APPENDIX A

How to Interpret Graphs

Presenting data in ways that help make trends and patterns visually apparent is a vital element of science. For scientists, businesspeople, journalists, policymakers, and others, the primary tool for expressing patterns in data is the graph. Thus, the ability to interpret graphs is a skill that you will want to cultivate. This appendix guides you in how to read graphs, introduces a few key conceptual points, and surveys the most common types of graphs, giving rationales for their use.

Navigating a Graph

A graph is a diagram showing relationships among *variables*, which are factors that can change in value. The most common types of graphs relate values of a *dependent variable* to those of an *independent variable*. As explained in Chapter 1 (p. 10), a dependent variable is so named because its values "depend on" the values of an independent variable. In other words, as the values of an independent variable change, the values of the dependent variable change in response. In a manipulative experiment (p. 11), changes that a researcher specifies in the value of the independent variable *cause* changes in the value of the dependent variable. In observational studies, there may be no causal relationship, and scientists may plot a correlation (p. 11). In a positive correlation, values of one variable go up or down along with values of another. In a negative correlation, values of one variable go up when values of the other go down. Whether we are graphing a correlation or a causal relationship, the values of the independent variable are known or specified by the researcher, whereas the values of the dependent variable are unknown until the research has taken place. The values of the dependent variable are what we are interested in observing or measuring.

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As a simple example, **FIGURE A.1** shows data from the Breeding Bird Survey that reflect population growth of the Eurasian collared dove following its introduction to North America. The *x* axis shows values of the independent variable, which in this case is time, expressed in units of years. The dependent variable, presented on the *y* axis, is the average number of doves detected on each route. For each year, a data point is plotted on the graph to show the average number of doves detected. In this particular graph, a line (dark red curve) was then drawn through the actual data points (orange dots), showing how closely the empirical data match an exponential growth curve (p. 66), a theoretical phenomenon of importance in ecology.

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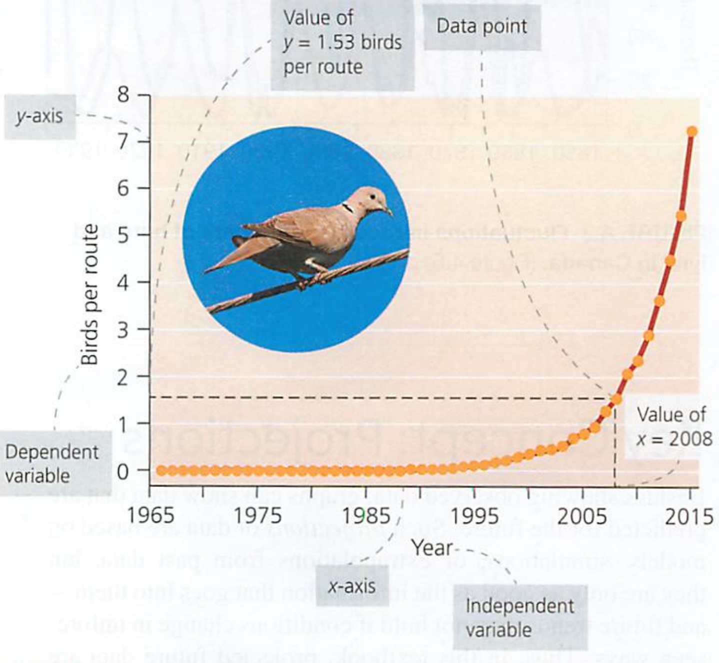

FIGURE A.1 Exponential population growth, demonstrated by the Eurasian collared dove in North America in recent years. (Figure 3.16, p. 66)

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Graph Type: Line Graph

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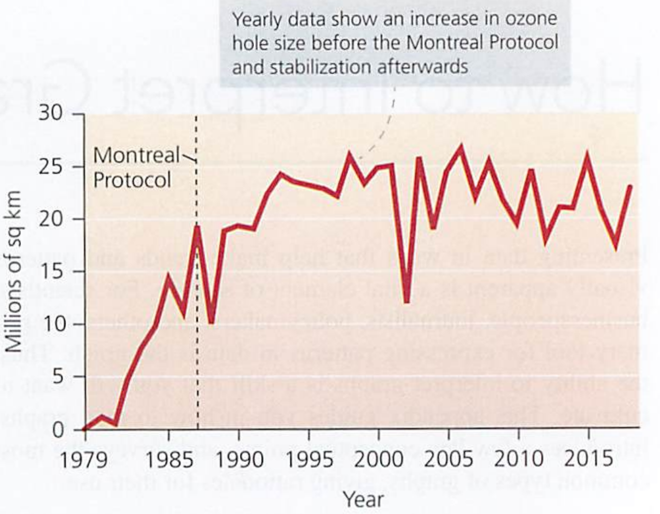

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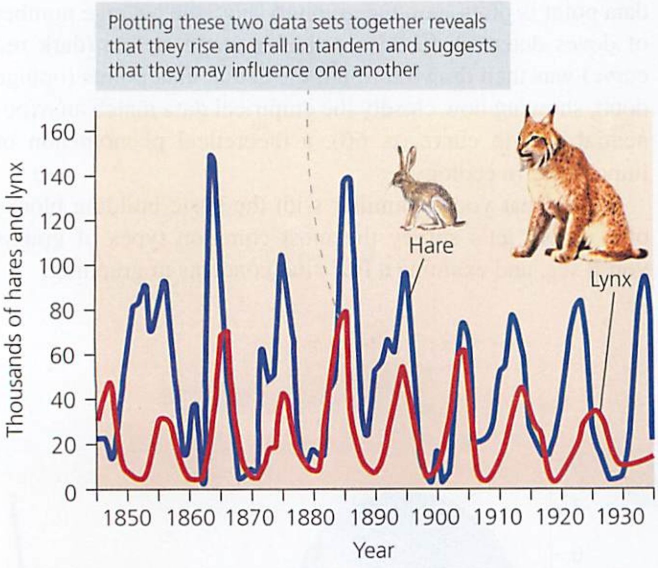
FIGURE A.2 Size of the Antarctic ozone hole before and after a treaty that was designed to address it. (Figure 17.22, p. 474)



Plotting these two data sets together reveals that they rise and fall in tandem and suggests that they may influence one another

FIGURE A.3 Fluctuations in recorded numbers of hare and lynx in Canada. (Figure 4.5, p. 79)

One useful technique is to plot two or more data sets together on the same graph. This allows us to compare trends in the data sets to see whether they may be related and, if so, the nature of that relationship. In **FIGURE A.3**, recorded numbers of a predator species rise and fall immediately following those of its prey, suggesting a possible connection.

