

Answers to Numerical Questions

page 127, Unit A Review

35. (a) 520 000 kJ/m²
(b) 520 kJ/m²

page 177, 5.1 Check and Reflect

11. (a) 9
(b) 9

page 183, Learning Checkpoint

4. (a) N
(b) Ni
(c) Pb

page 187, 5.2 Check and Reflect

2. (a) mercury, Hg and bromine, Br
(b) metal (mercury) and non-metal (bromine)
3. (a) germanium, Ge
(b) rubidium, Rb
(c) helium, He
(d) iodine, I
(e) hydrogen, H
(f) oxygen, O
(g) carbon, C
(h) chromium, Cr
(i) mercury, Hg
(j) fluorine, F
4. (a) sodium, Na
(b) iron, Fe
(c) silver, Ag
(d) lead, Pb
5. (a) for example, Cl, C, Ca, Cr, Cu
(b) for example, germanium, magnesium, copper
(c) He, Ne, Ar, Cl, Br
6. S, Si, Ag
8. (a) for example, iron and carbon
(b) hydrogen and oxygen
(c) sodium and chlorine

page 190, Learning Checkpoint

1. (a) 6
(b) 8
(c) 11
(d) 14
(e) 16
(f) 17
(g) 26

2. (a) 3
(b) 7
(c) 9
(d) 13
(e) 29
(f) 79

3. (a) hydrogen
(b) helium
(c) neon
(d) potassium
(e) calcium
(f) gallium
(g) silver

page 193, Learning Checkpoint

1. (a) 1.01 amu
(b) 4.00 amu
(c) 14.01 amu
(d) 19.00 amu
(e) 32.07 amu
(f) 40.08 amu
(g) 107.87 amu
2. (a) carbon
(b) oxygen
(c) potassium
(d) krypton
3. (a) 1+
(b) 2+
(c) 3-
(d) 2-
(e) 3+
(f) 1-

page 195, Learning Checkpoint

1. (a) sodium, Na
(b) boron, B
(c) copper, Cu
(d) iodine, I
2. (a) Period 3, Group 2
(b) Period 3, Group 14
(c) Period 3, Group 17
(d) Period 1, Group 18
(e) Period 6, Group 11
(f) Period 6, Group 14

page 199, Learning Checkpoint

1. (a) 1
(b) 3
(c) 4
(d) 6
(e) 7

2. (a) 1
(b) 2
(c) 5
(d) 8

page 204, 5.3 Check and Reflect

1. (a) Na
(b) mercury
(c) silicon
(d) potassium
4. halogens
7. (a) F
(d) S
10. (a) helium
(b) 2
(c) 2
(d) Group 18, noble gases
11. (b) gallium and germanium
12. Group 1, alkali metals

page 206, Chapter 5 Review

2.

Particle	Charge	Location	Relative Mass
electron	1-	shells	tiny (1)
neutron	0	nucleus	large (1837)

3. 2, 8, 8
5. (a) plumbum
(b) Pb
6. for example, carbon, phosphorus, sulphur, selenium
8. (a) technetium
(b) dysprosium
9. (a) 4
(b) 2
(c) helium
16. (d) germanium

page 213, Learning Checkpoint

2. metal and non-metal

page 217, 6.1 Check and Reflect

6. (a) 3
(b) 2
9. (a) Bohr diagram
(b) ionic compound
(c) magnesium and oxygen

page 220, Learning Checkpoint

3. (a) 2+, Ca²⁺, calcium ion
- (b) 1-, Cl⁻, chloride
- (c) 3-, P³⁻, phosphide
- (d) 3+, Au³⁺, gold(III) and 1+, Au⁺, gold(I)
- (e) 4+, Sn⁴⁺, tin (IV) and 2+, Sn²⁺, tin (II)

page 221, Practice Problems

1. sodium fluoride
2. potassium iodide
3. magnesium chloride
4. aluminum chloride
5. calcium phosphide

page 222, Practice Problems

1. iron(III) chloride
2. lead(IV) oxide
3. nickel(III) sulphide
4. copper(II) fluoride
5. chromium(III) sulphide

page 223, Practice Problems

1. potassium hydroxide
2. zinc carbonate
3. magnesium phosphate
4. calcium sulphate
5. aluminum carbonate

page 224, Practice Problems

1. LiBr
2. MgF₂
3. Ag₃N
4. FeCl₃
5. Cr₂S₃

page 225, Practice Problems

1. Al(OH)₃
2. CaSO₄
3. Na₂CO₃
4. Fe₂(CO₃)₃
5. CuSO₄

page 226, Practice Problems

1. carbon monoxide
2. carbon tetraiodide
3. oxygen difluoride
4. dinitrogen tetraoxide
5. phosphorus trichloride

page 227, Practice Problems

1. CO₂
2. OF₂
3. NF₃
4. PF₅
5. N₂O₃

page 229, 6.2 Check and Reflect

1. (a) atom
- (b) molecular compound
- (c) ion
- (d) atom
- (e) molecular compound
- (f) ionic compound
- (g) molecular compound
2. (a) Li⁺
- (b) Sr²⁺
- (c) V⁴⁺, V⁵⁺
- (d) Cl⁻
- (e) S²⁻
3. (a) lithium oxide
- (b) calcium fluoride
- (c) potassium fluoride
- (d) sodium nitride
- (e) magnesium hydroxide
- (f) iron(II) chloride
- (g) aluminum sulphate
4. (a) MgCl₂
- (b) Na₂S
- (c) Ca₃P₂
- (d) K₃N
- (e) CaF₂
- (f) Al₂O₃
5. (a) NI₃
- (b) CO₂
- (c) SF₆
- (d) CH₄
- (e) C₁₂H₂₂O₁₁
6. (a) carbon tetrabromide
- (b) nitrogen monoxide
- (c) oxygen difluoride
- (d) iodine dibromide
- (e) phosphorus trichloride
- (f) dinitrogen trioxide
9. (c) hydrogen peroxide

page 240, Chapter 6 Review

2. (a) hydrogen and oxygen, 1:1
- (b) molecular compound

3. (a) N³⁻
- (b) Li⁺
- (c) Al³⁺
- (d) O²⁻
- (e) Cl⁻
- (f) Na⁺
- (g) does not form ions
- (h) Cu²⁺, Cu³⁺
4. (a) potassium iodide
- (b) calcium chloride
- (c) aluminum bromide
5. (a) Li₃N
- (b) FeCl₂
- (c) NaOH
6. (a) phosphorus pentafluoride
- (b) dichlorine trioxide
- (c) carbon tetrafluoride
7. (a) NO
- (b) CS₂
- (c) PBr₃
10. (a) Mg(OH)₂
- (b) Na₂CO₃
- (c) Al₂(SO₄)₃
- (d) cesium hydrogen carbonate
- (e) barium carbonate
- (f) potassium sulphate

page 246, Unit B Review

16. (a) 1
- (b) 3
- (c) 4
- (d) 6
- (e) 7
17. (a) calcium
- (b) Group 2, alkaline earth metals
- (c) 2+
- (d) 20
21. (a) lithium and chlorine, 1:1
- (b) aluminum and sulphur, 2:3
- (c) silver and fluorine, 1:1
- (d) zinc and oxygen, 1:1
- (e) nitrogen and sulphur, 2:3
- (f) bromine
22. (a) ionic compound
- (b) ionic compound
- (c) ionic compound
- (d) ionic compound
- (e) molecular compound
- (f) neither (element)

33. (a) does not normally form ions
 (b) Ba^{2+}
 (c) Be^{2+}
 (d) does not form ions
 (e) Pb^{2+} or Pb^{4+}
 (f) Se^{2-}

38. (a) potassium chloride
 (d) MgO

57. (a) magnesium bromide
 (b) barium nitride
 (c) calcium phosphide
 (d) aluminum oxide
 (e) sodium iodide
 (f) calcium chloride
 (g) potassium carbonate
 (h) magnesium sulphate
 (i) cesium hydrogen carbonate

58. (a) ionic, Mg_3P_2
 (b) ionic, Li_3N
 (c) molecular, PCl_5
 (d) ionic, AlBr_3
 (e) ionic, CaS
 (f) molecular, SO_2
 (g) ionic, KI
 (h) ionic, Na_2O
 (i) ionic, $\text{Ca}(\text{OH})_2$
 (j) ionic, $\text{Al}(\text{HCO}_3)_3$
 (k) molecular, NCl_3

59. See answer at bottom of page.

page 265, C3 Just-in-Time Math

1. 4×10^{13}
2. 1.5×10^{11}
3. 1.3×10^{10}
4. 1.525×10^5
5. 1.99×10^{30}
6. 4.55×10^9

page 267, 7.1 Check and Reflect

12. (a) 17.1 years
 (b) 513 years
 13. 130 years

page 275, C6 Just-in-Time Math

1. 15 cm
2. 41.6 cm
3. 46.4 cm

page 277, 7.2 Check and Reflect

2. 100 000 ly in diameter; 2000 ly thick
3. about 35 000 years

page 321, 8.2 Check and Reflect

2. (a) 5 billion years
 (b) 5 billion years
4. 100 000 years

page 331, 8.3 Check and Reflect

1. 1 day
2. 1 year

page 382, Unit C Review

56. (a) 9×10^{13}
 (b) 1.5×10^{11}
 (c) 2.48×10^7
 57. (b) 10 000 times
 (c) 6000°C

page 460, Practice Problems

1. 45 V
2. 9.0 V
3. 120 V

page 461 (top), Practice Problems

1. 2.5 A
2. 0.2 A
3. 0.067 A

page 461 (bottom), Practice Problems

1. 4 Ω
2. 192 Ω
3. 600 Ω

page 467, 11.3 Check and Reflect

3.

V	I	R
0.5 V	0.01 A	50 Ω
2000 V	20 A	100 Ω
6.0 V	4.0 A	1.5 Ω

8. 2 Ω

9. (a) 0.5 A
 (b) 0.25 A

10. (a) 0.125 A
 (b) 1.5 V across the 12- Ω bulb and 4.5 V across the 36- Ω bulb

page 470, Chapter 11 Review

1. (c) 5.0 V
 (d) 3.0 A
8. 45 V
9. 12 Ω
10. (a) 1 600 000 V
 (b) 1.5 kW
 (c) 0.650 A
11. (a) 3000 Ω

Answer to question 59, page 246

Symbol	Name	Atomic Mass	Protons in Atom	Electrons in Atom
H	hydrogen	1.01	1	1
Cl	chlorine	35.45	17	17
Ca	calcium	40.08	20	20
Ag	silver	107.87	47	47
Ne	neon	20.18	10	10
U	uranium	238.03	92	92

page 492, Learning Checkpoint

Appliance	Average Use hours (per day)	kW•h (per year)	Cost (\$)
Vacuum cleaner	0.1	38	3.23
Hair dryer	0.25	100	8.50
Computer	4.0	520	44.20
Central air conditioning	12 (60 days/year)	1500	127.50

page 493, Practice Problems

- 22 %
- 22 %
- 88 %

page 500, 12.2 Check and Reflect

- (a) \$0.06
(b) \$0.02
(c) \$0.60
- 34 %

page 502, Chapter 12 Review

- 0.5 kW•h
- (a) 61 %
(b) 38 %
- (a) 900 kW•h/y
(b) 898 kW•h

page 507, Unit D Review

- (a) 6.0 V
(b) 2.0 A
- (a) 3.0 V
(b) 1 A
- 3000 Ω
- (a) 7.5 V
(b) 4 A
(c) 0.05 Ω

59.

Voltage (V)	Current (A)
2.0	0.017
4.0	0.033
6.0	0.050
8.0	0.067
10.0	0.083

- (a) 1 600 000 V
(b) 1.5 kV
(c) 0.65 A

62.

