APPENDIX G Answers to Selected Questions and Problems

Chapter 1 Review Questions

1. **c.** molecule, cell, tissue, organ
2. **a.** a cell.
3. **a.** organ → tissue → cell
4. **b.** response to stimuli
5. **a.** number of oxygen gas bubbles produced by the blue-green algae.
6. **c.** the number of squeezes.
7. **c.** to see if the vaccine is effective against the rabies virus
8. **a.** use a larger sample size
9. **b.** If fertilizer is applied to a yellow lawn, then the grass will turn green.
10. **c.** The experimental group is exposed to the factor being tested, but the control group is not exposed.
11. **b.** no pigeon peas were grown in the control pots, and no fertilizer was added.
12. The petri dish with the most effective antibacterial hand sanitizer will have the least amount of bacterial growth.
13. type of antibacterial soap
14. The control group should be exposed to water instead of the antibacterial sanitizer.
15. temperature and length of time for incubation should be kept the same
16. Four petri dishes were labelled A, B, C and D. The same amount and type of bacteria were added to each petri dish filled with agar. All four petri dishes were inoculated with bacteria. A different brand of antibacterial hand sanitizer was placed on each of three paper disks. The disks were placed on petri dishes A, B and D. Water was added to the fourth paper disk and placed on petri dish C. All four petri dishes were placed in an incubator. After 24 hours, the amount of bacterial growth on each petri dish was measured. The petri dish with the most effective hand sanitizer had the least amount of bacterial growth.
17. The type of data could include the amount of bacteria growth on each petri dish.
18. The study must be repeated several times.
19. how tall the pea plants grew; height of the pea plants
20. Answers may include: some pea plants may have received more water, sunlight, or nutrients; differences in genetic make-up of the pea plants; different types or species of pea plants; different water temperatures; different amount of soil in each pot; size of pot pea plants
21. Evolution explains the unity of life based on all organisms sharing a common ancestor, which is the first cell or cells that existed almost 4 billion years ago. Evolution also explains life's diversity which results from the environment always changing. Because there is variation among individuals, populations, and species, there is variation in responses to environmental pressures. Some individuals have had adaptations or features to make them more suited to the new environment and these individuals tend to live to produce more offspring than less suited individuals.
22. Life is defined as organisms that have the following basic characteristics: **1.** organization; **2.** ways to acquire materials and energy; **3.** reproduction; **4.** responses to stimuli; **5.** homeostasis; **6.** growth and development; **7.** capacity for adaptation to their environment. Computers are not living because they cannot acquire energy on their own and are not self-replicating.
23. The experimental chemical should be studied in a model species. The experiment should have both a control group (that receives no drug, or the inert ingredients used in the drug's formulation) and a treatment group (that receives the drug). Both groups should experience identical conditions and have the same type of cancer. Data is collected on tumour development in the treatment group relative to the control group. If the treatment group shows greater tumour reduction than the control group, the drug may then be approved for trials on humans.

Chapter 2 Diagnostic Questions

1. **b.** a neutron and a proton
2. **c.** a proton and an electron
3. **d.** they become negatively charged ions
4. **b.** It loses one electron to become a positively charged ion with a full valence shell.
5. **c.** KCl
6. **b.** NH_3
7. **b.** protons, but different number of neutrons
8. **a.** mass number
9. **c.** gained hydrogen ions
10. **c.** Acids have a pH of less than 7 while bases have a pH of more than 7
11. **a.** is basic
12. **c.** covalent bonds
13. **d.** the unequal sharing of electrons between the atoms of the molecule
14. **b.** cellulose and starch
15. An atom is the smallest part of an element that shows the characteristics of the element.
16. The atomic number represents the number of protons in an atom.
17. Diagram
18.

	Proton	Electron	Neutron
Symbol	p	e	n
Electric charge	positive	negative	no charge
Location	+1	−1	0
Mass	nucleus	shells	nucleus
	1	0	1

19. The chemical formula of a compound shows the different types of elements in the compound and how many atoms of each element.

20. An atom has no charge. An ion has a charge because it has either lost or gained electrons. The ion has a full valence shell, while the atom does not.
21. A covalent compound results from non-metallic atoms sharing electrons to form covalent bonds, while an ionic compound results when an ionic bond forms between a positively charged ion and a negatively charged ion.
22. Soil pH and Gardening – gardeners might have to determine the pH of soil to see if certain plants can grow in it; Pools and Hot Tubs – pH of the water has to be tested otherwise algae can grow; Baking – baking involves a series of chemical reactions that require the ingredients to be at a specific pH; Hair – use of hair dyes and shampoos require the correct pH balance to work.
23. Diagram
24. Diagram
25. Water forms beads of water because of attractive cohesive forces between the water molecules are responsible for surface tension.

Chapter 2 Review Questions

1. **d.** a proton has a positive charge; an electron has a negative charge; a neutron has no charge
2. **c.** They both have the same number of protons, but different number of electrons.
3. **d.** a buffer
4. **d.** 1000 times
5. **c.** covalent; hydrogen
6. **b.** Polar, water-loving; Nonpolar, water-fearing
7. **c.** protein and amino acid
8. **c.** the formation of a peptide bond between alanine and lysine
9. **d.** the conversion of monosaccharides into polysaccharides
10. **d.** carbohydrates
11. **d.** they have twice as many hydrogen atoms as oxygen atoms
12. **c.** disaccharide
13. **c.** 3
14. **b.** double bonds
15. **c.** the phosphate group
16. **b.** cholesterol
17. **b.** speeds up chemical reactions
18. **b.** keratin
19. **b.** insulin
20. **b.** a peptide bond
21. **a.** the R group
22. **b.** R group
23. **b.** amino acids
24. **b.** 3
25. **d.** hydrogen bonding
26. **a.** the linear sequence of amino acids
27. **b.** folded differently due to the hydrogen bonding and have a different sequence of amino acids
28. **a.** energy is released
29. **d.** phosphorus
30. **a.** nucleotide
31. **d.** a monosaccharide
32. **b.** triglyceride
33. **c.** nitrogen
34. **a.** triglyceride
35. **b.** a phosphate group, a nitrogenous base and a ribose sugar
36. **c.** the pentose sugar
37. **a.** uracil
38. **a.** cytosine and guanine
39. **d.** Safety goggles, juice, Benedict's solution, test tube, test tube tongs, graduated cylinder, hot plate, beaker, water, rubber gloves
40. **a.** 6 (fatty acid), 7 (glycerol)
    b. 3 (amino acid)
    c. 2 (glucose), 8 (maltose), 12 (cellulose), 13 (starch), 14 (glycogen)
    d. 11 (steroid)
    e. 13 (starch)
    f. 6 (fatty acid), 7 (glycerol)
    g. 12 (cellulose)
    h. 2 (glucose)
    i. 5 (water)
    j. 10 (phospholipid)
    k. 9 (ATP)
    l. 3 (amino acid)
    m. 14 (glycogen)
    n. 1 (triglyceride), 4 (dipeptide), 8 (maltose), 10 (phospholipid), 12 (cellulose), 13 (starch), 14 (glycogen)
    o. 3 (amino acid), 4 (dipeptide)
    p. 5 (water)
41. An atom has the same number of protons and electrons. The positive charges of the protons and the negative charges of the electrons add up to zero, making the atom neutral.
42. The negatively charged oxygen of one water molecule is attracted to the positively charged hydrogen of another water molecule.
43. The pH of the solution will decrease becoming more acidic.
44. Bond X is a hydrogen bond.
45. Bond X forms between the two molecules because the molecules are polar.
46. Three functions of water: 1. acts as a solvent – dissolves substances; 2. acts as a lubricant – lubricates joints; 3. acts as a temperature regulator – regulates body temperature.
47. The unequal sharing of electrons accounts for the polarity.
48. The partially positive and negative charges on the molecule allow water to act as a solvent.
49. The body will store the carbohydrates needed for the race. On the day of the race, glycogen will be converted into glucose so that glucose can be used to produce ATP during cellular respiration.

50. Two hydrogen atoms and one oxygen atom are used to produce a water molecule during the dehydration reaction.

51. The process is a dehydration reaction.

52. Bond X is a peptide bond.

53. A dipeptide (2 amino acids held together by a peptide bond) and a water molecule will form as a result of this reaction.

54. Nine water molecules are produced when 10 amino acids are linked together.

55. Lactose is classified as a disaccharide.

56. A water molecule is required for this reaction to occur.

57. A hydrolysis reaction is illustrated.

58. When nonpolar molecules, such as oil, come into contact with polar molecules, like water, they do not mix. The oil molecules tend to clump together rather than mix with the water. This is because oil molecules are nonpolar and therefore hydrophobic (water-fearing).

59. a. DNA codes for the sequence of amino acids in a protein.

b. A nucleotide consists of a nitrogenous base, a sugar and a phosphate group. It is the monomer that makes up a nucleic acid.

c. A monosaccharide consists of one sugar molecule, while a polysaccharide consists of many sugar molecules.

d. A polypeptide is a chain of amino acids held together by peptide bonds.

e. The secondary structure of a protein is determined by the hydrogen bonding between the different amino acids.

f. Due to the unequal sharing of electrons on a water molecule, the water molecule is said to be polar. The negative charge of one water molecule is attracted to the positively charged part of another water molecule. This causes the water molecules to stick together, displaying cohesion.

60. a. A glycerol molecule is only composed of a three-carbon chain, while a fatty acid is a long chain of carbons. Both of these molecules make up a triglyceride.

b. A triglyceride has a glycerol molecule attached to three fatty acid chains, while a phospholipid has a glycerol molecule attached to two fatty acid chains and a phosphate group.

c. A peptide bond forms between the carbon of the carboxyl group and the nitrogen of the amino group in a dipeptide. A hydrogen bond forms between different amino acids in the polypeptide chain.

d. Unsaturated fatty acids have double bonds, while saturated fatty acids only have single bonds.

61. a. A large amount of molecules can be produced with the same monomer. For example, glucose (a monomer) can form three different polymers (cellulose, starch and glycogen).

b. Hydrolysis breaks down a polymer that is no longer needed and its monomers can be used to produce other polymers through a dehydration reaction.

62. A positive test for Benedict's solution indicates the presence of glucose. Since maltose is made up of two glucose molecules it should test positive like the glucose solution.

63. The phospholipid bilayer forms in an aqueous solution because the polar (hydrophilic) head is soluble in water, while the non-polar (hydrophobic) tails are not. The hydrophilic heads will interact with the water on the outside and inside of the vesicle, while the hydrophobic tails interact with each other.

64. The molecular structure of a phospholipid consists of a hydrophilic head and a hydrophobic tail. The polar hydrophilic head faces outwards toward the watery solutions and the non-polar tails form the hydrophobic interior.

65. The non-polar, hydrophobic tails of the phospholipids are packed tightly together to form the interior of the cell membrane and the hydrophilic heads face outward where they interact with water. The phospholipids bilayer allows only lipid-soluble substances to pass through it. Cellulose is a huge polysaccharide consisting of unbranched chains of glucose molecules. The rigid structure of the plant cell wall owes its physical strength to cellulose.

66 a. The purpose of partial hydrogenation is to remove double bonds and to replace them with single bonds in the unsaturated fatty acid. This will add more hydrogen atoms to the unsaturated fatty acid.

b. The content of container would be liquid oil.

67. Starch and glycogen can be broken down into glucose monomers. Glucose can then be used to produce energy for cellular activities through cellular respiration.

68. It is a change in primary structure. The change in amino acid sequence might affect the tertiary structure and quaternary structure because valine now will bond differently with other amino acids in the polypeptide forming different hydrogen bonds, ionic bonds and covalent bonds. The interactions of the different amino acids along the polypeptide chain will affect the 3D globular shape of the polypeptide and now one polypeptide chain will interact with another polypeptide chain.

69. A polymer is a large molecule formed from the joining of smaller unit molecules called monomers. Proteins are made up of repeating units of amino acids, while steroids consist of just one component, a ringed structure.

70. A protein will fold a particular way as hydrogen bonding forms between the different R-groups of the amino acids along the polypeptide chain. In addition to this, non-polar hydrophobic R-groups of amino acids will move toward the interior of the protein's 3D shape. The resulting tertiary structure will determine the function of the protein.

71. Four biological molecules that would have phosphorus in them are ATP, DNA, RNA, and phospholipid.

72. With all the different combinations of amino acids and the different hydrogen bonding that form between the amino acids, thousands of different proteins are possible. With a variety in the amino acid sequence, this will result in different tertiary structures. The functions of proteins are dependent on the protein's 3D structure.

73. The sequence of amino acids along a polypeptide will affect how one amino acid interacts with another amino acid in the polypeptide chain. Hydrogen bonds, covalent bonds, and ionic

bonds will cause the polypeptide to fold into a specific shape based on what amino acids interact with one another along the chain.

74. The difference lies in the hydrogen bonding between the amino acids. The coiling of the chain produces an alpha helix, while the folding of the chain results in a beta pleated sheet.

75. If hydrogen bonding was absent, DNA would not be a double stranded molecule because there would not be complementary base pairing between the bases of the two strands.

76.

Type of Bond	Ionic Bond	Covalent Bond	Hydrogen Bond
Description	- bond that forms in compounds between a positively charged ion and a negatively charged ion - results in the transfer of electrons	- bond that forms within molecules due to sharing of electrons	- bond that forms between the partially positively charged hydrogen of one polar molecule and the partially negatively charged atom of another polar molecule.

77.

	Cellulose	Starch	Glycogen
Monomer	glucose	glucose	glucose
Description of Structure	no side chains	some side chains	many side chains
Plant Cell or Animal Cell	plant cell	plant cell	animal cell
Function	structural component of plant cell wall	energy storage in plants	energy storage in animals

78. The absence of side chains in cellulose allows the linear molecules to be side by side, adding strength and rigidity for the plant. Glycogen has many branches and acts as energy storage. The branching of the side chains allows glycogen to be more soluble and it can be synthesized and broken down more quickly for energy.

79.

Characteristic	DNA	RNA	Protein
Is it a polymer?	Yes (consists of nucleotides)	Yes (consists of nucleotides)	Yes (consists of amino acids)
Does it have a three dimensional structure?	Yes	Yes	Yes
Does it contain nitrogen atoms?	Yes (contains nitrogen in the bases)	Yes (contains nitrogen in the bases)	Yes (contains nitrogen in the amino group)
Does it contain phosphorus atoms?	Yes (phosphorus is in the sugar-phosphate backbone)	Yes (phosphorus is in the sugar-phosphate backbone)	No (amino acid does not have phosphorus)
Does it contain hydrogen bonding?	Yes (has hydrogen bonding between A-T and C-G)	Yes (has hydrogen bonding between A-U and C-G)	Yes (has hydrogen bonding between the amino acids)

80. Structural similarities include: they are monosaccharides, hexose, simple sugars; they have the same molecular formula; they occur as ring structures; they have "ose" endings; they provide energy.

81. a. The primary structure of a protein is due to the peptide bonding between the adjacent amino acids.

b. The secondary structure of a protein is due to the hydrogen bonding between the amino acids.

c. The tertiary structure of a protein is due to the covalent, ionic, and hydrogen bonding between the R-groups.

d. The quarternary structure of a protein is due to the bonding between 2 or more polypeptides.

82. Venn Diagram should have two circles interlocking. Place DNA label above the circle on the left hand side and RNA above the circle on the right hand side. The part where the two circles overlap will list the similarities that these two molecules have. Similarities include: nucleic acid, adenine, guanine, cytosine pentose. In the DNA circle, students should list: double stranded, thymine, double helix, deoxyribose, replication. In the RNA circle, students should list: single stranded, uracil, three type of RNA (mRNA, tRNA and rRNA), ribose, transcription.

83. a. A = proteins; B = cellulose; C = amino acids; D = glucose; X = hydrolysis

b. Maltose (a disaccharide) would form if two units of molecule D underwent a dehydration reaction.

c. Two other polymers that would form from glucose are glycogen and starch.

84. Fats produce almost twice the amount of energy for a given gram of protein and carbohydrate.

85. The carbons in fatty acids have more electrons around them. When the fatty acids are oxidized (eg. the electrons are transferred to oxygen), more energy is released than the same process with carbohydrates and proteins.

86. Different types of oils have different percentage of unsaturated and saturated fats. They tend to have the "healthier" unsaturated fats rather than the saturated fats.

87. Unsaturated fats are derived from plants and are liquid at room temperature.

88. Answers may vary - biomechanics, molecular biology, nuclear medicine, biomedical engineering, neuroscience, immunogenetics, microbiology, electrochemistry, geophysics.

For example, biomechanics uses engineering concepts to analyze structure and function in biological systems. Geophysics uses the concepts of physics (eg. electricity and magnetism) to study the Earth.

89. Scientists can inject radioactive material into a patient and trace its movement through the digestive system. They may want to use the radioisotope carbon-14 to track the digestion of starch into maltose, and then into glucose. By analyzing the path that the carbon takes, scientists can determine where carbohydrate digestion takes place in the body. Since nitrogen is found in proteins, scientists can use the radioisotope nitrogen-15 to track the digestion of proteins into peptides, and then into amino acids.
90. **a.** By restricting the consumption of carbohydrates, the body will not convert excess carbohydrates into fat. The body will also start to burn body fat instead of carbohydrates for fuel. This will result in weight loss.

    b. Your body would start to burn fats rather than carbohydrates as fuel.
91. A lack of proteins would not give the body the amino acids it needs to build important proteins for the body (eg. enzymes for metabolic reactions, keratin, collagen, etc.).
92. Diagram
93. Header: Organic Compounds

    First column: Carbohydrates; polysaccharides; dissacharides; monosaccharides

    Second column: Lipids; triglyceride; fatty acids; glycerol

    Third column: Proteins; peptides; amino acids

    Fourth column: Nucleic acids; RNA; DNA; nucleotides

    Fifth column: High-Energy Compounds; ATP; nucleotide; phosphate groups

Chapter 3 Diagnostic Questions

1. **a.** A red blood cell is larger than a virus.
2. **c.** the plasma membrane
3. **b.** to control all of the cell's activities
4. **d.** a cell wall
5. **c.** water + carbon dioxide + sunlight → oxygen + glucose
6. **d.** $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + ATP$
7. **d.** Mitochondria are found in both plant and animal cells, while the chloroplasts are found only in plant cells.
8. **b.** by diffusion
9. A cell is the basic unit of life.
10. **A.** nuclear envelope; **B.** nucleolus; **C.** nuclear pore; **D.** water vacuole; **E.** chloroplast; **F.** mitochondrion; **G.** microtubules; **H.** microfilaments; **I.** plasma membrane; **J.** granum of the chloroplast; **K.** cell wall; **L.** cytoplasm; **M.** Golgi apparatus; **N.** vesicle; **O.** smooth endoplasmic reticulum; **P.** rough endoplasmic reticulum; **Q.** ribosome
11. **1.** nucleus; **2.** chromosome; **3.** mitochondria; **4.** ribosome; **5.** chloroplast; **6.** vacuole; **7.** endoplasmic reticulum; **8.** plasma membrane; **9.** lysosome
12. Students might say that they could not find everyday examples for every cell structure.
13. DNA and RNA are found in the nucleus.
14. Answers may vary. When you are travelling through a crowded hallway at school into an empty classroom, you are going from an area of high concentration to an area of low concentration.
15. Answers may vary. The diffusion of food aroma molecules comes from the kitchen as someone is cooking.