Key Concept: Projections

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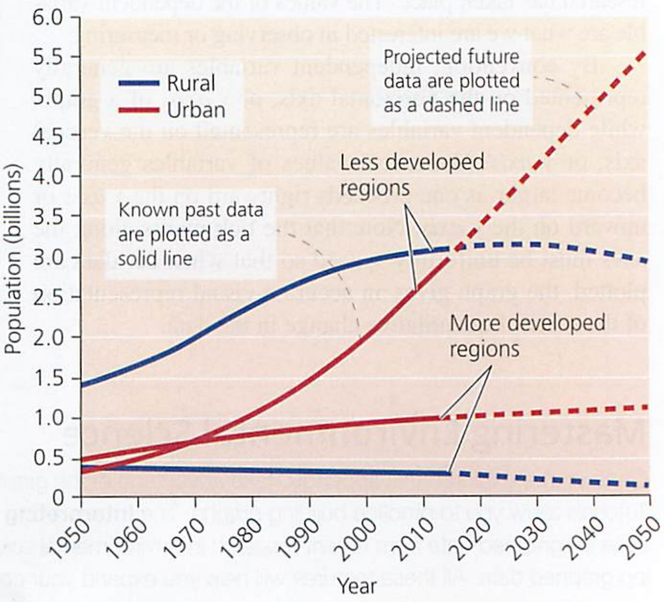

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FIGURE A.4 Past population change and projected future population change for rural and urban areas in more developed and less developed regions. (Figure 13.1, p. 338)

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A bar chart is most often used when one variable is a category and the other is a number. In such a chart, the height (or length) of each bar represents the numerical value of a given category. Higher or longer bars signify larger values. In **FIGURE A.5**, the bar for the category "Respiratory infections" is higher than that for "Malaria," indicating that respiratory infections cause more deaths each year (the numerical variable on the *y* axis) than does malaria.

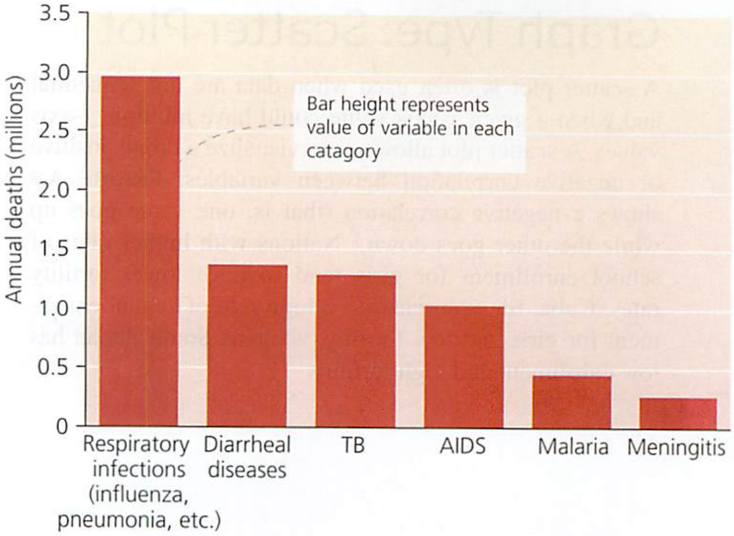


FIGURE A.5 Leading causes of death from infectious disease. (Figure 14.4b, p. 364)

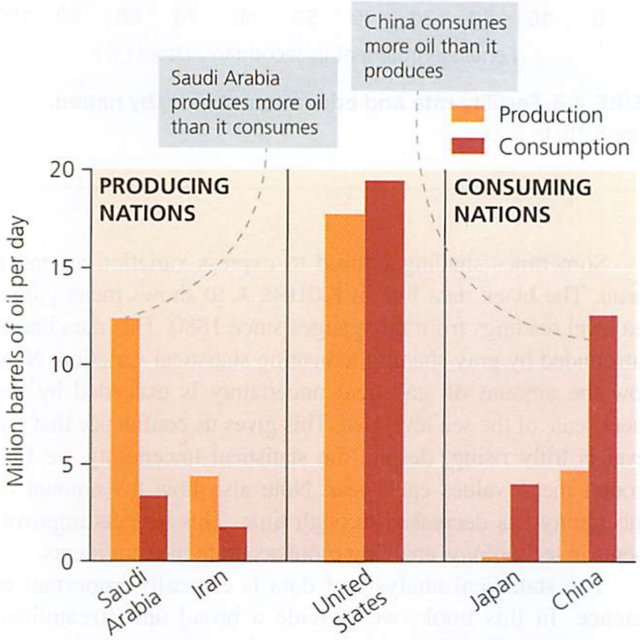


FIGURE A.6 Oil extraction and consumption by selected nations. (Figure 19.26, p. 551)

As we saw with line graphs, it is often instructive to graph two or more data sets together to reveal patterns and relationships. A bar chart such as **FIGURE A.6** lets us compare two data sets (oil production and oil consumption) both within and among nations. A graph that does double duty in this way allows for higher-level analysis (in this case, suggesting which nations depend on others for petroleum imports). Most bar charts in this book illustrate multiple types of information at once in this manner.

Graph Type: Pie Chart

A pie chart is used when we wish to compare the numerical proportions of some whole that are taken up by each of several categories. Each category is represented visually like a slice from a pie, with the size of the slice reflecting the percentage of the whole that is taken up by that category. For example, **FIGURE A.7** compares the percentages of genetically modified crops worldwide that are soybeans, corn, cotton, and canola.