Device	Input Energy (kJ)	Output Energy (kJ)	Percent Efficiency
Gas-powered SUV	675	81	12%
Gas-electric hybrid car	675	195	29%
Natural gas furnace	110 000	85 000	77%
Electric baseboard heater	9.5	6.0	63%
Alkaline dry cell	84.52	74.38	88%

Notes: The numbers in parentheses at the end of each definition indicates the page number in this book where the term is defined. A pronunciation guide, using the key below, appears in square brackets after selected words. Stressed syllables are capitalized.

a = cat, back	i = ditch, mitt
ae = day, lake	oh = go, phone
ah = barn, large	oo = room, true
aw = lawn, not	u = fun, done
e = wet, ten	uh = taken, sun
ee = tree, steam	uhr = fur, burn
ih = mine, light	

A

abiotic [ae-bih-AW-tik] non-living; physical things, such as rocks, air, and water, or things that are measured, such as air temperature, hours of daylight, and salt concentration in seawater (13)

acid rain rain that contains acids formed from nitrogen- and sulphur-containing emissions (70)

acidity abiotic factor that is connected to the chemical environment of soil (74)

adhesion property of sticking to other substances; a physical property of water (150)

alternating current (AC) electric current that flows back and forth at regular intervals called cycles (439)

ammeter [A-mee-tuhr] device used to measure the current in a circuit (439)

ampere (A) [AM-per] unit of electric current; a measure of the amount of charge moving past a point in the circuit every second (439)

aquatic water-based (17)

aquifer large underground lake (25)

artificial satellite a device placed in orbit around Earth or other celestial object (356)

asterisms [A-stu-riz-ums] smaller recognizable star patterns within a larger constellation (294)

asteroid belt region of rocky debris that forms a ring all the way around the Sun at a distance of about 3 AU (262)

astronomer person who studies astronomy (258)

astronomical phenomenon [AS-troh-NAWM-i-kul fen-AWM-e-nun] any observable occurrence relating to astronomy (294)

astronomical unit (AU) distance measure; 1 AU equals the average distance between the Sun and Earth, about 150 million km (261)

astronomy study of the universe and the objects in it (258)

at risk in danger of becoming extinct or disappearing from a region (94)

atmosphere layer of gases that surrounds Earth (19)

atom smallest part of an element that has all of the element's properties (168)

atomic mass average mass of an element's atoms (192)

atomic mass units (amu) measure of an atom's mass (192)

atomic number number of protons in an atom of an element (190)

atomic theory study of the nature of atoms and how they combine to form all types of matter (170)

aurora borealis [uh-ROR-uh bor-ee-A-luhs] display of green, yellow, and red light in the night sky near Earth's northern regions, produced when the charged particles of the solar wind collide with the atoms and molecules in Earth's atmosphere (312)

B

battery combination of electrochemical cells (435)

bedrock solid rock layer under the subsoil (72)

Big Bang theory theory that the universe formed when an infinitely dense point suddenly and rapidly expanded in a single moment 13.7 billion years ago (280)

binary system star system with two stars (263)

bioaccumulation [bih-oh-a-kyoo-myoo-LAE-shuhn] gradual build-up of chemicals in an organism's body (79)

biodiversity [bih-o-di-VUHR-si-tee] number of different types of organisms in an area (9)

biological oxygen demand (BOD) measure of how quickly oxygen is used up by micro-organisms in a given body of water (77)

biomagnification increase in concentration of a harmful substance at each link in the food chain as one animal eats many contaminated animals (79)

biomass [BIH-oh-mas] organic material made up of plant and animal waste (478)

biome [BIH-ohm] large geographical region that contains similar ecosystems (16)

biosphere part of our planet, including water, land, and air, where life exists. Biomes combine to form the biosphere. (18)

biotic [bih-AW-tik] living, biotic factors are organisms such as animals, plants, mushrooms, bacteria, and algae (13)

black hole region of space where gravity is so strong that nothing, not even light, can escape (270)

boiling point temperature at which a liquid turns to a gas (139)

bond connection between atoms or ions (213)

boreal forest biome that has trees, such as spruce and fir, that have cones and needles (17)

C

carnivores organisms that eat mostly meat, for example, wolves (30)

carrying capacity maximum number of individuals that an ecosystem can support without reducing its ability to support future generations of the same species (40)

celestial object object we can see in the sky, including the Sun, the Moon, Earth, other planets, and comets (258)

cellular respiration process organisms use to obtain energy from glucose and other carbohydrates (29)

charging by contact charging process in which electrons transfer from the charged object to the neutral object that it touches (407)

chemical change change in matter that results in the formation of a new substance or substances (152)

chemical family group of elements with certain shared physical and chemical properties; represented by one of the 18 vertical columns in the periodic table of the elements (193)

chemical formula combination of symbols that identifies which elements, and how much of each, are in a compound (219)

chemical property ability of a substance to change into a new substance or substances; e.g., how a substance interacts with other substances, such as acids, or how it reacts to heat or light (152)

chemical reaction process in which a chemical change occurs; produces a new substance or substances (152)

chlorophyll substance in plants that absorbs sunlight and causes leaves to be green (28)

chromosphere [KROH-muhs-feer] thin layer of the Sun, lying above the photosphere, and with a red cast to it (309)

circuit path for electrons to flow; includes energy source, electrical load, and conducting wires (434)

circuit breaker safety device in which a wire heats up and bends when there is excess current in the circuit; this triggers a spring mechanism that turns off the flow of electricity (463)

circuit diagram drawing made with symbols that shows the components and connections in a circuit (450)

clay soil soil that contains small rock particles that pack tightly together (73)

clearcutting removing all trees, regardless of size, in an area at one time (62)

climate average weather conditions that occur in a region over a span of 30 years or more (60)

climate change change of climate characteristics in a region, such as a rise or fall in average temperatures or an increase or decrease in rainfall (60)

cohesion property of sticking together; a physical property of water (150)

combustibility ability of a substance to react quickly with oxygen to produce heat and light (153)

comet celestial object made of ice and dust (318)

commensalism [kuh-MEN-suhl-iz-uhm] type of symbiosis in which one species benefits from the relationship without harming or helping the other species (40)

community populations of different species that live and interact in the same area (14)

competition interaction between two or more organisms competing for the same resource in a given habitat (38)

components parts of a system (11)

compound pure substance made from two or more elements that are combined together chemically (141)

condensation change of state from a gas to a liquid (138)

conduction movement or transmission of electric charges through a substance (400)

conductivity ability of materials to allow electrons to move freely in them (400)

conductor material that allows electrons to change positions (400)

conservation biology modern science that seeks to understand and protect biodiversity (94)

constellation group of stars that, from Earth, resembles a recognizable form (294)

consumer organism that eats other organisms to obtain energy because it cannot produce its own food (30)

corona [kuh-ROH-nuh] outermost layer of the Sun, extending beyond the chromosphere for millions of kilometres (309)

coronal mass ejection extremely powerful kind of solar flare that causes a large amount of plasma to be thrown out through the corona and into space (311)

coulomb (C) [KOO-lawm] metric unit of electric charge; one coulomb equals 6.24×10^{18} electrons added to or removed from a neutral object (399)

crop rotation practice of planting a different type of crop in a particular field each year (75)

current electricity continuous flow of electrons in a circuit (434)

D

dark matter matter in the universe that is invisible because it does not interact with light or any other kind of radiation; at least 90 percent of the universe may be composed of dark matter (271)

deciduous forest biome that has trees, such as maples and oaks, that lose their leaves in the winter (17)

decomposer consumer that breaks down organic matter and releases the nutrients back into the ecosystem; for example, fungi and bacteria (30)

denitrifying bacteria [dee-NIH-tri-fih-ing] bacteria that convert nitrates into nitrogen gas (26)

deposition change of state from a gas directly into a solid (138)

detritivore [de-TRI-ti-vor] consumer that feeds on organic matter; for example, earthworms (30)

direct current (DC) electric current flowing in one direction (439)

dissolved oxygen the level of oxygen present in water (77)

dry cell electrochemical cell that uses a paste instead of a liquid electrolyte (435)

E

ecological footprint estimate of how much land and water is needed to support a person's lifestyle (106)

ecology [ee-KAWL-uh-jee] study of how organisms interact with each other as well as with their environment in a system (12)

ecosystem [EE-koh-sis-tuhm] complex, self-regulating system in which living things interact with each other and with non-living things (13)

efficiency ratio of the useful energy that comes out of a device to the total energy that went in (493)

electric charges charged particles that exert an electric force on each other (394)

electric current measure of the amount of electric charge that passes by a point in an electrical circuit each second (439)

electrical discharge rapid transfer of electric charges (409)

electrochemical cell package of chemicals that converts chemical energy into electrical energy that is stored in charged particles (435)

electrode metal strip that reacts with the electrolyte in an electrochemical cell (435)

electrolyte [e-LEK-truh-liht] liquid or paste that conducts electricity because it contains chemicals that lose or gain electrons to form ions (435)

electromagnetic radiation energy that travels in waves of varying lengths; visible light is one form of electromagnetic radiation (281)

electromagnetic spectrum full range of electromagnetic radiation, organized by wavelength from very long to very short; examples include radio waves, microwaves, infrared, visible light, ultraviolet radiation, and X-rays (281)

electron negatively charged particle in an atom; located outside the nucleus of the atom (172, 396)

electron affinity [e-LEK-trawn a-FIN-i-tee] tendency of a substance to hold on to the electrons (398)

electroscope instrument that can detect static charge (404)

electrostatics [e-LEK-truh-STA-tiks] study of static electric charges (404)

element pure substance that cannot be broken down into a simpler substance (24, 141)

endangered species facing extinction or extirpation (94)

EnerGuide label that states how much energy an appliance will use in a month or year of average use (494)

energy grid web of interconnections between generating stations, substations, and users; also called a distribution grid (476)

energy pyramid diagram that shows the amount of available energy producers and consumers contain as energy flows through an ecosystem (32)

Energy Star symbol identifying the most efficient appliances in each class (494)

environment all the living and non-living things that exist on Earth (8)

environmental steward someone who manages resources wisely, ensuring that they are used in sustainable ways for current and future generations (107)

equilibrium in a population, a state where the number of births equals the number of deaths, so that the number of individuals stays the same over time (40)

equinox [E-kwi-nawks] day when the hours of daylight and the hours of night are of equal length (341)

eutrophication [yoo-tri-fi-KAE-shuhn] addition of nutrients to an aquatic ecosystem causing increased growth of plants such as algae (78)

evaporation change of state from a liquid to a gas; also known as vaporization (138)

ex-situ conservation [eks-SI-too] protection of species by removing them from their natural habitat (96)

extinction the death of every member of a species (54)

extirpated species that no longer exists in a particular region but still occurs elsewhere (94)

F

food chain diagram that shows the feeding relationships among organisms (31)

food web diagram that shows complex feeding relationships among organisms that eat many different things; interconnected food chains (31)

fossil fuel fuel formed from the organic matter of organisms that lived millions of years ago; includes coal, oil, and natural gas (478)

freezing change of state from a liquid to a solid (138)

freezing point temperature at which a liquid turns to a solid; same temperature as the melting point (139)

freshwater biome water-based biome in which the water has a very low salt content (17)

friction force resisting the relative motion of two surfaces in contact (397)

fuel cell electrochemical cell that generates electricity directly from a chemical reaction with a fuel, such as hydrogen (436)

fuse safety device in an electric circuit that has a metal conductor with a low melting point; if the current gets too high, the metal in the fuse melts and the current flow stops (463)

G

galaxy collection of hundreds of billions of stars held together by gravity (254)

generator device that transforms the energy of motion into an electric current (476)

genetic diversity differences among individuals of the same species (54)

geostationary [JEE-oh-STAE-shun-e-ree] orbit in which a satellite orbits Earth at the same rate as Earth rotates (356)

geothermal energy energy from water naturally heated by hot rock in the Earth's crust (479)

global warming increase in Earth's average temperature (60)

grassland biome that has few trees but is covered in various kinds of grasses and shrubs (17)

ground fault circuit interrupter (GFCI) residual current device that detects a change in current and opens the circuit, stopping current flow (464)

grounding process of connecting a charged object to Earth's surface (408)

group classification of elements with certain shared physical and chemical properties; represented by one of the 18 vertical columns in the periodic table of the elements; also known as a chemical family (193)

H

habitat area where an organism lives (14)

habitat change process in which habitats are altered enough by humans so that native species can no longer live there (55)

habitat fragmentation alteration of small areas within a large region, creating a patchwork of altered and original habitats (56)

heavy metal group of substances that have a density of 5 g/mL or higher; for example, mercury, lead, and cadmium (79)

herbivore animal that eats only plants; for example, moose and deer (30)

holistic approach [hoh-LIS-tic] emphasizes an entire system (11)

hydroelectricity electricity generated by harnessing the power of falling water (477)

hydrosphere all the water on Earth (19)

I

induction movement of electrons within a substance, caused by a nearby charged object, without direct contact between the substance and the object (407)

inert does not react easily with other chemicals (133)

in-situ conservation [in-SI-too] protection of species in their natural surroundings (96)

insulator solid, liquid, or gas that resists or blocks the movement of electrons (400)

integrated pest management method of pest control that uses knowledge about a pest's biology and habitats to keep the pest population under control rather than eradicating it (107)

invasive species non-native species that causes harm to the ecosystem into which it has been introduced (59)

ion atom or group of atoms that has lost or gained electrons (192)

ion charge electric charge that an atom or group of joined atoms takes on when it loses or gains electrons (192)

ionic bond attraction between ions; e.g., bond in an ionic compound (213)

ionic compound pure substance consisting of at least one metal and one non-metal (212)

