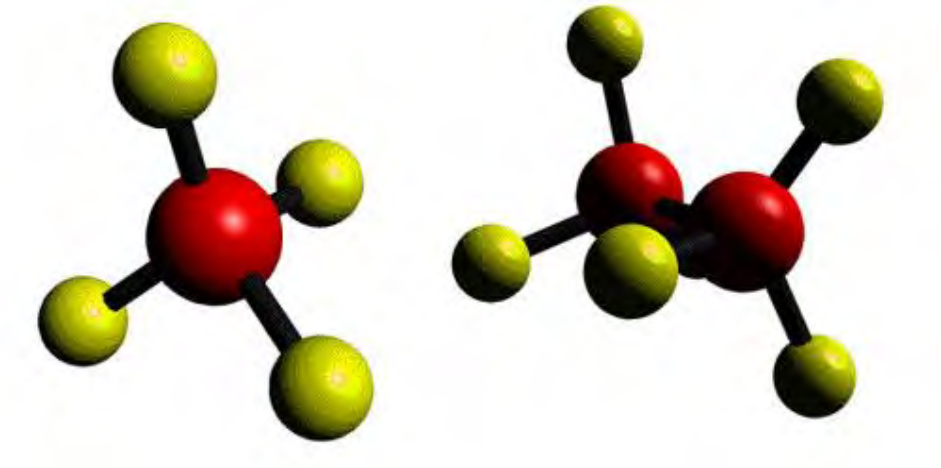
**Fig. 2-6, p. 39**

# Animation: Subatomic particles




PLAY

# Animation: Carbon bonds



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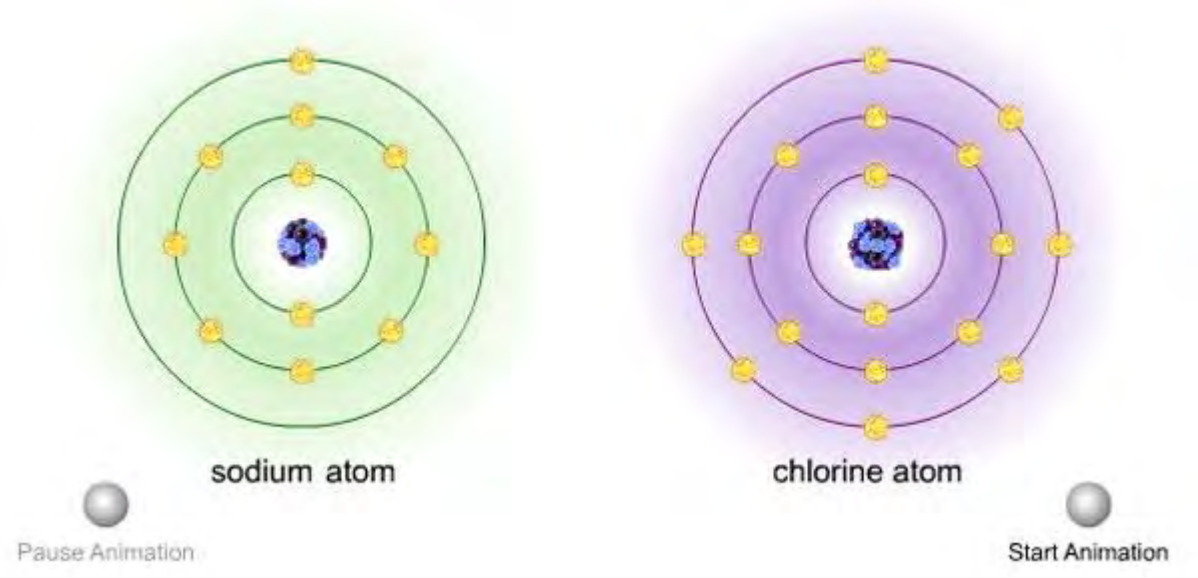
# Animation: Ionic bonds

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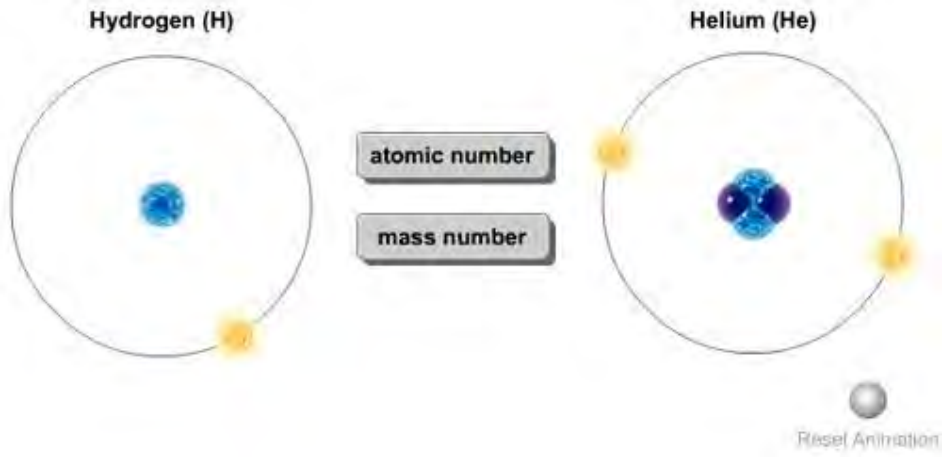
# Animation: Atomic number, mass number




PLAY

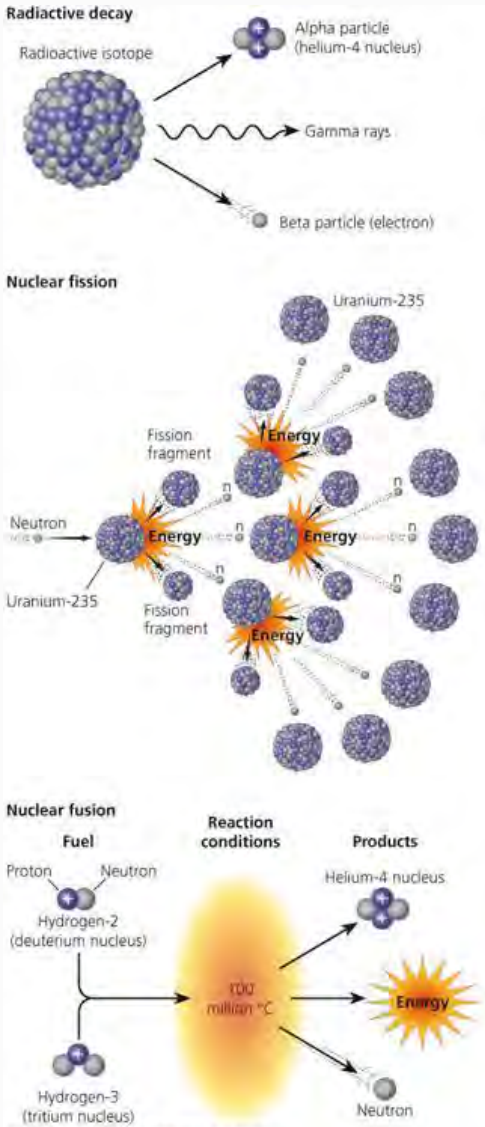
# *2-3 How Can Matter Change?*

- ***Concept 2-3*** *When matter undergoes a physical or chemical change, no atoms are created or destroyed (the law of conservation of matter).*

# Matter Undergoes Physical, Chemical, and Nuclear Changes

- **Physical change**
- **Chemical change, chemical reaction**
- **Nuclear change**
  - Natural radioactive decay
    - Radioisotopes: unstable
  - Nuclear fission
  - Nuclear fusion

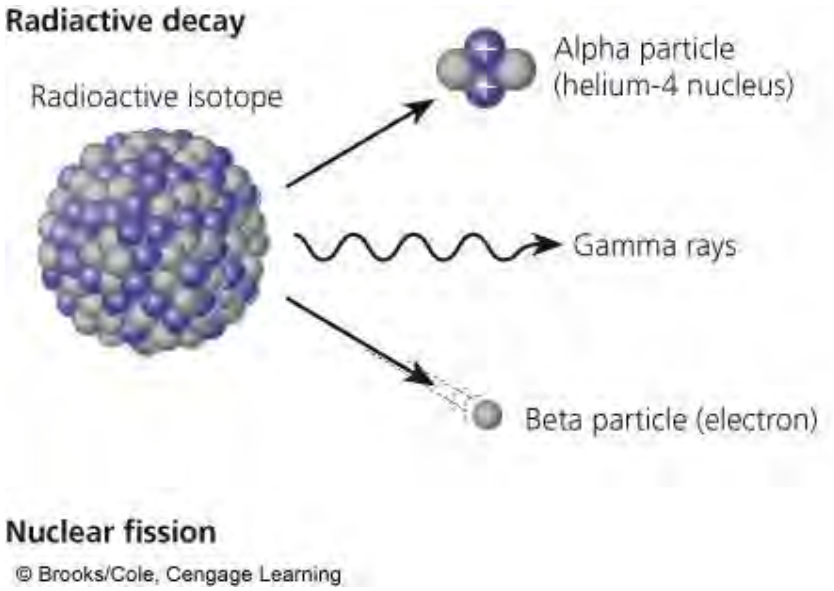
# Types of Nuclear Changes




**Radioactive decay** occurs when nuclei of unstable isotopes spontaneously emit fast-moving chunks of matter (alpha particles or beta particles), high-energy radiation (gamma rays), or both at a fixed rate. A particular radioactive isotope may emit any one or a combination of the three items shown in the diagram.

**Nuclear fission** occurs when the nuclei of certain isotopes with large mass numbers (such as uranium-235) are split apart into lighter nuclei when struck by a neutron and release energy plus two or three more neutrons. Each neutron can trigger an additional fission reaction and lead to a *chain reaction*, which releases an enormous amount of energy.

**Nuclear fusion** occurs when two isotopes of light elements, such as hydrogen, are forced together at extremely high temperatures until they fuse to form a heavier nucleus and release a tremendous amount of energy.