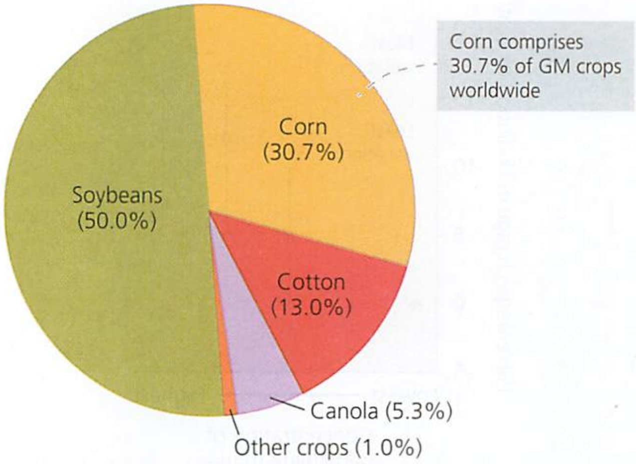


FIGURE A.7 Genetically modified crops grown worldwide, by type. (Figure 10.19a, p. 258)

Graph Type: Scatter Plot

A scatter plot is often used when data are not sequential and when a given x-axis value could have multiple y-axis values. A scatter plot allows us to visualize a broad positive or negative correlation between variables. **FIGURE A.8** shows a negative correlation (that is, one value goes up while the other goes down): Nations with higher rates of school enrollment for girls tend to have lower fertility rates. Cuba, for example, has a high rate of school enrollment for girls and low fertility, whereas South Sudan has low enrollment and high fertility.

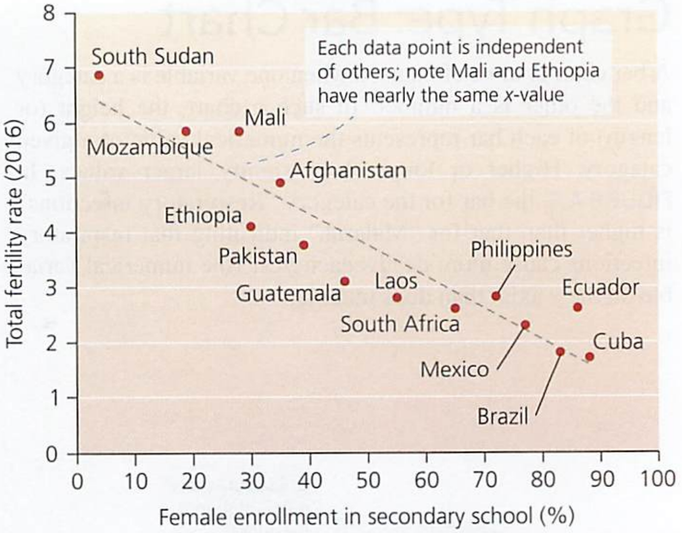


FIGURE A.8 Fertility rate and education of girls, by nation. (Figure 8.15, p. 206)

Key Concept: Statistical Uncertainty

Most data sets involve some degree of uncertainty. When a graphed value represents the *mean* (average) of many measurements, the researcher may want to use mathematical techniques to show the degree to which the raw data vary around this mean. Results from such statistical analyses may be expressed in a number of ways, and the two graphs in this section show methods used in this book.

In a bar chart or scatter plot (**FIGURE A.9**), thin black lines called *error bars* may be shown extending above and/or below each mean data value. In this example of likelihood of death from air pollution, error bars show the most variation at the highest measured concentration of pollutants and no variation at the lowest measured concentration.

Sometimes shading is used to express variation around a mean. The black data line in **FIGURE A.10** shows mean global sea level readings from tide gauges since 1880. This data line is surrounded by gray shading indicating statistical variation. Note how the amount of statistical uncertainty is exceeded by the sheer scale of the sea level rise. This gives us confidence that sea level is truly rising, despite the statistical uncertainty we find around mean values each year. Note also how the amount of uncertainty has decreased through time. This reflects improvements in technology, enabling more accurate measurements.

The statistical analysis of data is critically important in science. In this book, we provide a broad and streamlined introduction to many topics, so we often omit error bars from our graphs and leave out details of statistical significance from our discussions. Bear in mind that this is for clarity of presentation only; the research we discuss analyzes its data in far more depth than any textbook could possibly cover.

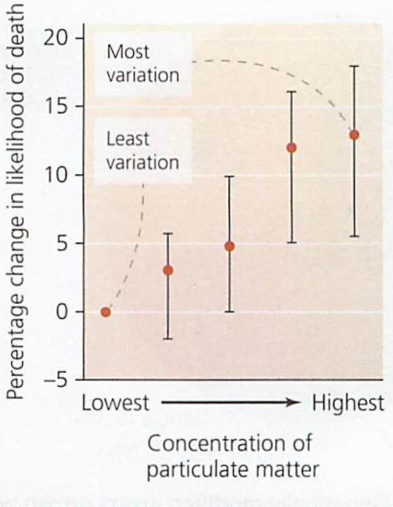


FIGURE A.9 Likelihood of death due to air pollution. (17-SBS1 Figure 3, p. 465)

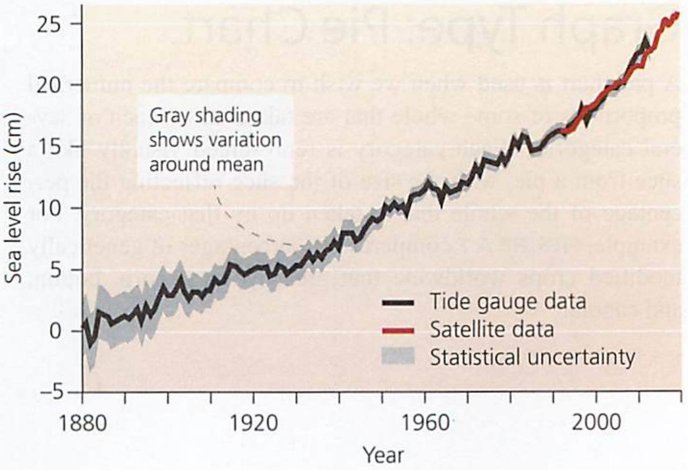


FIGURE A.10 Change in global sea level, measured since 1880. (Figure 18.19, p. 502)