K

kilowatt-hour (kW•h) commonly used unit of electrical energy, equal to a consumption of one kilowatt in one hour (492)

L

law of attraction law stating that particles with opposite charges attract each other (399)

law of repulsion law stating that particles with like charges repel each other (399)

lightning rod metal pole with a wire attached to it that runs down to the ground with the purpose of allowing the electrons that build up on a building to spread out into the air (418)

light-year (ly) distance measure; 1 ly equals the distance that a beam of light can travel through space in 1 year; it is equivalent to 63 000 AU or 9 000 billion km (261)

limiting factor environmental factor that prevents an increase in the number of organisms in a population or prevents them from moving into new habitats (41)

lithosphere [LITH-oh-sfeer] Earth's solid, outer layer (19)

load device that converts electrical energy to another form of energy (434)

loam soil that has rock particles of many different sizes (73)

lunar eclipse occurs when Earth blocks the Sun's light shining on the Moon, making the Moon briefly disappear (328)

M

marine biome water-based biome in which the water has a high salt content (17)

mass measure of the quantity of matter in an object (138)

matter anything that has mass and volume (138)

mechanical mixture combination of pure substances in which the different substances are individually visible (142)

melting change of state from a solid to a liquid (138)

melting point temperature at which a solid turns into a liquid; same temperature as the freezing point (139)

metal element that is malleable and ductile and conducts electricity and heat; most elements are metals (180)

metalloid element with metallic and non-metallic properties; e.g., silicon (181)

meteor a meteoroid (a small piece of rock or metal) that enters Earth's atmosphere and begins to burn up as a result of friction (318)

microgravity condition in which the gravitational forces that act on a mass are greatly reduced (367)

mimicry [MIM-uh-kree] copying the appearance of another species to avoid predators; for example, the viceroy butterfly looks very much like the foul-tasting monarch butterfly (39)

molecular compound pure substance that is formed when non-metals combine chemically (214)

molecule group of atoms that share electrons; molecular compounds contain molecules (214)

mutualism type of symbiosis in which both species benefit from the symbiotic partnership (40)

N

native species species that normally live in a habitat (55)

nebula [NEB-yoo-luh] large cloud of dust and gas (264)

neutron particle that has no electric charge so is neutral; located in the nucleus of the atom (173, 396)

niche [NEESH] all the interactions of a given species with its ecosystem (14)

nitrifying bacteria bacteria that convert ammonia into nitrites and then nitrates (26)

nitrogen fixation conversion of nitrogen gas into ammonia (25)

nitrogen-fixing bacteria bacteria that convert nitrogen gas into ammonia (25)

non-metal elements that are grouped together mainly because they do not resemble metals; e.g., carbon (180)

non-point source pollution pollution that enters bodies of water indirectly when rain or snow travels over land and picks up pollutants from many different sources before entering a stream or a lake; for example, fertilizer and pesticide run-off from farms (58)

non-renewable resource resource that cannot be replaced once it is used up, such as coal or oil (474)

nuclear fusion process in which the nuclei of atoms fuse together and form larger atoms; during this process, an enormous amount of energy is released (261)

nucleus (atomic) centre of the atom, which contains the protons and neutrons (173, 396)

nutrient cycle the process of moving a nutrient from the abiotic part of an ecosystem to the biotic part and back again (24)

nutrients substances that an organism uses to build and repair the cells of its body (22)

O

ohm (Ω) SI unit for measuring resistance (441)

Ohm's law law stating that as long as temperature stays the same, $V = IR$, where V is potential difference, I is current, and R is resistance (460)

ohmmeter device for measuring electrical resistance; usually part of a multifunctional meter called a multimeter (441)

omnivore animal that eats both animals and plants; for example, bears and raccoons (30)

orbital radius planet's distance from the Sun (343)

organic farming farming without the use of chemical fertilizers or pesticides (108)

organic matter remains of dead organisms and animal wastes (30)

overexploitation using a resource faster than it can be replaced (56)

P

parallel circuit electric circuit in which the parts are arranged so that electrons can flow along more than one path (451)

parasitism type of symbiosis in which one species benefits from the relationship at the expense of the other species (40)

particle theory of matter theory stating that all matter is composed of very tiny objects called particles; that all particles have spaces between them; that particles of matter are always in motion; that particles in a substance attract each other (139)

parts per million (ppm) measurement of chemicals that occur in low concentrations; e.g., a sample having a mercury concentration of 1 ppm has 1 part mercury per million parts sample (232)

period one of seven horizontal rows in the periodic table of the elements (193)

pesticides chemicals that kill unwanted organisms, usually ones that attack crops and reduce their yields (80)

photosphere layer of the Sun usually considered to be the boundary between the inside and the outside of the Sun (309)

photosynthesis [foh-toh-SIN-thuh-sis] process plants use to produce carbohydrates from carbon dioxide, water, and sunlight (28)

physical property characteristic of a substance that can be observed or measured (150)

planet celestial object that orbits one or more stars and is capable of forming into a spherical shape as it melds under the weight of its own gravity (313)

point source pollution pollution that enters a body of water at a specific place from an identifiable source; for example, oil spills from tankers and wastewater from pulp and paper mills (58)

pollution any substance added to the environment that produces a condition that is harmful to organisms (58)

population group of members of the same species that live in the same area (14)

potential difference or **voltage (V)** difference in electric potential energy between two points that will cause current to flow in a closed circuit (437)

potential energy energy stored in an object; each electric charge has electrical potential energy (437)

predation [pred-AE-shuhn] one organism eating another organism to obtain food (39)

predator animal that catches and feeds on other live animals (30)

prey animals that predators hunt and catch (30)

primary consumer organism that eats producers; for example, a caterpillar, which eats plants (30)

producer organism that carries out photosynthesis (30)

prominence large, often curved, bright stream of particles extending outward from the photosphere into the corona (313)

property characteristic that describes a substance (141)

proton positively charged particle in an atom, found in the nucleus (173, 396)

protostar star in its first stage of formation (296)

pure substance one kind of matter with a unique set of properties, such as colour, hardness, boiling point, and melting point; an element or compound (141)

R

relative mass mass of an object in comparison to the mass of another object (175)

renewable resources resource that can be reused or replaced, such as sunlight and wind (474)

reservoir any place where matter accumulates (24)

resistance degree to which a substance opposes the flow of electric current through it (441)

resistor any material that can slow current flow in a circuit, such as the filament in a light bulb (441)

retrograde motion apparent reversal of a planet's path relative to the starry backdrop (342)

revolution one complete orbit of Earth around the Sun, a journey of one year (325)

rotation one complete spin of Earth on its axis, which takes almost 24 hours (324)

run-off water that runs off the ground into nearby streams or rivers (25)

S

sandy soil soil that contains relatively large rock particles (73)

scavenger carnivore that eats the remains of dead animals; for example, vultures (30)

secondary consumer organism that feeds on primary consumers; for example, a robin, which eats caterpillars (30)

series circuit electric circuit in which the components are arranged one after another in series (451)

short circuit accidental low-resistance connection between two points in a circuit, often causing excess current flow (462)

soil loose covering on the ground containing organic matter, minerals, and moisture (72)

soil conservation use of farming methods that protect soil from erosion and loss of nutrients (108)

soil erosion loss of soil when water or wind wash or blow it away (74)

solar eclipse occurs when the Moon blocks the Sun's light to viewers on Earth; this happens when the Moon lies directly between Earth and the Sun (327)

solar flare massive explosion on the surface of the Sun (311)

solar system the Sun together with all the planets and other celestial objects that are held by the Sun's gravitational attraction and orbit around it (260)

solar wind thin but steady stream of subatomic particles flowing out of the Sun's surface in all directions (312)

solution combination of pure substances in which the different substances are not individually visible; a homogeneous mixture (142)

special concern has characteristics that make a species sensitive to human activities or natural events (94)

species [SPEE-sees] group of similar organisms that can reproduce with each other and their offspring can also reproduce (14)

spectral lines series of dark lines that appears across a star's light spectrum and indicates the chemical elements in the star's composition (282)

spectral shifting change in position of spectral lines to the left or the right of where they normally lie in the spectrum of a light source that is not moving (282)

spectroscope optical instrument that, like a prism, separates light into its spectral colours (281)

spectrum rainbow band of colours into which white light separates when it passes through a prism (278)

spinoff secondary beneficial effect or product of a thing or an activity (354)

star hot ball of plasma, an electrically charged gas, that shines because nuclear fusion is taking place at its core (261)

static charge or **static electricity** electric charge that builds up on the surface of an object (396)

stewardship way of acting that involves taking personal responsibility for the management and care of something (8)

subatomic particles particles that make up an atom, including protons, neutrons, and electrons (175)

sublimation change of state from a solid directly into a gas (138)

subsoil layer below the topsoil (72)

summer solstice day of the year with the longest period of daylight, representing the start of summer (340)

sunspot region on the Sun's surface that is cooler than the surrounding areas (310)

supernova [SOO-puhr-NOH-vuh] star's explosion, caused by the gradual build-up of heavy elements in the star's centre, resulting in the core's collapse (263)

suspension cloudy mixture in which tiny particles of one substance are held within another; a type of heterogeneous mixture (142)

sustainability the ability of populations of organisms to continue to live, to interact, and to reproduce indefinitely in an environment (9)

sustainable use using an ecosystem's resources in a way that meets our current needs without compromising the ability of future generations to meet their needs (54)

switch device that turns a circuit on or off by closing or opening the circuit (434)

symbiosis [sim-bee-OH-sis] close interaction between two different species in which members of one species live in, on, or near members of another species (39)

system group of individual parts that interact as a whole to accomplish a task (11)

T

temperate coniferous forest biome that has different types of needle- and cone-bearing trees than a boreal forest, such as Douglas fir, Sitka spruce, and western hemlock (17)

terrestrial land-based (17)

tertiary consumer [TUHR-shuh-ree] third level of consumer, which eats secondary consumers; for example, a hawk that feeds on small birds (30)

thermoelectric generating plant electricity-generating plant that uses a fuel such as coal or biomass to heat water to create high-pressure steam (478)

thermonuclear term describing electrical energy produced by heat in nuclear power stations (479)

threatened species at risk of becoming endangered if limiting factors are not reversed (94)

topsoil uppermost layer in soil, composed chiefly of decaying organic matter, rock particles, and organisms (72)

transistor tiny device that acts as a switch or amplifier in a circuit (449)

tundra biome that has no trees but only small shrubs, hardy grasses, mosses, and lichens (17)

turbine machine that uses the flow of a fluid to turn a shaft; used in generators to generate electricity (476)

U

universe everything that physically exists: the entirety of space and time, and all forms of matter and energy (255)

urban sprawl unplanned, disorganized growth of urban and suburban development into the surrounding countryside (62)

V

valence electron [VAE-luhns] electron in the valence shell of an atom (197)

valence shell outermost shell or energy level of an atom that has electrons in it (197)

volt (V) SI unit for measuring potential differences (438)

voltage or **potential difference** difference in electrical potential energy between two points that will cause current to flow in a closed circuit (437)

voltmeter device used to measure the potential difference between two locations in a circuit (438)

volume measure of how big an object is or how much space a fluid takes up (138)

W

wet cell electrochemical cell that has a liquid electrolyte (435)

wetland area in which the soil is saturated with water for at least part of the year (4)

winter solstice [SAWL-stis] day of the year with the shortest period of daylight, representing the start of winter (340)