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# Radioactive decay

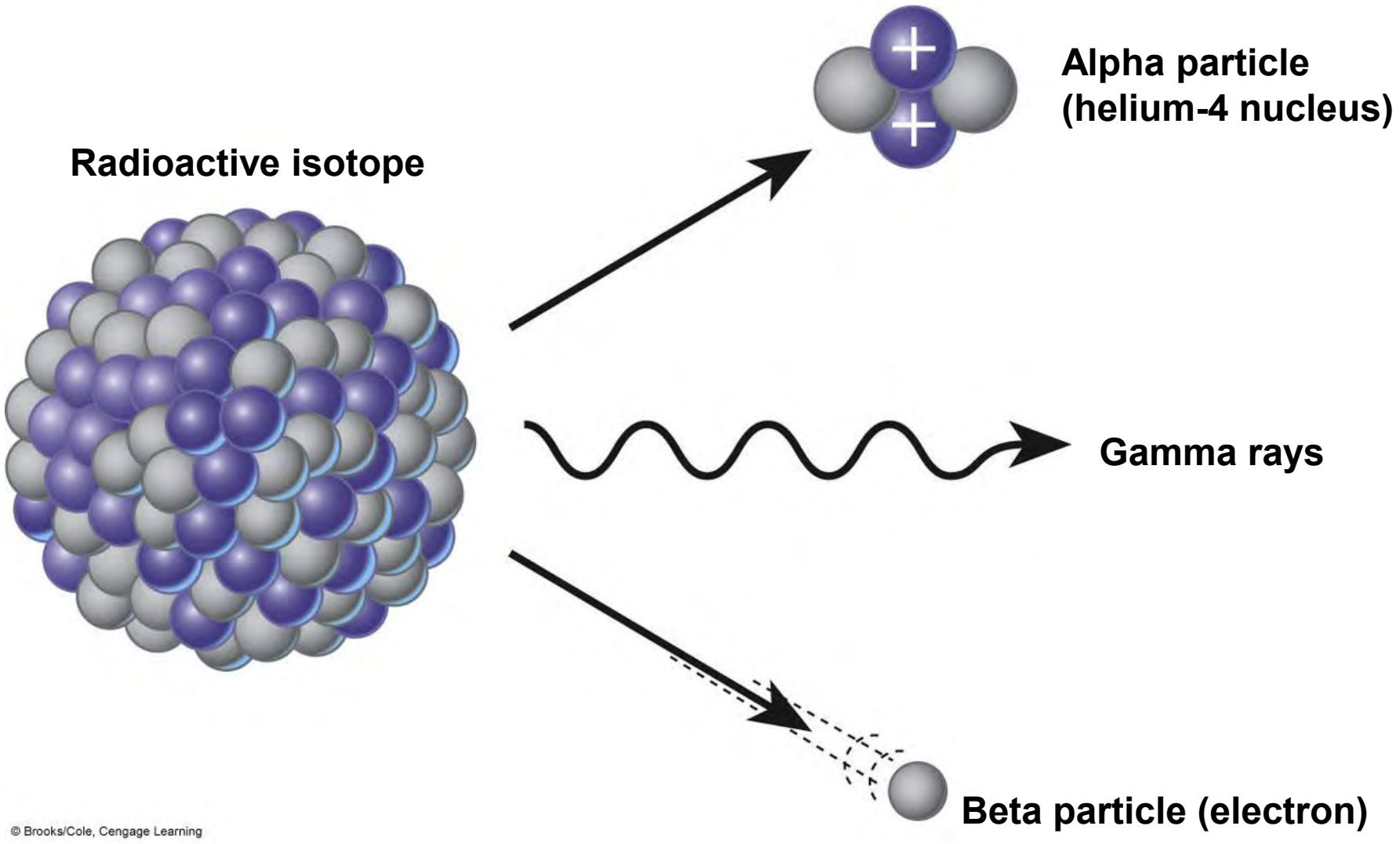




Fig. 2-7a, p. 41

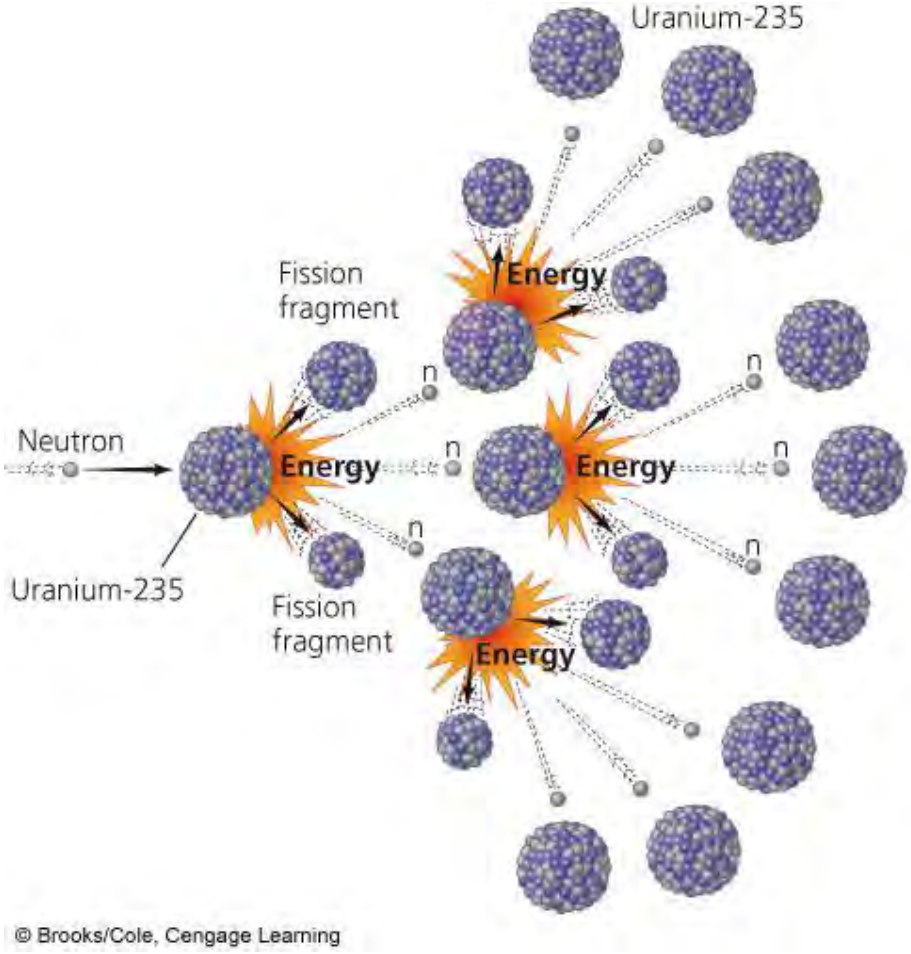




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**Fig. 2-7b, p. 41**

# Nuclear fission

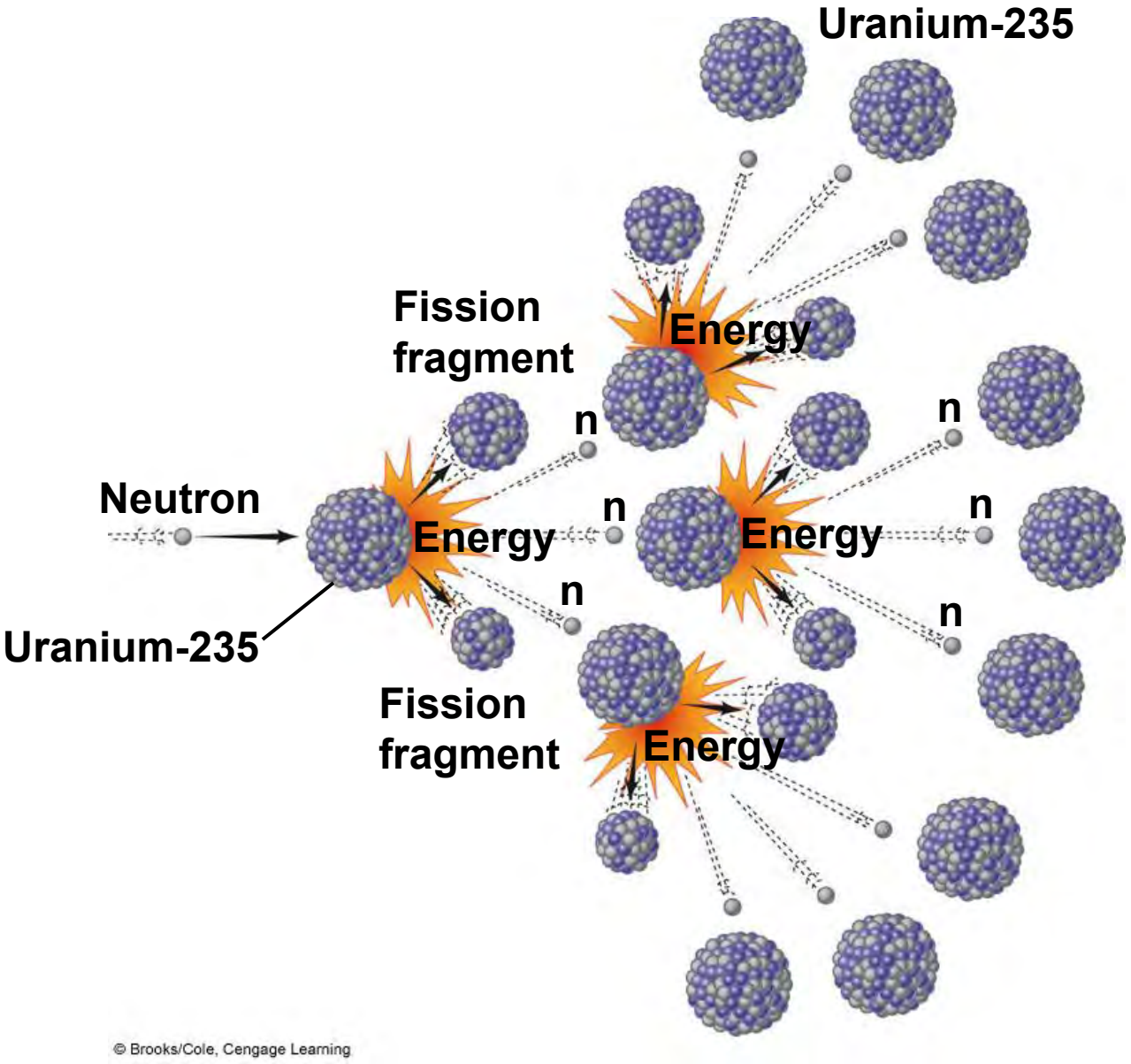
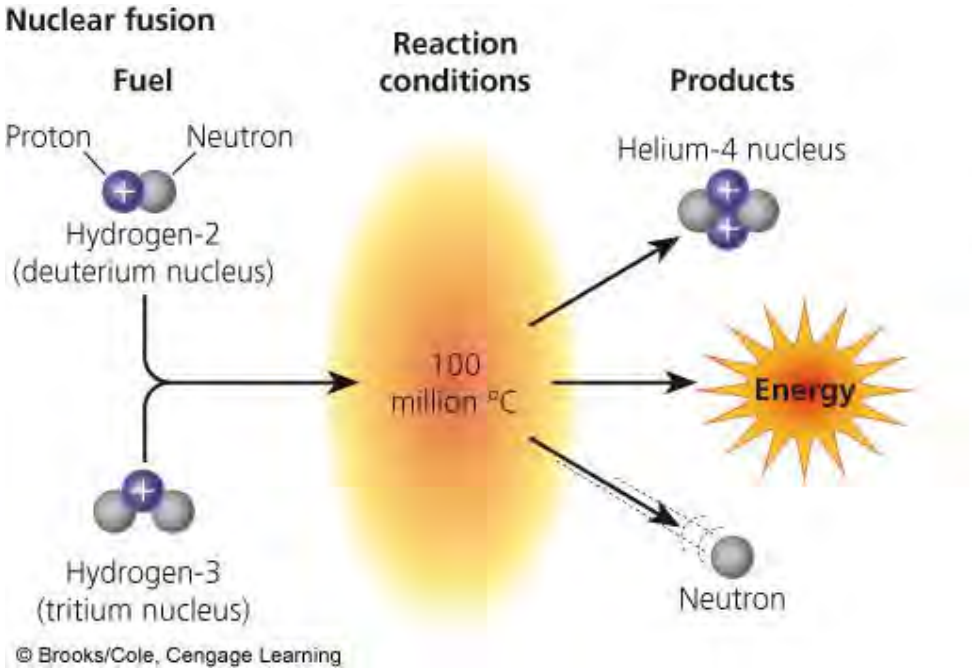



Fig. 2-7b, p. 41




**Nuclear fusion** occurs when two isotopes of light elements, such as hydrogen, are forced together at extremely high temperatures until they fuse to form a heavier nucleus and release a tremendous amount of energy.