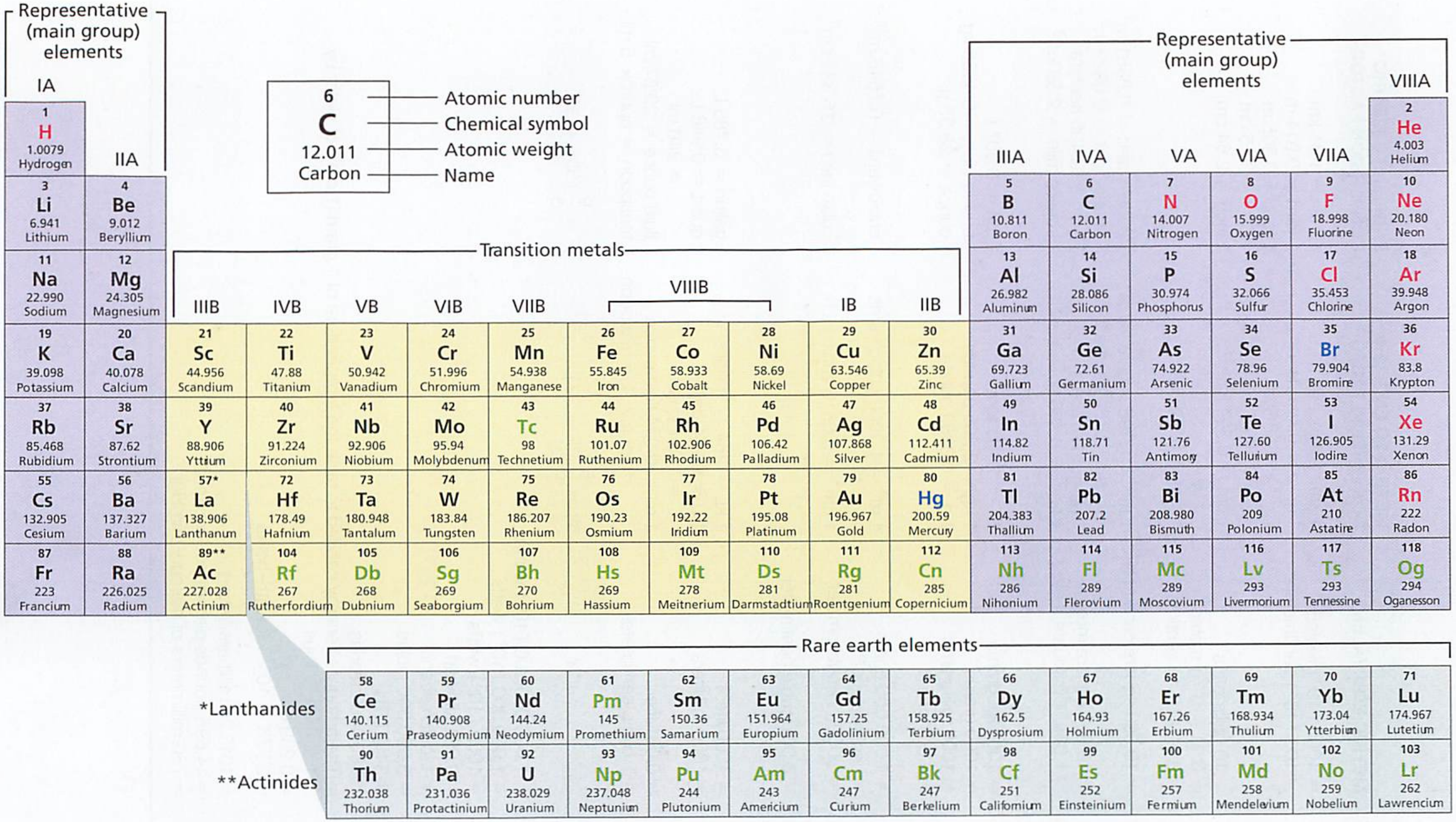
APPENDIX B

Metric System

MEASUREMENT	UNIT AND ABBREVIATION	METRIC EQUIVALENT	METRIC TO ENGLISH CONVERSION FACTOR	ENGLISH TO METRIC CONVERSION FACTOR
Length	1 kilometer (km)	= 1000 (10^3) meters	1 km = 0.62 mile	1 mile = 1.61 km
	1 meter (m)	= 100 (10^2) centimeters	1 m = 1.09 yards	1 yard = 0.914 m
			= 3.28 feet	1 foot = 0.305 m
			= 39.37 inches	= 30.5 cm
	1 centimeter (cm)	= 10 millimeters = 0.01 (10^{-2}) meter	1 cm = 0.394 inch	1 inch = 2.54 cm
	1 millimeter (mm)	= 0.01 (10^{-2}) centimeter	1 mm = 0.039 inch	
Area	1 square meter (m^2)	= 10,000 square centimeters	1 m^2 = 1.196 square yards	1 square yard = 0.8361 m^2
			= 10.764 square feet	1 square foot = 0.0929 m^2
	1 hectare (ha)	= 10,000 square meters	1 ha = 2.47 acres	1 acre = 0.405 hectare
	1 square kilometer (km^2)	= 1,000,000 square meters	1 km^2 = 0.386 square mile	1 square mile = 2.59 km^2
Mass	1 metric ton (t)	= 1000 kilograms	1 t = 1.103 tons	1 ton = 0.907 t
	1 kilogram (kg)	= 1000 grams	1 kg = 2.205 pounds	1 pound (lb) = 0.4536 kg
	1 gram (g)	= 1000 milligrams	1 g = 0.0353 ounce	1 ounce = 28.35 g
	1 milligram (mg)	= 0.001 gram		
Volume (solids)	1 cubic meter (m^3)	= 1,000,000 cubic centimeters	1 m^3 = 1.3080 cubic yards	1 cubic yard = 0.7646 m^3
	1 cubic centimeter (cm^3 or cc)	= 0.000001 cubic meter	1 cm^3 = 0.0610 cubic inch	1 cubic inch = 16.387 cm^3
	1 cubic millimeter (mm^3)	= 0.001 cubic centimeter		
Volume (liquids and gases)	1 kiloliter (kl or kL)	= 1000 liters	1 kL = 264.17 gallons	1 gallon = 3.785 L
	1 liter (l or L)	= 1000 milliliters	1 L = 0.264 gallon	1 quart = 0.946 L
			= 1.057 quarts	= 946 ml
	1 milliliter (ml or mL)	= 0.001 liter	1 ml = 0.034 fluid ounce	1 fluid ounce = 29.57 ml
		= 1 cubic centimeter	= approx. 1/5 teaspoon	1 teaspoon = approx. 5 ml
Temperature	Degrees Celsius (°C)		$°C = \frac{5}{9}(°F - 32)$	$°F = \frac{9}{5}(°C) + 32$
Energy and Power	1 gigawatt (GW)	= 1,000,000,000 (10^9) watts		
	1 megawatt (MW)	= 1,000,000 (10^6) watts		
	1 kilowatt (kW)	= 1000 (10^3) watts		
	1 watt (W)	= 0.001 kilowatt = 1 joule/second		
	1 kilowatt-hour (kWh)	= 3,600,000 joules = 3412 BTU = 860,400 calories		
	1 calorie (cal)	= The amount of energy needed to raise the temperature of 1 gram (1 cm^3) of water by 1 degree Celsius		
	1 joule	= 0.239 cal = 2.778×10^{-7} kilowatt–hours		
Pressure	1 atmosphere (atm)	= 1013.25 millibars (mbar) = 14.696 pounds per square inch (psi) = 760 millimeters of mercury (mmHg)		