- A**
- Abiotic factors, **13**, 15
 - Aboriginal people
 - and astronomical phenomena, 264, 340, 341
 - and ecosystem interactions, 38
 - and environmental stewardship, 9
 - holistic approach of, 11–12
 - and medicine wheels, 341
 - and mercury in fish, 232
 - Acetate, 235
 - Acid rain, **70**, 70–71, 488
 - Acidity, **74**
 - of soils, 74
 - of water, 78
 - Adhesion, **150**
 - Agriculture
 - First Nations, 341
 - sustainable, 107–109
 - Air
 - as conductor, 410
 - as insulator, 410
 - as mixture of chemicals, 210
 - pollution, 58, 184
 - Algae, 15, 29, 78, 79, 92
 - Algonquin Park, 99
 - Alkali metals, 194
 - Alkalinity, 74
 - Alloys, 178–179
 - Alpher, Ralph, 280
 - Alternating current (AC), **439**
 - Aluminum, 136, 138
 - Ammeters, **439**, 440, 454
 - Amperes, **439**
 - Animals
 - and cellular respiration, 29
 - and energy from food, 32
 - and nitrogen, 26
 - overgrazing by, 75
 - Aquaculture, 64–65
 - Aquatic biomes, **17**
 - Aquifers, **25**
 - Aral Sea, 57–58
 - Aristotle, 342
 - Artificial satellites, **356**
 - Asterisms, **294**
 - Asteroid belt, **262**, 315, 318
 - Astrolabes, 345
 - Astronauts, 8, 352
 - Astronomers, **258**, 340
 - Astronomical phenomena, **294**
 - Astronomical units (AU), **261**
 - Astronomy, **258**, 340–341
 - tools of, 345–348
 - At-risk species, **94**, 94–95
 - Atmosphere, **19**
 - Atomic mass, **192**
 - Atomic mass units (amu), **192**
 - Atomic number, **190**, 190–191, 192
 - Atomic theory, **170**, 170–176
 - 196–199
 - Atom(s), **168**
 - models of, 170–175
 - in molecule, 214
 - neutrality of, 396
 - particles of, 396
 - smallness of, 239
 - Aurora australis, 312
 - Aurora borealis, **312**, 312–313
- B**
- Bacteria, 15, 30, 244. *See also* Nitrogen-fixing bacteria
 - Batteries, 231, **435**, 436, 437–438
 - Becquerel, Edmond, 480
 - Bedrock, **72**
 - Bees, 10–11, 117
 - Benfey, Theodor, 199
 - Benzene, 235
 - Big Bang theory, **280**, 284–285, 348
 - Binary systems, **263**
 - Bioaccumulation, **79**
 - Biodiversity, **9**, 54–60, 96–97
 - conservation of, 94–97
 - “hot spots,” 98
 - increasing, 81
 - logging and, 62
 - stress and, 61
 - Biological oxygen demand (BOD), **77**
 - Biomagnification, **79**
 - Biomass, **478**
 - Biomes, 15–17, **16**, 18–19
 - Biosphere, **18**, 18–19
 - Biotic factors, **13**, 15
 - Black holes, **270**, 270–271, 289, 299
 - Blackouts, electrical, 390–391
 - Bohr, Niels, 174
 - Bohr diagrams, 174, 197, 198, 200, 214
 - Boiling, defined, **138**
 - Boiling point, **139**
 - Bonds, **213**
 - Boreal forests, 16, **17**, 62–63
 - Brahe, Tycho, 344
 - Brain pacemakers, 427
 - Breathing, 29
 - Butterflies
 - Karner blue, 94
 - monarch, 39, 47, 59
- C**
- Calcium, 169
 - Calcium carbonate, 218, 223
 - Calcium chloride, 219, 228
 - Calcium sulphate, 218
 - Campfires. *See* Fires
 - Carbohydrates, 28, 29
 - Carbon, 24, 184
 - compounds, 149
 - cycle, 26–27
 - and fires, 148, 149
 - reservoirs, 26–27
 - resistors, 442
 - trees and, 110
 - Carbon dioxide
 - carbon and, 26
 - and climate change, 60
 - and fires, 149
 - and glucose, 28
 - nutrient cycle and, 24
 - plants and, 24, 26, 28–29
 - and pollution, 58
 - preparation of, 144–145
 - and soda pop, 149
 - and water, 27
 - Carnivores, **30**
 - Carp, 4–5
 - Carrying capacity, **40**, 40–41, 42
 - Cathode ray tubes, 172
 - Celestial objects, **258**
 - Cellular respiration, **29**
 - Centauri system, 263
 - Chadwick, James, 173
 - Charging by contact, **407**, 413
 - Charon, 318
 - Chemical changes, **152**, 153, 158–159
 - Chemical families, **193**
 - Chemical formulas, **219**
 - for ionic compounds, 223, 224–225
 - for molecular compounds, 227
 - Chemical properties, **152**
 - Chemical reactions, **152**
 - Chemicals, 210–211, 230–231
 - Chemistry
 - art of, 163
 - backgrounder, 548–550
 - Chlorine, 183, 185, 196–197, 232–233
 - Chlorofluorocarbons (CFCs), 234
 - Chlorophyll, **28**
 - Chromosphere, **309**
 - Circuit breakers, **463**
 - Circuit diagrams, **450**
 - Circuits, **434**
 - designing, 448
 - integrated, 449
 - resistance in, 441
 - tiny, 449
 - transfer of energy in, 438
 - Clay soil, **73**
 - Clearcutting, **62**
 - Climate, **60**
 - Climate change, **60**
 - Coal, 27, 184, 478, 488
 - Cohesion, **150**
 - Combustibility, **153**
 - Comets, **318**
 - Commensalism, **40**, 47
 - Communicating in science, 528–531
 - Communications satellites, 356
 - Communities, **14**, 14–15
 - Competition, **38**, 38–39
 - Components, 10–11, **11**

- Compounds, **141**, 170, 210–211
 carbon, 149
 naming, 219
- Condensation, **138**, 139
- Conduction, **400**
- Conductivity, **400**, 446
- Conductors, **400**, 400–401, 441, 462
 metalloids as, 181
 metals as, 180
 sodium chloride as, 213
 water as, 401, 432–433
- Conservation biology, **94**, 94–97
- Constellations, **294**, 294–295
- Consumers, **30**, 31, 32
- Contact, charging by. *See* Charging by contact
- Convective zone, of Sun, 309
- Convention on Biological Diversity, 95
- Conventional current, 440
- Cootes Paradise, 4–5
- Copernicus, Nicholas, 343, 344
- Copper, 168, 227
- Coral reefs, 12
- Corn, 155
- Cornwall (Ontario), 99
- Corona, **309**
- Coronal mass ejections, **311**
- Coulomb, Charles-Augustin de, 399
- Coulombs, **399**
- Cowbirds, 117
- Crocodiles, 22, 23
- Crop rotation, **75**, 108
- Current electricity, **434**, 439–440, 445. *See also* Electric current
- Cycles, 24, 33
- D**
- Dalton, John, 171
- Dark matter, **271**
- DDT. *See* Dichloro-diphenyl-trichloroethane (DDT)
- Deciduous forests, 16, **17**
- Decision making for environmental and social issues, 520–521
- Decomposers, **30**, 75, 106
- Deforestation, 84
- Denitrifying bacteria, **26**
- Deposition, **138**
- Detritivores, **30**
- Diamonds, 184, 205
- Dichloro-diphenyl-trichloroethane (DDT), 80, 236
- Direct current (DC), **439**
- Dissolved oxygen, **77**
- Diversity. *See also* Biodiversity
 genetic, **54**
- Don River Valley, 104
- Donelan, Max, 468
- Dry cells, **435**, 435–436
- E**
- Earth, 316
 age of, 315
 and asteroid belt, 315
 axis of, 324, 325
 coronal mass ejections and, 311
 distance from Moon to, 259
 distance to Milky Way, 260
 habitable environment on, 306
 magnetic field, 310
 motion of, 322–323
 as rocky inner planet, 314
 rotation of, 324, 328
 tornadoes on, 306
 view of sky from, 323
 view of stars from, 294–295
 views of, from space, 353
 “Earthrise,” 352
- Easter Island, 52–53
- Eclipses, 327–328
- Eco-villages, 122–123
- Ecological consultants, 87
- Ecological footprints, **106**, 106–107, 115
- Ecology, **12**
- Ecosystems, **13**
 acid rain and, 70–71
 assessment of impacts on, 71–85
 birth of, 36–37
 combinations of, 15–17
 communities within, 14–15
 elements of, 13–15
 energy flows through, 28–29
 freshwater, 57, 61
 humans and, 54–60
 interactions, 38–40
 law and, 97
 natural vs. artificial, 20
 Ontario, 60–63
 restoration of, 99–100
 size of, 15
 stress on, 61
 sustainable use of, 54
- Efficiency, **493**, 493–494
- Electric charges, **394**, 395. *See also* Static charges
- Electric current, **439**, 439–440, 454, 455, 456, 459–462. *See also* Current electricity
- Electric shocks, 394, 463, 464
- Electrical discharges, **409**, 409–411
- Electricity. *See also* Energy
 backgrounder, 552–554
 coal and, 184
 consumption, 491
 cost of, 490–491
 environmentally friendly, 112
 and fish, 432–433
 generation of, 474–489
 household consumption, 491, 492, 495
 meters, 490–491
 sources of, 474–475
 use of, 490–491, 495
- Electrochemical cells, 213, **435**
- Electrodes, **435**
- Electrolytes, **435**
- Electromagnetic induction, 476
- Electromagnetic radiation, 281, **281**
- Electromagnetic spectrum, **281**, 308
- Electron affinity, **398**
- Electrons, **172**, 173, 175, **396**
 of chlorine atom, 197
 flow of, 434, 440, 441
 friction and, 397
 ion charge and, 192–193
 patterns in arrangement of, 198
 potential energy, 437
 and quantum mechanical model, 174
 and shells, 174
 transfer of, 397, 438
 in wire, 438
- Electroscopes, **404**, 405, 406
- Electrostatic generators, 411
- Electrostatic precipitators, 423, 425
- Electrostatics, **404**, 404–415. *See also* Static charges
 control products, 423
 environmental applications, 423
 and flammable materials, 419
 in home, 420
 and lightning, 416–418
 and photocopying, 422
 and spray painting, 421
 and vehicles, 419
- Elements, **24**, **141**, 178–187, 396
 atoms and, 168, 170, 171
 common, 183–185
 Dalton’s table of, 171
 and electrons, 172
 multivalent, 222
 patterns among, 188–189
 symbols of, 181–182
 toxic, 200
- Elliot Lake Secondary School, 474, 475
- Elliptical orbits, 344
- Emissions, 70, 71, 106
- Endangered Species Act, 97
- EnerGuide, **494**
- Energy. *See also* Electricity
 from food, 22–23, 32
 geothermal, 479
 nuclear, 479
 pyramids, **32**, 34
 self-sufficiency, 496

- solar, 480
tidal, 481
wind, 481, 484
- Energy grid, 390–391, **476**
- Energy Star, **494**
- Environment, **8**, 8–9
decision making and, 520–521
efficiency of devices and, 494
electrostatics and, 423
elements and compounds in, 232–236
holistic approach to, 11–12
renewable vs. non-renewable energy sources and, 484
sustainability and, 495
systems in, 10–13
toxic substances in, 231
- Environmental Farm Plan (EFP), 107
- Environmental stewards, **107**
- Environmental stewardship, 8–9, 105, 106, 107–114
- Enzymes, 30
- Equator, 322, 325
- Equilibrium, **40**
- Equinoxes, **341**
- Erie, Lake, 92–93
- Estimating, in measurement, 539
- Eutrophication, **78**, 112
- Ex-situ conservation, 95–96, **96**
- Extinction(s), **54**, 56, 94, 101
- F**
- Faraday, Michael, 476
- Fertilizers, 58, 78, 82–83, 92, 93, 107, 108
- Feynman, Richard, 239
- Fires, 148–149, 154
- Fireworks, 136–137
- First Nations. *See* Aboriginal people
- Fish
coral reefs and, 12
electric, 432–433
heavy metals in, 201
ice and, 150
invasive, 66
mercury and, 79, 232, 233
shellfish, 66, 70
- Fishing, 56. *See also* Overfishing
of wild vs. farmed fish, 64–65
- Flashlights, 448
- Flowers, 10–11
- Fluoride, 237, 244
- Foam, 146
- Food
chains, 31–32
energy from, 22–23, 32
freeze-dried, 154
locally produced, 109, 114
webs, **31**, 31–32
- Forestry, 63, 110–111
- Forests, 15–16, 17, 62–63.
See also Deforestation
carbon and, 26
rain, 55, 155
urban, 110–111
- Formulas. *See* Chemical formulas
- Fossil fuels, 60, **478**, 485
- Freezing, **138**, 150
- Freezing point, **139**
- Freshwater biomes, **17**
- Freshwater ecosystems, 57, 61
- Friction, **397**, 407, 411
- Fuel cells, **436**
- Fundy, Bay of, 329, 481
- Fungi, 30
- Fuses, **463**
- G**
- Galaxies, **254**, 254–255, 265, 268–277
and black holes, 270–271
clusters, 274
Hubble and, 278–279, 280
mapping distances to, 276
properties of, 270–272, 278–279, 280, 282
shapes of, 272–273
- Galileo Galilei, 344
- Gamow, George, 280
- Garbage. *See* Waste
- Gases, 138–139, 140
identifying, 144–145
- Generators, 390–391, **476**, 477. *See also* Electrostatic generators
- Genetic diversity, **54**, 97
- Geocentric model of planetary motion, 342–343
- Geostationary orbits, **356**
- Geothermal energy, **479**
- Global Positioning System (GPS) technology, 357, 362
- Global warming, **60**
- Glucose, 28, 29
- Gold, 141, 178–179
- Graphic organizers, 532–533
- Graphite, 184
- Graphs, 43, 349, 540–543
- Grasslands, 16, **17**
- Gravity, 270. *See also* Microgravity
and comets, 318
on Mars, 367
Moon and, 325
and real-time imaging, 359
and stars, 296, 298
and tides, 328
and weight, 367
- Great Lakes Water Quality Agreement, 93
- Griffith Smith, Neil, 117
- Ground fault circuit interruptors (GFCI), **464**
- Grounding, **408**, 419
- Groups, **193**, 193–195
- Gyres, 68–69
- H**
- Habitat change, **55**, 55–56
- Habitat fragmentation, **56**, 62–63
- Habitats, **14**. *See also* Ex-situ conservation; In-situ conservation
loss of, 60
protection of, 97
restoration of, 100
- Halogens, 194
- Hamilton (Ontario), 4–5, 62
- Heat
and chemical change, 153
for electricity generation, 478–479
metals and, 180
particles and, 140
- Heavy metals, **79**, 201, 231
- Heliocentric model of planetary motion, 343–344
- Helium, 190, 193, 195, 198, 298, 309
- Herbivores, **30**
- Hertzprung, Ejnar, 300
- Hertzprung-Russell diagram, 300–301
- Heterogeneous mixtures, 142, 143
- Holistic approaches, **11**, 11–12
- Holland Marsh, Ontario, 73
- Homogeneous mixtures, 142, 143
- Hubbard Brook Experimental Forest, 84
- Hubble, Edwin, 278–279, 280, 282, 283
- Hubble Space Telescope, 254, 347, 375
- Hund, Friedrich, 197
- Hydrates, 224
- Hydroelectricity, **477**, 484, 486–487
- Hydrogen, 24
atomic mass of, 192
atomic number of, 190
as element, 184
naming of molecular compounds containing, 226
preparation of, 145
spectral lines of, 282
and stars, 298
valence electrons of, 198
and water, 183
- Hydrogen peroxide, 210–211, 214
- Hydrosphere, **19**
- I**
- Ice, 140, 150
- Imaging, satellite, 358–360