**Fig. 2-7c, p. 41**

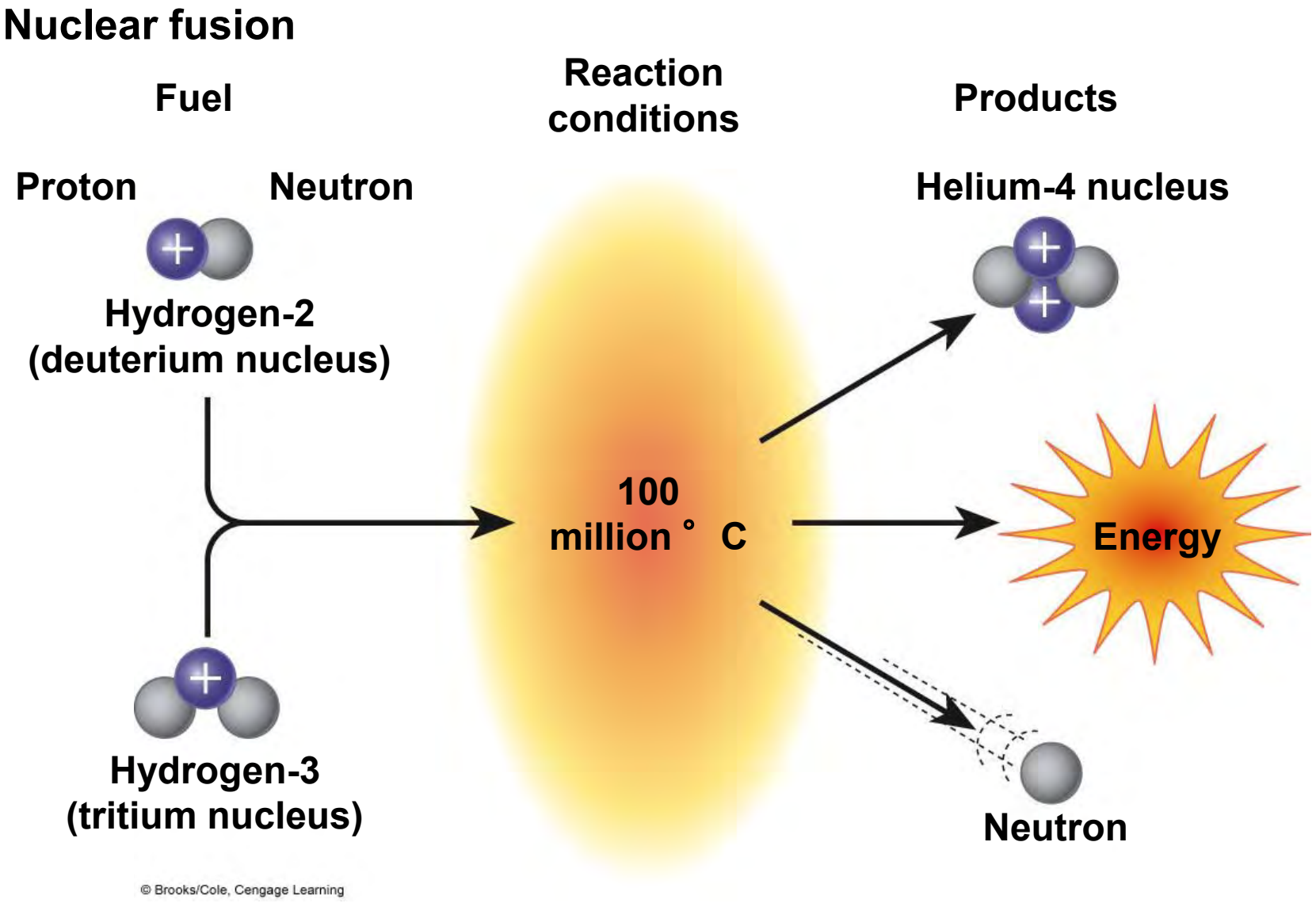
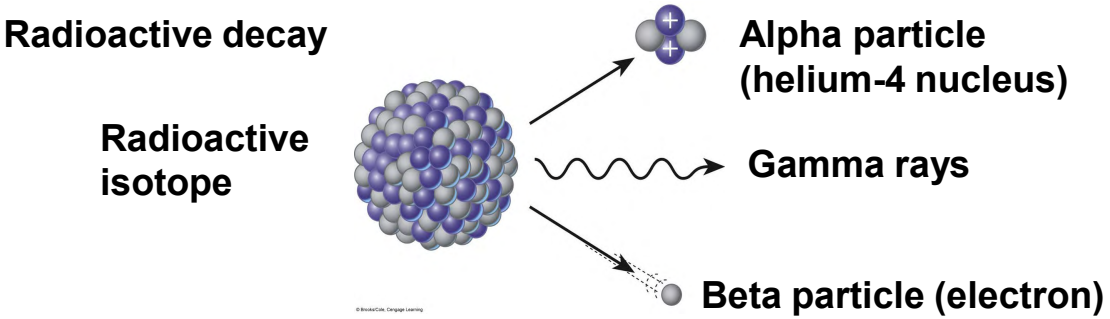
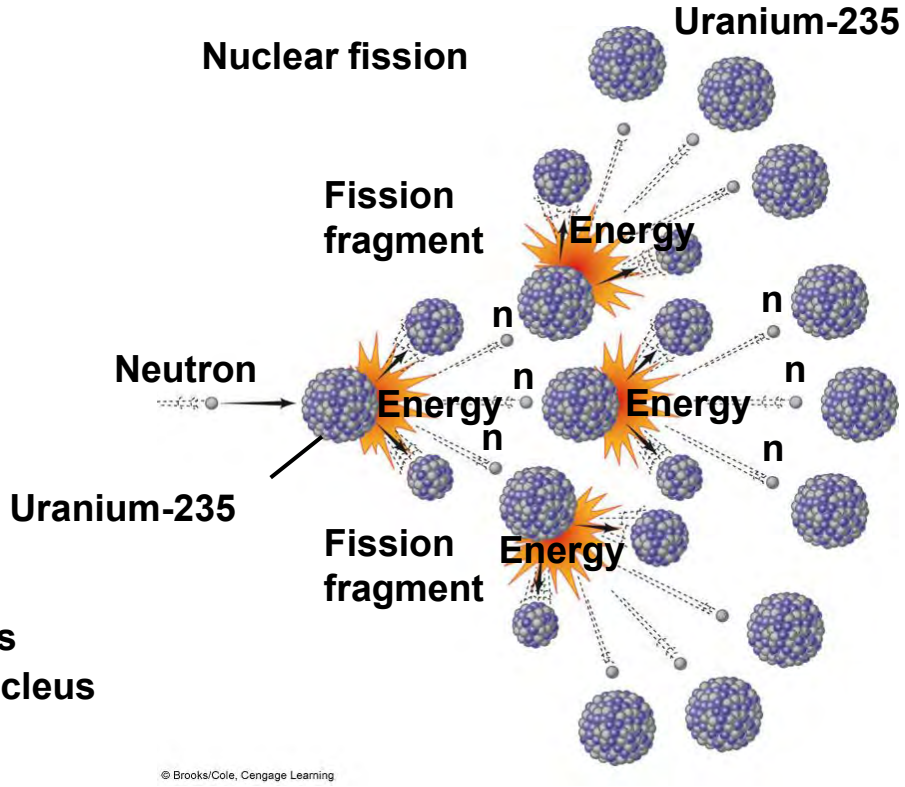
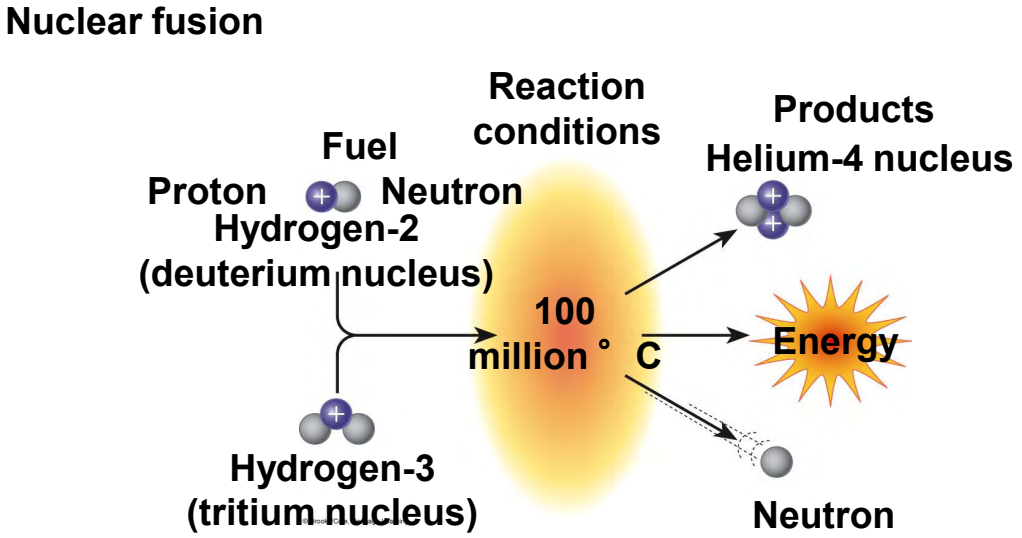

Nuclear fusion
Fuel
Reaction conditions
Products
Proton
Neutron
Helium-4 nucleus
Hydrogen-2
(deuterium nucleus)
100 million ° C
Energy
Hydrogen-3
(tritium nucleus)
Neutron
© Brooks/Cole, Cengage Learning

Fig. 2-7c, p. 41




Stepped Art

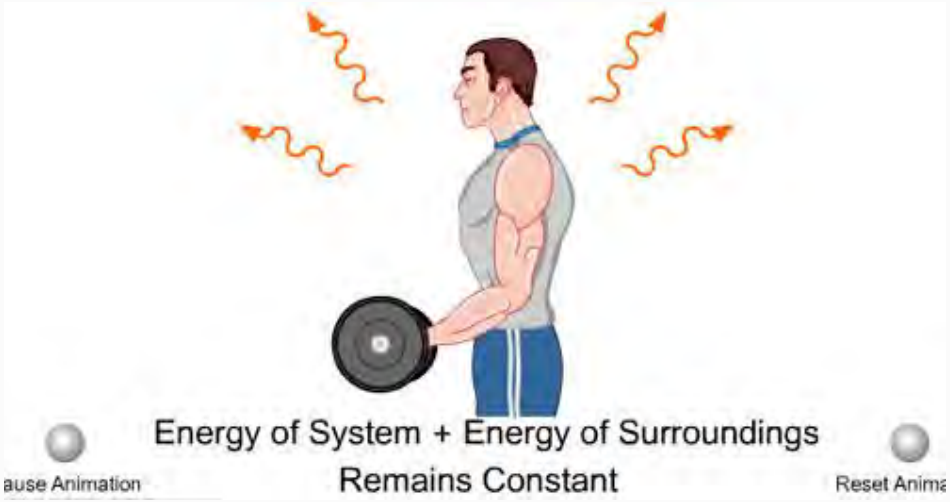
Fig. 2-7, p. 41

# We Cannot Create or Destroy Matter

- **Law of conservation of matter**

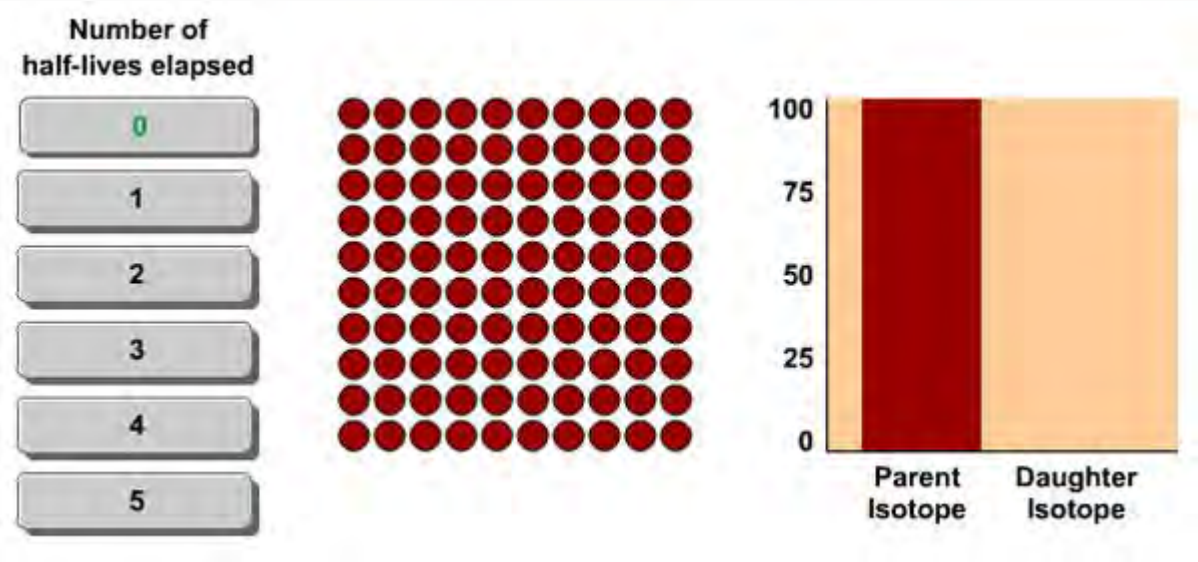
- Matter consumption
  - Matter is converted from one form to another