APPENDIX C

Periodic Table of the Elements



6 — Atomic number
C — Chemical symbol
12.011 — Atomic weight
Carbon — Name

Representative (main group) elements — Transition metals — Representative (main group) elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 H 1.0079 Hydrogen																	2 He 4.003 Helium
2	3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.811 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluorine	10 Ne 20.180 Neon
3	11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminum	14 Si 28.086 Silicon	15 P 30.974 Phosphorus	16 S 32.066 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.098 Potassium	20 Ca 40.078 Calcium	21 Sc 44.956 Scandium	22 Ti 47.88 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.845 Iron	27 Co 58.933 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 69.723 Gallium	32 Ge 72.61 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.8 Krypton
5	37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.906 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.868 Silver	48 Cd 112.411 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.905 Iodine	54 Xe 131.29 Xenon
6	55 Cs 132.905 Cesium	56 Ba 137.327 Barium	57* La 138.906 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.948 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.967 Gold	80 Hg 200.59 Mercury	81 Tl 204.383 Thallium	82 Pb 207.2 Lead	83 Bi 208.980 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon
7	87 Fr 223 Francium	88 Ra 226.025 Radium	89** Ac 227.028 Actinium	104 Rf 267 Rutherfordium	105 Db 268 Dubnium	106 Sg 269 Seaborgium	107 Bh 270 Bohrium	108 Hs 269 Hassium	109 Mt 278 Meitnerium	110 Ds 281 Darmstadtium	111 Rg 281 Roentgenium	112 Cn 285 Copernicium	113 Nh 286 Nihonium	114 Fl 289 Flerovium	115 Mc 289 Moscovium	116 Lv 293 Livermorium	117 Ts 293 Tennessine	118 Og 294 Oganesson

Rare earth elements

*Lanthanides	58 Ce 140.115 Cerium	59 Pr 140.908 Praseodymium	60 Nd 144.24 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.925 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.934 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.967 Lutetium
**Actinides	90 Th 232.038 Thorium	91 Pa 231.036 Protactinium	92 U 238.029 Uranium	93 Np 237.048 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 262 Lawrencium

The periodic table arranges elements by atomic number and atomic weight into horizontal rows called *periods* and vertical columns called *groups.*

Elements of each group in Class A have similar chemical and physical properties. This reflects the fact that members of a particular group have the same number of valence shell electrons, which is indicated by the group's number. For example, group IA elements have one valence shell electron, group IIA elements have two, and group VA elements have five. In contrast, as you progress across a period from left to right, properties of the elements change, varying from the very metallic properties of groups IA and IIA to the nonmetallic properties of group VIIA to the inert elements (noble gases) in group VIIIA. This reflects changes in the number of valence shell electrons.

Class B elements, or transition elements, are metals and generally have one or two valence shell electrons. In these elements, some electrons occupy more distant electron shells before the deeper shells are filled.

In this periodic table, elements with symbols printed in black exist as solids under standard conditions (25°C and 1 atmosphere of pressure); elements in red exist as gases; and those in dark blue as liquids. Elements with symbols in green do not exist in nature and must be created by some type of nuclear reaction.

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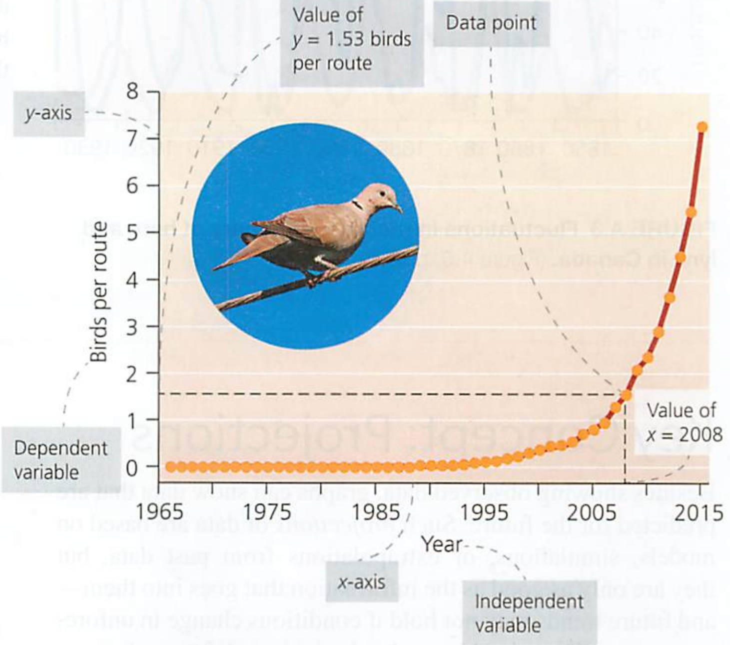