- In-situ conservation, **96**, 96–97
- Induction, **407**, 407–408, 414
- Inert, defined, **133**
- Inquiry process of science, 514–517
- Insulators, **400**, 400–401, 441
- Integrated pest management, **107**, 107–108
- Interactions
 biotic, 38–40
 ecosystem, 38–40
 within systems, 10–11
- International Space Station, 255, 354, 355, 366, 367, 368, 480
- Invasive species, **59**, 66, 100–101
- Ion charges, **192**, 192–193, 220
- Ionic bonds, **213**
- Ionic compounds, **212**, 212–213
 formulas for, 223, 224–225
 naming, 221–223
- Ions, **192**
- Iron, 141, 168, 183
- J**
- James Webb Space Telescope, 347
- Jupiter, 259, 262, 315, 317, 338, 342, 343
- K**
- Kepler, Johannes, 344
- Kilowatt-hours, **492**
- L**
- Lakes, 57–58, 61, 70, 92–93
- Landfills, 58, 231
- Law of attraction, **399**
- Law of repulsion, **399**
- Laws, scientific, 459
- Leadership in Energy and Environmental Design (LEED), 111–112
- Legumes, 26, 75
- Lemaître, Georges, 278
- Length, measuring, 536
- Levi ben Gerson, 345
- Light. *See also* Spectra
 from Sun, 308
 travelling time of, 258–259
 wave nature of, 281–284
- Light bulbs, 438, 441, 449, 451, 452, 493, 497
- Light-years (ly), **261**
- Lightning, 25, 394, 410, 416–417
- Lightning rods, **418**
- Limiting factors, **41**, 41–42
- Line installers and repairers, 468
- Liquids, 138–139, 140
- Lithium, 198
- Lithosphere, **19**
- Load, electrical, **434**
- Loam soil, **73**
- Lunar cycle, 326
- Lunar eclipses, **328**
- Lynxes, 42, 44
- M**
- Magnetic fields
 of Earth, 310
 of Sun, 310
- Malaria, 80, 236
- Marine biomes. *See* Aquatic biomes
- Mars, 261, 314, 316
 gravity on, 367
 retrograde motion of, 342, 343, 344
 travel to, 380–381
 visiting, 369–370
- Mass, **138**. *See also* Relative mass
 measuring, 537–538
- Material Safety Data Sheet (MSDS), xxii, xxiii
- Math scaling, 275
- Matter, **138**
 changes in, 137
 changes in states of, 138–139
 classifying, 141–143
 forms of, 138, 170
 particle theory of, 139–140
 physical properties of, 150–151
- Measurement, 534–539
- Mechanical mixtures, **142**
- Melting, defined, **138**
- Melting point(s), **139**, 150
 of gold, 178
 of halogens, 194
- Mendeleev, Dmitri, 188–189, 196
- Mercury, 261, 314, 316
- Mercury, 79, 180, 200, 231, 232–233
- Merkhet, 345
- Metalloids, **181**
- Metals, 141, **180**
 alkali, 194
- Meteors, **318**
- Meteoroids, 318
- Methane, 478
- Microcircuits, 449
- Microgravity, **367**, 367–368
- Microscopes, 186, 544–547
- Microwaves, 284–285, 348
- Milky Way, 254, 265
 black holes in, 270
 dark matter and, 271
 distance from Earth, 260
 and galaxy clusters, 274
 solar system and, 268–269
 visibility of, 375
- Mimicry, **39**
- Mixtures, 142, 143, 170
- Molecular compounds, **214**
 formulas for, 227
 naming, 226
- Molecular models, 215–216
- Molecules, **214**
- Moon, 260, 314
 “buggy,” 369
 distance from Earth to, 259
 gravity on, 367
 living on, 369
 phases of, 326, 330
 rotation of, 325–326
 size of, 325, 327
 spacecraft and, 352
 and tides, 328
 water on, 369
- Moons, 314, 315, 318
- MOST (Microvariability and Oscillations of Stars) telescope, 347
- Multimeters, 454
- Multivalent elements, 222
- Mutualism, **40**, 47
- N**
- Names and naming
 chemical vs. common, 218–219
 compounds, 219
 ionic compounds, 221–223
 molecular compounds, 226
 multivalent ions, 222
 polyatomic ions, 223
 salts, 218–219
- National Aeronautics and Space Administration (NASA), 338, 369, 370
- Native species, **55**
- Nebulae, **264**, 299, 308, 312
- Neptune, 262, 269, 315, 317
- Neutrality, 74
- Neutron stars, 299
- Neutrons, **173**, 175, **396**
- Niagara Escarpment, 62
- Niches, **14**, 14–15
- Nitrifying bacteria, **26**
- Nitrogen, 24
 cycle, 25–26
 gas, 25, 26
- Nitrogen fixation, **25–26**
- Nitrogen-fixing bacteria, **25–26**, 75
- Noble gases, 195
- Nollet, Jean, 404
- Non-metals, **180**, 214
- Non-point source pollution, **58**, 58–59
- Non-renewable resources, **474**, 474–475, 482–483, 484
- Nuclear fission, 479
- Nuclear fusion, **261**
- Nuclear power. *See* Thermonuclear power
- Nuclear reactions
 and stars, 296
 in Sun, 308
- Nucleus, **396**
 of atom, **173**
 of chlorine atom, 196–197
- Nutrient cycles, **24**, 24–27
- Nutrients, **22**, 22–23, 75, 108

- O**
- Oceans
 as carbon reservoirs, 27
 currents, 68–69
 water cycle and, 25
- Ohm, Georg Simon, 458–459
- Ohmmeters, **441**
- Ohms, **441**
- Ohm's law, 458–467, **460**
- Omnivores, **30**
- Orbital radius, **343**, 343–344, 350
- Organic farming, **108**
- Organic matter, **30**
- Overexploitation, **56**, 56–57
- Overfishing, 56–57
- Oxygen, 24
 algae and, 29
 in atmosphere, 19
 and breathing, 29
 as element, 184–185
 and fires, 148, 149
 gas, 29, 184
 in photosynthesis, 29
 preparation of, 144
 trees and, 29
 and water, 77, 78, 183
- Ozone, 19, 184–185, 234, 329
- P**
- Pacific Ocean, 68–69
- Paints, 112–113, 230
- Parallel circuits, **451**, 456
- Parasitism, **40**, 47
- Parks, 98–99
- Particle theory of matter, **139**, 139–140
- Particles
 and art, 168
 of atom, 172, 173, 396
- Parts per million (ppm), **232**
- Payette, Julie, 332
- Penzias, Arno, 285
- Periodic table, 188–199, 200, 202–203, 220
- Periods, **193**
- Persistent organic pollutants (POPs), 236
- Pesticides, 5, 58, **80**, 93, 107–108, 236
- PH scale, 74
- Photocopying, 422, 424
- Photosphere, **309**
- Photosynthesis, 27, **28**, 28–29
- Physical changes, 149, 158–159
- Physical properties, **150**, 150–151
- Planetary stewardship, 8
- Planets, 266, **313**, 313–318, 342–344. *See also Names of individual planets*
- Plants
 and carbon dioxide, 26, 28–29
 and cellular respiration, 29
 nitrogen and, 75
 transpiration, 25
- Plastics, 69, 132–133, 155, 230
- Plato, 342
- Plugs, three-prong, 464
- Pluto, 318
- Point source pollution, **58**
- Pollution, **58**, 58–59
 air, 58
 farms and, 107
 water, 76–80, 108
- Polyatomic ions, 223, 225
- Polyethylene, 133, 155
- Polystyrene, 404
- Populations, **14**, 37
 characteristics of, 40–41
 limiting factors, 41–42
 sustainability of, 42, 52–53
- Potential difference, **437**, 437–438, 442, 445, 451–452, 456, 459–462
- Potential energy, **437**
- Precipitation, 24
- Predation, **39**, 44
- Predators, **30**
- Prey, **30**, 39, 41–42, 44
- Primary consumers, **30**
- Problem solving for technological development, 518–519
- Producers, **30**, 31, 32
- Prominences, **311**
- Properties, **141**. *See also*
 Chemical properties;
 Physical properties
 atoms and, 170
 changes in, 149
 of common substances, 160
 in identifying pure substances, 156–157
- Protected areas, 98–99
- Protons, **173**, 175, 190, **396**
- Protostars, **296**
- Ptolemy, 342
- Pure substances, **141**, 143, 156–157
- Q**
- Quadrants, 345
- Quantum mechanical model of atom, 174
- Quasars, 348
- R**
- Rabbits, 40–41
- Radiation, cosmic background, 284–285
- Radiative zone, of Sun, 309
- Reading, 526–527
- Recycling, 58, 102, 106, 112–113, 230–231, 436
- Relative mass, **175**
- Remote sensing, 358–359
- Renewable resources, **474**, 474–475, 482–483, 484
- Research, 522–525
- Reservoirs, **24**
 carbon, 26–27
- Resistance, **441**, 441–443, 445, 451, 455, 456, 459–462, 466
- Resistors, **441**, 441–442, 451
- Resources. *See also* Non-renewable resources;
 Renewable resources
 sustainability of, 53, 54
- Respiration, 27
- Retrograde motion, **342**, 343–344
- Revolution
 of Earth, **324**
 of Moon, 325–326
- Robotics engineers, 333
- Rotation
 of Earth, **324**, 328
 of Moon, 325–326
- Run-offs, **25**, 58, 93, 110
- Russell, Henry Norris, 300
- Rutherford, Ernest, 173, 174
- S**
- Safety
 electrical, 463–464
 procedures, xxii–xxv
 symbols, 513
- Salts, 218–219, 228
 table, 183, 185. *See also*
 Sodium chloride
- Sandy soil, **73**
- Satellites, 356–360
- Saturn, 262, 315, 317, 338, 342, 343
- Scavengers, **30**
- Scientific notation, 265, 535
- Seasons, 322
- Secondary consumers, **30**
- Seed banks, 96
- Semiconductors, 181
- Series circuits, **451**, 455
- Sewage, 92, 93
- Shells, in atoms, 174, 197
- Short circuits, **462**
- SI units, 535–536
- Significant digits, 534
- Silicon, 181
- Silver, 178–179, 180, 181, 186
- Snowshoe hares, 42, 44
- Social issues, decision making for, 520–521
- Sodium, 180, 183, 185, 198
- Sodium carbonate, 158, 159
- Sodium chloride, 212–213, 215, 219, 228
- Sodium hydroxide, 223, 225
- Soil conservation, **108**
- Soil erosion, **74**, 74–75, 108, 111
- Soil(s), **72**
 acidity levels of, 74
 assessing, 72–75
 fertilizers and, 82
 human impact on, 74–75