Chapter 3 Review Questions

1. **a.** The cell is the basic unit of life.
2. **b.** a cell with a surface-area-to-volume of 3:2
3. **d.** cell structure 12
4. **d.** organelle 11
5. **d.** 7
6. **b.** the plasma membrane
7. **c.** cholesterol
8. **c.** diagram of polypeptide chain
9. **d.** it is a double membrane structure that has pores and separates the contents of the cytoplasm from the nucleus
10. **b.** DNA
11. **d.** rough endoplasmic reticulum
12. **c.** rough endoplasmic reticulum
13. **d.** a plastid that has the ability to capture light energy and convert it into organic molecules
14. **b.** peroxisome – fatty acids
15. **d.** mitochondria
16. **c.** membrane-bound vesicles that have hydrolytic enzymes
17. **a.** The secretion of peptidase would not occur.
18. **c.** glucose
19. **d.** cellular respiration
20. **c.** to produce ATP for active transport of calcium ions
21. **a.** cell division
22. **c.** I, II and III only
23. **a.** They both use a carrier protein.
24. **c.** pinocytosis
25. **c.** exocytosis
26. **c.** glycoprotein
27. **d.** the plasma membrane and the nuclear envelope
28. **c.** the number of amino acids entering the cell would decrease
29. **d.** only certain substances can move across it
30. **d.** the excretion of hydrogen ions in the distal convoluted tubule of the kidneys
31. **a.** IV (DNA replication)

    b. V (protein synthesis)

    c. VII (intracellular digestion)

    d. III (rRNA synthesis)

    e. I (photosynthesis)

    f. V (protein synthesis)

    g. II (lipid synthesis)

32. **a.** VI (mitochondrion)
b. I (nucleus)
c. II (nucleolus)
d. VI (mitochondrion)
e. V (chloroplast)
f. VII (Golgi Apparatus)
g. IX (smooth endoplasmic reticulum)
h. III (ribosome) and VIII (rough endoplasmic reticulum)
i. III (ribosome) and VIII (rough endoplasmic reticulum)
j. IX (smooth endoplasmic reticulum)
k. IX (smooth endoplasmic reticulum)
l. VI (mitochondrion)
m. IV (centriole)
n. VII (Golgi apparatus)
o. VIII (rough endoplasmic reticulum)
p. III (ribosome) and VIII (rough endoplasmic reticulum)

33. **a.** to provide movement in the cell
b. to provide structural support for the plant cell
c. to produce mitotic spindles during cell division
d. to produce ribosomal subunits
e. to break down fats and produce bile salts from cholesterol
f. to allow movement in the cell
g. to modify, package and sort proteins
h. to regulate what enters and exits the cell

34. to provide support and protection for plant cells

35. Cellulose makes up cell structure AE (cell wall).

36. Photosynthesis occurs at cell structure A (chloroplast).

37. Products of reactions at cell structure D (rough endoplasmic reticulum) are transported to cell structure AC (Golgi apparatus) in transport vesicles.

38. The functions of cell structure B (central water vacuole) are to control turgor pressure, to maintain the structural integrity of the plant cell, and to exert pressure against the cell wall.

39. A (chloroplast) and AE (cell wall)

40. carbon dioxide, water, and light energy

41. Centrioles and lysosomes are found in animal cells, but not in plant cells.

42. Plant cells have a cell wall, chloroplasts and a central water vacuole.

43. The endoplasmic reticulum produces proteins that are then sent to the Golgi apparatus in transport vesicles. At the Golgi apparatus, the proteins are then modified, sorted and packaged and sent off in secretory vesicles to the plasma membrane.

44. The plasma membrane takes in dissolved solutes or bigger macromolecules by producing an invagination around the molecules. This forms a vesicle. The vesicle then fuses with a lysosome in the cytoplasm and the contents of the vesicle are digested by the hydrolytic enzymes of the lysosome.

45. Cardiac muscle cells are very active and require huge amounts of energy. Mitochondria will produce enough energy for the muscle cells. The testes have lots of smooth endoplasmic reticulum because they produce the steroid hormone testosterone.

46. Without the enzyme catalase, the body could not break down toxic hydrogen peroxide into water and oxygen gas. The buildup of hydrogen peroxide could be fatal.

47. [Centre CIRCLE] Similarities between chloroplast and mitochondrion: both found in plant cells, are double-membrane organelles, and contain their own DNA. Differences between chloroplast and mitochondrion: [LEFT CIRCLE chloroplast] The chloroplast has chlorophyll, thylakoid, grana, and stroma. The chloroplast is involved in photosynthesis and is only found in plant cells. [RIGHT CIRCLE mitocondrion] The mitochondrion has cristae and a fluid-filled matrix. The mitochondrion is involved in cellular respiration.

48. Both are membrane-bound sacs that transport material around the cell. They produce transport vesicles that send materials to the Golgi apparatus. The rough ER is covered with ribosomes and synthesizes proteins. In contrast, the smooth ER has no ribosomes and synthesizes lipids, phospholipids, cholesterol and steroid hormones.

49. Centrioles have a 9 + 0 arrangement of microtubule triplets, while both cilia and flagella have a 9 + 2 pattern of microtubules doublets.

50. The cell membrane (plasma membrane) of the macrophage forms a vesicle around the bacterium. The vesicle with the bacterium in it fuses with a lysosome. The hydrolytic enzymes of the lysosome break down and digest the bacterium.

51. When there is not enough water, turgor pressure decreases and the central vacuole shrinks and pulls away from the cell wall.

52. The products of photosynthesis (oxygen and glucose) are the reactants of cellular respiration; the products of cellular respiration (carbon dioxide and water) are the reactants of photosynthesis.

53. Microtubules and microfilaments both maintain cell shape, are involved in cell division, and are protein fibres in the cytoskeleton.

54. Carbohydrate chains are exposed on the surface of the plasma membrane to serve as recognition sites and to facilitate adhesion between the cells.

55. The white blood cells would not recognize the cancer cells because the white blood cells depend on the glycolipids to recognize the cancer cells.

56. The asymmetry gives the two surfaces of the plasma membrane different properties.

57. It must divide.

58. The cell with the largest surface area to volume ratio, 3:1, is the most effective.

59. Active transport must overcome the concentration gradient and transport the sodium ion in the opposite direction of its tendency to move.

60. These organisms tend to take in water from the environment because their body fluids are more concentrated than the environment. These organisms adapt by having structures that pump out excess water. Organisms can excrete dilute urine to get rid of the excess water.

61. Factors that affect the rate of diffusion: size of molecule, temperature, concentration gradient and polarity of the molecule.

62.

	Diffusion	Osmosis	Facilitated Transport	Active Transport
Energy Required?	no	no	no	yes
Protein Carrier Required?	no	no	yes	yes
Driving Force	concentration gradient	concentration gradient	concentration gradient	ATP hydrolysis
Direction of Movement	high concentration to low concentration	high concentration to low concentration	high concentration to low concentration	low concentration to high concentration
Specificity	no	no	yes	yes
Types of Molecules	carbon dioxide, oxygen	water	glucose, amino acids	sodium ions, potassium ions

63. The smaller the molecule, the larger the diffusion coefficient.

64.

	Observation	Will it cross the cell membrane easily? Why?	Method of Transport
a.	The concentration of the plasma protein fibrinogen is higher in the plasma.	No, because fibrinogen is too big to cross the plasma membrane.	N/A
b.	The concentration of carbon dioxide is higher in the cytoplasm of the liver cell.	Yes, because carbon dioxide is non-polar and is small enough to diffuse across the membrane from high concentration to low concentration.	Diffusion
c.	The concentration of low-density lipoproteins is higher in the cytoplasm of the liver cell.	No, because a low-density lipoprotein is a large polar molecule. It will not cross the non-polar membrane.	N/A
d.	The concentration of glucose is higher in the blood plasma.	Yes, glucose will cross the membrane using a protein carrier down the concentration gradient.	Facilitated Transport
e.	The concentration of oxygen is higher in the blood plasma.	Yes, oxygen will diffuse across the plasma membrane from an area of high concentration to an area of low concentration.	Diffusion
f.	The concentration of iron ions is higher in the cytoplasm.	Yes, the iron ions will move against the concentration gradient using a protein carrier.	Active Transport
g.	The concentration of water is higher in the cytoplasm of the liver cell.	Yes, water will diffuse across the plasma membrane through osmosis from an area of high concentration to an area of low concentration.	Osmosis

65. Slide #1 has the hypotonic solution and slide #2 has the hypertonic solution.

66. Since the central water vacuole is filled with water and it takes up most of the room in the cell. It pushes the cytoplasm, including the chloroplasts right up against the plasma membrane.

67. Water left the *Elodea* cells.

68. When the plant cells were placed in salt water, the central water vacuole lost water. Chloroplasts that were found around the perimeter of the cell were drawn toward the centre of the cell because the collapsed central water vacuole has less water in it.

69. No, the plant cells do not get smaller, only the water vacuole does.

70. plasmolysis

71. Water would flow into the cell, causing the water vacuole to swell. This creates turgor pressure and the plasma membrane pushes against the rigid cell wall.

72. test tube 1 – isotonic; test tube 2 – hypertonic; test tube 3 - hypotonic

73. The red blood cells would shrivel up because water leaves the cells. This process is called crenation.

74. The red blood cells would swell because water moved into the cells. The cells would burst due to hemolysis.

75. Pancreatic amylase is synthesized at the ribosome. The data shows that at time 5 minutes and 10 minutes, the ribosomes show the largest percentage of amylase.

76. ribosomes → ER → Golgi apparatus → secretory vesicles

77. Pancreatic amylase is a protein that is going to be excreted from the cell. There is a high percentage of amylase found in secretory vesicles which are bound for the plasma membrane. This data shows large amounts of pancreatic amylase in the secretory vesicles.

78. It showed that membrane proteins were free to migrate throughout the plasma membrane. The plasma membrane has a fluid consistency.

79. The rate of protein movement would increase as temperature increases. The concepts investigated are diffusion and membrane fluidity.

80. Osmosis was responsible for the potato cells gaining and losing water.

81. Potato cells were placed in a hypotonic solution in test tube 2. Water entered the potato cells, increasing the mass of the cells.

82. Potato cores that lost mass were placed in hypertonic solution and therefore lost water. Potato cores that gained mass were placed in hypotonic solution and therefore gained water.

83. test tubes 4 and 5

84. about 15% sucrose concentration

85. Graph

86. The molarity of the glucose solution is directly proportional to the percent change in mass. As the molarity increases, so does the percent change in mass.

87. The selectively permeable membrane does not allow the sugar molecules to pass through because they are too big. Because the right side has the dilute solution, there are more water molecules on the right side than the left side. Water diffused from an area of higher concentration (right side) to an area of lower concentration (left side) through the process of osmosis. This results in the rise in the solution level on the left side.

88. Graph

89 **a.** Both the surface area and volume increase as the cell gets bigger, but the volume increases at a faster rate.

b. As the cell gets bigger, the surface area to volume ratio decreases.

c. The 3-mm cube has the smallest surface-area-to-volume ratio.

90. The Blob would not have an adequate surface area for exchanging nutrients and wastes and it would not be able to survive for long.

91. Without a properly functioning cell wall, the bacterium is not protected by the outside environment and is susceptible to attacks by other organisms like viruses.

Chapter 4 Diagnostic Questions

1. **b.** sequence of amino acids in the polypeptide chain.
2. **d.** the sequence of nitrogenous bases in the DNA molecule of an organism.
3. **a.** There are more genes than chromosomes.
4. **b.** DNA controls the production of proteins in the cell.
5. **a.** nucleotide.
6. **d.** adenine, cytosine, guanine, and thymine
7. **a.** genes
8. **a.** The gene for albumin has a different sequence of nitrogenous bases than the gene for melanin.
9. **a.** a gamete.
10. **d.** it cannot be passed on from one generation to the next.
11. **c.** change the arrangement of the genetic material.
12. It carries the genetic information of an organism and is passed on from one generation to the next.
13. Genes are found on chromosomes, which are found in the nucleus of a cell.
14. mutagens, radiation, drugs
15. rabbit
16. No, just because there are 10 amino acids different, doesn't mean the amino acids are in the exact same order for both whales and kangaroos.

Chapter 4 Review Questions

1. **b.** are nucleic acids.
2. **a.** adenine and guanine.
3. **c.** C-A-T-G-T-A-C
4. **c.** T-A-G
5. **a.** uracil
6. **b.** replication
7. **a.** ribosome.
8. **b.** The primary structure of Molecule 2 would be different.
9. **a.** adenine pairs with thymine by forming two hydrogen bonds
10. **a.** a gene.
11. **c.** to carry specific amino acids to the ribosome
12. **b.** the nucleolus.
13. **b.** to read the codons on the mRNA
14. **b.** histidine
15. **c.** anticodon
16. **a.** GAC
17. **c.** mRNA nucleotide bases.
18. **b.** 4
19. **a.** insulin
20. **b.** peptide bonds

21. **d** The sequence of amino acids may be different during protein synthesis.

22. **c.** helicase breaks the hydrogen bonds between the complementary DNA strands

23. **d.** 3 → 5 → 1 → 2 → 4

24. **b.** leucine

25. **d.** 75 nucleotides

26. **a.** a plasmid.

27. **a.** they reproduce quickly.

28. **c.** restriction enzyme and DNA ligase

29. **d.** to introduce foreign DNA into the bacterial DNA

30. **b.** Humans can use it to produce Hepatitis B vaccine.

31. **d.** recombinant DNA technology.

32. **d.** splicing pieces of DNA from one organism into the DNA of another organism

33. **d.** to cut out specific base-pair sequences out of a DNA molecule

34. **a** to produce large amounts of human hormones

35. **b.** is used to produce large amounts of a targeted sequence of DNA.

36. **b.** Silk fibres will be produced in the goat's milk

37. **d.** a transgenic organism.

38. **c.** genetic engineering.

39. **b.** help treat cancer.

40. **b.** Cold temperatures can influence the expression of genes.

41. **a.** I and II only

42. **c.** The genetically engineered bacteria may out-compete the native species of bacteria that already exist in the environment.

43. base sequence on DNA → amino acid sequence → tertiary structure of a protein → protein function → expression of a trait

44. **a.** I

b. II, III and IV

c. I

d. I, II, III and IV

e. I

f. I

g. II

h. III

i. IV

j. I, II, III and IV

45.

	DNA	RNA
Subunit	Nucleotide (sugar, phosphate, base)	Nucleotide (sugar, phosphate, base)
Sugar	Deoxyribose	Ribose
Nitrogenous bases	Thymine, Adenine, Cytosine and Guanine	Uracil, Adenine, Cytosine and Guanine
Number of Strands	Double-stranded	Single-stranded
Base Pairings	Adenine with Thymine Cytosine with Guanine	Adenine with Uracil Cytosine with Guanine
Process that Produces this Nucleic Acid	Replication	Transcription

46. semi-conservative replication

47. helicase, DNA polymerase and DNA ligase

48. In Step X, the enzyme helicase unwinds the double-stranded DNA by breaking the hydrogen bonds between the nitrogenous bases. In Step Y, complementary base pairing occurs. DNA nucleotides present in the nucleus are joined to the DNA molecule by DNA polymerase.

49. in the nucleus

50. **a.** adenine

b. thymine

c. deoxyribose sugar

d. phosphate group

51. ATP and RNA

52. it is ribose instead of deoxyribose

53. double hydrogen bonds; covalent bonds

54. Combination of 2, 3, and 4 or 1, 3, and 4.

55. They might be different because each amino acid is coded by more than one codon.

56. **a.** gene mutation

57. A change in a single amino acid can cause a change in the primary structure of a protein. This therefore will change the tertiary structure of the protein and its function. The function of the protein is dependent on its shape.

58. The red blood cell's shape has now changed due to the change in amino acid sequence. This therefore affects its function to effectively carry oxygen around the body.

59. Sickle cell disease still persists in the human population because it provides those people with resistance against malaria. There is a benefit to having the disease.

60. Percentages would be higher because people who have sickle cell anemia are resistant to malaria.

61. deletion mutation

62. the gene would code for a different amino acid

63. **a.** gel electrophoresis and DNA fingerprinting

b. If the bands on the gel matched up between the two samples, then the meat came from the same animal.

64. **a.** Comparative genomics is used to identify similarities between human DNA and DNA of other organisms. It allows scientists to insert a suspected human gene associated with a disease into another organism to confirm that this gene is the cause of the disease.

b. Functional genomics help scientists understand the function of various genes and their expression. This information can be used for treatment of a disease.

c. Proteomics is used to study the structure, function and interaction of cellular proteins in different cell types. This is essential to the discovery of better drugs.

d. Bioinformatics is the use of computer technologies to find significant patterns to help study proteomics, structural genomics, functional genomics and comparative genomics.

65.

DNA	**GCA**	**ATG**	**TCA**	**GTT**
mRNA	CGU	UAC	AGU	CAA
tRNA	GCA	AUG	UCA	GUU
Amino acid	arginine	tyrosine	serine	glutamine

66. The base pairs of DNA (A/T and G/C) and RNA (A/U and G/C) need to be highly specific so that replication, transcription and translation are accurate when they are carried out. The copying of the genetic code and the making of the correct proteins depend on the specificity of the base pairings. If specificity of the base pairing is compromised, then potential mutations could occur more often.

67. the amino acid sequence would now be "cysteine"-tyrosine-serine-glutamine

68. The shape of the protein could now change because the amino acid sequence (primary structure) is now different.

69. 64 combinations

70. The farmer gets to choose the cow that has the desirable traits and reproduce more copies of that cow in a shorter amount of time.

71. a. The cows in a cloned herd would be identical to each other because they have the same genetic makeup. The cows from a non-cloned herd will have some genetic variation.

b. The cloned herd will have the desirable traits that the farmer wants because it is identical to the best cow in the herd; help improve the overall quality of the herd.

c. If a disease is introduced and all the cows are genetically identical, they may all be susceptible to the disease and can die.

d. a cow that is healthy and resistant to disease; a dairy cow that can produce larger amounts of high quality milk; a cow that is well-adapted for extreme climates; a cow that is fertile

e. There will be genetic variation in the offspring because the normal cow would contribute different genes each time an offspring is produced.

f. These cows would more likely develop diseases.

72.

Species W	DNA sequence	CAG	TGT	CCT	GTA
	mRNA sequence	GUC	ACA	GGA	CAU
	amino acids sequence	**valine**	**threonine**	**glycine**	**histidine**
Species X	DNA sequence	CAG	TGC	CCG	GCA
	mRNA sequence	GUC	ACG	GGC	CGU
	amino acids sequence	**valine**	**threonine**	**glycine**	**arginine**
Species Y	DNA sequence	CAT	TGC	CCG	GTG
	mRNA sequence	GUA	ACG	GGC	CAC
	amino acids sequence	**valine**	**threonine**	**glycine**	**histidine**
Species Z	DNA sequence	CAA	TGC	CGT	GTA
	mRNA sequence	GUU	ACG	GCA	CAU
	amino acids sequence	**valine**	**threonine**	**alanine**	**histidine**

73. The sequences of amino acids are the same, with the exception of one amino acid.

74. Species W and Species Y

75. Take segments of DNA from each of the four flowers and run them on gel electrophoresis. Compare the patterns on the gel.