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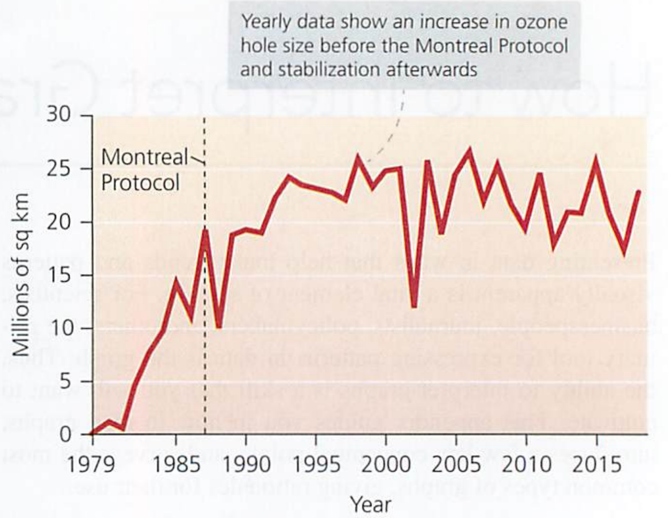
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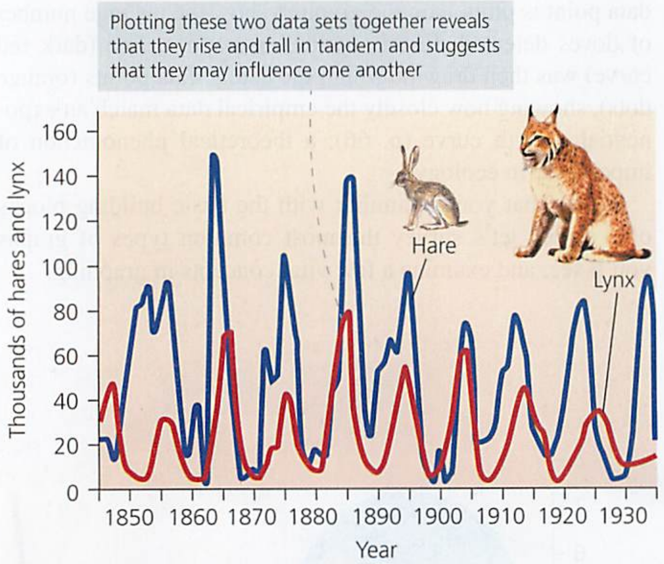
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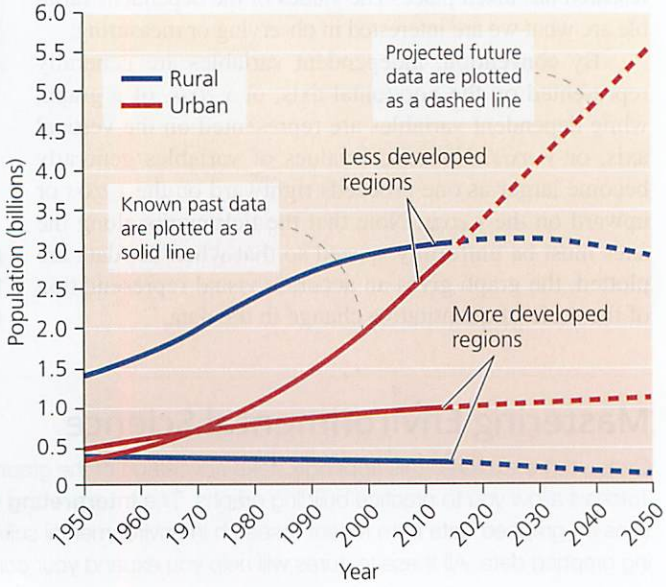
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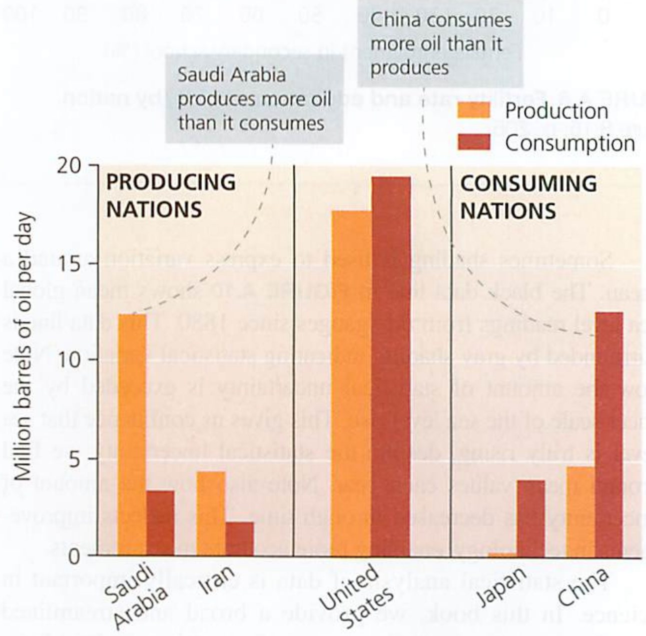

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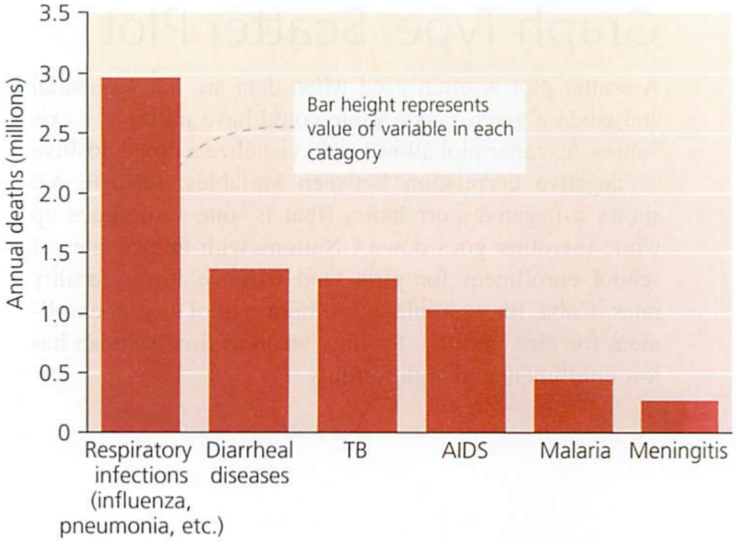

FIGURE A.5 Leading causes of death from infectious disease. (Figure 14.4b, p. 364)

As we saw with line graphs, it is often instructive to graph two or more data sets together to reveal patterns and relationships. A bar chart such as **FIGURE A.6** lets us compare two data sets (oil production and oil consumption) both within and among nations. A graph that does double duty in this way allows for higher-level analysis (in this case, suggesting which nations depend on others for petroleum imports). Most bar charts in this book illustrate multiple types of information at once in this manner.

Graph Type: Pie Chart

A pie chart is used when we wish to compare the numerical proportions of some whole that are taken up by each of several categories. Each category is represented visually like a slice from a pie, with the size of the slice reflecting the percentage of the whole that is taken up by that category. For example, **FIGURE A.7** compares the percentages of genetically modified crops worldwide that are soybeans, corn, cotton, and canola.