# Animation: Total energy remains constant

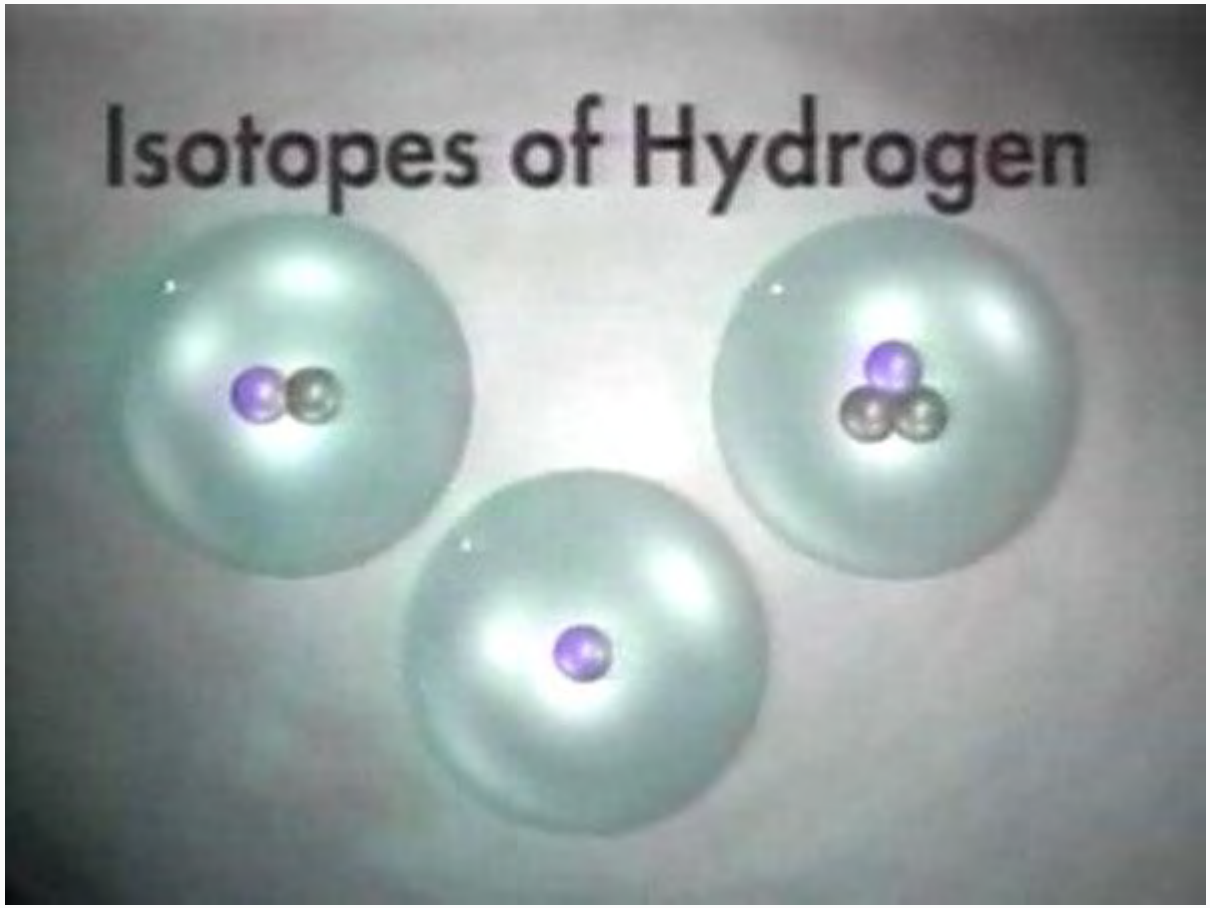



PLAY

# Animation: Half-life



# Animation: Isotopes

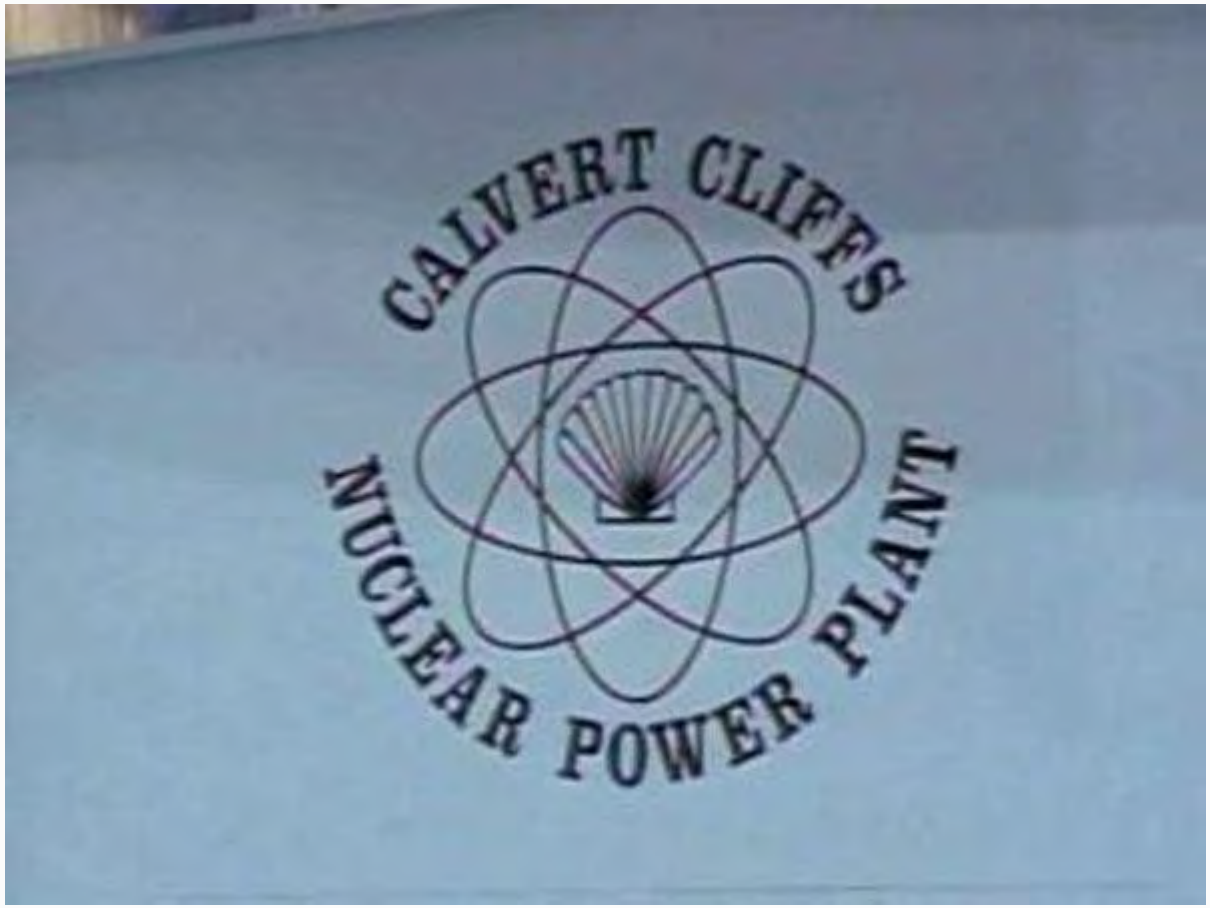



PLAY

# Animation: Positron-emission tomography (PET)


PLAY

# Video: Nuclear energy




PLAY

# *2-4 What is Energy and How Can It Be Changed?*

- ***Concept 2-4A*** *When energy is converted from one form to another in a physical or chemical change, no energy is created or destroyed (first law of thermodynamics).*

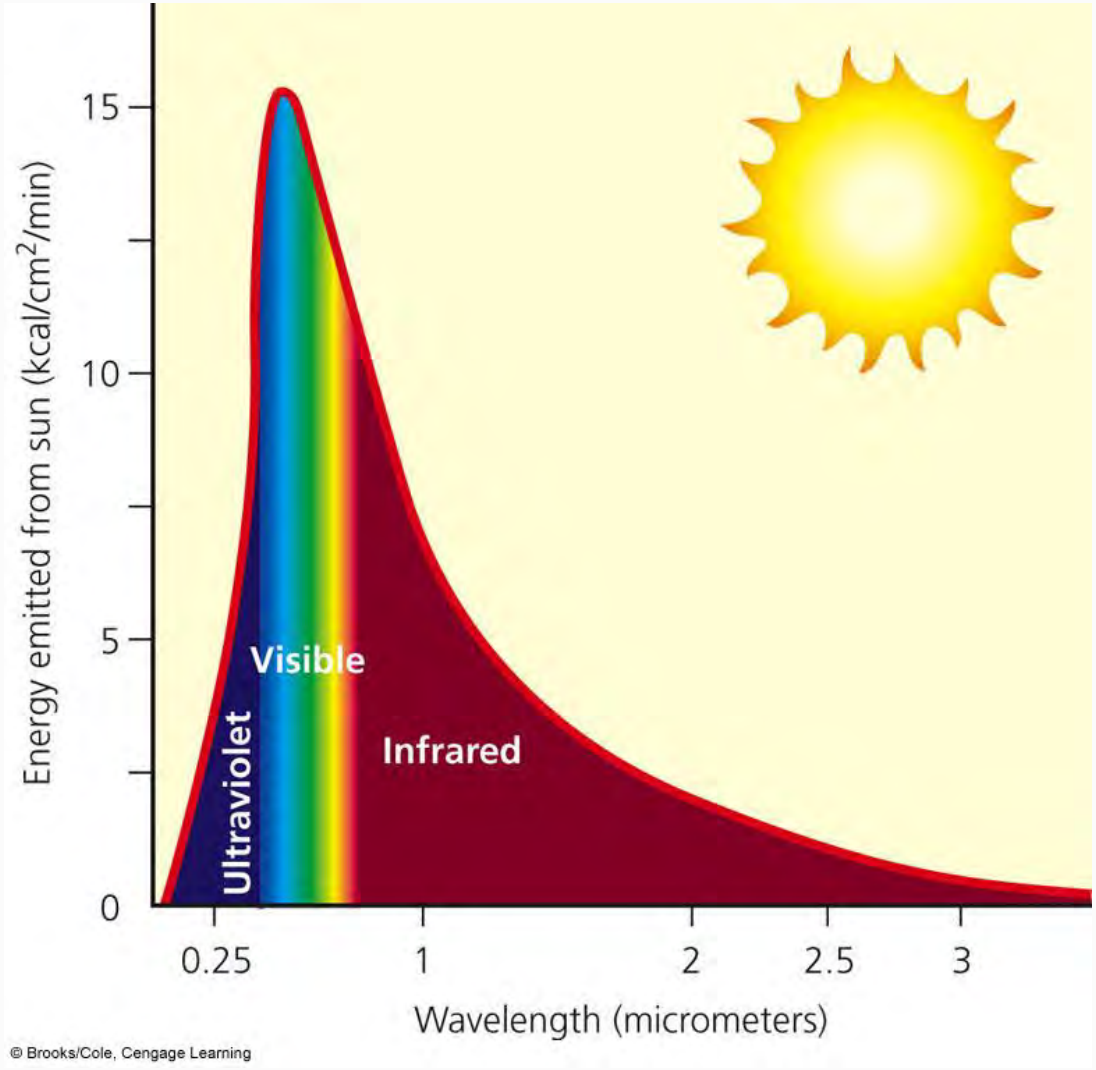
- ***Concept 2-4B*** *Whenever energy is changed from one form to another, we end up with lower-quality or less usable energy than we started with (second law of thermodynamics).*

# Energy Comes in Many Forms

- **Kinetic energy**
  - Heat
    - Transferred by radiation, conduction, or convection
  - Electromagnetic radiation

- **Potential energy**
  - Stored energy
    - Can be changed into kinetic energy