76. It would produce no change because it would still code for valine. The amino acid sequence has not changed.]

77. a. 4, 639, 221 bases

b. 3866 bases/second

78. HGP was important to determine the location of all the genes in the human genome. This allowed scientists to identify the location of defective genes that caused diseases. The defective genes could be replaced with normal genes to cure diseases.

79. The benefit of knowing the location and sequence of bases in a gene is being able to identify defective genes and using gene therapy to replace these defective genes.

80. Scientists must be careful because a normal gene could be removed by accident and this would cause the person to not produce a protein that might be needed for normal functioning.

81. Some ethical issues could include: Should humans decide who gets to live or not? How do we determine which diseases are more important and others? Who decides how much this is going cost?

82. You could change this by counting all the characters in the entire novel to determine the exact number of characters in the entire book.

83. The assumption is that that all books the size of your novel will contain the exact same number of characters and therefore bases. Some books that are the same size have more or less characters.

84. Restriction enzymes are used to produce the DNA fragments placed in the well.

85. An electric current is used to separate DNA fragments on the basis of size.

86. Species C is most closely related because it has four matching bands on the gel.

87. If plants are closely related, then they should have similar genetic makeup and DNA segments. The physical characteristics of plants may vary and can be influenced by environmental factors. Therefore these characteristics will not be accurate at indicating the degree of the relationship between different species.

88. In ex vivo gene therapy, bone marrow stem cells are removed from the body and an RNA retrovirus is used to insert a normal gene into the bone marrow stem cells. The viral recombinant DNA carries the normal gene into the genome and the genetically engineered cells are returned to the human body. In vivo gene therapy is used to treat cystic fibrosis patients. The gene needed to cure cystic fibrosis is delivered to the lower respiratory tract using an adenovirus vector found in an aerosol spray.
89. Answer will depend on what topic the student picks. For example, using restriction enzymes, the insulin gene from a human chromosome is inserted into a vector, a circular piece of bacterial DNA from *E. coli*. The bacteria that received the gene now can produce the protein insulin. Insulin is then collected for use by people with diabetes.
90. Research
91. Research

Chapter 5 Diagnostic Questions

1. **b.** proteins
2. **b.** the ribosomes
3. **c.** the lysosomes
4. **b.** plasmid
5. **b.** It speeds up chemical reactions.
6. **d.** an increase in temperature causes the reactants to move more quickly, therefore increasing the number of collisions between the reactants
7. **a.** substrate; **b.** enzyme; **c.** enzyme-substrate complex; **d.** products
8. structure B and structure D
9. structure C
10. DNA polymerase, RNA polymerase, ligase, restriction enzymes
11. Enzymes are important in the digestion of food. Without enzymes, it would take too long for you to digest your food.
12. **a.** all enzymes are proteins, but not all proteins are enzymes

    b. enzymes are molecules, not organisms and cannot be killed; heat causes the enzyme to denature, therefore changing its active site and this causes a loss in function

    c. the enzyme has an active site that the substrate binds to

    d. enzymes undergo a conformational change once it forms the enzyme-substrate complex, but once it releases its products, it changes back to its original shape

    e. enzymes will denature only by a change in pH, high temperature and exposure to a heavy metal; enzyme will not denature due to the depletion of the substrate

    f. once an enzyme binds with the substrate, it forms an enzyme-substrate complex which cause the reaction to proceed further

    g. enzymes are not used up in the course of a chemical reaction; they will be used again for the next reaction

    h. reactant 1 + reactant 2 $\leftrightarrow$ product 1 + product 2; use double headed arrow

Chapter 5 Review Questions

1. **d.** by temporarily combining with the substrates
2. **d.** there has to be a perfect fit between the enzyme's active site and the substrate.
3. **b.** a triglyceride.
4. **a.** The amount of glycerol and fatty acids produced in 10 minutes at different pH levels.
5. **d.** changing the temperature from 37°C to 15°C
6. **c.** an inhibitor.
7. **c.** maltase.
8. **c.** amino acids.
9. **b.** maltose.
10. **b.** step 2
11. **a.** enzymes and hydrolysis.
12. **c.** size of the substrate
13. **c.** The disaccharide would break down slower or not at all.
14. **a.** Cellulose would not fit into the active site of the catalyst.
15. **c.** Each enzyme works best within a particular pH range.
16. **a.** pepsin
17. **b.** It would decrease.
18. **c.** The shape of amylase was altered with the increasing pH level.
19. **c.** 7
20. **d.** Trypsin is less active at a pH of 10 than at a pH of 7.
21. **c.** 7.5
22. **a.** pepsin
23. **d.** to measure the amount of oxygen produced per unit time and therefore catalase activity
24. **b.** The liver cells had a greater amount of catalase than the potato cells.
25. **b.** Catalase denatured when it was exposed to high temperatures.
26. **a.** amino acid
27. **b.** I and III only
28. **a.** threonine
29. **b.** Isoleucine inhibits enzyme #1 from reacting with threonine and therefore prevents the production of α-ketobutyrate.
30. **d** the rate of production of α-keto-β-methylvalerate would decrease
31. Graph
32. The substrate, sucrose, binds to the active site of the enzyme. This forms an enzyme-substrate complex. Water is needed during this hydrolysis reaction to break the bond between glucose and fructose. The products are released from the enzyme.
33. glucose and fructose
34. With the increase in temperature, this will cause denaturation of the enzymes in bacteria and this will cause the bacteria to die.

35. An enzyme works best at a body temperature of 37°C. With a fever and an increase in temperature, this will cause a decrease in enzyme activity. The high temperature will denature the enzyme and alter the shape of the enzyme. Substrates will no longer be able to bind to the active site and the enzyme will not be able to do its job. The function of the enzyme is dependent on its shape, therefore a denatured enzyme will not be able to carry out any chemical reactions in the body. Death may result.
36. Cyanide prevents the transfer of electrons to oxygen. Cytochrome oxidase will not be able to accept electrons and therefore not be able to produce enough ATP for the cells.
37. Iodine would move into the thyroid gland by active transport.
38. The modified cellulose will start to dissolve at a specific pH in the small intestine. It is not affected by the low pH of the stomach.
39. Graph
40. 37°C
41. Trypsin denatured and therefore could not function properly. Without trypsin, proteins could not be digested into peptides.
42. hydrolytic enzyme
43. proteins
44. peptides
45. hydrolysis
46. water
47. Trypsin is very specific to its substrate and will only act on proteins, not sucrose.
48. Design an experiment.

Chapter 6 Diagnostic Questions

1. **b.** step 2 only
2. **a.** ATP
3. **d.** in the phosphate bonds
4. **c.** animal and plant cells
5. **d.** cellular respiration
6. **d.** carbon dioxide
7. **a.** the absence of oxygen.
8. **b.** viruses
9. **a.** to produce ATP
10. **c.** so that it is in a form that cells can use the energy
11. **c.** active transport of potassium ions
12. **a.** Cellular respiration does not consist of just one step as the equation implies. It consists of many phases.

    b. Photosynthesis and cellular respiration are complementary to each other. The reactants of photosynthesis are the products of cellular respiration. The products of photosynthesis are the reactants of cellular respiration.

    c. Plants carry out both photosynthesis and cellular respiration.

    d. Some of the energy is lost as heat.
13. **1.** cristae (inner membrane); **2.** outer membrane; **3.** intermembrane space; **4.** matrix
14. Diagram
15. respiration is the exchange of gases; it is a process that provides blood cells with oxygen
16. to get energy; process in which the oxygen is necessary to convert the energy stored in carbon containing molecules into ATP
17. to provide a constant supply of oxygen for our cells and to produce ATP for metabolic activities
18. When the muscle cells in your body work vigorously during a run or heavy exercise, they carry out fermentation. Fermentation supplies the body with ATP when oxygen is scarce.
19. The runners do not have enough oxygen for their cells to produce ATP. Heavy breathing occurs to get as much oxygen into the body as possible because the cells are not getting enough oxygen.

Chapter 6 Review Questions

1. **a.** is transformed into heat.
2. **c.** in the cytoplasm.
3. **c.** C.
4. **d.** Acetyl CoA goes through a series of reactions that extract electrons and hydrogen ions
5. **a.** A and B
6. **c.** C.
7. **a** It reduces 2 NAD^+ for every glucose molecule.
8. **c.** 20 ATP.
9. **c.** FAD – is a reducing agent in the citric acid cycle
10. **a.** They are coenzymes that accept electrons.
11. **c.** II and III only
12. **a.** O_2
13. **c** produces a large quantity of reducing power in the form of NADH and $FADH_2$
14. **c.** to aerobically degrade pyruvate to carbon dioxide and water with the generation of 2 ATP molecules
15. **d.** They occur in the matrix of the mitochondrion and produce carbon dioxide.
16. **a.** the hydrogen ion gradient across the inner mitochondrial membrane.
17. **d.** NADH
18. **c.** II and III only
19. **c.** to convert ADP to ATP.
20. **c.** II and III only
21. **d.** I, II, and III
22. **d.** NADH will donate high-energy electrons to the electron transport chain
23. **a.** preparatory reaction, citric acid cycle, electron transport chain

    b. glycolysis and fermentation

    c. glycolysis, citric acid cycle, fermentation

    d. preparatory reaction, citric acid cycle, alcoholic fermentation

    e. glycolysis, fermentation

f. electron transport chain

g. ATP synthase

h. preparatory reaction, citric acid cycle

i. glycolysis, citric acid cycle

j. citric acid cycle

k. electron transport chain

l. citric acid cycle, preparatory reaction

m. electron transport chain

n. preparatory reaction

o. fermentation

p. electron transport chain

q. electron transport chain

r. electron transport chain

s. glycolysis

t. fermentation

u. ATP synthase in inner mitochondrial membrane

v. electron transport chain

w. electron transport chain

x. citric acid cycle

y. electron transport chain

24.

	Glycolysis	Preparatory Reaction	Citric Acid Cycle	Electron Transport Chain
Location in the Cell	cytoplasm	matrix of mitochondria	matrix of mitochondria	cristae of the mitochondria
Net ATP yield	2 ATP		2 ATP	26-28 ATP
Products	2 ATP 2 pyruvate 2 NADH + H^+	2 NADH + H^+ 2 CO_2 2 Acetyl CoA	2ATP 4 CO_2 6 NADH + H^+ 2 $FADH_2$	26-28 ATP H_2O
Aerobic or Anaerobic	anaerobic	aerobic	aerobic	aerobic

25. ATP (adenosine triphosphate) consists of the nitrogenous base adenine, a ribose sugar and three phosphate groups. Energy is stored in the high-energy bonds between the phosphate groups. When ATP breaks down to ADP (adenosine diphosphate) and a molecule of inorganic phosphate, stored energy is released. This energy is used for biological functions such as protein synthesis and nerve conduction.

26. Most of the chemical energy is lost to heat.

27. Organisms use oxidation and reduction reactions to produce energy.

28. Oxidation of glucose to carbon dioxide. Reduction of oxygen to water.

29. Aerobic exercise requires oxygen in order to produce ATP through cellular respiration. Oxygen is needed for this process.

30. The cristae of the mitochondrion have the electron transport chain. The cristae increase the internal surface area of the mitochondrion to increase the area for ATP production.

31. glycolysis = 2 ATP; citric acid cycle = 2 ATP; electron transport chain = 26–28 ATP

32. **a.** Glycolysis is the breakdown of glucose to 2 pyruvates. It produces 2 NADH and 2 ATP. ATP is made by substrate-level ATP synthesis.

b. The citric acid cycle involves the acetyl group attached to CoA breaking down to 2 CO_2 molecules. It produces 2ATP, 4 CO_2, 6 NADH + H^+ and 2 $FADH_2$. ATP is made by substrate-level ATP synthesis.

c. The electron transport chain oxidizes NADH or $FADH_2$ and creates a H^+ gradient. The enzyme ATP synthase uses this H^+ gradient to produce ATP via chemiosmosis.

d. In anaerobic conditions, cells use glycolysis to produce 2 ATP in a process called fermentation. In lactate fermentation, pyruvate is converted into lactate and oxidizes NADH to NAD^+. In alcoholic fermentation, pyruvate is converted into alcohol (ethanol) and carbon dioxide is produced. This reaction regenerates NAD^+.

33. Aerobic cellular respiration has oxygen as a final electron acceptor in the electron transport chain. The electron transport chain produces more ATP (26–28 ATP) by chemiosmosis compared to substrate-level ATP synthesis during fermentation (2 ATP).

34. NAD^+ is the oxidized form and acts as an electron acceptor. NADH + H^+ is the reduced form and is a major carrier of hydrogen atoms and free energy in the cell.

35. Substrate-level ATP synthesis uses an enzyme to add a phosphate group to ADP to produce ATP. Chemiosmosis uses a hydrogen ion gradient to produce ATP. Substrate-level ATP synthesis occurs in glycolysis and the citric acid cycle, while chemiosmosis occurs during the electron transport chain.

36. NADH is formed from NAD^+, while $FADH_2$ is formed from FAD. Both have gained electrons and are reduced compounds. For every two electrons that NADH donates, 2-3 ATP are produced. For every two electrons that $FADH_2$ donates, 1-2 ATP are produced.

37. It takes 2 ATP molecules to activate glucose at the beginning of glycolysis and then produces 4 ATP molecules by the end of the reaction. This gives a net gain of 2 ATP.

38. Coenzyme A, FAD and NAD^+ are important components of cellular respiration. They are needed for the production of ATP. Without these coenzymes, there would be minimum production of ATP and the person would show signs of fatigue.

39. Flow Chart

40. The purpose of fermentation is to regenerate NAD^+ so that it returns to glycolysis to pick up more electrons to keep glycolysis going.

41. [VENN DIAGRAM: LEFT CIRCLE: FERMENTATION IN MUSCLES]: pyruvate is converted into lactic acid; occurs in bacteria and in human muscle cells; Lactic acid fermentation → glucose → glycolysis (pyruvate) → lactic acid + 2 ATP. [RIGHT

CIRCLE: FERMENATION IN YEAST]: pyruvate is converted into carbon dioxide and ethanol; occurs in yeast and other bacteria; Alcoholic fermentation → glucose → glycolysis (pyruvic acid) → carbon dioxide + alcohol + 2 ATP. [CentreCIRCLE]: both occur anaerobically (in the absence of oxygen); glucose is converted into cellular energy (ATP); reducing agent is NADH + H^+]

42. Flow Chart
43. The citric acid cycle turns twice because two acetyl CoA molecules enter the cycle per glucose molecule.
44. Pyruvate is converted to a C_2 acetyl group attached to coenzyme A.
45. The citric acid cycle produces carbon dioxide.
46. **a.** During substrate-level ATP synthesis, an enzyme passes a high-energy phosphate to ADP and ATP is formed.

    b. As oxidation occurs, hydrogen atoms (H^+ and e^-) are removed and this forms NADH + H^+

    c. As oxidation occurs, hydrogen atoms (H^+ and e^-) are removed and this forms $FADH_2$

    d. Each acetyl group received from the preparatory reaction is oxidized to two carbon dioxide molecules.
47. Carbon monoxide will block electron transfer from NADH to oxygen. If the electron transport chain stops, then no ATP will be produced for cellular function. Absence of ATP will not allow metabolic activities to occur and cells will die as a result.
48. The electron transport chain consists of a series of protein complexes located in the cristae of the mitochondria. The protein carriers accept high-energy electrons and pass them along from one protein to another. As this occurs, hydrogen ions are pumped from the matrix to the intermembrane space. As hydrogen ions flow from the intermembrane space into the matrix down the concentration gradient, the ATP synthase complex produces ATP through chemiosmosis.
49. As the high-energy electrons are passed from one electron carrier to the next, energy is captured to produce ATP. Oxygen is the final electron acceptor and forms water.
50. The ATP synthase complex allows hydrogen ions to diffuse across the inner mitochondrial membrane. As a result of this, ATP synthase produces ATP from ADP and P by chemiosmosis.
51. They all carry out fermentation to produce ATP.
52. The carbohydrates will be stored as glycogen in the muscle cells. On the day of the race, glycogen will be converted to glucose. In the presence of oxygen, the mitochondria in the muscle cells break down the glucose to produce ATP for the muscle cells during the race.
53. During a marathon, the mitochondria are producing ATP for the body through aerobic respiration. During a sprint, where the muscle cells in the body are working vigorously, the muscle cells will tend to carry out fermentation when oxygen is scarce. Lactic acid can build up in the muscle cells.
54. The electron transport chain would be compromised by the presence of rotenone and a proton gradient would not form. The amount of ATP from glycolysis and the citric acid cycle would be insufficient to maintain the cell.
55. The faster fatty acids are converted to acetyl CoA and enter the citric acid cycle, the greater the rate of respiration. These compounds may convert fatty acids to acetyl CoA more rapidly.
56. carbon dioxide
57. If there was enough oxygen present in the juice, the bubbles could be carbon dioxide from aerobic respiration.
58. aerobic
59. rate of bubble production would increase
60. They pick up electrons and carry the high energy electrons to the electron transport chain and drop them off.
61. Blocking ATP synthase prevents the flow of protons across the membrane and chemiosmotic production of ATP, causing the cell to die.
62. Graphic Organizer
63. ADP is like a battery low on energy and ATP is like a battery full of energy.
64. ATP is produced when a phosphate is added to ADP: ADP + P → ATP. ATP is broken down into ADP by removing a phosphate group: ATP → ADP + P
65. The electron transport chain is analogous to a flight of stairs. As the object bounces down the stairs, it loses potential energy. Similarly, in the electron transport chain, high-energy electrons give off a small amount of energy with each step as they pass electrons from one protein to the next. The energy released is used to produce ATP.
66. **a.** the investment of the two ATP molecules

    b. energy is transferred to ATP, NADH and $FADH_2$

    c. citric acid cycle
67. Chemiosmosis Analogy: When the gates (=ATP synthase) of a dam (=inner mitchondrial membrane) are opened, water (=H^+ ions) flows through the dam down the slope. The potential energy stored in the water is used to do work, in the mitochondrial case, to generate energy (=ATP).
68. Research
69. Skeletal muscle cells and liver cells have different net energy yield because there is a difference in the requirement for intermediates from the citric acid cycle.
70. Graph
71. 35°C

Chapter 7 Diagnostic Questions

1. **a.** is reflected.
2. **c.** autotrophic.
3. **b.** to convert light energy into chemical energy
4. **c.** mitochondria and chloroplasts.
5. **c.** in plant cells and animal cells.
6. **a.** in plant cells, some bacteria, and some protists.
7. **b.** chlorophyll
8. **b.** chlorophyll
9. **b.** withdraw energy.
10. **d.** they have the ability to synthesize carbohydrates.