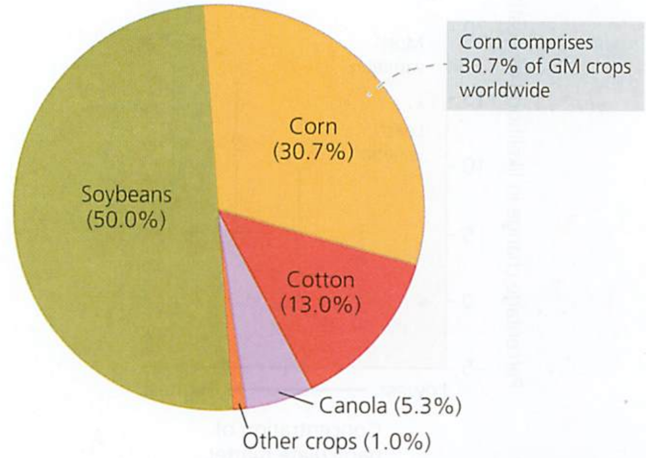

FIGURE A.7 Genetically modified crops grown worldwide, by type. (Figure 10.19a, p. 258)

Graph Type: Scatter Plot

A scatter plot is often used when data are not sequential and when a given *x*-axis value could have multiple *y*-axis values. A scatter plot allows us to visualize a broad positive or negative correlation between variables. **FIGURE A.8** shows a negative correlation (that is, one value goes up while the other goes down): Nations with higher rates of school enrollment for girls tend to have lower fertility rates. Cuba, for example, has a high rate of school enrollment for girls and low fertility, whereas South Sudan has low enrollment and high fertility.

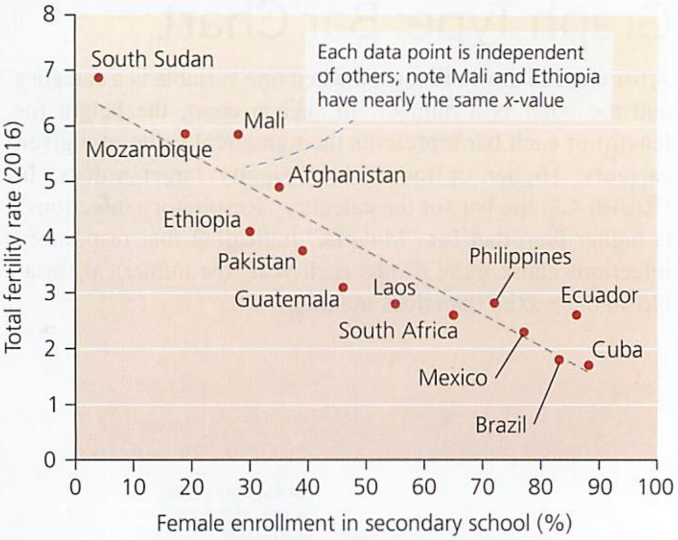

FIGURE A.8 Fertility rate and education of girls, by nation. (Figure 8.15, p. 206)

Key Concept: Statistical Uncertainty

Most data sets involve some degree of uncertainty. When a graphed value represents the *mean* (average) of many measurements, the researcher may want to use mathematical techniques to show the degree to which the raw data vary around this mean. Results from such statistical analyses may be expressed in a number of ways, and the two graphs in this section show methods used in this book.

In a bar chart or scatter plot (**FIGURE A.9**), thin black lines called *error bars* may be shown extending above and/or below each mean data value. In this example of likelihood of death from air pollution, error bars show the most variation at the highest measured concentration of pollutants and no variation at the lowest measured concentration.

Sometimes shading is used to express variation around a mean. The black data line in **FIGURE A.10** shows mean global sea level readings from tide gauges since 1880. This data line is surrounded by gray shading indicating statistical variation. Note how the amount of statistical uncertainty is exceeded by the sheer scale of the sea level rise. This gives us confidence that sea level is truly rising, despite the statistical uncertainty we find around mean values each year. Note also how the amount of uncertainty has decreased through time. This reflects improvements in technology, enabling more accurate measurements.

The statistical analysis of data is critically important in science. In this book, we provide a broad and streamlined introduction to many topics, so we often omit error bars from our graphs and leave out details of statistical significance from our discussions. Bear in mind that this is for clarity of presentation only; the research we discuss analyzes its data in far more depth than any textbook could possibly cover.

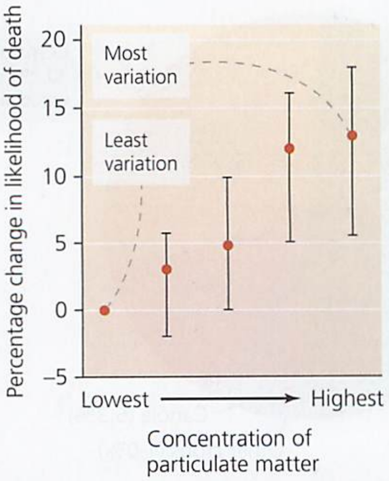

FIGURE A.9 Likelihood of death due to air pollution. (17-SBS1 Figure 3, p. 465)

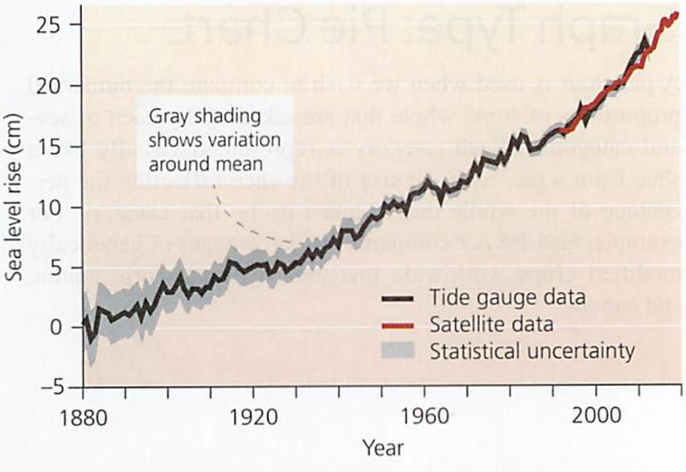

FIGURE A.10 Change in global sea level, measured since 1880. (Figure 18.19, p. 502)