- as mechanical mixture, 142
- profile of, 72
- types of, 73
- Solar and Heliospheric Observatory (SOHO), 306
- Solar eclipses, **327**
- Solar energy, 480
- Solar flares, **311**
- Solar storms, 329
- Solar system, **260**, 260–262, 268–269, 306–321
 - age of, 315
 - formation of, 313–315
 - models of, 320
 - sizing of, 307
- Solar winds, **312**, 313, 315
- Solids, 138–139
- Solstices, 340–341
- Solutions, **142**
- Solvents, 155
- Space
 - Canadian contributions and, 361
 - debris in, 372
 - distances in, 254–255
 - expansion of, 284
 - exploration of, 255, 364
 - living in, 366–370
 - measuring distances in, 261
 - ownership of, 364, 365
 - time and, 258–259
 - travelling in, 366
 - weather, 329
- Space exploration
 - cost of, 364
 - and health, 368, 371
 - physical environment, 367
 - product technologies from, 355
 - transportation technologies from, 354
- Space research, 354–360
 - cost of, 364
 - spinoffs, 364
- Spacecraft, 338–339, 352, 354, 369
- Sparks, 409, 410
- Species, **14**
 - diversity within, 54
 - endangered, 97–101
 - invasive, 59, 66, 100–101
 - native, 55
 - at risk, 94–95
- Species Survival Plans (SSPs), 96
- Spectra, **278**, 279, 281–282
- Spectral lines, **282**, 282–284
- Spectral shifting, **282**
- Spectroscope, 279, **281**
- Spinoffs, **354**, 364
- Spray painting, 421
- Squirrels, 14
- St. Lawrence River, 99
- Stars, **261**, 263–265
 - artificial light and, 375
 - birth of, 296
 - brightness of, 303
 - charts, 295, 302, 551
 - clusters, 272
 - distance to, 263
 - exploding, 263–264, 270, 301
 - Hertzprung-Russell diagram of, 300–301
 - life cycle of, 296–301
 - mass, 297–299
 - red dwarfs, 297
 - red giants, 301
 - spectral patterns of, 304
 - supergiants, 301
 - view from Earth of, 294–295
 - white dwarfs, 297, 301
- Static charges, **396**, 412. *See also* Electric charges; Electrostatics
- Static electricity, 394–403, **396**
 - current electricity and, 439
- Stewardship, **8**, 8–9
- Subatomic particles, **175**
- Sublimation, **138**
- Subsoil, **72**
- Sucrose, 215
- Sulphur, 180, 181
- Summer solstice, **340**
- Sun, 261, 306. *See also* *Headings beginning solar*
 - age of, 315
 - diameter of, 319
 - and Earth's revolution, 325
 - and Earth's rotation, 324
 - formation of, 308
 - layers of, 308–309
 - magnetic field, 310
 - radiation, 308
 - size of, 327
 - and space weather, 329
 - as star, 298, 308
 - surface features of, 310–311
 - tornadoes on, 306
 - and water cycle, 24
- Sundials, 345
- Sunspots, **310**
- Supergiants, 298
- Supernovas, **263**, 263–264, 270, 299
- Surtsey Island, 36–37
- Suspension, **142**
- Sustainability, **9**, 485, 495
 - of agriculture, 107–109
 - businesses and, 112–113
 - of communities, 122–123
 - of construction, 111–112
 - and Easter Island, 52–53
 - ecological footprints and, 106
 - of forestry, 63, 110–111
 - individuals and, 113
 - in resource use, 53
 - stress and, 61
- Sustainable use, of resources, **54**
- Suzuki, David, 86
- Switches, **434**, 438, 444
- Symbiosis, **39**, 39–40, 47, 75
- Systems, **11**
 - components of, 10–11
 - ecological, 12–13
 - in environment, 10–13
 - holistic approach to, 11–12
 - interactions within, 10–11
- T**
 - Technological development, problem solving for, 518–519
 - Telescopes, 264, 284, 306, 354, 375
 - optical, 346–347, 348
 - radio, 348
 - reflecting, 346
 - refracting, 346
 - Temperate coniferous forests, 16, **17**
 - Temperature
 - measuring, 539
 - and resistance, 462
 - Terrestrial biomes, **17**
 - Tertiary consumers, **30**
 - Thermoelectric generating plants, **478**
 - Thermonuclear power, **479**
 - Thomson, J.J., 172
 - Three Gorges Dam, 486–487
 - Tidal energy, 481
 - Tides, 328–329
 - Time
 - astronomical phenomena and, 349
 - and space, 258–259
 - Toothpaste, 244
 - Topsoil, **72**, 74–75
 - Tornadoes, 306
 - Toronto Evergreen Brick Works, 104–105
 - Toxicity, 200, 230–231
 - Tracking devices, 357
 - Transistors, **449**
 - Transmission lines, 390–391, 462, 468, 476
 - Transpiration, 25
 - Treaties, 95
 - Trees, 29, 100
 - Triboelectric series, 398
 - Tundra, 16, **17**
 - Turbines, **476**, 477
- U**
 - Ultraviolet (UV) light, 308
 - United Nations Environment Programme (UNEP), 69
 - Universe, **255**. *See also* Space expansion of, 286–287 mapping of, 259, 275
 - Uranus, 262, 315, 317
 - Urban sprawl, **62**
- V**
 - Valence electrons, **197**, 198
 - Valence shell, **197**

Venus, 261, 314, 316
Voltage, **437**, 454, 455
Voltmeters, **438**, 440, 454
Volts, **438**
Volume, **138**
 measuring, 537

W

Wabigoon River system,
 232–233
Waste. *See also* Sewage
 mercury in, 231
 in Pacific Ocean, 68
 plastics, 68, 69
 solid, 58
Water. *See also* Aquatic
 biomes

acidity, 78
Bohr diagram of, 214
calcium in, 169
carbon dioxide and, 27
as chemical, 210
as compound, 210–211,
 214
as conductor, 401,
 432–433
copper(II) sulphate and,
 159
cycle, 24–25, 84
elements of, 183
erosion, 37
fertilizers and, 78
fluoridation of, 237
ground, 25, 72

heavy metals and, 79
melting point of, 139
on Moon, 369
neutrality of, 74
organisms in, 76
over-use of, 57–58
oxygen in, 77, 78
physical properties of, 150
pollution, 108
power. *See* Hydroelectricity
 pure, 74
 quality of, 76–80
 table, 72
 vapour, 24, 25, 70
Watts, 492
Weight, measuring, 537–538
Weightlessness, 367

Wet cells, **435**
Wetlands, **4**, 4–5, 25, 93, 100
WHMIS symbols, 513, xxiii
Wildebeest, 22–23
Wilson, Lee, 162
Wilson, Robert, 285
Wind energy, 481, 484
Winter solstice, **340**
Wintergreen candy, 499
Word equations, 28

Z

Zoos, 95, 96

The publisher would like to thank the following people and institutions for permission to use their © copyright materials. Every reasonable effort has been made to find copyright holders of the material in this text. The publisher would be pleased to know of any errors or omissions.

Front Matter: p.vii Ron Erwin © AllCanadaPhotos.com; p.ix Zhengwei Pan, University of Georgia; p.xi NASA; p. xiii © Workbook Stock/Jupiter Images; p.xxvi Ray Boudreau; p. xxviii Dave Starrett.

UNIT A: Pete Turner/The Image Bank/Getty Images; pp.2-3 Ron Erwin © AllCanadaPhotos.com; p.4 (top) Ron Garnett/Airscapes.ca, (left) Alvin E. Staffan/Photo Researchers, Inc.; p.5 Courtesy of Royal Botanical Gardens; pp.6-7 © Tom Brakefield/Corbis; p.8 © AbleStock.com/Jupiter Images; p.10 © Ragnar/Dreamstime.com; p.11 (top) © Kari Marttila/Alamy, (bottom) © Dimitri lundt/TempSport/Corbis; p.12 © Comstock/Jupiter Images; p.13 Raymond Gehman/National Geographic Stock; p.15 © Argument/Dreamstime.com; p.16 (top l-r) Don Johnston/A.G.E. Fotostock/First Light, Michael P. Gadomski/ Photoresearchers/First Light, (middle l-r) William Weber/Visuals Unlimited, Inc., John E. Marriott © All Canada Photos, (bottom right) © Clint Farlinger/Alamy; p.17 (top) © Pavelsh/Dreamstime.com, (bottom) © Oxford Scientific/Jupiter Images; p.19 © Pavelsh/Dreamstime.com; p.18 (illustration) Mapping Specialists; p.21 George Grall/National Geographic Stock; p.22 (top) Ken & Michelle Dyball/Photographer's Choice/Getty Images, (bottom left) © Oxford Scientific/Jupiter Images; p.23 (top left to right) © Anikasalsera/Dreamstime.com, © iStockphoto, © Rhambley/Dreamstime.com, © iStockphoto, (middle l-r) © Admphoto2/Dreamstime.com, © Leighton Photography & Imaging/Shutterstock, © Rui Saraiva/Shutterstock, © Kurt_G/Shutterstock, (bottom left to right) © Jan Krejci/Shutterstock, © Magdalena Bujak/Shutterstock, © iStockphoto, © Medical-on-Line/Alamy; p.24 © Ian Tragen/Shutterstock; p.25 (illustration) Imagineering; p.29 (top) Michael Abbey/Visuals Unlimited, Inc., (middle) © Oli Gardner/Alamy; p.30 © Anikasalsera/Dreamstime.com; p.31 (top-bottom row, left – right) James Hager/Robert Harding World Imagery/Getty Images, © Jason Cheever/Dreamstime.com, © Mike Grandmaison, © Pablo Caridad/Dreamstime.com, © Steven J. Kazlowski/Alamy, © Top-Pics TBK/Alamy, © Robert McGouey/Alamy, © iStockphoto, © Fishguy66/Dreamstime.com, © Stephen Meese/Shutterstock, USDA-NRCS Plants Database, Robert H. Mohlenbrock @ USDA-NRCS PLANTS Database / USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln, © Michael J. Thompson/Shutterstock; p.32 (illustration) Carlyn Iverson p.36 (top) © Arctic Images/Alamy, (bottom) © Joe Gough/Shutterstock; p.39 (left) Millard H. Sharp/Photo Researchers, Inc., (right) © Goran Kapov/Shutterstock; p.40 (top) Scott Camazine/ Photoresearchers/First Light, (bottom) Mauro Fermariello/Science Photo Library; p.41 (left to right) © Michael Francis/Animals Animals, © Arthur Morris/Corbis, Photo by Bamphitlhi Tiroesele/Agricultural Research Service (ARS)/U.S. Department of Agriculture, © David Lyons/Alamy, © Kwest19/Dreamstime.com; p.42 © Creatas/Jupiter Images; p.44 © Creatas/Jupiter Images; p.47 (top) © Ecophoto/Dreamstime.com, (middle) © Comstock/Jupiter Images, (bottom) © iStockphoto; p.48 © Chrislofoto/Shutterstock; pp.50-51 © Mike Grandmaison; p.52 © Leksele/Dreamstime.com; p.53 Thomas J. Abercrombie/National Geographic Stock; p.54 (left) © iStockphoto, (bottom) © Chris Harris/All Canada Photos; p.55 © iStockphoto; p.56 (both) Fisheries and Oceans Canada/Peches et Oceans Canada, (bottom) Haywood Magee/Picture Post/Getty Images; p.58 (both) © UNEP/GRID—Sioux Falls; p.59 (right) © Steve Byland/Dreamstime.com, (bottom) Michael Irvine, Ontario Ministry of Natural Resources; p.60 © INTERFOTO Pressebildagentur/Alamy; p.61 Al Harvey/SlideFarm.com; p.62 Ethan Meleg/All Canada Photos/Getty Images; p.63 AIVA-Paul Nopper; p.66 © blickwinkel/Alamy; p.67 © Bill Brooks/Alamy; p.68 © Jacus/Dreamstime.com; p.69 David Liittschwager/NationalGeographicStock.com; p.70 (illustration) © Benjamin Cummings; p.71 © Peter Arnold, Inc./Alamy; p.73 © Radius