11. **c.** water and carbon dioxide
12. **d.** the stomata.
13. **b.** visible light
14. **b.** sucrose
15. **c.** glucose
16. **a.** Plants live on land and in the water.

    b. Not all plants are photosynthetic. A small portion of plants lack chlorophyll and therefore are not photosynthetic. An example includes *Rafflesia arnoldii*.

    c. Plants do not grow best in green light. Plants do not absorb green light. Plants reflect green light and therefore do not use it to power photosynthesis.

    d. Photosynthesis consists of a series of many step-by-step reactions called metabolic pathways.

    e. Plants produce their own food through their leaves. Plants take up water and minerals through their roots.

    f. Plants, protists, and some bacteria can photosynthesize.

    g. Plants need oxygen to break down food (carbs) and release energy stored in those molecules.

    h. Plants take in carbon dioxide for photosynthesis and take in oxygen for cellular respiration.

    i. Plants respire all day and night.

    j. Plants are green because they reflect green light.
17. **a.** outer membrane; **b.** grana; **c.** thylakoid space (lumen); **d.** inner membrane; **e.** stroma; **f.** thylakoid
18. The shorter days and the cooler temperatures in the fall slow down the tree's metabolism. The leaves change colours in the fall because the reduced production of chlorophyll allows the other pigments to dominate.
19. Visible light is composed of the colours of the rainbow.
20. Energy fuels all the metabolic processes in the body.
21. Plants provide us with oxygen and they are a source of food.
22. Each protein (person) in the electron transport chain (bucket brigade) passes energized electrons (bucket of water) to the next protein. At each step in the electron transport chain, the electrons lose energy (just like some water might have spilled out of the bucket as the bucket is passed down the human assembly line).
23. *Euglena* would be found by the hole where light is available.

Chapter 7 Review Questions

1. **b.** oxygen
2. **b.** water is oxidized and carbon dioxide is reduced.
3. **d.** green
4. **d.** NADPH
5. **c.** II and III only
6. **d.** converted to cellulose by dehydration reaction and becomes the structural component of plant cell walls.
7. **d.** number of gas bubbles produced on the surface of the *Cabomba* leaves.
8. **a.** It is a reduced molecule.
9. **b.**
10. **c.** glucose
11. **b.** in the stroma
12. **d.** 3 carbon dioxide molecules are attached to 3 molecules of RuBP
13. **d.** I, II and III
14. **b.** oxygen
15. **a.** Calvin cycle
16. **d.** to supply electrons for the reduction of carbon dioxide in the Calvin cycle.
17. **a.** chlorophyll a
18. **d.** Electrons carriers responsible for the light-dependent reactions are embedded in the outer membranes of the chloroplast
19. **d.** I, II and III
20. **d.** carbon dioxide.
21. **c.** the reduction of 3PG molecules in the Calvin cycle.
22. **b.** $NADP^+$
23. **a.** cytoplasm
24. **a.** reduced to G3P

    b. provides energy to allow for reduction

    c. is the product of reduction of carbon dioxide

    d. is attached to carbon dioxide

    e. donates electrons and releases oxygen

    f. accepts electrons and hydrogen ions and becomes NADPH

    g. forms ATP

    h. provides electrons for reduction

    i. provides energy

    j. absorbs solar energy
25. **a.** thylakoid

    b. thylakoid, photosystems I and II

    c. grana

    d. thylakoid membrane

    e. thylakoid membrane

    f. thylakoid space

    g. stroma

    h. portions of the noncyclic electron transport path

    i. thylakoid, photosystems, chlorophyll

    j. stroma
26. **a.** noncyclic electron pathway

    b. Calvin cycle - reduction of carbon dioxide

    c. Calvin cycle - reduction of carbon dioxide

    d. light reactions

    e. Calvin cycle - fixation of carbon dioxide
27. Diagram

28.

	Photosynthesis	Cellular Respiration
Function	To store energy To synthesize food	To release energy To break down food
Location in the Cell	Chloroplast	Mitochondrion
Type of Cell	Plant Cell	Plant Cell and Animal Cell
Reactants	Low-energy reactants Carbon Dioxide and Water	High-energy reactants Glucose and Oxygen
Products	High-energy products Glucose and Oxygen	ATP Carbon Dioxide and Water
Equation	light energy + $6CO_2$ + $6H_2O \rightarrow C_6H_{12}O_6$ + $6O_2$	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + ATP
Electron Transport Chain	Yes	Yes
Electron Carriers	NADPH	NADH, $FADH_2$
ATP Synthesis by Chemiosmosis	Yes	Yes
Conditions	Takes place only in the presence of light	Takes place all the time in light or dark
Energy	Energy added in the production of food	Energy released from food

29. A photosystem consists of a pigment complex to absorb solar energy, an electron acceptor within the thylakoid membrane, and molecules of chlorophyll a, chlorophyll b and carotenoids.

30. They both donate the high-energy electrons to the electron transport chain.

31. Diagram

32. The light reactions produce oxygen.

33. The role of $NADP^+$ is to carry hydrogen atoms from the light reactions to the Calvin cycle.

34. Water provides electrons to photosystem II.

35. Two events are linked to chemiosmosis: ADP + P → ATP; pumping hydrogen ions from the thylakoid space to the stroma.

36. When hydrogen ions flow from the thylakoid space to the stroma down the concentration gradient through ATP synthase, ATP is produced.

37. Photosystem I is involved in both the cyclic and the noncyclic pathways, while photosystem II is only involved in the noncyclic pathway.

38. Without light, the light reaction cannot produce NADPH for the Calvin cycle. Without NADPH, BPG cannot be converted to G3P and the cycle will stop.

39. Flow Chart

40. Photosystem II: Light absorption - absorbs light energy and enters the reaction centreof Photosystem II, exciting the chlorophyll higher energy level; Electron capture - the electron is captured by the electron acceptor; Splitting of water and releasing oxygen - Water (H_2O) is split and its electrons replace those lost by the chlorophyll. Oxygen (O_2) is released as a waste product. Photosystem I: Electron transport chain - electrons are passed through the chain to Photosystem I; the chain provides energy from the production of ATP needed in the Calvin cycle; Chlorophyll is the excited reaction centreof Photosystem I; Conversion of NADP+ to NADPH - the excited electrons oxidize NADP+ to NADPH.

41. The electron transport chain passes electrons from one carrier to the next. The energy that is released is used to move hydrogen ions from the stroma into the thylakoid space in the chloroplast, but from the matrix into the intermembrane space in the mitochondrion.

42.

	Light-dependent Reaction	Light-independent Reaction
Light	Used for splitting water	Not required during reaction
Location in the Chloroplast	Thylakoid membranes	Stroma
Raw Materials	Water	Carbon dioxide, electrons, and ATP
Products	Hydrogen ions, electrons, and ATP	Carbohydrates

43. a. Light-dependent Reactions: produces oxygen gas and converts ADP and $NADP^+$ to ATP and NADPH; occurs in the thylakoid; involves photosystem I and photosystem II; photons are absorbed by photosynthetic pigments of photosystems; photon energy drives the transfer of electrons from chlorophyll to an acceptor molecule which donates them to a transport system in the membrane

b. Light-independent Reactions (Calvin Cycle): uses ATP and NADPH from the light-dependent reaction to produce high-energy sugars; takes place in the stroma; ATP deliver energy and NADPH delivers electrons to the stroma of the chloroplasts; RuBP is needed to capture the carbon

44. Both C3 and C4 plants use the Calvin cycle. In terms of the leaf anatomy, the C3 plants have mesophyll, while the C4 plants have mesophyll and bundle sheath cells. C3 plants include wheat, rice, and oats, while C4 include sugarcane and corn. Photorespiration does not occur in C4 plants, but does occur extensively in C3 plants.

45. If the water plant is exposed to light, then it will produce a gas.
46. A control could be a plant that is not exposed to any light (or kept in the dark).
47. oxygen gas
48. Graph
49. Pigments in spinach leaves absorb blue and violet light more efficiently than all other light colours.
50. **a.** G3P molecule
    b. oxygen molecule
    c. G3P molecule
    d. G3P molecule
51. The plant was placed in bright light from 0 min to 23 min. Photosynthesis occurred because carbon dioxide was consumed.
52. The plant was placed in complete darkness between 23 min to 60 min. The level of carbon dioxide was relatively the same.
53. The process is cellular respiration.
54. There were four pigments.
55. The pigment that was most soluble was carotene.
56. Chlorophyll b travelled the shortest distance.
57. Spinach leaves have 4 different pigments with different solubilities.
58. Experiment

Chapter 8 Diagnostic Questions

1. **b.** organ
2. **a.** digestive system.
3. **c.** circulatory system and respiratory system
4. **c.** circulatory system.
5. **a.** line the nasal cavity.
6. **d.** 37°C
7. **d.** I, II and III
8. **a.** the hairs on skin lie flat, sweating occurs, blood vessels dilate
9. **a.** curl up to reduce the surface area
10. **b.** decrease heat loss.
11. **b.** to maintain constant internal body conditions
12. **a.** the brain
13. body temperature, blood pH, blood glucose levels, blood pressure, carbon dioxide levels, oxygen levels
14. **A.** cellular level; **B.** tissue level; **C.** organ level; **D.** organ system; **E.** organism
15. **a.** Dark Blue Box: cooling mechanisms: sweating and blood vessels dilate
    b. Pink Box: heating mechanisms: shivering and blood vessels constrict
    c. White Box: detected by thermoreceptors in skin and hypothalamus
    d. Lilac Box: detected by thermoreceptors in skin and hypothalamus

Chapter 8 Review Questions

1. **b.** cells → tissues → organs → organ systems
2. **a.** a tissue.
3. **c.** digestive system and respiratory system
4. **b.** the circulatory system and the urinary system
5. **c.** different tissues that consist of cells with similar functions.
6. **c.** stratified squamous epithelial tissue.
7. **d.** different cells express different genes on the DNA molecule.
8. **c.** A tissue in the circulatory system is made up of a group of cells specialized to do a specific job.
9. **b.** nervous tissue
10. **b.** smooth muscle tissue
11. **a.** calf
12. **d.** cells are bound by intercalated disks
13. **c.**
14. **a.** There will be a disruption in homeostasis.
15. **a.** illness or death
16. **c.** high levels of blood glucose levels
17. **a.** Blood vessels near the surface of the skin dilate and sweat glands release water.
18. **c.** a negative feedback mechanism.
19. **d.** it keeps the internal environment relatively constant.
20. **c.** II and III only
21. **d.** A negative feedback mechanism in the body.
22. **b.** positive feedback.
23. **a.** IV; **b.** I; **c.** III; **d.** IV; **e.** I; **f.** II; **g.** II; **h.** II; **i.** III; **j.** II; **k.** II; **l.** III; **m.** I; **n.** IV; **o.** II
24.

Type of Epithelial Tissue	Characteristic	Location in the Body
Squamous Epithelium	Flattened cells	Lines the lungs and blood vessels
Cuboidal Epithelium	Cube-shaped cells	Lines the kidney tubules
Columnar Epithelium	Rectangular-shaped cells	Lines digestive tract and the oviducts

25. Diagram
26. **a.** stem cell research; cloning humans from a single cell
    b. how to increase the supply of human organs for transplantation; transplanting animal organs into humans
    c. enhancing human performance with drugs or genetic engineering

27.

Level of Organization	Description	Examples
Cell	Smallest unit of life	Muscle cell Skin cell Neuron
Tissue	A group of cells with the same general structure and function.	Muscle tissue Epithelial tissue Connective tissue Nervous tissue
Organ	A group of several tissue types that carry out a specific function.	Stomach Heart Lungs
Organ System	A group of organs that work together to complete a generalized set of tasks.	Digestive system Circulatory system Respiratory system
Organism	An organism is made up of a group of organ systems that work together.	Human

28. Glands that release hormones are inhibited to prevent an imbalance

29. **a.** The digestive system regulates blood glucose levels. The liver converts excess glucose into glycogen. When the blood sugar level is low, then glycogen is converted into glucose for the body to use.

b. The circulatory system transports oxygen to the cells and carries carbon dioxide away from the cells. It helps maintain the proper pH in the blood.

c. The respiratory system regulates blood pH by removing excess carbon dioxide that can lower the blood pH.

30. **a.** muscles are important for the chewing, swallowing, churning and movement of digestion products along the digestive tract

b. nervous system speeds up/slows down heart rate; constricts/dilates blood vessels to control blood pressure

c. lacteals (part of the lymphatic system) absorb fats digested by the digestive system

d. the lymphatic system collects excess fluid and drains it back into the circulatory system

e. endocrine system secrete hormones that affect the development of reproductive organs

31. **a.** iv; **b.** i; **c.** ix; **d.** v; **e.** vii, iii, vi; **f.** ii; **g.** vii; **h.** viii, iii; **i.** ii, vi; **j.** v; **k.** xi

32. Diagram

33. Diagram

34. Flow Chart #1: body temperature drops below normal → brain signals blood vessels to constrict and sweat glands to remain inactive → body heat is conserved → body temperature rises and returns to normal

Flow Chart #2: body temperature drops below normal → brain signals blood vessels to constrict and sweat glands to remain inactive → if body temperature continues to drop, signals muscles to contract (shivering will occur) → muscle activity generates body heat → body temperature rises and returns back to normal

35. fever; exercise

36. body temperature rises above normal → brain signals blood vessels to dilate and sweat glands will secrete water to initiate sweating → body heat is lost to its surroundings → body temperature drops and returns to normal

37. negative feedback or homeostasis

38. The body is trying to cool down by sweating.

39. The enzymes could denature.

40. **a.** Negative Feedback

b. Positive Feedback

c. Positive Feedback

41. Homeostatic mechanisms are classified according to their feedback mechanisms.

42. Concept Map

43. Green box at the top: c. decrease in room temperature; Blue box on the left: shivering; Blue box in the center: curling up; Blue box on the right: constriction of blood vessels; Green box at the bottom: return of body temperature toward original value

Chapter 9 Diagnostic Questions

1. **a.** to lubricate food.

2. **b.** absorbs nutrients and eliminates waste.

3. **c.** the use of enzymes to break down food.

4. **a.** chewing in the mouth

5. **c.** epiglottis

6. **a.** liver.

7. **b.** amino acids.

8. **c.** vitamins

9. **c.** small intestine.

10. **a.** water

11. **a.** hydrolysis

12. **c.** calories.

13. **A.** esophagus; **B.** liver; **C.** gall bladder; **D.** ascending part of the large intestine; **E.** small intestine; **F.** appendix; **G.** anus; **H.** descending part of the large intestine; **I.** pancreas; **J.** stomach

14. Food moves down the esophagus by peristalsis, a series of muscular contractions.

15. Hydrolytic enzymes are responsible for breaking down a polymer into smaller subunits.

16. Soaps and detergents are examples of emulsifiers.

17. Accessory glands that aid in digestion include the salivary glands, the liver, the pancreas, and gall bladder.

18. The stomach is just an organ to store food. If there is no stomach, then protein can be digested in the small intestine instead. The body will still be able to digest food without a stomach.

19. Fad diets are unhealthy because they involve eating only a limited variety of foods. Therefore you are completely cutting out carbohydrates, fats or proteins from your diet. You need all of these nutrients to perform different jobs in a healthy body.
20. Diagram
21. Sequence of organs that food passes through: mouth, esophagus, stomach, small intestine, large intestine and anus.
22. **a.** The liver represents the bank.
    b. Glucagon represents the withdrawal slip.

Chapter 9 Review Questions

1. **a.** lysosome
2. **a.** Mechanical digestion and chemical digestion begin in the mouth and end in the small intestine.
3. **c.** hydrolysis.
4. **c.** rhythmic muscular contractions that assists with the movement of food
5. **d.** hemoglobin.
6. **a.** bile
7. **d.** an emulsifier.
8. **a.** Proteases have active sites that only proteins can fit.
9. **a.** bile
10. **d.** Structure W - detoxifies blood by removing and metabolizing alcohol
11. **c.** cholecystokinin
12. **b.** proteins.
13. **c.** X and Y
14. **a.** W
15. **c.** structure Y.
16. **a.** structure T.
17. **d.** increasing the pH of the solution to 14
18. **b.** the mouth and the small intestine.
19. **b.** pancreas
20. **c.** pH = 8
21. **c.** maltose
22. **b.** the products would not form at all
23. **c.** nuclease and nucleic acid at pH 8.0
24. **a.** maintain homeostasis
25. **b.** pepsin
26. **c.** small intestine
27. **d.** pancreatic juices
28. **b.** B
29. **c.** hydrochloric acid.
30. **d.** sodium bicarbonate.
31. **c.** C
32. **c.** Absorption of glucose from the small intestine.
33. **c.** Only Person X has diabetes.
34. **a.** 0 h to 1 h
35. **c.** homeostatic mechanisms.
36. **a.** insulin
37. **d.** (glycogen)
38. **d.** Person X does not have the insulin receptors on tissue cells that function properly.
39. **b.** the use of ex vivo gene therapy
40. **d.** the alpha cells of the pancreas release glucagon into the blood
41. **d.** stomach cells have receptors on the cell membrane that bind to gastrin
42. **b.** B
43. **c.** II and III only
44. **a.** I and II only
45. **a.** the sequence of DNA nitrogenous bases.
46. **a.** 3
    b. 5
    c. 7
    d. 7
    e. 4
    f. 2
    g. 2
    h. 1
    i. 7
    j. 10
    k. 9
    l. 4
    m. 7
    n. 9
    o. 1
    p. 6
    q. 8
    r. 2
    s. 9
    t. 1
47.

Secretion	Site of Production	Function
Hormones	Stomach, pancreas, small intestine	Aids in digestion and nutrient absorption
Hydrochloric Acid	Stomach	Promotes digestion of protein; kills bacteria
Digestive Enzymes	Mouth, stomach, small intestine, pancreas	breaks macromolecules down into subunits
Sodium Bicarbonate	Pancreas and small intestine	Neutralizes acid chyme

48. The advantage is food can be regurgitated (vomiting) when you are sick or have ingested something harmful.
49. It has a protective layer of mucus that prevents the hydrochloric acid from digesting itself.

50. The stomach has sufficient space to accommodate ingested food. It contains smooth muscles in its walls that aid in physical digestion.

51. The muscular stomach wall can move the food along and physically churn it so that food mixes with the gastric juices breaking it down into small pieces. The hydrochloric acid and pepsin content of the stomach help digest the food chemically.

52. Structurally, the small intestine is smaller in diameter, but much longer than the large intestine. Functionally, the small intestine's job is to digest the food, breaking the macromolecules down into monomers. The small intestine absorbs nutrients, while the large intestine absorbs water, salts and vitamins.

53. Starch is first broken down in the mouth by salivary amylase into maltose. Starch is again digested in the small intestine where it is broken down into maltose by pancreatic amylase. Maltose is then hydrolyzed into glucose by the enzyme maltase.

54. The concentration of glycerol, fatty acids, amino acids and sugars increases as they enter the blood capillaries of the villi.

55. The stomach produces gastrin which causes the stomach to churn and secrete gastric juices. The gastric glands produce gastric juice containing pepsinogen, hydrochloric acid and mucus. In the presence of HCl, pepsinogen is converted to pepsin. Pepsin is then used to digest proteins.

56. If sodium bicarbonate was not present in the duodenum, the acid chyme from the stomach would damage the lining of the small intestine because would be there to neutralize the acid chyme.

57. a. Diagram

b. The villus is found in the small intestine.

c. The function of the villus is to absorb glycerol and fatty acids.

d. The villus is made up of many folds and ridges. This increases the surface area to promote absorption of fats.

e. If the liver was not functioning properly, the absorption of fats would decrease because fats would not be emulsified due to the absence of bile.

58. Pancreatic juice consists of sodium bicarbonate, pancreatic amylase, lipase, peptidase, nuclease, and trypsin. The function of sodium bicarbonate is to neutralize the acid chyme that enters the small intestine from the stomach. Pancreatic amylase breaks starch down into maltose. Lipase breaks fats down into glycerol and fatty acids. Peptidase breaks peptides down into amino acids. Nuclease breaks down nucleic acids into nucleotides. Trypsin breaks proteins down into peptides.