# The Spectrum of Electromagnetic Radiation



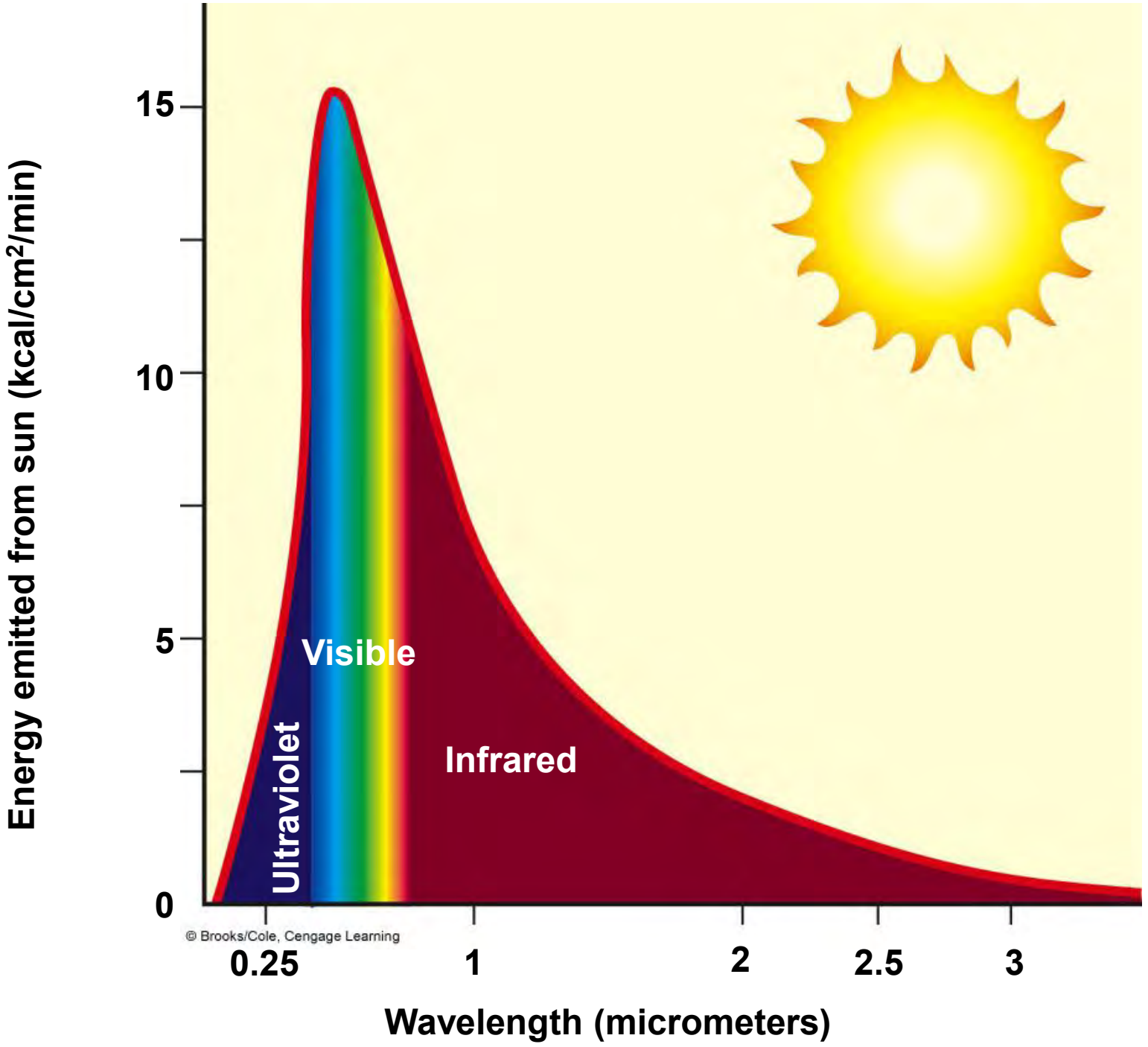
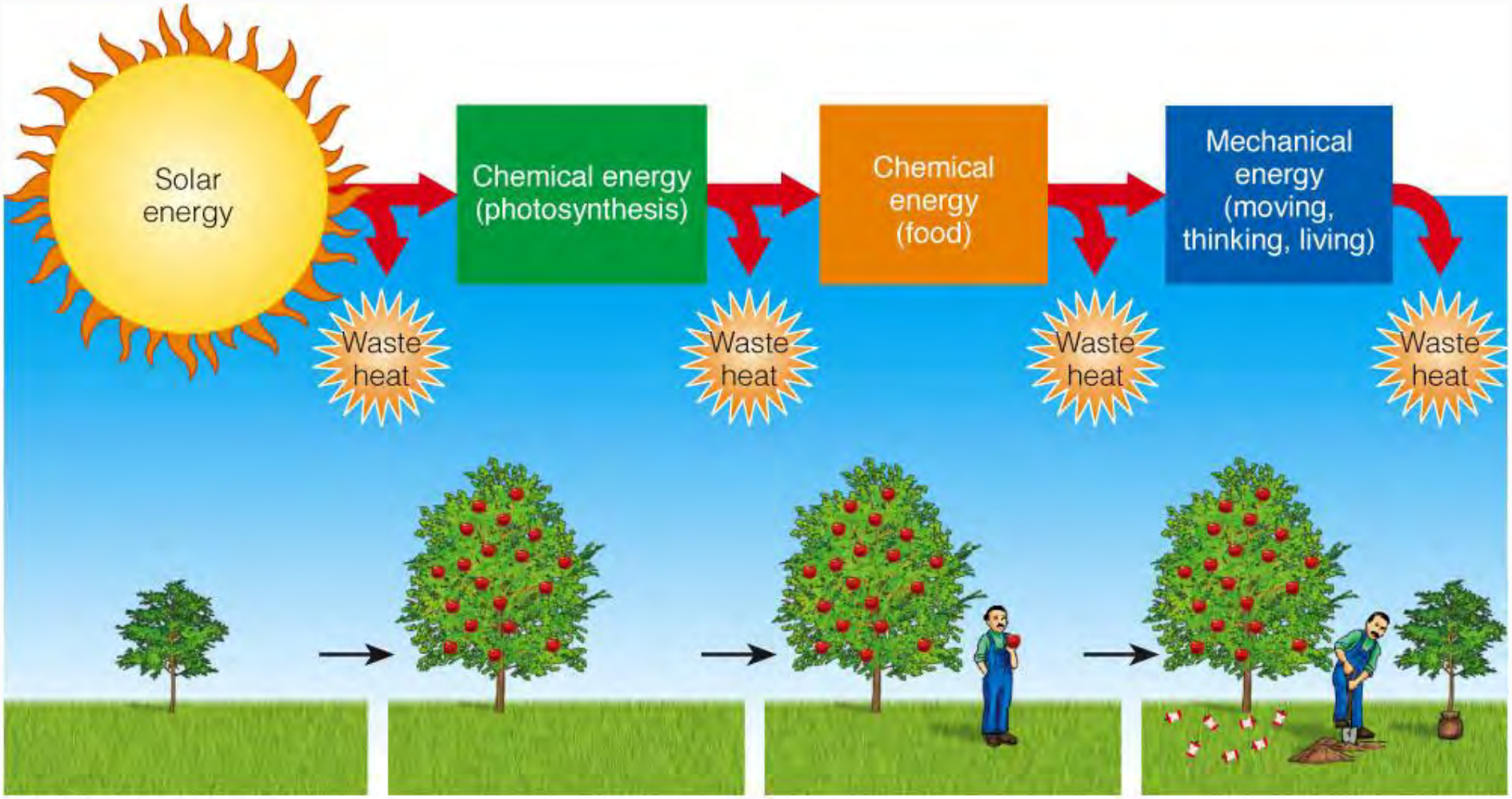

Energy emitted from sun (kcal/cm²/min)
15
10
5
0
Visible
Ultraviolet
Infrared
© Brooks/Cole, Cengage Learning
0.25
1
2
2.5
3
Wavelength (micrometers)

Fig. 2-8, p. 42

# The Second Law of Thermodynamics in Living Systems



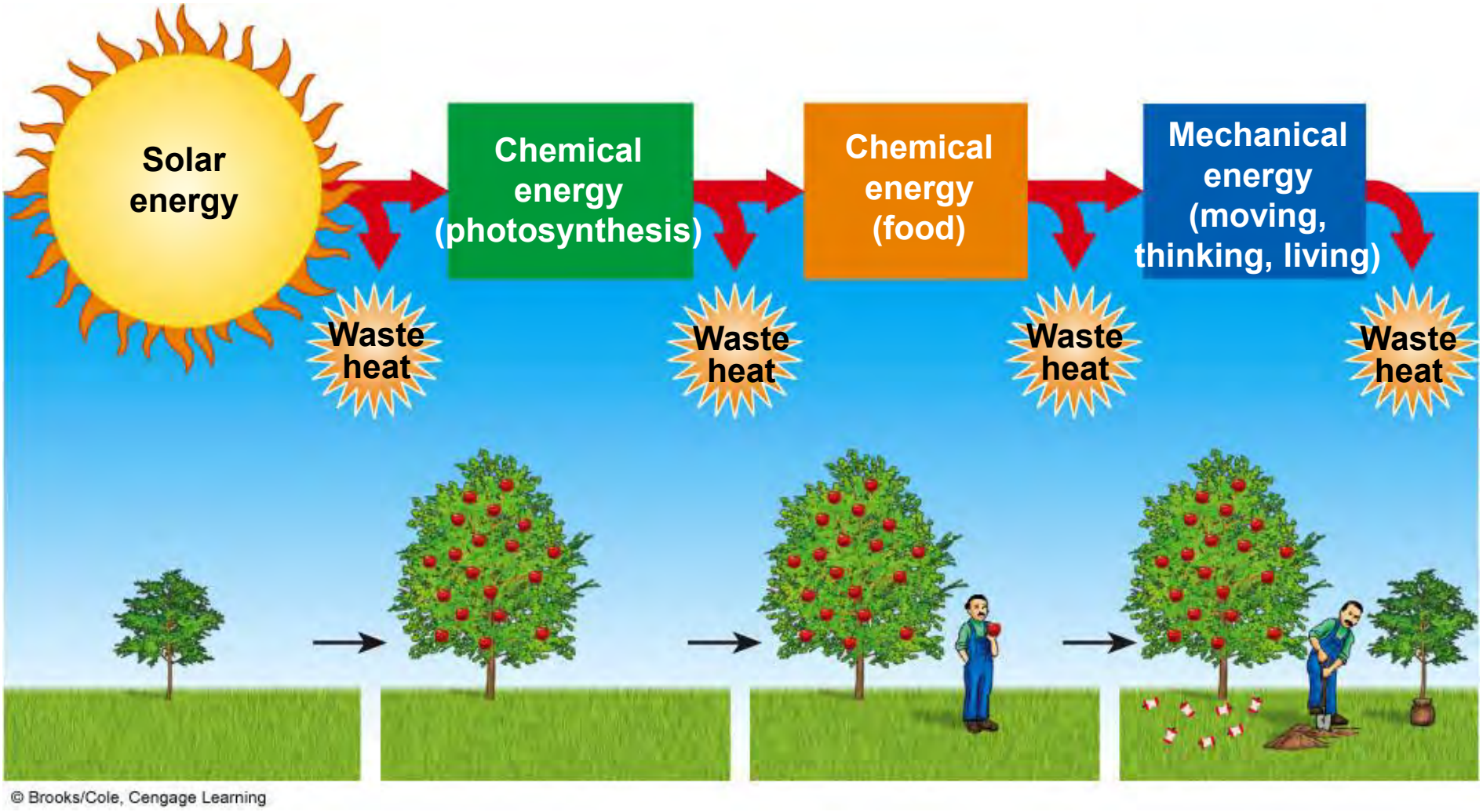





Fig. 2-9, p. 43

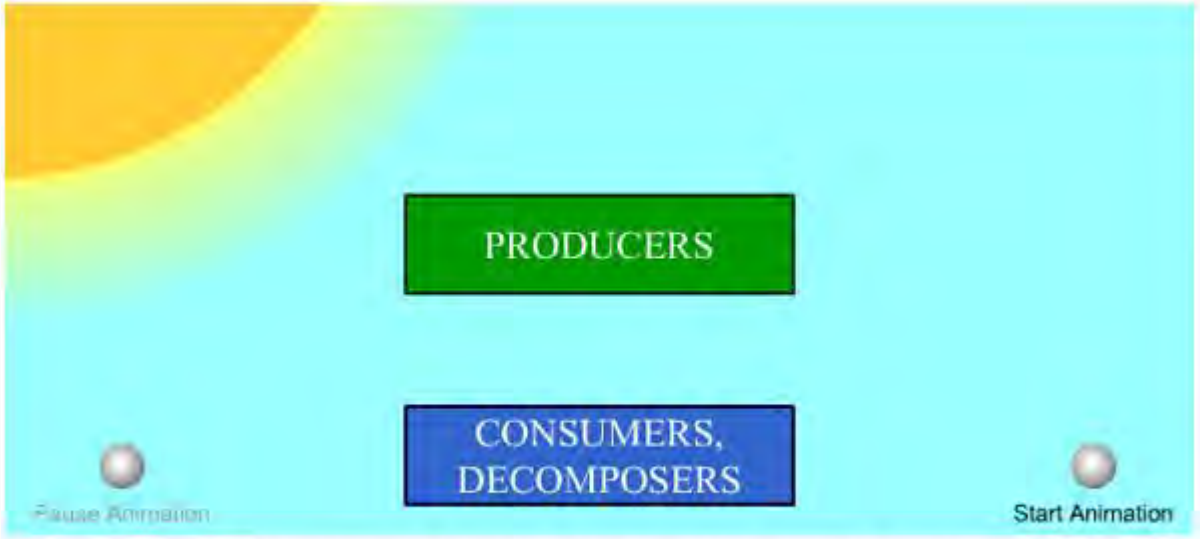
# Some Types of Energy Are More Useful Than Others

- High-quality energy
- Low-quality energy

# Energy Changes Are Governed by Two Scientific Laws

- First Law of Thermodynamics
  - Energy input **always** equals energy output
- Second Law of Thermodynamics
  - Energy always goes from a more useful to a less useful form when it changes from one form to another
- Energy efficiency or productivity