Images/Jupiter Images, (illustration) © Benjamin Cummings; p.74 © Organica/Alamy; p.75 (top) © Costa007/Dreamstime.com, (bottom) Wally Eberhart/Visuals Unlimited/Getty Images; p.77 Thomas Ames Jr./Visuals Unlimited/Getty Images; p.80 © Don Johnston/Alamy; p.82 © Edmund Neil; Eye Ubiquitous/Corbis; p.83 © Photofusion Picture Library/Alamy; p.84 U.S. Forest Service; p.85 USDA/NRCS/Natural Resources Conservation Service; p.86 (left) The Canadian Press (Tom Hanson), (inset) Michael Stuparyk/Toronto Star; p.87 (left) AIVA-Paul Nopper, (inset) © A. Ramey/Photo Edit; p.88 © PhotoSouth/Alamy; pp.90-91 © Rolf Hicker Photography; p.92 (top) © Jeff Greenberg/Alamy, (left) Alfred Eisenstaedt/Time & Life Pictures/Getty Images; p.94 (top, left to right) © Ross Frid/Alamy, ©Clint Farlinger/Alamy, (bottom, left to right) © Jdeboer152/Dreamstime.com, © Rhambley/Dreamstime.com; p.95 United States Fish and Wildlife Services; p.96 (top) Mari Tefre/Svalbard Global Seed Vault, (bottom) © Robert Shantz/Alamy; p.97 © Wayne Lynch/All Canada Photos; p.98 (top, left to right) © Jgroup/Dreamstime.com, © Katherine Haluska/Dreamstime.com, Jamie Marshall © Dorling Kindersley, © OnAsia/Jupiter Images, (bottom, left to right) © Arco Images GmbH/Alamy, © iStockphoto, © franzfoto.com/Alamy, © iStockphoto, (illustration) Mapping Specialists; p.99 © Superstock/Maxx Images; p.100 Courtesy of Royal Botanical Gardens; p.101 (top left to right) Photo by Charles Harrington. Agricultural Research Service (ARS)/U.S. Department of Agriculture, Photo Courtesy of the Canadian Food Inspection Agency. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2009, (bottom) Toronto Star/The Canadian Press (Mike Slaughter); p.102 © Bob Daemrich/Photo Edit; p.103 © Fotos.com/Jupiter Images; p.104 (top) DTAH (du Toit Allsopp Hillier), (bottom) Erin Chan, for Evergreen; p.105 Michelle Scrivener, for Evergreen; p.107 Photo: Andrew Graham (OSCIA). Courtesy of Ontario Soil and Crop Improvement Association; p.108 © AGStockUSA, Inc./Alamy; p.109 © Janusz Wrobel/Alamy; p.110 © Andrew Moss/Alamy; p.111 De Agostini Picture Library/Getty Images; p.112 Courtesy of Enermodal Engineering Limited. www.enermodal.com; p.113 (left) © 2009 The Clorox Company. Reprinted with permission, (centre) The EcoLogo Program is owned by the Government of Canada and managed by TerraChoice. www.ecologo.org, (right) Courtesy of Peintures récupérées du Québec Inc.; p.114 © lofoto/Dreamstime.com; p.116 © 1996 Forest Stewardship Council A.C.; p.117 (top) Jay Ingram, (bottom) © David Tipling/Alamy, (inset left) © Don Johnston/All Canada Photos, (inset right) Jeff Foott/Discovery Channel/Getty Images; p.118 Ashley Hutcheson/Toronto Star; p.119 © Harold R. Stinnette Photo Stock/Alamy; p.122 © Gideon Mendel/Corbis; p.123 (left) © Johnny Greig/Alamy, (right) © Wildscape/Alamy; p.126 (top) © Technology And Industry Concepts/Alamy, (bottom) © Nancy Hixson/Shutterstock.

UNIT B: pp.130-131 Zhengwei Pan, University of Georgia; p.132 © Dave Pattison/Alamy; p.133 Photo courtesy of Ron Prendergast, Melbourne Zoo; pp.134-135 © McCoy Wynne/Alamy; p.136 (top) The Canadian Press (Sean Kilpatrick), (left) © Corbis/Jupiter Images; p.138 Wikipedia; p.140 © Kotourist/Dreamstime.com; p.141 (top) © Carlos E. Santa Maria/Shutterstock, (bottom) © iStockphoto; p.142 (top) © Wardcapoen/Dreamstime.com, (bottom, left to right) © Comstock/Jupiter Images, © Ermek/Shutterstock; p.144-146 Dave Starrett; p.147 (top) © Ifistand47/Dreamstime.com, (bottom) © Colin Young-Wolff/Photo Edit; p.148 © Robilix/Dreamstime.com; p.150 (top) © Alamac/Dreamstime.com, (middle) © Stephen Mcsweeney/Dreamstime.com, (bottom) © Chrisgh/Dreamstime.com; p.151 (top to bottom) © Seesea/Dreamstime.com, Dave King © Dorling Kindersley, Clive Streeter © Dorling Kindersley, Clive Streeter © Dorling Kindersley, Harry Taylor © Dorling Kindersley, © FoodPix/Jupiter Images, © Michael Newman/PhotoEdit; p.152 (top) © Phil Degginger/Alamy, (bottom) © Eminozkan/Dreamstime.com; p.153 (top) © Darren Fisher/Dreamstime.com, (bottom) Susanna Price © Dorling Kindersley; p.154 © Rob Howard/Corbis; p.155 Photo compliments of EFI™ VUTEK® Copyright © 2009, EFI™. VUTEK® is a registered trademark of EFI™. All rights reserved; p.156 Dave Starrett; p.159 Ray Boudreau; p.160

Dave Starrett; p.161 © Catalinus/Dreamstime.com; p.162 Courtesy of Lee Wilson, University of Saskatchewan; p.163 (top) Courtesy of Heather A. Mace, Ottawa-Carleton District School Board, (bottom) Courtesy of Tim Forbes, Artist; p.164 (top to bottom) © silver-john/Shutterstock, Pearson Education/PH College, © Can Balcioglu/Shutterstock; pp.166-167 © Chris Cheadle/Alamy; p.168 (top) Artwork by Rustic Twist, photo provided by Aotearoa.co.nz, (left) Artists: C.P. Lutz and D.M. Eigler/IBM Almaden Research Center; p.170 © Pryzmat/Dreamstime.com; p.171 (top) © INTERFOTO Pressebildagentur/Alamy, (bottom) © Science Museum/Science & Society Picture Library; p.172 © SSPL/The Image Works; p.174 © Science Photo Library; p.178 (top) © Steven Vidler/Eurasia Press/Corbis, (left) © Nathan Benn/Alamy; p.179 © Leslie Garland Picture Library/Alamy; p.180 (top) © Aberenyi/Dreamstime.com, (bottom left) Andrew Lambert Photography/Science Photo Library, (bottom right) Andy Crawford and Tim Ridley © Dorling Kindersley; p.181 (top) Astrid & Hanns-Frieder Michler/Science Photo Library, (middle) Courtesy of and © copyright Prof. Mark Welland and Ghim Wei Ho, Nanoscience Centre, University of Cambridge; p.183 © Snarfie82/Dreamstime.com; p.184 (top to bottom) © Eric Nathan/Alamy, Scott Audette/Reuters/Landov, © Corbis RF/Jupiter Images; p.185 (left) Natural Resources Canada, Canadian Forest Service, (right both) Andrew Lambert Photography/Science Photo Library; p.187 Andrew Lambert Photography/Science Photo Library; p.189 © Mary Evans Picture Library/Alamy; p.194 (top) Martyn F. Chillmaid/Science Photo Library, (bottom) © Ashley Hutchesonsciencephotos/Alamy; p.195 Lighted Glass Sculpture "Anemone 2000" by Candice Gawne www.luminousartworks.com; p.197 AIP Emilio Segre Visual Archives, Friedrich Hund, Gift of Jost Lemmerich; p.203 (left) Ray Boudreau, (right) Dave Starrett; p.205 (top) AIVA-Paul Nopper, (inset) © Ashley HutchesonPat Behnke/Alamy, (bottom) © Jlvdream/Dreamstime.com; p.206 Harry Taylor © Dorling Kindersley/ Courtesy of the Natural History Museum, London; pp.208-209 Dr. Keith Wheeler/Science Photo Library; p.210 © Ashley HutchesonBlend Images/Jupiter Images; p.212 (left to right) Andrew Lambert Photography/Science Photo Library, Andrew Lambert Photography/Science Photo Library, © FoodPix/Jupiter Images; p.215 Ray Boudreau; p.216 Andrew Lambert Photography/Science Photo Library; p.218 (top) © fauxware/Shutterstock, (bottom) © Robyn Mackenzie/Shutterstock, © Brian Weed/Shutterstock; p.219 Andrew Lambert Photography/Science Photo Library; p.222 © Robert Redelowski/Shutterstock; p.224 Pasieka/Science Photo Library; p.225 (left) © iStockphoto, (right) © Rachel Epstein/PhotoEdit; p.227 © Katrindell/Dreamstime.com; p.228 Terri Rothman; p.230 (top) Colin McConnell/Toronto Star, (bottom) © hardtmuth/Shutterstock; p.231 Colin Cuthbert/Science Photo Library; p.233 (left) Brent Wesley/Wawatay News. Used with permission, (right) Mercury Disability Board; p.234 NASA; p.235 Marvin Fong/The Plain Dealer/Landov; p.236 © Oxford Scientific/Jupiter Images; p.238 Jose Luis Pelaez/Iconica/Getty Images; p.239 (top) Jay Ingram, (centre) © 2008 Encyclopædia Britannica, Inc. (bottom) Dr. Mitsuo Ohtsuki/Science Photo Library; p.243 (top to bottom) © Alamac/Dreamstime.com, © Phil Degginger/Alamy, Andrew Lambert Photography/Science Photo Library, Andrew Lambert Photography/Science Photo Library; p.244 (top) Thierry Berrod, Mona Lisa Production/Science Photo Library, (bottom) Dave Starrett; p.249 Colin Keates © Dorling Kindersley, Courtesy of the Natural History Museum, London; p.251 © Circotasu/Dreamstime.com.

UNIT C: pp.252-253 NASA; p.254 NASA, ESA, S. Beckwith (STScI) and the HUDF Team; p.255 Jean-Charles Cuillandre (CFHT) Canada-France-Hawaii Telescope; pp.256-257 © Dennis Hallinan/Alamy; p.258 © 2008 Kerry-Ann Lecky Hepburn; p.259 © Chris Cheadle/Alamy; p.260 NASA; p.261 (left to right) NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington, NASA, © Neo Edmund/Shutterstock, NASA, J. Bell (Cornell U.) and M. Wolff (SSI); p.262 Wikipedia; p.263 (top) NASA/JoA.J.Sanders & A.Fabian, (bottom) John Chumack/Photoresearchers/First Light; p.264 (top) Anglo-Australian Observatory/David Malin Images, (left top) NASA/CXC/SAO, (left bottom) © Danita Delimont/Alamy; p.265 NASA, ESA, and the Hubble