59. Drawing

60. [CentreCIRCLE] Similarities between pepsin and trypsin: proteases; digestive enzymes; involved in hydrolysis; breaks proteins down into peptides. Differences between pepsin and trypsin: [LEFT CIRCLE Pepsin] produced by the stomach; secreted in the stomach; has an optimum pH of 2. [RIGHT CIRCLE Trypsin] produced by the pancreas; secreted in the small intestine; has an optimum pH of 8.5].

61. Graph

62.

	Insulin	Glucagon
Type of Molecule	Hormone	Hormone
Secreted By	Beta cells in the pancreas	Alpha cells in the pancreas
Secreted in response to	High blood glucose levels	Low blood glucose levels
Function	To lower the blood glucose levels	To increase the blood glucose levels

63. a. blood glucose level drops below normal: blood glucose level drops below normal → alpha cells of the pancreas secrete glucagon → stimulates the release of glycogen in the liver and muscle → glycogen is converted to glucose → blood glucose rises to normal level

b. blood glucose levels rises above normal: blood glucose level rises above normal → beta cells of the pancreas secrete insulin → stimulates glucose uptake by cells and glycogen formation → glucose is converted to glycogen in the liver → blood glucose falls to normal range

64.

Hormone	What stimulates the release of the hormone?	Where is it produced?	Where does it act?	What does it do?
Gastrin	Protein	Stomach	Gastric glands of the Stomach	Stimulates gastric glands to secrete gastric juices
Secretin	Hydrochloric acid in acid chyme	Duodenum (small intestine)	Pancreas Liver Gallbladder	Stimulates the pancreas to secrete pancreatic juices; stimulates liver to produce bile; stimulates gall bladder to release bile

Cholecystokinin (CCK)	Partially digested protein and fat	Duodenum (small intestine)	Pancreas Liver Gallbladder	Stimulates the pancreas to secrete pancreatic juices; stimulates liver to produce bile; stimulates gall bladder to release bile

65. **a.** 3
b. 8
c. 6
d. 7
e. 5
f. 1
g. 2
h. 4

66. Concept Map

67. Test Tube 1: control; no digestion will take place because no enzyme is present; Test Tube 2: no digestion will take place because pepsin is not in an acidic conditions; Test Tube 3: no digestion will take place; denaturation of the egg white will occur; Test Tube 4: digestion of the egg white into peptides will occur because pepsin is in an acidic environment provided by the hydrochloric acid. Only test tube 4 containing pepsin, HCl, and water should result in the breakdown of the egg white. The other tubes lack a necessary component of this reaction mix.

68. X = maltase; Y = peptidase; Z = lipase

69. pH = 8.5

70. Reaction X involves maltase; maltose (substrate) → glucose (product) + glucose (product); Reaction Y involves peptidase; peptide (substrate) → amino acid (product) + amino acid (product); Reaction Z involves lipase: triglyceride (substrate) → glycerol (product) + 3 fatty acids (product)

71. maltase

72. maltose → glucose + glucose

73. You would expect side A to have glucose present and side B to just have water present.

74. You would use Benedict Solution to do the test.

75. The traditional diet will allow Aboriginal people to be healthier. With low carbohydrate diets, they can control their blood glucose levels and therefore regulate their diabetes.

76.

Food	Calories	Resting	Running	Swimming
French fries (large serving)	400	400 calories + 2000 calories / day × 24 h/day = 4.8 hr	4.8 h +10 MET = 0.48 h or 29min	4.8 h + 7 MET = 0.69 h or 41 min
Pepperoni pizza (2 slices)	460	460 calories + 2000 calories / day × 24 h/day = 5.52 hr	5.52 h +10 MET = 0.552 h or 33 min	5.52 h + 7 MET = 0.78 h or 47 min
Vanilla Milkshake	350	350 calories + 2000 calories / day × 24 h/day = 4.2 hr	4.2 h +10 MET = 0.42 h or 25.2 min	4.2 h + 7 MET = 0.6 h or 36 min

77. **a.** By reducing the size of the stomach in gastric stapling (restrictive) surgery, this prevents the person from eating large quantities of food. This will then lead to weight loss.

b. With the smaller stomach, a person would feel full after a small meal. In addition to this, by bypassing the upper portion of the small intestine, less food and nutrients will be absorbed.

Chapter 10 Diagnostic Questions

1. **b.** blood vessels, blood, and the heart.
2. **a.** water.
3. **d.** the hemoglobin molecule in the red blood cells.
4. **a.** the heme group
5. **d.** oxygen molecules, carbon dioxide molecules and hydrogen ions.
6. **b.** away from the heart.
7. **b.** side streets.
8. **a.** veins.
9. **d.** capillaries.
10. **a.** clot blood.
11. **a.** atria.
12. **b.** oxygen-rich blood.
13. **d.** lungs.
14. **c.** left ventricle.
15. **a.** aorta.
16. **d.** right atrium.
17. **d.** 4 chambers.
18. **c.** septum.
19. **c.** the pulmonary circuit and the systemic circuit.
20. **b.** the umbilical cord
21. **d.** the placenta.
22. **c.** They are both vascular systems.
23. **d.** white blood cells
24. **a.** liver

25. **A.** left atrium; **B.** left ventricle; **C.** right ventricle; **D.** right atrium
26. arteries and veins; antidiuretic hormone; sodium ion concentration in the body; blood volume; sympathetic and parasympathetic nervous system
27. the nervous system
28. radial artery (in the wrist); carotid artery (in the neck); brachial artery (in the arm)
29. The coronary arteries provide the heart with oxygen and nutrients, while all the other arteries provide oxygen and nutrients to the other organs in the body.
30. cholesterol deposits in the arteries causing the arteries to harden; diet affects atherosclerosis
31. by returning all the lost fluids to the circulatory system

Chapter 10 Review Questions

1. **c.** cell V
2. **a.** antibodies, water, oxygen, glucose, urea, hormones
3. **a.** engulfing and digesting the pathogen.
4. **b.** cell V – transports oxygen
5. **a.** a bacterial infection.
6. **b.** liver and large intestine
7. **a.** Both blood volume and blood pressure would increase
8. **b.** It carries oxygen-rich blood, while the other veins carry oxygen-poor blood.
9. **d.** superior vena cava
10. **d.** a reading of the heart's electrical activity during each cardiac cycle
11. **c.** the ventricles are contracting.
12. **d.** delay of AV node to allow filling of ventricles
13. **b.** structure VII
14. **c.** blood vessel 7
15. **d.** The pulmonary semi-lunar valves.
16. **b.** renal artery
17. **b.** blood vessel 3
18. **a.** iliac artery
19. **d.** superior vena cava.
20. **d.** blood vessel 14
21. **d.** delivers oxygen-rich blood to the brain, head and neck
22. **a.** delivers nutrient-rich blood to the liver.
23. **b.** right ventricle has a lower concentration of oxygen; left ventricle has a high concentration of oxygen
24. **a.** aorta
25. **d.** parasympathetic nervous system
26. **c.** veins and the flow of lymph in lymph vessels.
27. **b.** The blood cells will crenate because of the hypertonic conditions.
28. **c.** body below the thorax, left arm, left side of the head and left side of the neck.
29. Blood is composed of a liquid component called plasma which consists of mostly water, plasma proteins and other solutes. The other component of blood is the formed elements which consist of red blood cells, white blood cells and platelets.
30. **a.** Without a nucleus, the red blood cell has more room for hemoglobin and therefore can carry more oxygen.
    b. cell division
31. **c.** arterioles
32. **a.** veins
33. **c.** Arteries have small diameters and therefore have the greatest blood pressure.
34. **d.** The difference between the systolic and diastolic pressure decreases the further blood gets from the left ventricle.
35.

	Red Blood Cells	White Blood Cells	Platelets
Other Name	erythrocyte	leukocyte	thrombocyte
Site of Production	red bone marrow	red bone marrow	red bone marrow
Structure and Appearance	biconcave disks; no nucleus; has hemoglobin	larger cells; have a nucleus; lacks hemoglobin; may have granules	fragments of megakaryocytes
Function	carries oxygen and carbon dioxide	phagocytose pathogens; involved in specific immunity	helps in blood clotting

36. There is lower oxygen concentration in the body tissues at high altitudes and this causes the increase in red blood cell production.
37. **c.** Blood flow slows down as it passes through the capillaries.
38. **b.** as total cross-sectional area increases, blood velocity decreases
39. **b.** umbilical vein
40. **d.** carbon dioxide
41. **c.**
42. [VENN DIAGRAM CentreCIRCLE] Similarities between agranular and granular leukocytes: both are white blood cells; both fight infection; both involved in phagocytosis. Differences between agranular and granular leukocytes: [LEFT CIRCLE: agranular leukocytes] The agranular leukocytes include lymphocytes and monocytes; have no granules; have spherical nucleus; produced in lymphoid tissues. [RIGHT CIRCLE: agranular leukocytes] The granular leukocytes include neutrophils, esoinophils and basophils; have lobed nuclei; produced in bone marrow.

43.

Blood Vessel	Structure	Function
Artery	-strong, elastic blood vessels -has 3 layers: inner layer is endothelium; middle layer is thick smooth muscle; outer layer is fibrous and loose connective tissues	-carries blood away from the heart
Arteriole	-smaller versions of arteries -inner layer is endothelium and thick middle layer is smooth muscle	-carries blood from the artery to the capillaries
Capillary	-blood vessel that is extremely narrow and has thin walls -has large surface area -only a single layer of endothelium	-allows exchange of nutrients, gases, and waste products with the body tissues
Venule	-smaller versions of veins	-carries blood from the capillaries to the veins
Vein	-thin blood vessel -has 3 layers: inner layer is endothelium; middle layer is thick smooth muscle; outer layer has less fibrous and loose connective tissues than artery -has valves to ensure unidirectional blood flow	-carries blood to the heart -acts as fluid reservoir

44. The heart is an organ made up of different layers of muscles. The different layers of muscles form strong protective layers that allow the heart to pump blood effectively throughout the body with forceful contractions.

45. **a.** helps clot blood to prevent excessive bleeding

b. transports oxygen, carbon dioxide, hydrogen ions, hormones, nutrients, wastes and solutes around the body

c. buffers in the blood make sure pH remains around 7.4

d. regulates body temperature by controlling the blood flow through the skin and dispersing the body heat

e. white blood cells fight against pathogens

46. **A.** aorta; **B.** pulmonary artery; **C.** left atrium; **D.** pulmonary veins; **E.** aortic semi-lunar valves; **F.** chordae tendinae; **G.** left ventricle; **H.** right ventricle; **I.** inferior vena cava (posterior vena cava); **J.** chordae tendinae; **K.** pulmonary semi-lunar valves; **L.** pulmonary veins; **M.** right atrium; **N.** superior vena cava (anterior vena cava); **O.** pulmonary artery

47. **a.** 10; **b.** 13; **c.** 6; **d.** 16; **e.** 12; **f.** 7; **g.** 1; **h.** 3; **i.** 11; **j.** 9; **k.** 5; **l.** 5; **m.** 14; **n.** 4; **o.** 17; **p.** 18; **q.** 2

48. **a.** An artery carries blood away from the heart, while a vein carries blood back to the heart.

b. The atrium is the upper chamber of the heart, while the ventricle is the lower chamber of the heart.

c. Blood flows through the blood vessels of the circulatory system, while the interstitial fluid flows through the vessels of the lymphatic system.

d. Plasma is the liquid portion of blood that consists of water, plasma proteins and solutes. Formed elements make up the solid portion of blood and consist of red blood cells, white blood cells and platelets.

e. The tricuspid prevents backflow into the right atrium and the biscuspid valve prevents backflow into the left atrium.

f. The systemic circuit carries blood to the rest of the body, while the pulmonary circuit carries blood to the lungs.

g. The atrioventricular valve prevents backflow into the atrium and the semilunar valve prevents backflow into the ventricle.

h. Intrinsic control of heartbeat is regulated by the SA node, AV node, atrioventricular bundle and Purkinje fibres, while the extrinsic control of heartbeat is regulated by the autonomic system and hormones.

i. left side of the heart pumps blood to the body, while the right side of the heart pumps blood to the lungs.

49. The lub sound is the atrioventrcular valves closing as the ventricles contract, and the dub sound is the semilunar valves closing as the ventricles relax.

50. The SA node, aka pacemaker, depolarizes causing the atria to contract. Nerve impulses from the SA node pass to the AV node, then to the atrioventricular bundle and finally to the Purkinje fibres. This causes the ventricles to contract.

51. As blood flows through the different types of blood vessels, it has to overcome resistance to the flow of blood. Pressure and energy is lost.

52. Blood flowing in the leg usually has to go against the pull of gravity. The valves prevent blood from flowing backward down the leg when it is supposed to be pumped up toward the heart.

53. At the arterial side of a capillary, the blood pressure is greater than the osmotic pressure. This pushes water, oxygen, amino acids and glucose out of the capillaries out of the blood vessel. At the venule side of a capillary, the blood pressure is less than the osmotic pressure. This causes the water, waste and carbon dioxide to diffuse back into the blood vessel.

54. left ventricle → aorta → upper and lower body → superior and inferior vena cava → right atrium → right ventricle → pulmonary arteries → lungs → pulmonary veins → left atrium

55. right atrium → atrioventricular tricuspid valve → right ventricle → pulmonary semilunar valve → pulmonary trunk → pulmonary arteries → lungs → pulmonary veins → left atrium

→ atrioventricular bicuspid valve → left ventricle → aortic semilunar valve → aorta

56. Diagram

57. The circulatory system delivers nutrients to the tissues. As the nutrients in the plasma move from the capillaries to the tissues, some of the plasma is lost into the interstitial fluid of the tissue. The lymphatic system collects the interstitial fluid known as lymph and returns it to the circulatory system.

58. Exercising regularly makes the heart stronger and therefore it can pump blood more efficiently through the body.

59. it absorbs excess tissue fluid and returns it to the bloodstream; it absorbs fats from the digestive tract and transports them to the bloodstream; it helps defend the body against infections

60. They both have valves to prevent backflow.

61. Blood pressure is greater than osmotic pressure on the arterial side. The blood pressure squeezes water and small molecules out of the capillaries and into the interstitial spaces.

62. Osmotic pressure is greater than blood pressure on the venous side. This causes the fluids from the interstitial to be pulled back into the capillaries on the venous side.

63. **a.** blood pressure

b. osmotic pressure

64. Diagram

65. **a.** 8; **b.** 3; **c.** 6; **d.** 1; **e.** 10; **f.** 11; **g.** 9; **h.** 3; **i.** 11; **j.** 10; **k.** 8, 10; **l.** 6; **m.** 6; **n.** 8; **o.**1; **p.** 3; **q.** 10; **r.** 8; **s.** 9

66. Blood flow is related to metabolic rate. As an organ, the liver has the greatest blood flow because it has the greatest metabolic rate. This is because it has a relatively high mass-specific metabolic rate and is also a relatively large organ.

67. During exercise, blood flow through the tissues is changed significantly. Blood is shunted away from the major organs and redirected to the muscles to meet the increased oxygen demands.

68. Most of the blood is shunted away from the liver during exercise because the body does not need to be digesting food or carrying out any of the functions of the liver. It only supplies the liver with the minimum amount of blood to maintain the function of the liver.

69. There is a correlation between increased blood flow and increased demand for oxygen consumption during exercise.

70. Yes

71. No, the cardiac output would not be the same. The person who exercises regularly will have a higher cardiac output.

72. Design an experiment.

73. **a.** For a student who is 18 years old: 18 years × 365 days × 24 hours × 60 minutes × 75 bpm = 709, 560, 000 times

b. 709 560 000 x 70 mL = 4.96692×10^{10} mL

74. The lymphatic vessels are obstructed and flow of lymph throughout the body is blocked. This causes fluids to collect and swelling results.

75. By getting the blood clotting factors, hemophiliacs now have the plasma proteins that will allow them to clot blood.

Chapter 11 Diagnostic Questions

1. **b.** the nose.

2. **c.** hydrogen ions

3. **a.** pH.

4. **a.** a protein.

5. **c.** pharynx

6. **c.** hemoglobin.

7. **c.** from areas of high pressure to areas of low pressure.

8. **a.** true; **b.** true; **c.** false

9. **A.** lungs; **B.** bronchioles; **C.** nose; **D.** mouth; **E.** trachea; **F.** diaphragm

10. breathing

11. circulatory system

12. mitochondria

13. cellular respiration

14. X = external respiration; Y = internal respiration

Chapter 11 Review Questions

1. **d.** I, II and III

2. **c.** bronchus

3. **b.** beating of the cilia

4. **a.** It is strengthened by rings of cartilage.

5. **c.** structure C.

6. **c.** structure C.

7. **c.** increased toxic chemicals in the respiratory tract.

8. **b.** to change the volume of the thoracic cavity

9. **a.**

10. **d.** I, II and III

11. **c.** the diaphragm contracts and moves down and the rib cage moves up and out

12. **c.** inspiration is normally an active process; expiration is normally a passive process

13. **c.** diaphragm and intercostal muscles contract → rib cage moves up and out → pressure in the lungs decreases → air flows into the lungs

14. **d.** diaphragm becomes dome-shaped and volume of thoracic cavity decreases

15. **d.** I, II and III

16. **a.** the diaphragm to increase contractions.

17. **d.** oxygen-poor blood pumped to the lungs via the pulmonary arteries.

18. **a.** I and II only

19. **c.** 4800 mL

20. **a.** 500 mL

21. **a.** A

22. **d.** the maximum volume of air contained in the lungs after a maximum inspiratory effort.

23. **d.** inspiratory reserve volume – volume of air that can be inhaled over and above resting tidal volume

24. **d.** sum of tidal, inspiratory reserve and expiratory reserve volumes.

25. **c.** helps keep the alveoli open and prevent the lungs from collapsing.

26. **b.** 20% in male; 25% in female

27. **b.** 1500 mL

28. **b.** speeds up the conversion of CO_2 to HCO_3^- in the tissues.

29. **c.** Hemoglobin picks up oxygen in the lungs where P_{O2} is high, and releases oxygen in the tissues where P_{O2} is low.

30. **c.** X is at the tissue capillaries; Y is at the lung capillaries.

31. **c.** two of every four Fe^{2+} on hemoglobin have bound to O_2.

32. **b.** the volume of oxygen unloaded to the tissues.

33. **c.** $HbO_2 \rightarrow Hb + O_2$

34. **d.** $H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow H_2O + CO_2$

35. **a.** to the left of point W

36. **c.** the rate and depth of breathing increase.

37. **a.** bicarbonate ion.

38. **b.** internal respiration.

39. **d.** $Hb + CO_2 \rightarrow HbCO_2$

40. **b.** takes up excess hydrogen ions in the blood.

41. **d.** pulmonary arteriole

42. **a.** oxygen

43. **d.** superior vena cava

44. **1.** pharynx; **2.** trachea; **3.** lung; **4.** bronchus; **5.** diaphragm; **6.** nasal cavity; **7.** larynx; **8.** external intercostals; **9.** internal intercostals; **10.** muscles; **11.** abdominal muscles

45. **a.** structures 8 and 9; **b.** structures 10 and 11

46. the diaphragm contracts and pulls down

47. Structure 2 has cartilage around it; lined with cilia and mucus to prevent dust and debris from getting into the lungs.