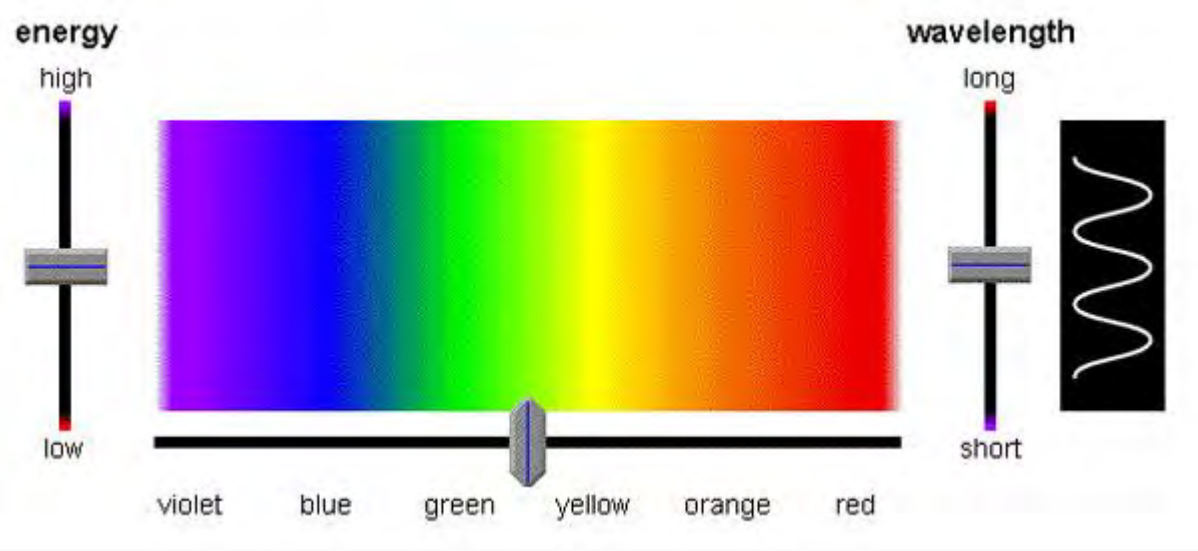
# Active Figure: Energy flow




A one-way flow of energy through organisms and a cycling of materials among them organizes life in the biosphere. **Click** Start Animation for an animated demonstration.

PLAY

# Active Figure: Visible light




PLAY

# Animation: Martian doing mechanical work


PLAY

# *2-5 What Are Systems and How Do They Respond to Change?*

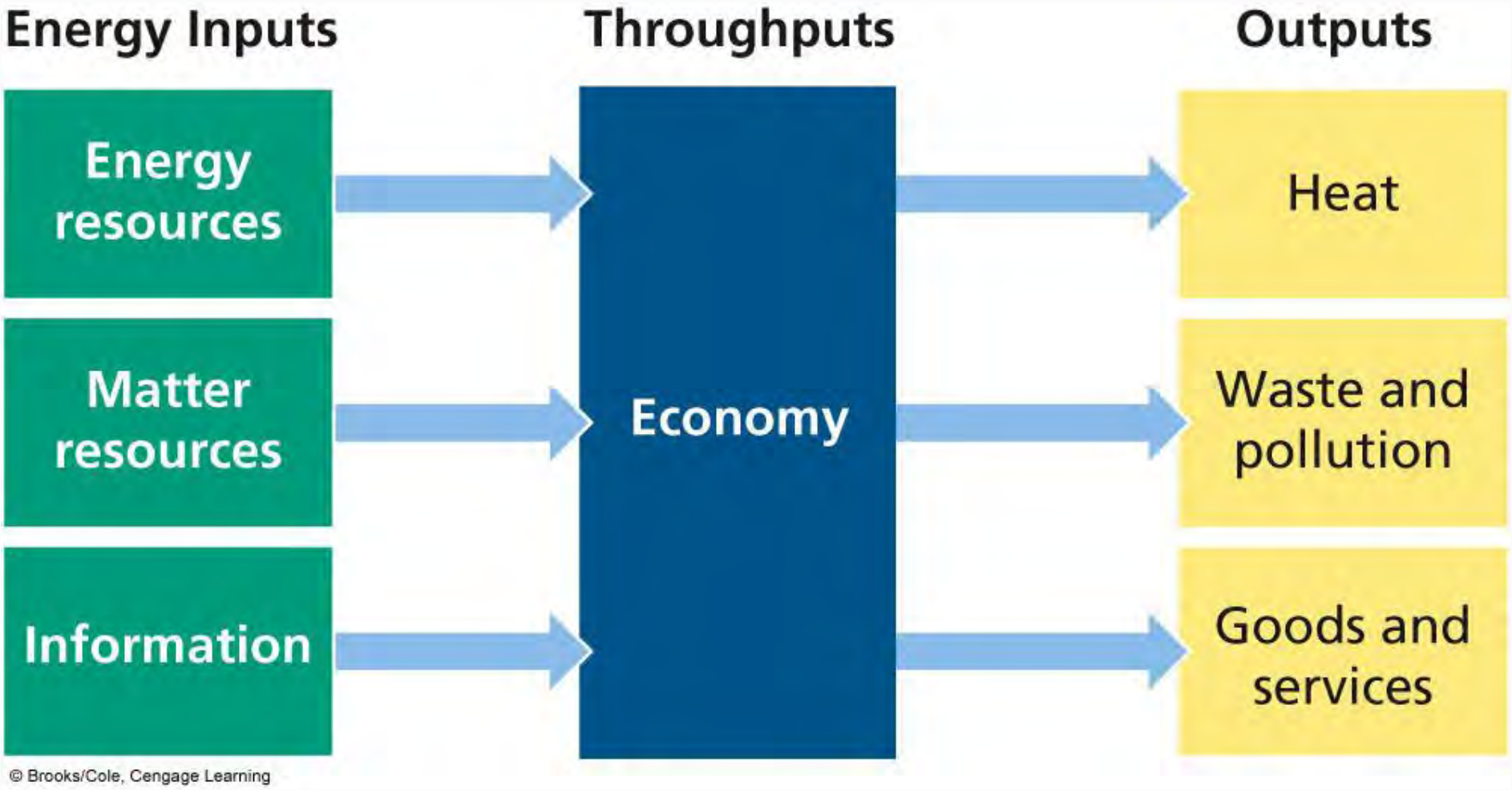
- ***Concept 2-5A*** *Systems have inputs, flows, and outputs of matter and energy, and their behavior can be affected by feedback.*

- ***Concept 2-5B*** *Life, human systems, and the earth's life support systems must conform to the law of conservation of matter and the two laws of thermodynamics.*

# Systems Have Inputs, Flows, and Outputs

- **System**
  - **Inputs** from the environment
  - **Flows, throughputs**
  - **Outputs**

# Inputs, Throughput, and Outputs of an Economic System



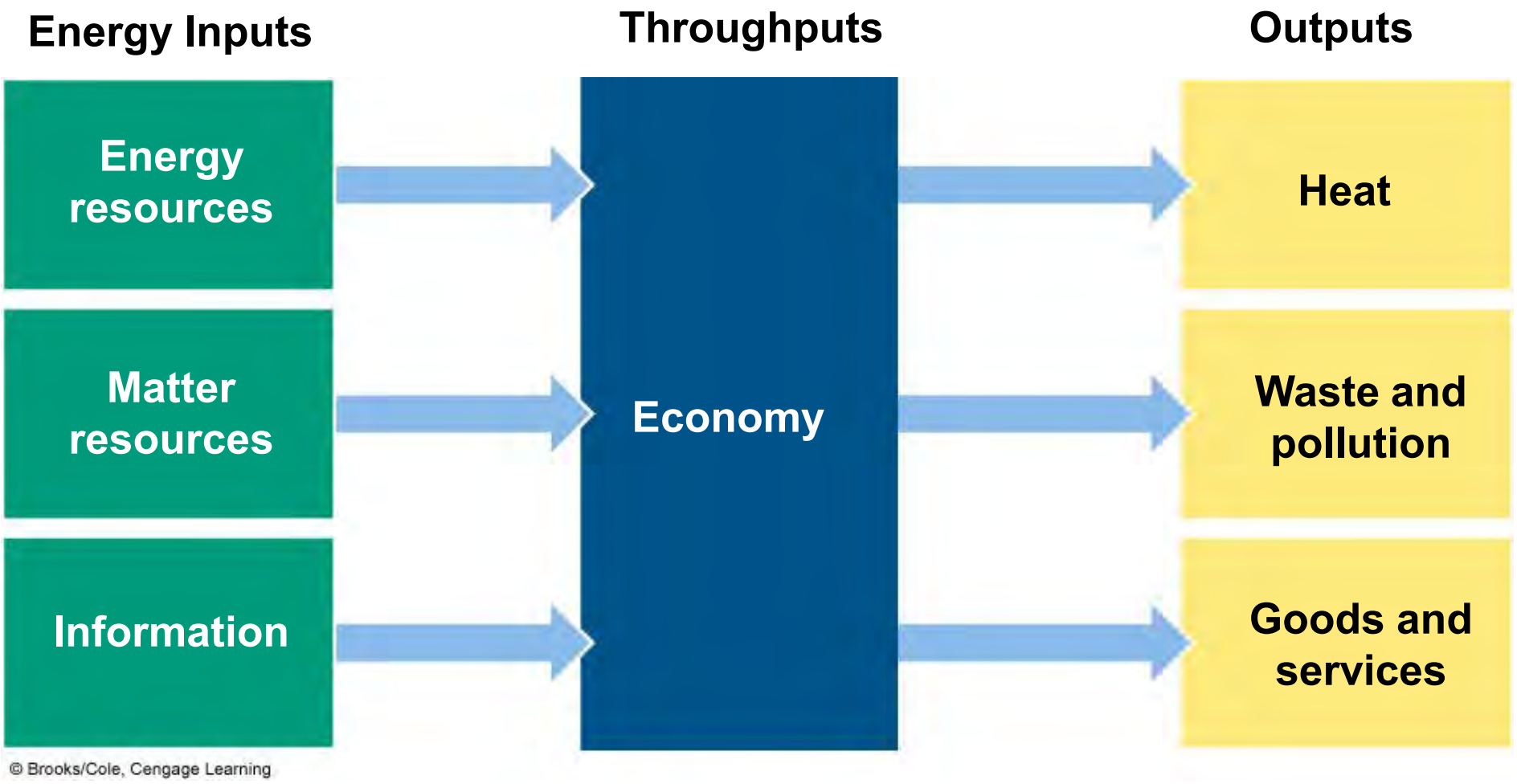
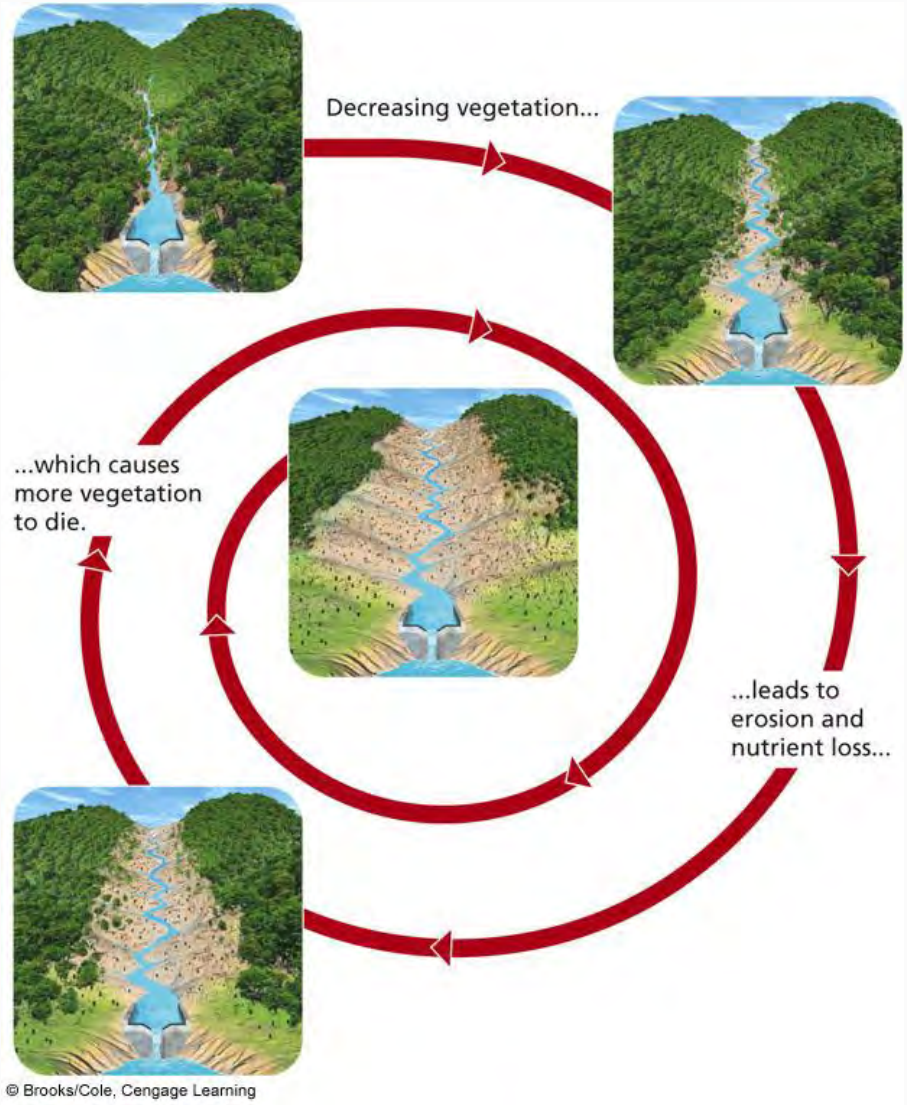