Heritage (STScI/AURA)-ESA/Hubble Collaboration; p.266 Robert Williams and the Hubble Deep Field Team (STScI) and NASA; p.267 John Chumack/Science Photo Library; p.268 Photo by U.S. National Park Service; p.270 (top) NASA/Dana Berry, SkyWorks Digital, (bottom) Walter Jaffe/Leiden Observatory, Holland Ford/JHU/STScI, and NASA; p.271 (top) NASA/CXC/MPE/S.Komossa et al., (bottom) NASA/ESA/M J Jee/Johns Hopkins University; p.272 (top) NASA, ESA, A. Sarajedini (University of Florida) and G. Piotto (University of Padua [Padova]), (middle) NASA, ESA, and The Hubble Heritage Team (STScI/AURA), (bottom left) NASA, ESA, and The Hubble Heritage Team (STScI/AURA), (bottom right) X-ray: NASA/CXC/U. Copenhagen/K.Pedersen et al; Optical: Palomar DSS; p.273 (top) NASA, ESA, and The Hubble Heritage Team (STScI/AURA), (bottom) NASA, ESA, and The Hubble Heritage Team (STScI/AURA); p.275 2dF Project/Anglo-Australian Observatory; p.276 (top to bottom) NASA, NASA, ESA and A. Nota (STScI/ESA), NASA and The Hubble Heritage Team (STScI/AURA), NASA, ESA, and the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration, REU program, N.A.Sharp/NOAO/AURA/NSF, Kirk Borne (STScI), and NASA, NASA, ESA and B. Mobasher (STScI/ESA); p.277 NASA, ESA and AURA/Caltech; p.278 (top) STScI and NASA, (bottom) Margaret Bourke-White/Time Life Pictures/Getty Images; p.279 Dave Starrett; p.280 Philippe Mouche © CERN; p.284 W.M. Keck Observatory/Rick Peterson; p.285 (top) NASA, (bottom) NASA/WMAP Science Team; p.289 (top) Moondigger/Wikipedia/Creative Commons Attribution and Share Alike 2.5 license, (inset) NASA/JPL-Caltech/S. Stolovy (Spitzer Science Center/Caltech), (bottom) NASA/UMass/D.Wang et al; p.290 (both) NASA, ESA, and The Hubble Heritage Team (STScI/AURA); pp.292-293 © Corbis/Jupiter Images; p.294 © T. Credner, AlltheSky.com; p.296 (left) T.A.Rector (NRAO/AUI/NSF and NOAO/AURA/NSF) and B.A.Wolpa (NOAO/AURA/NSF), (inset) NASA, ESA, STScI, J. Hester and P. Scowen (Arizona State University); p.298 (left) © Dale O'Dell/Alamy, (bottom) Andrea Dupree (Harvard-Smithsonian CfA), Ronald Gilliland (STScI), NASA and ESA; p.299 (top) © Haneck/Dreamstime.com, (bottom) NASA/Dana Berry; p.300 Mark Garlick/Science Photo Library; p.301 On Lomberg/Science Photo Library; p.303 Dave Starrett; p.305 NASA, H.E. Bond and E. Nelan (Space Telescope Science Institute, Baltimore, Md.); M. Barstow and M. Burleigh (University of Leicester, U.K.); and J.B. Holberg (University of Arizona); p.306 (top) SOHO/LASCO (ESA & NASA), (bottom) SOHO (ESA & NASA); p.309 Chris Butler/Science Photo Library; p.310 (top) NASA, (bottom) National Optical Astronomy Observatory/Association of Universities for Research in Astronomy/National Science Foundation (NOAO/AURA/NSF); p.311 SOHO (ESA & NASA); p.313 © Roman Krochuk/Shutterstock; p.315 (bottom) NASA/JPL/University of Arizona; p.316 (top to bottom) NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington, NASA, © Neo Edmund/Shutterstock, NASA, J. Bell (Cornell U.) and M. Wolff (SSI); p.317 (top to bottom) NASA, NASA/Dorling Kindersley, NASA and Erich Karkoschka, University of Arizona, NASA/Finley Holiday Films © Dorling Kindersley; p.318 © Dale O'Dell/Alamy; p.321 (left to right) NASA, © OlesiaRu&IvanRu/Shutterstock, Christian Marois /RC Herzberg Institute of Astrophysics and Bruce Macintosh/Lawrence Livermore National Laboratory; p.322 © Rob Howard/Corbis; p.325 (top) © Orchidpoet/Dreamstime.com, (bottom) © Nordicphotos/Alamy; p.327 (left) © John Prior Images/Alamy, (right) © Simon Lane/Alamy; p.328 (top) © Miss canon/Dreamstime.com, (bottom) © Shutterstock; p.329 (both) © Bill Brooks/Alamy; p.332 (top) NASA, (bottom) Canadian Space Agency; p.333 (both) Courtesy of MDA; p.334 NASA/ST561A-35-86; p.335 NASA, ESA, H. Weaver (JHU/APL), A. Stern (SwRI), and the HST Pluto Companion Search Team; pp.336-337 NASA; p.338 Andrzej Mirecki/Wikipedia; p.339 (Fig.9.3) NASA; p.340 (top) © David R. Frazier Photolibrary, Inc./Alamy, (bottom) © John Burke/Maxx Images; p.341 (top) © Marc Hill/Alamy, (bottom) Georg Gerster/Photoresearchers/First Light; p.342 Tunç Tezel; p.345 (right) © iStockphoto; p.347 (top to bottom) Jean-Charles Cuillandre (CFHT) Canada-France-Hawaii Telescope, MOST Team, Canadian Space Agency, and the University of British Columbia, Space Telescope Science Institute

(STScI); p.348 © imagebroker/Alamy; p.351 Tunç Tezel; p.352 NASA; p.353 (top) Images acquired and processed by CRISP, National University of Singapore, Singapore. IKONS Image © CRISP 2005, (bottom) NASA; p.354 (top) © SHOUT/Alamy, (bottom) NASA; p.355 (top) © Indiart/Dreamstime.com, (bottom) © Mark Boulton/Alamy; p.356 (top) NASA, (bottom) Telesat Anik F3 Satellite - Image provided by EADS Astrium. www.telesat.com; p.357 © Kai-Uwe Och/Alamy; p.358 (both) Courtesy of the University of Papua New Guinea Remote Sensing Centre; p.359 (left) European Space Agency, (right) ESA - AOES Medialab; p.360 (top) Image © 2008 Digital Globe. © 2008 Tele Atlas. © 2008 Google, (bottom) Data courtesy Marc Imhoff of NASA GSFC and Christopher Elvidge of NOAA NGDC. Image by Craig Mayhew and Robert Simmon, NASA GSFC; p.361 NASA; p.363 NASA/Science Photo Library; p.364 (top left) Adeel Halim/Reuters/Landov, (right) NASA; p.365 Babu/Reuters/Landov; p.366 (both) NASA; p.367 NASA Orbital Debris Program Office; p.368 (top) Hulton Archive/MPI/Getty Images, (bottom) NASA; p.369 NASA; p.370 Flashline Mars Arctic Research/The Mars Society; p.371 NASA; p.372 ESA; p.373 NASA; p.374 NASA; p.375 (top) Jay Ingram, (bottom) © Chris Howes/Wild Places Photography/Alamy, (inset) Base Map: P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (NOAA National Geophysical Data Center, Boulder). Copyright Royal Astronomical Society. Reproduced from the Monthly Notices of the RAS by permission of Blackwell Science. Labels: Royal Astronomical Society of Canada; p.376 Data courtesy Marc Imhoff of NASA GSFC and Christopher Elvidge of NOAA NGDC. Image by Craig Mayhew and Robert Simmon, NASA GSFC.; p.377 NASA; p.379 (top, left to right) Robert Williams and the Hubble Deep Field Team (STScI) and NASA, NASA, ESA, and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration, (middle, left to right) NASA, ESA, STScI, J. Hester and P. Scowen (Arizona State University), © Roman Krochuk/Shutterstock, (bottom, left to right) Andrzej Mirecki/Wikipedia, Jean-Charles Cuillandre (CFHT) Canada-France-Hawaii Telescope; p.380 NASA/JPL/JA/Lockheed Martin; p.381 (left) © Brand X/Jupiter Images, (right) Mohsin Raza/Reuters/Landov; p.382 © Dale O'Dell/Alamy; p.383 (left) © The Print Collector/Alamy, (right) NASA; p.384 POSS-II Northern Hemisphere Surveys/Palomar Observatory © 1993-2003 by the California Institute of Technology; p.385 (left) © Roger Ressmeyer/Corbis, (right) © SHOUT/Alamy; p.386 Reuters TV/Landov.

UNIT D: pp.388-389 © Workbook Stock/Jupiter Images; p.390 Andrew Wallace/Reuters/Landov; p.391 © iStockphoto; pp.392-393 © David Wall/Alamy; p.394 Prentice Hall School Division; p.397 © markrhiggins/Shutterstock; p.399 © INTERFOTO Pressebildagentur/Alamy; p.400 © Judy Drietz/Shutterstock; p.401 © Vladimir Breytberg/Shutterstock; p.402 Ray Boudreau; p.404 © Leslie Garland Picture Library/Alamy; p.405 (left) Courtesy of Science Kit and Boreal Laboratories, (right) Image courtesy of Wayne Schmidt, www.waynesthisandthat.com; p.409 (top) © Photolibary.com, (bottom) Prentice Hall School Division; p.411 (top) Pearson Learning Photo Studio, (bottom) Wikipedia; p.416 Tory Zimmerman/Toronto Star; p.418 (left top) © Pink Sun Media/Alamy, (left bottom) © Corbis RF/Jupiter Images; p.419 (top left) Courtesy of Daryl Reeves/Building Biology Australia, (top right) Chris Brady www.b737.org.uk, (bottom) © John Coletti/Maxx Images; p.420 (top) © iStockphoto, (bottom) Andrew Lambert Photography/Science Photo Library; p.421 © Oxford Scientific/Jupiter Images; p.423 Courtesy of PPC Industries; p.426 © AbleStock.com/Jupiter Images; p.427 Tim

Vernon, Lth Nhs Trust/Science Photo Library, © Sovereign/Phototake, © Jeffrey MacMillan; pp.430-431 J.F.Raga/First Light; p.432 (top) © Russ Kinne/Animals Animals, (bottom left) © AbleStock/Jupiter Images; p.433 © Visual&Written SL/Alamy; p.435 Charles D. Winters/Photo Researchers/First Light; p.436 (top) © Paul Glendell/Alamy, (middle) © Friedrich Saurer/Alamy; p.438 © sciencephotos/Alamy; p.439 © sciencephotos/Alamy; p.440 Andy Crawford © Dorling Kindersley; p.441 (top) © Lfchavie/Dreamstime.com, (middle) © Mrgreen/Dreamstime.com, (bottom) © Stuartkey/Dreamstime.com; p.442 © Leslie Garland Picture Library/Alamy; p.444 Dave Starrett; p.446 Courtesy of Science Kit and Boreal Laboratories; p.448 Yoshikazu Tsuno/AFP/Getty Images; p.449 © eprom/Shutterstock; p.454 Andrew Lambert Photography/Science Photo Library; p.458 (top) © srdjan draskovic/Shutterstock, (bottom) © Bettmann/Corbis; p.463 (top to bottom) © Serghei Velusceac/Dreamstime.com, © PhotoObjects/Jupiter Images, © D. Hurst/Alamy; p.464 (left) © Taboomer/Dreamstime.com, (right) © Brand X/Jupiter Images; p.466 Ray Boudreau; p.468 Photo by Greg Ehlers. Courtesy of Simon Fraser University; p.469 © iStockphoto; pp.472-473 © Mike Grandmaison; p.474 Courtesy of Elliot Lake Secondary School/ Algoma District School Board; p.475 Photography © Toronto and Region Conservation, All Rights Reserved; p.476 (top) © The Print Collector/Alamy, (bottom) © SuperStock/Maxx Images; p.477 AP Photo/The Canadian Press (David Duprey); p.478 © iStockphoto; p.479 (top) David Cooper/Toronto Star, (middle) © iStockphoto; p.480 Courtesy of OptiSolar; p.481 (top) David Cooper/Toronto Star, (bottom) © iStephen Saks Photography/Alamy; p.483 © Paul Norman Browne/Painet Inc.; p.485 Courtesy of John Wilson; p.486 © China Photos/Reuters/Corbis; p.487 (top) Institute of Hydrobiology, the Chinese Academy of Sciences, (bottom) © Jean-Pierre Zwaenepoel/Naturpl.com; p.488 Ethan Meleg/All Canada Photos/Getty Images; p.489 NASA, (inset) Tommaso Guicciardini/Science Photo Library; p.490 (top) © Najlah Feanny/Corbis, (bottom) © Liane Cary/Maxx Images; p.491 Toronto Hydro-Electric System Limited; p.492 Toronto Hydro-Electric System Limited; p.494 The ENERGY STAR mark is administered and promoted in Canada by Natural Resources Canada and is registered in Canada by the United States Environmental Protection Agency. © Reproduced with permission of the Minister of Natural Resources, Canada 2005; p.495 © iTihis/Shutterstock; p.497 © Tinabelle/Dreamstime.com; p.498 The ENERGY STAR mark is administered and promoted in Canada by Natural Resources Canada and is registered in Canada by the United States Environmental Protection Agency. © Reproduced with permission of the Minister of Natural Resources, Canada 2005; p.499 (top) Jay Ingram, (bottom) Image courtesy of Wayne Schmidt, www.waynesthisandthat.com; p.500 © Reproduced with permission of the Minister of Natural Resources, Canada 2005; p.501 © Steve Hamblin/Corbis; p.503 (top to bottom) J.F.Raga/First Light, © srdjan draskovic/Shutterstock, Courtesy of John Wilson; p.504 (top) U.S. Department of Energy, (bottom) © Age Fotostock/Maxx Images; p.507 © allOver photography/Alamy; p.509 © Lyroky/Alamy.

SKILLS REFERENCE: p.522; p.523; p. 530; p. 534; p.536; p. 537 Ray Boudreau; p. 538 (top) Ray Boudreau; (bottom) Andrew Lambert Photography/Science Photo Library; p.548 Ray Boudreau; p.551 Evening Sky Map: © 2000-2005 Kym Thalassoudis www.skymaps.com; p.553 (left) Martyn F. Chillmaid/Science Photo Library, (right) Andrew Lambert Photography/Science Photo Library

Periodic Table of the Elements

	1															
1	1															2
	3 4 5 6 7 8 9															
1	1															2
2	3	4														
3	11	12														
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
6	55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84
7	87	88	89-103	104	105	106	107	108	109	110	111	112	113	114	115	116
	↑															
6	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
7	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104

 metal	C solid	atomic number — 8	2 — ion charge (if more than one, first one is the most common)
 metalloid	Br liquid	symbol — O	
 non-metal	He gas	name — oxygen	
		atomic mass — 16.00	