48. The surfactant may be depleted.

49. **a.** 1; **b.** 2; **c.** 7; **d.** 8; **e.** 1; **f.** 5; **g.** 2; **h.** 4, 5, 9; **i.** 3; **j.** 3; **k.** 2; **l.** 6; **m.** 10

50. **d.** hepatic portal vein

51.

	Inspiration	Expiration
Diaphragm	Contracts and moves down	Relaxes and moves up
Intercostal Muscles	Contracts	Relaxes
Rib Cage	Moves up and out	Moves down and in
Pressure in Lungs	Decreases	Increases
Volume of Thoracic Cavity	Increases	Decreases
Movement of Air	Air moves in	Air is pushed out

52. Internal respiration is the exchange of gases between the systemic capillaries and the body tissues, while external respiration is the exchange of gases between the pulmonary capillaries and the air in the alveoli.

53. During swallowing, the larynx pulls up pushing the glottis against the epiglottis. With the glottis closed, food and fluid goes down the esophagus instead of the trachea.

54. When you whisper, the vocal cords do not vibrate.

55. The trachea and bronchi are surrounded by cartilage to keep the airway open during inspiration. On the inside, they are lined with mucus and cilia to trap and move debris up and out of the respiratory tract.

56. The alveoli are small and numerous. This increases surface area to volume ratio to maximize the diffusion of gases. The alveoli are covered in a lipoprotein which lowers the surface tension and prevents them from collapsing to receive inhaled air. The alveoli are thin and covered in an extensive network of capillaries to allow gas exchange to occur more easily.

57. The pleural membranes line the thoracic cavity to help create pressure and lubricate the lungs to reduce friction during inspiration and expiration.

58. There will be air in the pleural space and the lungs will not inflate.

59. Oxygen is carried in the blood as dissolved oxygen and oxyhemoglobin.

60. Carbon dioxide is carried in the blood as dissolved carbon dioxide, carbaminohemoglobin, and bicarbonate ion.

61. The hydrogen ion binds with the globin portion of hemoglobin to form reduced hemoglobin, HHb.

62. Diagram.

63. In the winter when air is less humid, the dry air that is inhaled can dry out the surface of the nasal tissues. When this occurs, blood vessels rupture and nosebleeds occur.

64. The air breathed through your mouth would be colder and drier because it has not been warmed up or moistened by your nasal cavity.

65. By breathing in expired air, you are breathing in carbon dioxide which will then increase the levels of carbon dioxide in the blood.

66. The surface tension of fluid coating the alveoli would cause them to collapse or close up.

67. The temperature increases because the tissues will be producing more ATP and therefore more heat. The blood pH will decrease because more carbon dioxide will be produced and it forms carbonic acid and then dissociates into hydrogen ion and bicarbonate ion.

68. Person B

69. Person C

70. All three of them, A, B, and C.

71. **a.** 8; **b.** 6; **c.** 9; **d.** 2; **e.** 7; **f.** 4; **g.** 10; **h.** 3; **i.** 5

72. **a.** Carbon dioxide levels will increase in the blood.

b. The smaller diameter will reduce the amount of exhaled carbon dioxide remaining in the tube, but this will also increase the resistance of airflow making the person work harder to breathe.

c. The further you go under water, the higher the water pressure. The higher water pressure prevents the lungs from inflating because the diaphragm is not strong enough to contract at such high pressures.

73. a. Tidal volume is about 500 mL and the vital capacity is 4500 mL.

b. 5 breaths per minute

c. The total lung capacity will be greater for the healthy individual than the smoker.

74. a. The intent is to expel the morsel of food.

b. The diaphragm is directly affected.

c. This procedure increases abdominal pressure and causes the diaphragm to elevate and forceful expiration to eject the piece of food out of the trachea and larynx.

d. The person should be given high levels of oxygen so that the cells in the body will continue to produce ATP needed for the heart to pump, the brain the function, etc.

75. a. Carbon monoxide would bind to the hemoglobin and therefore hemoglobin is unavailable to the oxygen. This causes the oxygen concentration to decrease even though the hemoglobin concentration and partial pressure of oxygen in the blood is normal.

b. The curve will shift to the left.

c. Carbon monoxide would bind to the hemoglobin and oxygen would not be transported to cells around the body. Without oxygen, the cells could not produce ATP and muscle cells like the heart would stop working.

76. At high partial pressures of oxygen, hemoglobin binds to oxygen to form oxyhemoglobin. When the blood is fully saturated, all the red blood cells are bound to oxygen molecules and are in the form of oxyhemoglobin. As oxygen level decreases, so does hemoglobin saturation. This occurs when red blood cells move to body tissues that have low level of oxygen. Oxyhemoglobin will release lots of oxygen molecules needed by active tissue cells and become haemoglobin.

77. You have a large reserve of oxygen. This means, your blood will have lots of hemoglobin to provide you when you become more active and require more oxygen.

78. a. in the tissues; **b.** in the lungs

79. a. The affinity of oxygen decreases and oxygen is released to the tissues.

b. The affinity of oxygen increases and oxygen is picked up by hemoglobin.

80. a. The curve will shift to the left.; **b.** The curve will shift to the right.; **c.** The curve will shift to the right.; **d.** The curve will shift to the left.; **e.** The curve will shift to the right.; **f.** The curve will shift to the left.; **g.** The curve will shift to the left.; **h.** The curve will shift to the right.; **i.** The curve will shift to the left.

81. a. The iron lung mimics the physiological action of breathing. When pressure decreases inside the lungs, this creates a partial vacuum. Air is forced into the lungs.

b. The iron lung would decrease the pressure inside the lungs, forcing air to flow into the lungs via the nose and mouth.

c. An air tight seal allows the chamber to be pressurized.

Chapter 12 Diagnostic Questions

1. c. neuro
2. a. cell
3. b. nervous tissues.
4. b sneezing
5. c. They are involuntary actions.
6. a. to get quick responses
7. c. energy is required.
8. a. a carrier protein.
9. c. spinal cord.
10. a. the skull.
11. a. brakes.
12. d. the vertebrae.
13. d. all of the above
14. c. the left side of the body.
15. a. paralysis.
16. b. amino acids.
17. a. threshold

b. An impulse at one point on a neuron will cause an impulse at the next point along the neuron.

c. Each time the dominoes fall, they always move at the same speed and intensity.

18. a. You would sneeze. **b.** You would blink. **c.** You would pull your hand back.

Chapter 12 Review Questions

1. d. muscles or glands that respond to stimuli.
2. b. a sensory neuron to a motor neuron.
3. a. a gland releasing a hormone
4. c. Myelin sheath - fatty protective layer covering the axon
5. a. nerve impulses will slow down or stop
6. d. stimulus → sensory neuron → interneuron → motor neuron → effector
7. b. I and III only
8. c. It allows quick response to environmental stimuli.
9. c. detects changes in the environment.
10. a. sodium gates open.
11. c. sodium ions are transported out of the axon and potassium ions into the axon.
12. a. the synaptic cleft.
13. c. structure 3
14. b. the dendrite of an interneuron
15. b. the dendrite
16. b. motor neuron
17. c. C
18. b. sodium-potassium pump
19. b. the gates on the sodium and potassium channels are closed
20. c. C

21. **d.** the action potential is in a brief reversal of polarity of the membrane potential.
22. **c.** potassium gates open and potassium ions flow out of the axon
23. **b.** start an action potential more often in a given time interval.
24. **c.** hyperpolarization.
25. **c.** the type of postsynaptic neurotransmitter receptors
26. **c.** depolarization
27. **c.** potassium ions.
28. **c.** active transport.
29. **b.** the refractory period.
30. **d.** presynaptic membrane to the postsynaptic membrane.
31. **b.** calcium ions
32. **d.** neurotransmitters
33. **a.** to break down acetylcholine
34. **d.** a neurotransmitter
35. **b.** hypothalamus
36. **a.** thalamus—smell
37. **d.** involuntary activity.
38. **d.** the motor neurons ending in the cardiac muscles
39. **a.** depolarization of an effector
40. **b.** involuntary.
41. **d.** increase intestinal activity.
42. **b.** inhibit urination.
43. **c.** hypothalamus
44. **d.** reticular activating system.
45. **a.** pons
46. **c.** Structure E
47. **b.** reasoning through a problem
48. **d.** hit a tennis ball with a smooth, coordinate swing.
49. **d.** Structure D
50. norepinephrine
51. A stimulus either produces an impulse or it won't produce an impulse. If a stimulus has adequate strength, it has reached a threshold and causes a neuron to transmit an impulse. If the stimulus is too weak, then the threshold will not produce an impulse.
52. A nerve impulse is generated in the sensory neuron and is carried to the spinal cord. The nerve impulse is passed on to the motor neuron which then causes the quadriceps femoris muscles in the leg to contract. This results in the knee jerk.
53. Advantages include: speed and less ATP is used due to fewer numbers of sodium-potassium pumps needed.
54. When a minimum threshold is reached, an action potential is triggered. Depolarization occurs causing sodium ion channels to open and sodium ions move into the axon. The membrane potential changes from negative to positive. Repolarization then occurs causing potassium ion channels to open and potassium ions move out of the axon. The membrane potential changes from positive to negative. During the refractory period, both potassium and sodium gates are closed and resting potential is restored.
55. A nerve impulse travels a lot faster along a myelinated axon than an unmyelinated axon.
56. **a.** 6; **b.** 6; **c.** 3; **d.** 2; **e.** 2; **f.** 6; **g.** 6; **h.** 4; **i.** 3; **j.** 6; **k.** 4; **l.** 4; **m.** 5
57. **a.** sympathetic nervous system; **b.** parasympathetic nervous system; **c.** sympathetic nervous system; **d.** sympathetic nervous system; **e.** sympathetic nervous system; **f.** parasympathetic nervous system; **g.** sympathetic nervous system; **h.** parasympathetic nervous system
58. The autonomic nervous system functions automatically and without conscious awareness. The ANS can either stimulate or inhibit effectors. The somatic nervous system controls conscious or voluntary regulation and stimulates skeletal muscles.
59. [CentreCIRCLE] Similarities between sympathetic and parasympathetic nervous systems: both are part of the peripheral nervous system and autonomic nervous system. Differences sympathetic and parasympathetic nervous systems: [LEFT CIRCLE: Sympathetic Nervous System] involved with stressful situations; "fight or flight" response; neurotransmitter = norepinephrine. [RIGHT CIRCLE: Parasympathetic Nervous System] involved with maintenance situations; "rest and digest" response; neurotransmitter = acetylcholine.]
60. hypothalamus
61. There is a conflict between the right side and left side of the brain. One side wants you to read the word, while the other side identifies the word and wants you to say the word you see, rather than the colour that you see.
62. receptors for acetylcholine
63. **a.** acetylcholine

    b. The levels of acetylcholine would increase as acetylcholine accumulates in the synapse.

    c. The build up of acetylcholine in the synapse would cause the muscles to continue contracting. Since there are no enzymes to break down acetylcholine, the nerve impulse would continue to fire.

    d. If exposed to nerve gases, the diaphragm would continue to contract and exhalation could not occur.
64. hypothalamus
65. Norepinephrine is released by the sympathetic nervous system.
66. Students will form their hypothesis.

Chapter 13 Diagnostic Questions

1. **c.** the bladder
2. **a.** to store urine
3. **c.** active transport
4. **d.** medulla oblongata
5. **a.** the concentration of H^+
6. **c.** the renal artery carries blood to the kidneys and the renal vein carries blood away from the kidneys
7. **d.** *nephro*
8. **a.** osmolarity.
9. **b.** amino acid metabolism.
10. **a.** urea

11. **a.** urination.
12. **c.** urethra.
13. **a.** inhibits urination.
14. **a.** at the back
15. **d.** antidiuretic hormone
16. **d.** contributes to the growth of hair and nail
17. Four excretory organs include the lungs, skin, kidneys, and the large intestine. Lungs excrete carbon dioxide and water vapour; Kidneys excrete nitrogenous waste, hydrogen ions, sodium ions, and water; Skin excretes sweat and salt; The large intestine excretes solid waste in the form of feces.
18. Two examples of diuretics are alcoholic drinks and caffeinated drinks.
19. One function of the kidneys is to filter blood.
20. Some of the waste might be toxic and can pose a threat to an individual.
21. The nervous system and the endocrine system affect the urinary system.
22. There would be a need for a huge number of mitochondria because the nephrons of the kidneys need ATP for active transport.
23. Reabsorption refers to removing the substance from the urine and keeping it in the body, while excretion refers to the removal of waste products in the urine.
24. Water passes through the kidney tubules by osmosis.
25. Formed elements like blood cells and proteins are too big to pass from the blood vessels into the tubules of the nephrons.
26. **1.** abdominal muscles; **2.** adrenal glands; **3.** kidney; **4.** renal artery; **5.** renal vein; **6.** inferior (posterior) vena cava; **7.** ureter; **8.** uterus; **9.** bladder; **10.** urethra
27. There are twice as much fluid found inside the cells than outside the cells.
28. The fluids are found in the tissue fluid, plasma, and lymph.
29. The lymphatic system.
30. The other fluids are the cerebrospinal fluid and synovial fluid.

Chapter 13 Review Questions

1. **a.** I and II only
2. **c.** the reabsorption of sodium.
3. **c.** stimulates urination in structure 6.
4. **d.** muscle contractions.
5. **c.** Structure 5 - reabsorption
6. **c.** Structure 7
7. **b.** glucose
8. **a.**
9. **b.** Glucose and amino acids are actively reabsorbed by carrier proteins.
10. **d.** Osmosis of water occurs at the descending limb and active transport of Na^+ and Cl^- occurs the ascending limb.
11. **d.** Structure 8
12. **c.** Structure 6
13. **d.** $NH_3 + H^+ \rightarrow NH_4^+$
14. **c.** descending limb of the loop of Henle and the collecting duct.
15. **b.** It will inhibit the secretion of ADH.
16. **d.** The posterior pituitary gland will secrete ADH which will cause water to be reabsorbed, increasing blood volume.
17. **c.** kidneys secrete renin → adrenal cortex secretes aldosterone → sodium is reabsorbed → water is reabsorbed → blood volume increases
18. **a.** the collecting duct to water.
19. **c.** The posterior pituitary gland will release ADH, which causes more water to be reabsorbed and less urine to form.
20. **d.** an increase in the release of aldosterone.
21. **b.** ADH regulates the concentration of urine by controlling the permeability of the CD to water.
22. **c.** II and III only
23. **b.** nephron of the kidneys
24. **c.** II and III only
25. **a.** collecting duct; **b.** loop of Henle; **c.** Bowman's capsule; **d.** distal convoluted tubule; **e.** collecting duct; **f.** proximal convoluted tubule; **g.** proximal convoluted tubule; **h.** proximal convoluted tubule; **i.** Bowman's capsule, PCT, DCT; **j.** distal convoluted tubule; **k.** Bowman's capsule; **l.** distal convoluted tubule; **m.** distal convoluted tubule; **n.** distal convoluted tubule; **o.** glomerulus
26. **a.** Nervous system: The parasympathetic and sympathetic nervous system control urine production and elimination.

    b. Digestive system: The kidneys make up for the loss of fluids by the digestive system.

    c. Endocrine system: The endocrine system influences the production of urine through the secretion of hormones.

    d. Lymphatic system: The kidneys regulate extracellular fluid composition and volume.

    e. Circulatory system: The kidneys control blood volume and blood pressure by regulating the reabsorption of water and salt.

    f. Respiratory system: The respiratory system and the urinary system regulate blood pH.

    g. Reproductive system: The urinary and reproductive system share organs in males.
27. **a.** yes; **b.** yes; **c.** yes; **d.** no; **e.** yes; **f.** yes; **g.** yes; **h.** yes; **i.** no; **j.** yes
28.

Part of Nephron	Active Transport	Diffusion and Osmosis
Proximal Convoluted Tubule	Na^+ Nutrients (glucose)	Water
Descending Limb of Loop of Henle		Water
Ascending Limb of Loop of Henle	Na^+, Cl^-, K^+	

Distal Convoluted Tubule	Na^+, Ca^{2+}	Water, Cl^-
Collecting Duct	Na^+, K^+, HCO^{3-}, Cl^-, H^+	Water

29.

	Aldosterone	**ADH**
Type of molecule	Hormone	Hormone
Origin	Adrenal gland	Hypothalamus
Where it works	Distal convoluted tubule	Distal convoluted tubule Collecting duct
Regulation	By blood pressure; renin and angiotensin	By osmotic pressure

30. renal artery → afferent arteriole → glomerulus → efferent arteriole → peritubular capillary network → renal venule → renal vein

31. The ascending limb of the loop of Henle is impermeable to water and the active transport of salt moves salt into the renal medulla. Urea leaks from the collecting duct into the renal medulla. Both of these events create a hypertonic environment which causes water to diffuse out of the descending limb of the loop of Henle and the collecting duct and return to the peritubular capillary network. As a result, urine is very concentrated with solutes and very little water.

32. The glomerular filtrate consists of water, nitrogenous wastes, glucose, amino acids and salts. The plasma contains all of these dissolved molecules as well, in addition to formed elements (eg. red blood cells, white blood cells and platelets) and plasma proteins which are too big to pass into the Bowman's capsule.

33. ADH is secreted by the posterior pituitary gland, which makes the collecting duct more permeable to water. Water is reabsorbed into the peritubular capillaries, which then results in an increase in blood volume and therefore an increase in blood pressure.

34. Aldosterone is secreted by the adrenal cortex, which makes the tubules more permeable to sodium ions. Sodium ions are reabsorbed into the peritubular capillaries by active transport, which then causes the reabsorption of water. This increases blood volume and therefore blood pressure.

35. A decrease in blood pressure triggers the posterior pituitary gland to secrete ADH. This causes the reabsorption of water, which then causes an increase in blood volume and blood pressure.

36. When the posterior pituitary gland secretes low levels of ADH, the DCT and CD are relatively impermeable to water. Therefore, water is not reabsorbed and ends up in the urine, resulting in dilute urine. When the posterior pituitary gland secretes high levels of ADH, the DCT and CD are highly permeable to water. Since water is reabsorbed, concentrated urine is excreted.

37. Renin is released by the juxtaglomerular apparatus when there is a decrease in blood pressure. Renin changes angiotensinogen, a plasma protein produced by the liver, into angiotensin I. Angiotensin I, a vasoconstrictor, promotes the release of aldosterone from the adrenal cortex. Aldosterone promotes the reabsorption of sodium ions, which leads to water reabsorption. This results in the increase in blood volume and blood pressure.

38. The reabsorption of sodium is by active transport. When sodium ions move actively back into the blood, chloride ions follow passively during tubular reabsorption at the proximal convoluted tubule.

39. When salt is actively moved out of the nephron at the ascending limb of the loop of Henle, this creates a hypertonic environment in the renal medulla. This results in water diffusing passively out of the descending limb of the loop of Henle and the collecting duct.

40. The posterior pituitary gland secretes ADH which promotes water reabsorption at the DCT. This leads to increased fluid volume. At the same time, the adrenal cortex secretes aldosterone which promotes increased sodium ion reabsorption in the tubules. This results in water reabsorption and increased fluid volume.