APPENDIX B

Metric System

MEASUREMENT	UNIT AND ABBREVIATION	METRIC EQUIVALENT	METRIC TO ENGLISH CONVERSION FACTOR	ENGLISH TO METRIC CONVERSION FACTOR
Length	1 kilometer (km)	= 1000 (10^3) meters	1 km = 0.62 mile	1 mile = 1.61 km
	1 meter (m)	= 100 (10^2) centimeters	1 m = 1.09 yards = 3.28 feet = 39.37 inches	1 yard = 0.914 m 1 foot = 0.305 m = 30.5 cm
	1 centimeter (cm)	= 10 millimeters = 0.01 (10^{-2}) meter	1 cm = 0.394 inch	1 inch = 2.54 cm
	1 millimeter (mm)	= 0.01 (10^{-2}) centimeter	1 mm = 0.039 inch	
Area	1 square meter (m^2)	= 10,000 square centimeters	1 m^2 = 1.196 square yards = 10.764 square feet	1 square yard = 0.8361 m^2 1 square foot = 0.0929 m^2
	1 hectare (ha)	= 10,000 square meters	1 ha = 2.47 acres	1 acre = 0.405 hectare
	1 square kilometer (km^2)	= 1,000,000 square meters	1 km^2 = 0.386 square mile	1 square mile = 2.59 km^2
Mass	1 metric ton (t)	= 1000 kilograms	1 t = 1.103 tons	1 ton = 0.907 t
	1 kilogram (kg)	= 1000 grams	1 kg = 2.205 pounds	1 pound (lb) = 0.4536 kg
	1 gram (g)	= 1000 milligrams	1 g = 0.0353 ounce	1 ounce = 28.35 g
	1 milligram (mg)	= 0.001 gram		
Volume (solids)	1 cubic meter (m^3)	= 1,000,000 cubic centimeters	1 m^3 = 1.3080 cubic yards	1 cubic yard = 0.7646 m^3
	1 cubic centimeter (cm^3 or cc)	= 0.000001 cubic meter	1 cm^3 = 0.0610 cubic inch	1 cubic inch = 16.387 cm^3
	1 cubic millimeter (mm^3)	= 0.001 cubic centimeter		
Volume (liquids and gases)	1 kiloliter (kl or kL)	= 1000 liters	1 kL = 264.17 gallons	1 gallon = 3.785 L
	1 liter (l or L)	= 1000 milliliters	1 L = 0.264 gallon = 1.057 quarts	1 quart = 0.946 L = 946 ml
	1 milliliter (ml or mL)	= 0.001 liter = 1 cubic centimeter	1 ml = 0.034 fluid ounce = approx. 1/5 teaspoon	1 fluid ounce = 29.57 ml 1 teaspoon = approx. 5 ml
Temperature	Degrees Celsius (°C)		$°C = \frac{5}{9}(°F - 32)$	$°F = \frac{9}{5}(°C) + 32$
Energy and Power	1 gigawatt (GW)	= 1,000,000,000 (10^9) watts		
	1 megawatt (MW)	= 1,000,000 (10^6) watts		
	1 kilowatt (kW)	= 1000 (10^3) watts		
	1 watt (W)	= 0.001 kilowatt = 1 joule/second		
	1 kilowatt-hour (kWh)	= 3,600,000 joules = 3412 BTU = 860,400 calories		
	1 calorie (cal)	= The amount of energy needed to raise the temperature of 1 gram (1 cm^3) of water by 1 degree Celsius		
	1 joule	= 0.239 cal = 2.778×10^{-7} kilowatt–hours		
Pressure	1 atmosphere (atm)	= 1013.25 millibars (mbar) = 14.696 pounds per square inch (psi) = 760 millimeters of mercury (mmHg)		

APPENDIX C

Periodic Table of the Elements

6 — Atomic number
C — Chemical symbol
12.011 — Atomic weight
Carbon — Name

	Representative (main group) elements		Transition metals										Representative (main group) elements					
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 H 1.0079 Hydrogen																	2 He 4.003 Helium
2	3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.811 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluorine	10 Ne 20.180 Neon
3	11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminum	14 Si 28.086 Silicon	15 P 30.974 Phosphorus	16 S 32.066 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.098 Potassium	20 Ca 40.078 Calcium	21 Sc 44.956 Scandium	22 Ti 47.88 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.845 Iron	27 Co 58.933 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 69.723 Gallium	32 Ge 72.61 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.8 Krypton
5	37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.906 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.868 Silver	48 Cd 112.411 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.905 Iodine	54 Xe 131.29 Xenon
6	55 Cs 132.905 Cesium	56 Ba 137.327 Barium	57* La 138.906 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.948 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.967 Gold	80 Hg 200.59 Mercury	81 Tl 204.383 Thallium	82 Pb 207.2 Lead	83 Bi 208.980 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon
7	87 Fr 223 Francium	88 Ra 226.025 Radium	89** Ac 227.028 Actinium	104 Rf 267 Rutherfordium	105 Db 268 Dubnium	106 Sg 269 Seaborgium	107 Bh 270 Bohrium	108 Hs 269 Hassium	109 Mt 278 Meitnerium	110 Ds 281 Darmstadtium	111 Rg 281 Roentgenium	112 Cn 285 Copernicium	113 Nh 286 Nihonium	114 Fl 289 Flerovium	115 Mc 289 Moscovium	116 Lv 293 Livermorium	117 Ts 293 Tennessine	118 Og 294 Oganesson

	Rare earth elements													
*Lanthanides	58 Ce 140.115 Cerium	59 Pr 140.908 Praseodymium	60 Nd 144.24 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.925 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.934 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.967 Lutetium
**Actinides	90 Th 232.038 Thorium	91 Pa 231.036 Protactinium	92 U 238.029 Uranium	93 Np 237.048 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 262 Lawrencium

The periodic table arranges elements by atomic number and atomic weight into horizontal rows called *periods* and vertical columns called *groups.*

Elements of each group in Class A have similar chemical and physical properties. This reflects the fact that members of a particular group have the same number of valence shell electrons, which is indicated by the group's number. For example, group IA elements have one valence shell electron, group IIA elements have two, and group VA elements have five. In contrast, as you progress across a period from left to right, properties of the elements change, varying from the very metallic properties of groups IA and IIA to the nonmetallic properties of group VIIA to the inert elements (noble gases) in group VIIIA. This reflects changes in the number of valence shell electrons.

Class B elements, or transition elements, are metals and generally have one or two valence shell electrons. In these elements, some electrons occupy more distant electron shells before the deeper shells are filled.

In this periodic table, elements with symbols printed in black exist as solids under standard conditions (25°C and 1 atmosphere of pressure); elements in red exist as gases; and those in dark blue as liquids. Elements with symbols in green do not exist in nature and must be created by some type of nuclear reaction.

APPENDIX D

Geologic Time Scale