Energy Inputs
Throughputs
Outputs
Energy resources
Matter resources
Information
Economy
Heat
Waste and pollution
Goods and services
© Brooks/Cole, Cengage Learning

Fig. 2-10, p. 44

# Systems Respond to Change through Feedback Loops

- **Positive feedback loop**
- **Negative,** or **corrective, feedback loop**

# Positive Feedback Loop



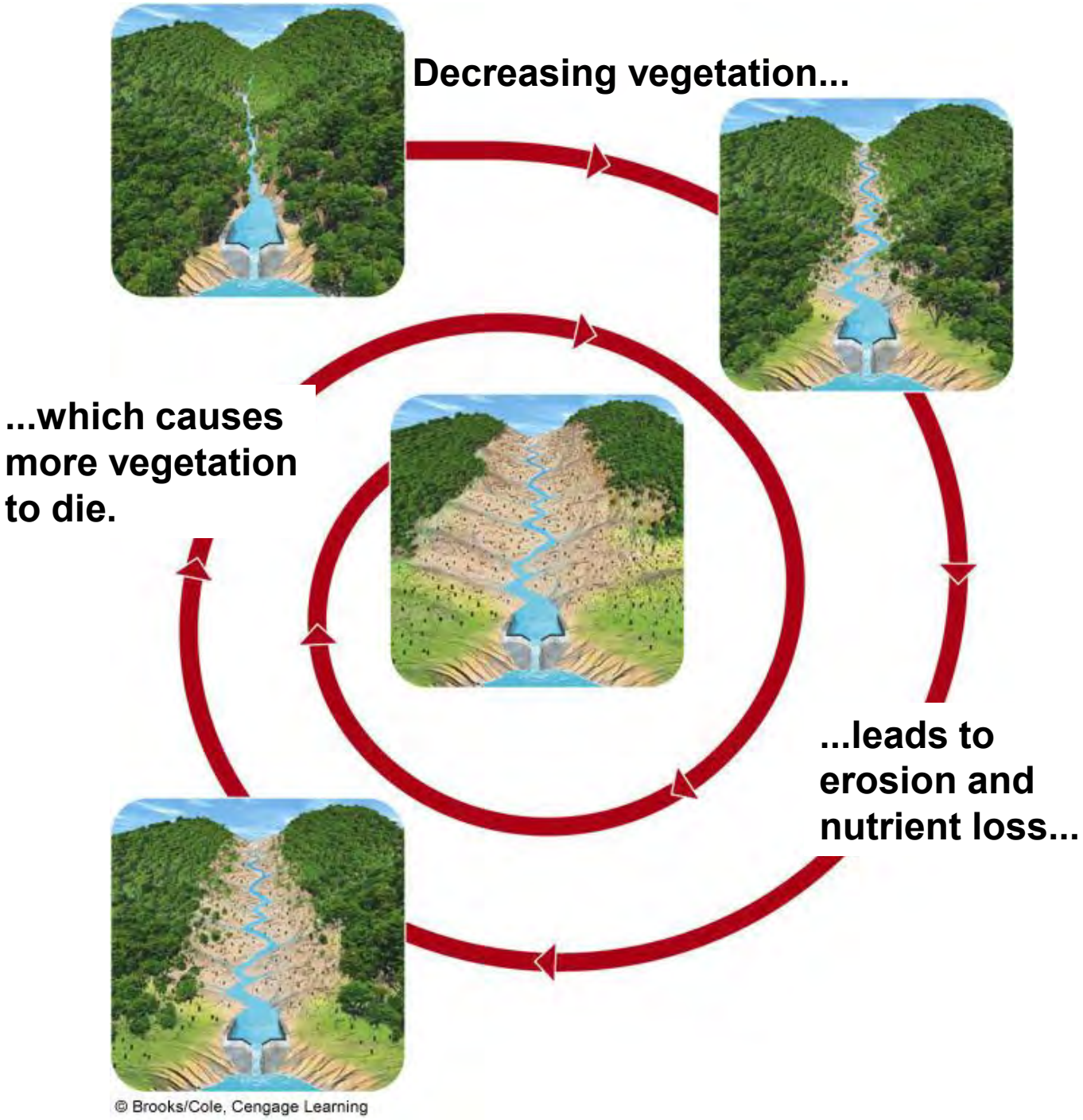
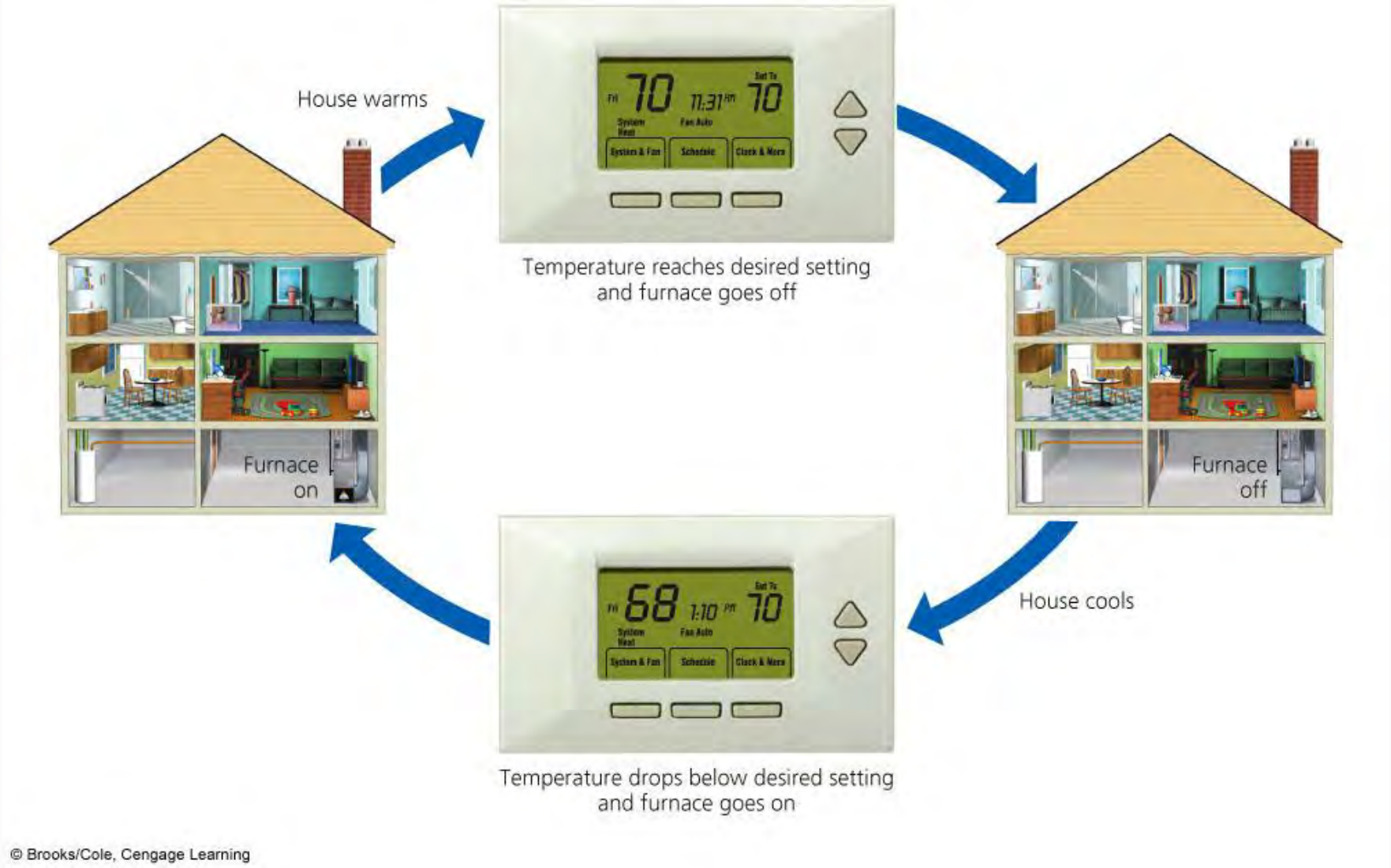

Decreasing vegetation...
...which causes more vegetation to die.
...leads to erosion and nutrient loss...
© Brooks/Cole, Cengage Learning

Fig. 2-11, p. 45

# Negative Feedback Loop



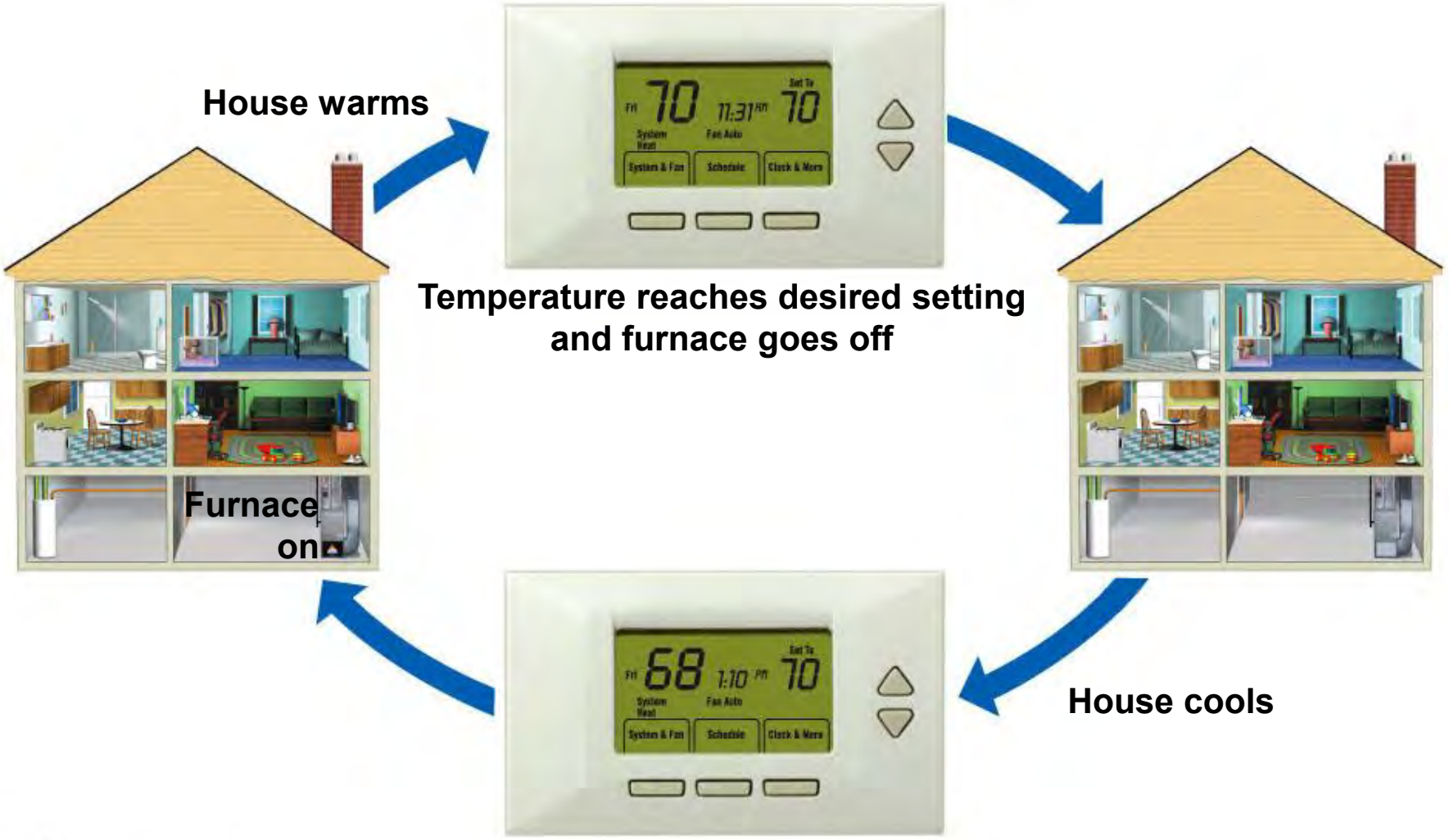





Fig. 2-12, p. 45

# Time Delays Can Allow a System to Reach a Tipping Point

- Time delays vary
  - Between the input of a feedback stimulus and the response to it
- **Tipping point,** threshold level
  - Causes a shift in the behavior of a system