41. The pregnant woman has gestational diabetes because the liver and muscles are not storing glucose as glycogen. The kidneys cannot reabsorb all the glucose in the filtrate and therefore some of it is ending up in the urine.

42. The kidneys maintain acid-base balance by secreting hydrogen ions and reabsorbing bicarbonate ions.

43. Hydrogen ions combine with bicarbonate ions to form carbonic acid.

44. The term "urinary system" is more appropriate because metabolic wastes are removed (eg. hydrogen ions, drugs, excess water, etc.) in urine. The urinary system not only is involved in excreting substances, but also is involved in maintaining homeostasis by regulating water and acid-base balance. The term "excretory system" is not as appropriate because other systems in the body have excretory functions. For example, the respiratory system eliminates carbon dioxide, the digestive system gets rid of digestive wastes and the integumentary system removes excess water and salts.

45. Having a relatively long loop of Henle allows an animal to reabsorb as much water as possible in order to conserve water. The animal would need this adaptive advantage if it lives in a very arid environment where it needs to produce concentrated urine.

46. There would be kidney failure and no urine would be produced.

47. **1.** Angiotensin causes the efferent arteriole to constrict, which causes the blood pressure in the glomerulus to increase. **2.** Angiotensin stimulates the adrenal cortex to release aldosterone, which promotes the reabsorption of sodium. This in turn causes the reabsorption of water, which increases blood volume and blood pressure. **3.** Angiotensin stimulates thirst, which promotes water intake, which increases blood volume and blood pressure.

48. A caffeinated drink causes the osmoreceptors in the hypothalamus to inhibit the secretion of ADH. This results in the DCT and CD becoming less permeable to water, and water reabsorption is inhibited. This leads to a high volume of water being excreted, resulting in dehydration. The dehydration

contributes to symptoms similar to a hangover. To minimize these symptoms, drink lots of water.

49. Substance X is filterable at the glomerulus. If it was not, then it would have remained in the blood with the formed elements and plasma proteins.

50. The low salt diet would cause a decrease in blood volume and blood pressure. Without renin, angiotensin would not be produced to stimulate the release of aldosterone. Therefore, the kidneys would not reabsorb sodium and water and they will end up in the urine. Consequently, blood volume and blood pressure would not increase as needed.

51. About 9.95 g of sodium would be reabsorbed per day (e.g. less than 10g/day would be excreted).

52. The low pH is due to the hydrogen ions in the urine.

53. Glucose should be completely reabsorbed by the proximal convoluted tubule and proteins are too big to pass from the glomerulus into the Bowman's capsule.

54. The sodium hydroxide diffused from the solution in the beaker into the dialysis bag. In the presence of a base (NaOH), phenolphthalein turns bright pink. Sodium hydroxide is much smaller than phenolphthalein and that is why it moved and not phenolphthalein.

55. **a.** Increased aldosterone secretion would cause an increase in sodium reabsorption and an increase in potassium excretion. The levels of sodium would be too high and the levels of the potassium would be too low in the patient's body.

b. This would result in high blood pressure.

c. High levels of aldosterone would cause the person to be constantly thirsty and stimulate frequent urination.

56. Some things to consider: what are the other hidden costs that come with both options (eg. transportation to get to hospital visits; hydro cost at home to operate a dialysis machine; how long the wait list is for a kidney transplant; other hidden costs).

57. The drug would be excreted at the distal convoluted tubule.

58. Flowchart.

59. Water gain comes from the liquids we drink, the food we eat and as a by-product of metabolism. Water loss is due to excretion in the form of urine, sweat, exhaled air and feces.

60. Under normal conditions, the total water input is equal to the total water output so that the body maintains a constant volume.

61. Hydration results when water input is greater than water output. Dehydration results when water input is less than water output.

62. Homeostasis is maintained by antidiuretic hormone. It is produced by the hypothalamus, released by the posterior pituitary gland and acts on the collecting duct.

63. Substance Y is glucose.

64. Substance Z is urea.

65. **a.** isotonic; **b.** isotonic; **c.** hypertonic, **d.** hypotonic; **e.** hypertonic

66. The hypertonic environment in the tissues of the renal medulla of the kidneys draws the water out and it ends back up in the circulatory system.

Chapter 14 Diagnostic Questions

1. **a.** steroids.

2. **c.** gametes.

3. **a.** 23 chromosomes.

4. **b.** be haploid.

5. **b.** meiosis.

6. **a.** testis.

7. **a.** ovary.

8. **c.** 46 chromosomes.

9. **b.** once a month.

10. **c.** the foreskin on the penis.

11. **b.** menstruation

12. **b.** urethra

13. **a.** Her hips widen.

14. **a.** growth of facial hair.

15. **a.** after a woman gives birth

16. **b.** two X chromosomes.

17. **d.** one X chromosome and one Y chromosome.

18. **b.** 9 + 2 pattern of microtubules.

19. **b.** they reach menopause.

20. **c.** abstinence

21. **1.** bladder; **2.** urethra; **3.** seminal vesicles; **4.** ejaculatory duct **5.** prostate gland; **6.** Cowper's glands; **7.** vas deferens; **8.** epididymis; **9.** testis; **10.** scrotum; **11.** penis

22. **1.** oviduct; **2.** ovary; **3.** uterus; **4.** bladder; **5.** urethra; **6.** vagina

23. Some harmful substances include alcohol, drugs and cigarettes. The negative effects of these substances may include addiction, fetal alcohol syndrome, low birth weight, and being born prematurely.

24. Signs of pregnancy include missed period; enlargement of breasts; weight gain; morning sickness.

25. Yes, she can still get pregnant because she still has one ovary to release eggs every month.

26. No, a vasectomy prevents a man from ejaculating sperm in the semen.

Chapter 14 Review Questions

1. **d.** There is a greater chance that one sperm will reach and fertilize the egg.

2. **d.** The motility of the sperm would decrease

3. **d.** uterus – acts as a site of implantation of the embryo

4. **d.** allows the exchange of nutrient and waste between the mother and the fetus.

5. **b.**

6. **b.** Ovulation is marked by an increase in body temperature.

7. **a.** the shedding of the endometrium.

8. **c.** hormone 3

9. **c.** anterior pituitary gland.

10. **d.** prepare the uterus for the implantation of the fertilized egg.

11. **b.** the corpus luteum to secrete hormones 3 and 4.

12. **b.** hormones 3 and 4.

13. **c.** the secretion of large amounts of GnRH from the hypothalamus as a result of high levels of hormone 3.

14. **b.** prostaglandin and oxytocin

15. **b.** Hypothalamus releases GnRH → anterior pituitary gland secretes LH → LH stimulates interstitial cells to produce testosterone

16. **a.** the production of sperm cells

17. **c.** Progesterone secreted by the corpus luteum dominates during the secretory phase.

18. **d.** I, II and III

19. **d.** Follicular phase - FSH promotes the development of the follicle

20. **c.** the development of breasts during puberty.

21. **c.** structure 3.

22. **a.** Structure 4 - site where the sperm fertilizes the egg

23. **d** vagina.

24. **d.** human chorionic gonadotropin

25. **c.** structure 3.

26. **b.** hypothalamus, anterior pituitary gland and ovaries

27. **c.** anterior pituitary gland

28. **d.** structure 4

29. **d.** the thickening of the endometrium and widening of the pelvic girdle.

30. **a.** the follicle will not develop

31. **c.** X represents positive feedback that occurs during days 12 through 14, while Y represents negative feedback that occurs throughout most of the cycle.

32. **d.** it shuts down the anterior pituitary gland from producing LH and FSH so that no follicle will develop

33. **d.** birth control pills and contraceptive patch

34. **1.** bladder; **2.** ureter; **3.** seminal vesicles; **4.** prostate glands; **5.** Cowper's gland (bulbourethral glands); **6.** vas deferens; **7.** epididymis; **8.** testis; **9.** urethra; **10.** penis

35 **a.** structure 8 (testes); **b.** structure 7 (epididymis); **c.** structure 10 (penis); **d.** structure 8 (testes); **e.** structure 9 (urethra)

36. The placenta secretes progesterone and estrogen which inhibits the anterior pituitary gland so that no LH and FSH are secreted. This prevents follicles from developing in the ovaries during pregnancy. Progesterone and estrogen from the placenta also maintains the endometrium.

37. The sperm has a head where the nucleus, containing the 23 chromosomes, is located. The head is covered with an acrosome that has enzymes to penetrate the cell (plasma) membrane of the egg during fertilization. The sperm has a midpiece that has mitochondria to provide the sperm with ATP for swimming. The tail of the sperm, also known as the flagellum, allows it to move.

38. seminiferous tubules → epididymis → vas deferens → ejaculatory duct → urethra

39. The egg leaves the ovary and heads into the oviduct where it is usually fertilized by the sperm. The fertilized egg then moves to the uterus where it implants itself in the endometrium.

40. These three glands add secretions to semen: the prostate gland secretes a milky, alkaline fluid to help neutralize the acidic environment of the female vagina; the seminal vesicles produce fructose to provide energy for the sperm; the Cowper's glands (bulbourethral glands) produce viscous fluid that helps with lubrication.

41. Cells in the ovaries have receptor sites for FSH, while the cells in the uterus do not.

42. During the follicular phase (days 1 -13) of the ovarian cycle, primary oocytes in the ovaries begin to mature in a follicle. The surrounding follicular cells provide nutrients for the developing oocyte and produce estrogen. On day 14, ovulation occurs with the follicle rupturing and releasing the egg. During the luteal phase (days 15 -28), the corpus luteum forms and produces progesterone and estrogen. It degenerates if pregnancy does not occur.

43. A nursing baby suckling on the mother's nipple stimulates the secretion of prolactin and milk production. The more the baby suckles on the nipple, the more milk is produced.

44. The stretching of the cervix induces uterine contractions. This results in the release of oxytocin from the posterior pituitary gland. Through a positive feedback mechanism, oxytoxin stimulates strong uterine contractions during labour. Oxytocin is also secreted when a baby suckles on the mother's nipple during nursing. Oxytocin causes the "let-down" or secretion of milk.

45. The baby's head puts pressure on the cervix. This results in the hypothalamus producing oxytocin. Oxytocin is secreted by the posterior pituitary gland. Oxytocin along with prostaglandins, produced in the uterus, stimulates uterine contraction. This marks the onset of labour. Uterine contraction will occur at regular intervals during labour.

46.

Hormone	Source	Target	Action
Testosterone	Interstitial cells of the testes	Testes; muscles	Stimulates secondary sex characteristics
FSH	Anterior pituitary gland	Follicle in the ovary	Stimulates the follicle to develop
LH	Anterior pituitary gland	Follicle in the ovary	Causes ovulation during LH surge; causes formation and maintenance of corpus luteum
Estrogen	Developing follicle in the ovary	Lining of the uterus	Causes thickening of the uterine lining; inhibits FSH; stimulates LH
Progesterone	Corpus luteum in the ovary	Lining of the uterus	Causes thickening of the uterine lining; inhibits LH

47. age of the male, physical activity, genetic background

48. Diagram.

49. **1.** GnRH; **2.** LH; **3.** FSH; **4.** testosterone; **5.** inhibin

50. Women are most fertile around 30 because of the high levels of estrogen.

51. A decrease in estrogen and progesterone levels marks the onset of menopause

52. age 35–50

53. There is a huge gap between estrogen and progesterone levels.

54. The hormone levels permanently decrease.

55. The ovulation kit is designed to detect high levels of luteinizing hormone in the urine.

56. Ovulation is caused by the LH surge (increased levels of LH).

57. **1.** record their menstrual cycle; **2.** record the monthly basal temperature; **3.** observe changes in the cervical mucus

58. Ovulation kits should not be used as a contraceptive because it does not prevent the sperm from fertilizing the egg. It just tells you when you are probably ovulating by detecting the amount of LH in the blood. You can still get pregnant 24 hours after ovulation because the sperm can survive in the female reproductive tract for up to 48 hours.

59. Gonadotropins stimulate the release of LH and FSH. These hormones then cause the multiple follicles in the ovaries to be produced. Multiple eggs may be released from the ovaries at one time and this could lead to multiple births.

60. Effects may include: back pains because of the weight at the front; urge to urinate frequently because of the pressure on the urinary bladder; abdominal pains because of the stretching of the muscles and ligaments.

61. The infertility may be due to the Olympic athlete not having regular menstrual periods. Irregular menstrual periods may be due to low body weight and excessive exercise routines associated with training for the Olympics and stress.

GLOSSARY

A

acids substances that release hydrogen ions when they dissociate in water (2.3)

actin filaments component of the cytoskeleton that plays a role in the movements of the cell and its organelles as well as a structural role (3.3)

action potential electrochemical changes that take place across the axon membrane; the nerve impulse (12.2)

active site a small part of an enzyme that forms a complex with a substrate(s) (5.2)

active transport the movement of molecules or ions through the plasma membrane against their concentration gradient; requires an expenditure of energy (3.5)

acute bronchitis an inflammation of the primary and secondary bronchi (11.4)

adaptations certain features that make a species better suited to a new environment (1.1)

adaptive immunity an immune system that recognizes, responds to, and usually eliminates antigens from the body when innate defences have failed to prevent an infection (10.7)

adenine (A) one of four nitrogen-containing bases in nucleotides composing the structure of DNA and RNA; pairs with thymine in DNA and uracil in RNA (2.8)

ADP (adenosine diphosphate) a nucleotide that can accept another phosphate group and become ATP (2.8, 5.1)

aerobic a metabolic process that requires oxygen and gives off carbon dioxide; usually involves the complete breakdown of glucose (6.1)

aldosterone a hormone secreted by the adrenal cortex; promotes the excretion of potassium ions and the reabsorption of sodium ions (13.3)

alveoli (sing., **alveolus**) the air sacs or air pockets in the lungs (11.1)

Alzheimer's disease a disorder of the brain in which abnormal neurons are present throughout the brain but especially in the hippocampus and amygdala (12.5)

amino acid an organic molecule composed of an amino group and an acidic group (2.7)

ammonia a product of the breakdown of amino acids in the liver; extremely toxic (13.1)

amyotrophic lateral sclerosis an incurable condition that affects the motor nerve cells of the spinal cord (12.5)

anabolism the building up (synthesis) of molecules (5.1)

anaerobic a metabolic process that does not use oxygen (6.1)

anemia a condition that occurs when the body has an insufficient number of red blood cells or the red blood cells do not contain enough hemoglobin (10.2)

aneurysm the ballooning of a blood vessel, most often the abdominal aorta or the arteries leading to the brain (10.8)

angina pectoris occurs when a coronary artery becomes partially blocked; characterized by a squeezing or burning sensation in the chest (10.8)

angiogenesis formation of new blood vessels to increase blood supply to a growing tumour (4.4)

antibodies the secreted form of the receptor of the B cell that was activated due to the presence of an antigen (10.7)

antibody-mediated immunity specific mechanism of defence in which plasma cells derived from B cells produce antibodies that combine with antigens (10.7)

anticodon a triplet of three bases complementary to a codon of mRNA (4.3)

antidiuretic hormone (ADH) a hormone released by the posterior pituitary gland when the urine needs to be hypertonic to body fluids (13.3)

antigens any molecules, usually protein or carbohydrates, that stimulate an adaptive immune response (10.7)

antigen-presenting cells (APCs) cells that display an antigen to certain cells of the immune system so they can defend the body against that particular antigen (10.7)

anus the opening of the rectum where the expulsion of feces occurs (9.1)

aorta the largest artery in the human body that carries oxygen-rich blood from the heart to other parts of the body (10.1)

aortic bodies a group of cells located in the aorta that are sensitive to blood oxygen levels and influence respiration rate (11.2)

appendix a small projection from the cecum; plays a role in fighting infection (9.1)

aquaporins proteins embedded in the plasma membrane (13.3)

arteries types of blood vessel that carry blood away from the heart to the capillaries (10.1)

arterioles small arteries just visible to the naked eye (10.1)

asthma a disease of the bronchi and bronchioles that is marked by wheezing, breathlessness, and sometimes a cough and coughing up of mucus (11.4)

atherosclerosis an accumulation of soft masses of fatty materials, particularly cholesterol, beneath the inner linings of arteries (10.8)

atomic number the number of protons within the nucleus of an atom (2.1)

atoms the smallest parts of an element that display the properties of the element (2.1)

ATP (adenosine triphosphate) the common energy currency of cells; supplies energy for chemical work, transport work, and mechanical work by being converted to ADP plus a phosphate group (2.8, 5.1)

ATP synthase the complex of proteins in chloroplasts that produces ATP from the diffusion of hydrogen ions across a membrane (7.2)

atria (sing., **atrium**) the two upper, thin-walled chambers of the heart (10.3)

atrial natriuretic hormone (ANH) a hormone secreted by the atria of the heart when cardiac cells are stretched due to increased blood volume (13.3)

atrioventricular valves valves that lie between the atria and the ventricles in the heart (10.3)

autonomic system part of the peripheral nervous system that regulates the activity of cardiac and smooth muscle, and glands (12.4)

autotrophs photosynthetic organisms, such as plants, algae, and cyanobacteria, that produce their own food (7.1)

axon part of a neuron; conducts nerve impulses away from the cell body toward other neurons or effectors (12.1)

B

basal nuclei masses of grey matter located deep within the white matter that integrate motor commands (12.3)

bases substances that either take up hydrogen ions (H^+) or release hydroxide ions (OH^-) (2.3)

basophils granular leukocytes that release histamine and can cause inflammation (10.2)

B cells lymphocytes that remain in bone marrow until mature; also called B lymphocytes (10.6)

behaviour the movement of an organism, whether self-directed or in response to a stimulus, largely directed toward minimizing injury, acquiring food, and reproducing (1.1)

benign abnormal cell growth that is not cancerous and usually does not grow larger (4.4)

benign prostatic hyperplasia (BPH) enlargement of the prostate gland (14.4)

bicarbonate ion the form in which most of the carbon dioxide is carried in the plasma (11.3)

bile produced by the liver; contains bile salts that emulsify fat in the small intestine (9.2)

bioinformatics the application of computer technologies and statistical techniques to the study of biological information (4.7)

biology the scientific study of life (1.2)

biotechnology products produced by transgenic bacteria, plants, and animals (4.6)

bladder stones condition that causes inflammation of the bladder; may be caused by kidney stones, infections, or other conditions that restrict the flow of urine from the bladder (13.4)

blood fluid circulated by the heart through a closed system of vessels with transport, regulatory, and protective functions; a type of connective tissue (8.1, 10.2)

blood pressure a measurement of the force of blood pushing against the inside wall of blood vessels (10.4)

brain located in the cranial cavity of the skull; contains four major parts: the cerebrum, the diencephalon, the cerebellum, and the brain stem (12.3)

brain stem a portion of the brain that contains the midbrain, the pons, and the medulla oblongata (12.3)

bronchi (sing., **bronchus**) branch of the trachea that leads to the lungs (11.1)

bronchioles small tubes that conduct air from the bronchi to the alveoli (11.1)

buffer a substance that keeps pH within normal limits (2.3)

C

C_3 plants plants that fix carbon dioxide via the Calvin cycle; the first detectable molecule following fixation is a 3-carbon molecule (7.4)

C_4 plants plants that fix carbon dioxide to produce a 4-carbon molecule that releases carbon dioxide to the Calvin cycle (7.4)

calcitonin a hormone produced by the thyroid gland that helps control blood calcium levels (5.3)

calorie the amount of heat energy needed to raise the temperature of 1 g of water by 1°C (2.3)