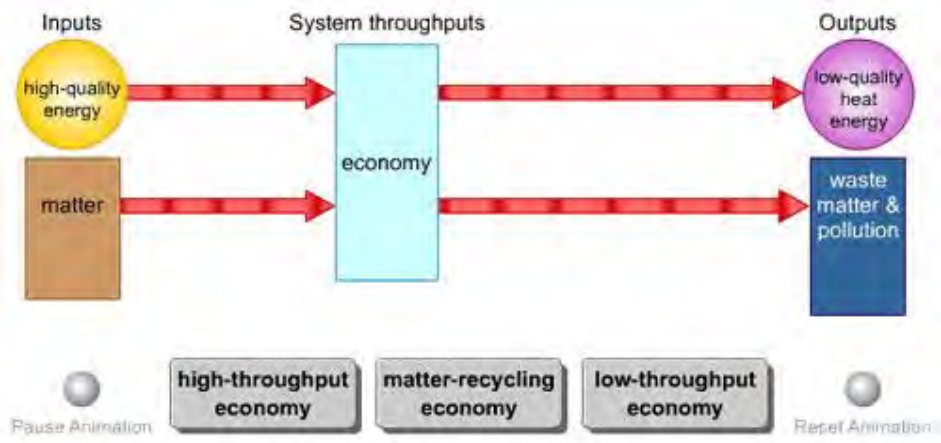
# System Effects Can Be Amplified through Synergy

- **Synergistic interaction, synergy**
  - Helpful
  - Harmful
    - E.g., Smoking and inhaling asbestos particles

# Human Activities Can Have Unintended Harmful Results

- Deforested areas turning to desert
- Coral reefs dying
- Glaciers melting
- Sea levels rising

# Animation: Economic types




PLAY

# Animation: Feedback control of temperature


PLAY

# ECOLOGY AND SUSTAINABILITY

## Chapter 2

## Science, Systems, Matter, and Energy

**Summary**


1. Science is an attempt to discover the natural world's order and use that in describing what is likely to happen in nature. Scientists ask a question or identify a problem to investigate. Then, they collect scientific data through observation and measurement. Experiments may be used to study specific phenomena.

2. The major components of complex systems are environmental inputs, flows within the system, and outputs to the environment.

3. The basic forms of matter are elements and compounds. Matter is useful to us as a resource because it makes up every material substance.

4. The major forms of energy are kinetic energy and potential energy. Energy is useful to us as a resource because it moves matter.

5. The Law of Conservation of Matter states that matter is neither created nor destroyed when a physical or chemical change occurs.

6. Matter can undergo three types of nuclear changes: natural radioactive decay, nuclear fission, and nuclear fusion.

7. The First Law of Thermodynamics states that in all physical and chemical changes, energy may be converted from one form to another but it is neither created nor destroyed. The Second Law of Thermodynamics states that when energy is changed from one form to another, there is always less usable energy left.

8. These laws, then, show that energy goes from a more useful to a less useful form and that high-quality energy cannot be recycled. So, the quality as well as the quantity of our resources and our environment will be reduced.


**Key Questions and Concepts**

**2-1 What is science?**

**CORE CASE STUDY**. Controlled experiments involve an experimental group, in which a known variable is changed, and a control group, in which the variable is not changed. The example involves two drainages that were dammed. One was deforested and one

left forested. The deforested landscape showed an increase in erosion and an increase in water flow carrying dissolved nutrients.

A. Science assumes that events in the natural world follow orderly patterns and that, through observation and experimentation, these patterns can be understood.
   1. Scientists collect facts or scientific data.
   2. Based on observations of phenomenon, scientists form a scientific hypothesis—an unconfirmed explanation of an observed phenomenon to be tested.
   3. Parts of the scientific process are skepticism, reproducibility, and peer review.
B. A scientific theory is a verified, believable, widely accepted scientific hypothesis.
C. A scientific/natural law describes events/actions of nature that reoccur in the same way.
D. There are many types of scientific methods used to gather data, formulate hypotheses, state theories and laws and, then test them. Observation leads to a hypothesis, then to an experiment that produces results, which lead to a conclusion.
   1. In an experimental group, one chosen variable is changed.
   2. In a control group, the chosen variable is not changed.
   3. Multivariable analysis uses mathematical models to analyze interactions of many variables.
E. Scientists try to establish that a particular theory/law has a high probability of being true. They always include a degree of uncertainty. **SCIENCE FOCUS**: Easter Island Revisited—an example of how a once accepted hypothesis has been replaced as a result of new evidence.
   1. Scientists use both inductive reasoning and deductive reasoning.
      a. Inductive reasoning uses specific observations and measurements to arrive at a general conclusion.
      b. Deductive reasoning uses logic to arrive at a specific conclusion based on a generalization.
F. Paradigm shifts occur when new discoveries overthrow well-accepted scientific theory.
G. Frontier science is scientific results that have not been confirmed; sound science or consensus science results from scientific results that have been well tested and are widely accepted. **SCIENCE FOCUS**: Global Warming—how global warming can be made to look like frontier science.
H. Environmental science has limitations.
   a. Scientists can disprove things, but not prove anything absolutely.
   b. Scientists are sometimes biased.
   c. Environmental scientists often rely on estimates.
   d. Environmental phenomena often involve a multitude of interacting variables.
   e. **SCIENCE FOCUS**: Statistics and Probability—understanding how statistics work.

**2-2 What is Matter?**

A. Matter is anything that has mass and takes up space, living or not. It comes in chemical forms, as an element or a compound.
   1. An element is the distinctive building block that makes up every substance.
   2. Chemists classify elements by their chemical behavior by arranging them in a periodic table of elements.

B. The building blocks of matter are atoms, ions, and molecules.
   1. An atom is the smallest unit of matter that exhibits the characteristics of an element.
   2. An ion is an electrically charged atom or combinations of atoms.
   3. A molecule is a combination of two or more atoms/ions of elements held together by chemical bonds.

C. Each atom has a nucleus containing protons and neutrons. Electron(s) orbit the nucleus of an atom.
   1. A proton (p) is positively charged, a neutron (n) is uncharged, and the electron (e) is negatively charged.
   2. Each atom has an equal number of positively charged protons in the nucleus and negatively charged electrons outside the nucleus, so the atom has no net electrical charge.
   3. Each element has a specific atomic number that is equal to the number of protons in the nucleus.
   4. The mass number of an atom equals the total number of neutrons and protons in its nucleus.
   5. Isotopes are various forms of an element that have the same atomic number, but different mass number.

D. Atoms of some elements can lose or gain one or more electrons to form ions with positive or negative electrical charges.
   1. Elements known as metals tend to lose one or more electrons; they are electron givers.
   2. Elements known as nonmetals tend to gain more electrons; they are known as electron receivers.
   3. Hydrogen ions (H+) in a solution are a measure of how acidic or basic the solution is. Neutral pH is 7, acid solutions are below 7, and basic solutions are above 7.

E. Chemical formulas are a type of shorthand to show the type and number of atoms/ions in a compound.
   1. Ionic compounds are made up of oppositely charged ions, ($Na^+$ and $Cl^-$).
   2. Compounds made of uncharged atoms are called covalent compounds ($CH_4$).

F. Organic compounds contain carbon atoms combined with one another and with various other atoms.
   1. Hydrocarbons: compounds of carbon and hydrogen atoms.
   2. Chlorinated hydrocarbons: compounds of carbon, hydrogen, and chlorine atoms.
   3. Simple carbohydrates: specific types of compounds of carbon, hydrogen, and oxygen atoms.

G. Polymers are larger and more complex organic compounds that have molecular units.
   1. Complex carbohydrates contain two or more monomers of simple sugars linked together.
   2. Proteins are formed by linking monomers of amino acids together.
   3. Nucleic acids are made of sequences of nucleotides linked together.
      a. Genes: specific sequences of nucleotides in a DNA molecule.
      b. Chromosomes: combinations of genes that make a single DNA molecule, plus some proteins.

c. Genome: the complete sequence of DNA base pairs that combine to make up the chromosomes in a typical member of each species.

H. All compounds without the combination of carbon atoms and other elements' atoms are inorganic compounds.

I. According to the usefulness of matter as a resource, it is classified as having high or low quality.
   1. High-quality matter is concentrated with great potential for usefulness and is usually found near the earth's surface.
   2. Low-quality matter is dilute and found deep underground and/or dispersed in air or water.

**2-3 How can matter change?**

A. When matter has a physical change, its chemical composition is not changed; the molecules are organized in different patterns.
B. In a chemical change, the chemical composition of the elements/compounds change.
C. The Law of Conservation of Matter states that no atoms are created/destroyed during a physical or chemical change.
D. Matter can undergo a change known as a nuclear change. Three types of nuclear change are radioactive decay, nuclear fission, and nuclear fusion.
E. Radioactive isotopes emit high-energy radiation at a fixed rate until the original unstable isotope is changed into a stable isotope.
   1. Nuclei of certain isotopes with large mass numbers (uranium-235) are split apart into lighter nuclei
      when struck by neutrons. This is nuclear fission.
F. Nuclear fusion occurs at extremely high temperatures and involves the fusion of two isotopes of light elements (H).

**2-4 What is energy and how can it be changed?**

A. Energy is the capacity to do work and transfer heat; it moves matter.
   1. Kinetic energy has mass and speed: wind, electricity are examples.
   2. Potential energy is stored energy, ready to be used: unlit match, for example.
   3. Potential energy can be changed to kinetic energy: drop an object ,for example.
B. Electromagnetic radiation is energy that travels as a wave, a result of changing electric and magnetic fields.
   1. Each form of electromagnetic radiation has a different wavelength and energy content.
   2. The electromagnetic spectrum describes the range of electromagnetic waves that have different wavelengths and energy content.
C. Heat is the total kinetic energy of all moving atoms, ions, or molecules in a substance.
   1. It can be transferred from one place to another by convection, conduction, and radiation.
   2. Temperature is the average speed of motion of atoms, ions, or molecules in a sample of matter.

3. Enegy quality is measured by its usefulness; high energy is concentrated and has high usefulness. Low energy is dispersed and can do little work.

D. The First Law of Thermodynamics states that energy can neither be created/destroyed, but can be converted from one form to another.

E. The Second Law of Thermodynamics states that when energy is changed from one form to another, there is always less usable energy. Energy quality is depleted.
   1. In changing forms of energy, there is a loss in energy quality; heat is often produced and lost.
   2. Changing forms of energy produces a small percentage of useful energy; much is lost in the process.
   3. In living systems, solar energy is changed to chemical energy, then to mechanical energy. High quality energy degraded to low quality heat.
   4. High-quality energy cannot be recycled/reused.
   5. Energy efficiency/productivity measures the amount of useful work by a specific input of energy.

**2-5 What are systems and how do they respond to change?**

A. A system is a set of components that interact. **SCIENCE FOCUS**: The Usefulness of Models—how models can be used to understand a system?
   1. Most systems have inputs from the environment, throughputs of matter and energy within the
      system, and outputs to the environment.
   2. Systems are affected by feedback and feedback loops (positive and negative).
   3. Systems often show time delays between input and response
   4. Problems can build slowly in systems until reaching a tipping point.
   5. Synergy is when processes interact such that the combined effect is greater than the individual effects.