Calvin cycle reactions (light-independent reactions) part of photosynthesis in which carbon dioxide is reduced to a carbohydrate (7.1)

CAM crassulacean acid metabolism; a form of photosynthesis in succulent plants that separates the light-dependent and Calvin reactions by time (7.4)

capillaries types of blood vessels that permit exchange of material with the tissues (10.1)

carbaminohemoglobin ($HbCO_2$) a compound formed when hemoglobin binds with carbon dioxide (11.3)

carbohydrates organic compounds that typically contain carbon, hydrogen, and oxygen; used for quick fuel and short-term energy storage in all organisms (2.5)

carbon dioxide fixation the first step of the Calvin cycle, in which carbon dioxide is attached to an organic compound (7.3)

carbonic anhydrase an enzyme present in red blood cells that speeds the breakdown of carbonic acid during external respiration (11.3)

cardiac cycle one complete cycle of systole and diastole for all heart chambers (10.3)

cardiac muscle a type of muscular tissue found only in the walls of the heart; movement is involuntary (8.1)

cardiac output the volume of blood that the left ventricle pumps per minute (10.3)

carotenoids pigments that give photosynthesizing cells a yellow to red colour (7.1)

carotid bodies a group of cells located in the carotid arteries that are sensitive to blood oxygen levels and influence respiration rate (11.2)

carrier proteins involved in the passage of molecules through a cell's membrane (3.4)

catabolism the breaking down of molecules (5.1)

cecum part of the large intestine just below the small intestine; has a small projection called the appendix (9.1)

cell the smallest unit of life; some organisms are single-celled (1.1)

cell body the part of a neuron that contains the nucleus, as well as other organelles (12.1)

cell-mediated immunity immunity mediated by helper T cells and cytotoxic T cells (10.7)

cell recognition proteins glycoproteins that help the body recognize when it is being invaded by pathogens so that an immune reaction can occur (3.4)

cell theory a basic theory of biology stating that (1) all organisms are made up of basic living units called cells, and (2) all cells come only from previously existing cells (3.1)

cellular respiration the process by which the chemical energy of carbohydrates is converted to that of ATP (3.2, 6.1)

cellulose a polysaccharide found in plant cell walls (2.5)

central nervous system (CNS) where sensory information is received and motor control is initiated; includes the spinal cord and the brain (12.3)

centrioles cell structures existing in pairs that occur in the centrosome (3.3)

centrosome the main microtubule organizing centre in most eukaryotic cells (3.3)

cerebellum a portion of the brain that coordinates skeletal muscles to produce smooth, graceful motions (12.3)

cerebral cortex a thin, highly convoluted outer layer of grey matter that covers the cerebral hemispheres (12.3)

cerebral hemispheres the two lobes of the cerebrum (12.3)

cerebrospinal fluid a fluid in between the meninges of the spinal cord and brain, which cushions and protects the central nervous system (12.3)

cerebrum largest portion of the brain; communicates with and coordinates the activities of the other parts of the brain (12.3)

cervix narrow end of the uterus, which leads into the vagina (14.2)

channel proteins units involved in the passage of molecules through a cell's membrane (3.4)

chemiosmosis the process by which mitochondria and chloroplasts use the energy of an electron transport chain to create a hydrogen ion gradient that drives ATP formation (6.4)

chlorophyll pigment that gives photosynthetic organisms a green colour (7.1)

chloroplasts eukaryotic membranous organelles that use solar energy to synthesize carbohydrates (3.2)

chromatin consists of DNA and associated proteins within a nucleus of a cell (3.2)

chromosomes highly condensed structures of coiled chromatin present when a cell is ready to undergo cell division (3.2)

chronic bronchitis occurs in bronchi that have undergone degenerative changes and are more susceptible to infection (11.4)

chyme a thick, soupy liquid food material that passes from the stomach to the small intestine (9.1)

cilia (sing., **cilium**) hairlike projections of a cell that are capable of movement (3.3)

circulatory system a type of organ system containing the heart and blood vessels; responsible for moving blood and substances throughout the body (8.2, 10.1)

circumcision surgical removal of the foreskin of the penis (14.1)

cirrhosis a chronic disease of the liver; commonly caused by frequent alcohol consumption (9.4)

citric acid cycle cyclical metabolic pathway in mitochondria resulting in the production of two ATP; also called the Krebs cycle (6.4)

clitoris organ of sexual arousal in a female (14.2)

cloning the production of identical copies of an organism through some asexual means (4.5)

clotting the process of blood coagulating when a blood vessel is damaged (10.2)

codon a triplet of nucleotides in mRNA that either codes for a particular amino acid or signals polypeptide termination (4.3)

coenzymes organic, nonprotein molecule helpers required by enzymes to function properly (5.2)

cofactors inorganic ion helpers required by enzymes to function properly (5.2)

collecting ducts carry urine to the renal pelvis (13.2)

colostrum thin, yellow, milky fluid produced during the early days of lactation; rich in protein and antibodies (14.3)

comparative genomics identifying similarities between the sequence of human bases and those of other organisms (4.7)

complementary base pairing hydrogen bonding between purines and pyrimidines in DNA (4.1)

compound the unit formed when atoms of two or more different elements bond together (2.2)

concentration gradient gradual change in chemical concentration between two areas of differing concentrations (3.5)

conclusion a statement made following an experiment as to whether or not the results support the hypothesis (1.2)

connective tissue a type of tissue that binds organs together, provides support and protection, fills spaces, produces blood cells, and stores fats (8.1)

constipation dry and hard feces (9.4)

control a group that goes through all the steps of an experiment but lacks the factor, or is not exposed to the factor, being tested; also called a control group (1.2)

control group a group that goes through all the steps of an experiment but lacks the factor, or is not exposed to the factor, being tested; also called the control (1.2)
corpus luteum a glandlike structure that produces progesterone (14.3)
coupled reactions reactions that occur at the same time; one is an exergonic reaction that releases energy, the other is an endergonic reaction that requires an input of energy (2.8)
covalent bond a bond in which atoms share electrons (2.2)
Cowper's glands male sex glands that secrete a mucus-rich fluid to help lubricate the penis and facilitate penetration during sexual intercourse (14.1)
cranial nerves nerves that arise from the brain (12.4)
cristae (sing., **crista**) the inner membrane of a mitochondrion folded inward on itself (3.2)
cyclic electron pathway an alternate form of the light-dependent reactions in photosynthesis that produces ATP but not NADPH (7.2)
cystic fibrosis a genetic lung disease caused by a defect in the CFTR gene; causes the mucus of the body to be viscous (11.4)
cystitis inflammation of the bladder (13.4)
cytokines chemical messengers that influence the activities of other immune cells (10.7)
cytoplasm a semi-fluid medium inside cells composed of water, salts, and dissolved organic molecules (3.2)
cytosine (C) one of four nitrogen-containing bases in nucleotides composing the structure of DNA and RNA; pairs with guanine (2.8)
cytoskeleton contains actin filaments, intermediate filaments, and microtubules, which maintains cell shape and allows its parts to move (3.3)
cytotoxic T cells types of T cells that recognize only antigen presented by various cell types with MHC class I proteins on their surface. (10.7)

D

data the results of an experiment; should be observable and objective, rather than subjective or based on opinion (1.2)
deductive reasoning using "if, then" logic to determine how to test a hypothesis (1.2)
dehydration reaction a reaction to build polymers in which the components of water are removed (2.4)
denatured describes a protein that has had an irreversible change in its shape; occurs when proteins are exposed to extremes in heat and pH (2.7, 5.2)
dendrites part of the neuron; extensions leading toward the cell body that receive signals from other neurons and send them on to the cell body (12.1)
dendritic cells present in tissues that are in contact with the environment; capture microbes and stimulate other white blood cells to defend the body (10.2)
dependent variable the result or change that occurs due to the experimental variable; also referred to as responding variable (1.2)
development in humans, all the changes that take place between conception and death; also includes repair that takes place following an injury (1.1)
diabetes mellitus a condition that affects a person's ability to regulate glucose metabolism (9.4)
diaphragm a dome-shaped muscle that separates the thoracic cavity from the abdominal cavity (11.1)
diarrhea loose, watery feces; can be acute or chronic (9.4)
diastole relaxation of the heart muscle (10.3)
diffusion the movement of molecules from a higher to a lower concentration until equilibrium is achieved (3.5)
digestive system a type of organ system including the mouth, esophagus, stomach, intestines, and associated organs; receives food and digests it into nutrient molecules (8.2, 9.1)
disaccharide a carbohydrate containing two monosaccharides that have joined during a dehydration reaction (2.5)
disease an abnormality in the body's normal processes that significantly impairs homeostasis (8.3)
distal convoluted tubule final portion of a nephron that joins with a collecting duct (13.2)
diuretics chemicals that increase the flow of urine (13.3)
DNA (deoxyribonucleic acid) a nucleic acid that stores genetic information in the cell and organism (2.8, 4.1)
DNA fingerprint a pattern of distinctive bands resulting from gel electrophoresis (4.5)
DNA ligase an enzyme used to seal the foreign piece of DNA into the vector DNA (4.5)
DNA replication the process of copying one DNA double helix into two identical double helices (4.2)
dorsal root ganglia structures that house the cell body of a sensory neuron (12.4)
double helix the structure of DNA resulting from two strands twisting about each other (2.8, 4.1)
ductus arteriosus structure of the heart associated with fetal circulation; provides a pathway for returning any blood that enters the right ventricle back to the aorta (10.5)
duodenum the first part of the small intestine, where chyme enters from the stomach (9.1)

E

electrocardiogram (ECG) a recording of the electrical changes that occur in the myocardium during a cardiac cycle (10.3)
electronegativity the attraction of an atom for the electrons in a covalent bond (2.2)
electrons negatively charged subatomic particles that move around the nucleus of an atom (2.1)
electron transport chain a series of carriers that pass electrons from one to the other, located in the cristae of mitochondria; the energy released is used to synthesize ATP (6.4)
elements substances that cannot be broken down to simpler substances with different properties by ordinary chemical means (2.1)
elongation second step of protein synthesis, in which a polypeptide increases in length one amino acid at a time (4.3)
emphysema a chronic and incurable disorder in which the alveoli are distended and their walls damaged so that the surface area available for gas exchange is reduced (11.4)
endergonic reactions reactions that require an input of energy to occur (5.1)
endocrine glands glands that secrete hormones into tissue fluid rather than use ducts (8.4)
endocrine system a type of organ system consisting of hormonal glands, which secrete hormones; helps coordinate body activities and maintains the functioning of the male and female reproductive organs (8.2, 8.4)
endocytosis a way substances can enter a cell; cells take in substances by vesicle formation (3.5)
endometriosis presence of endometrial-like tissue at locations outside the uterine cavity (14.4)
endometrium the lining of the uterus (14.2)
endoplasmic reticulum (ER) a complicated system of membranous channels and sacs (3.2)
energy the capacity to do work (1.1)
energy of activation (E_a) the energy that must be added to cause molecules to react with one another (5.2)
enzymatic proteins types of proteins that carry out metabolic reactions directly (3.4)
enzyme inhibition occurs when the substrate is unable to bind to the active site of an enzyme (5.2)
enzymes types of proteins that function as catalysts to speed up chemical reactions (2.7, 5.2)
eosinophils granular leukocytes that are thought to fight parasitic worms and are involved in some allergies (10.2)
epididymis the site where sperm produced by the testes mature (14.1)
epiglottis a flap of tissue that prevents food from passing into the larynx (11.1)
epithelial tissue tightly packed cells that form a continuous layer to cover body surfaces and line body cavities; also called epithelium (8.1)

erectile dysfunction (ED) the inability to produce or maintain an erection sufficient to perform sexual intercourse; also called impotence (14.4)
erythropoietin (EPO) a hormone secreted by the kidneys that stimulates red blood cell production (13.1)
esophagus a long muscular tube that is ordinarily collapsed but opens and receives the bolus when swallowing occurs (9.1)
estrogen female sex hormone that helps maintain sexual organs and secondary sex characteristics (14.3)
eukaryotic cells a type of cells that contain a nucleus and other organelles (3.2)
evolution a change in the frequency of traits that affect reproductive success in a population or species; a result of natural selection (1.1)
excretion the removal of metabolic wastes from the body (13.1)
exergonic reactions reactions that are spontaneous and release energy (5.1)
exocytosis a way substances can exit a cell; a vesicle fuses with the plasma membrane as secretion occurs (3.5)
exons portions of the gene that are ultimately expressed, resulting in a protein product (4.3)
experimental design the manner in which a scientist intends to conduct an experiment (1.2)
experimental group a group in an experiment that has the factor, or is exposed to the factor, being tested (1.2)
experimental variable a factor of the experiment being tested; also referred to as independent variable (1.2)
expiration passive phase of breathing in which air is expelled from the body (11.2)
external respiration the exchange of gases between air in the alveoli and blood in the pulmonary capillaries (11.3)

F

facilitated transport the act of a carrier assisting the passage of a molecule across the plasma membrane with no expenditure of energy (3.5)
FAD (flavin adenine dinucleotide) a coenzyme frequently used as an electron carrier during cellular respiration (6.1)
fats lipids that tend to be of animal origin and are solid at room temperature; energy storage molecules; e.g., lard, butter (2.6)
fatty acid a hydrocarbon chain that ends with the acidic group —COOH (2.6)
fermentation an anaerobic breakdown of glucose resulting in a gain of two ATP (6.3)
fibre indigestible plant material (9.1)
fibrin long thread-like structure involved in the process of blood clotting by providing a framework for the clot (10.2)
fimbriae (sing., **fimbria**) fingerlike projections on uterine tubes that sweep an oocyte into the tube (14.2)
flagella hairlike projections of a cell that are capable of movement (3.3)
fluid-mosaic model a mosaic pattern of proteins, steroids, and phospholipids embedded in the membrane of a cell (3.4)
follicle structure in the ovary that contains oocytes; site of oocyte production (14.3)
follicle-stimulating hormone (FSH) a hormone released by the anterior pituitary; in males it promotes the production of sperm; in females it promotes the development of the follicle in the ovary (14.1)
foramen ovale the flap dividing the left atrium from the right atrium of the heart (10.5)
formed elements the portion of blood that contains white blood cells, platelets, and red blood cells (10.2)
free energy the amount of energy available after a chemical reaction as occurred; also called ΔG (5.1)
functional genomics efforts to understand the function of the various genes discovered within each genomic sequence and how these genes interact (4.7)
functional groups specific combinations of bonded atoms attached to carbon groups that always react in the same way (2.4)

G

gall bladder an organ attached to the liver that serves to store and concentrate bile (9.2)
gallstones hardened form of bile that may block the bile ducts and cause pancreatitis (9.4)
gametes haploid sex cells that become united during fertilization (14.1)
ganglia (sing., **ganglion**) swellings associated with nerves that contain collections of cell bodies (12.4)
gene cloning the production of many identical copies of a single gene (4.5)
gene mutation a permanent change in the sequence of bases in DNA (4.4)
genes units that contain encoded information within each individual's DNA (1.1, 4.3)
gene therapy insertion of genetic material into human cells to treat genetic disorders and illnesses (4.6)
genetically modified organisms (GMOs) transgenic bacteria, plants, and animals (4.6)
genetic engineering cloning genes and using them to alter the genome of viruses and cells (4.5)
genetic profile using DNA microarrays to identify various mutations in a human's genome (4.7)
genome the complete genetic makeup of an organism (4.5)
genomics the study of the complete genetic sequences of humans and other organisms (4.7)
glands epithelial cells or groups of cells that are specialized to secrete a substance (8.1)
glomerular capsule a cuplike structure that is the initial portion of a nephron (13.2)
glomerulus a knot of capillaries inside the glomerular capsule (13.2)
glottis the slit between the vocal cords (11.1)
glucagon a hormone secreted by the pancreas, usually when the blood glucose level is low (9.2)
glucose a hexose sugar found in the blood (2.5)
glycogen a large storage form of glucose found in plants and animals (2.5)
glycolipids phospholipids with attached carbohydrate chains (3.4)
glycolysis the first phase of cellular respiration, where glucose is broken down into two pyruvate molecules (6.2)
glycoproteins proteins with attached carbohydrate chains (3.4)
Golgi apparatus the shipping centre of the cell that collects, sorts, packages, and distributes materials such as proteins and lipids; also known as Golgi body (3.2)
gonadotropin-releasing hormone (GnRH) a hormone that stimulates the anterior pituitary to secrete the gonadotropic hormones (14.1)
gout a painful ailment caused by too much uric acid in the blood, which forms crystals and precipitates out in the joints (13.1)
grana stacked structures of thylakoids (3.2)
grey matter a type of nervous tissue making up the central nervous system; contains neurons with short, nonmyelinated axons (12.1)
growth factors hormones that promote cell division and mitosis (8.4)
guanine (G) one of four nitrogen-containing bases in nucleotides composing the structure of DNA and RNA; pairs with cytosine (2.8)
Guillain-Barré syndrome an inflammatory disease that causes demyelination of peripheral nerve axons (12.5)

H

heart a muscular organ whose contractions cause blood to circulate through the body (10.3)
heart attack occurs when a coronary artery is completely blocked, causing a portion of the heart muscle to die due to lack of oxygen; also called a myocardial infarction (10.8)
helper T cells types of T cells with a receptor that recognize only antigen presented by specialized antigen-presenting cells with MHC class II proteins on their surface (10.7)
hemodialysis a treatment for kidney failure in which the patient's blood is passed through an artificial kidney machine (13.4)
hemoglobin (Hb) iron-containing respiratory pigment occurring in red blood cells (10.2, 11.3)
hemophilia a group of inherited clotting disorders caused by a deficiency in a clotting factor (10.2)
hepatitis inflammation of the liver (9.4)

heterotrophs consumers that must take in preformed organic molecules as a source of chemical energy for cellular work (7.1)

hexose a 6-carbon sugar (2.5)

histamine a chemical that binds to receptors present on endothelial cells lining blood vessels (10.7)

homeostasis the internal environment of an organism staying relatively constant (1.1, 3.4, 8.3)

hormones chemicals that affect the behaviour of other glands or tissues, which can be located far away from the sites of hormone production (8.4)

human chorionic gonadotropin (HCG) produced by the placenta, which maintains the corpus luteum in the ovary until the placenta begins its own production of progesterone and estrogen (14.3)

Human Genome Project (HGP) an initiative to determine and analyze the complete sequence of the human genome (4.7)

hydrogen bond a weak bond between hydrogen atoms and other atoms within the same molecule or between different molecules (2.2)

hydrolysis reaction a reaction to degrade polymers in which the components of water are added (2.4)

hydrophilic describes molecules that can attract water (2.3)

hydrophobic describes molecules that cannot attract water (2.3)

hypertension high blood pressure (10.8)

hypertonic solutions solutions with a higher percentage of solute than the cell; results in net movement of water from the inside to the outside of the cell (3.5)

hypothalamus an integrating centre that helps maintain homeostasis; regulates hunger, sleep, thirst, body temperature, and water balance; also controls the pituitary gland and thereby serves as a link between the nervous and endocrine systems (12.3, 14.1)

hypotonic solutions solutions with a lower concentration of solute than inside the cell; results in net movement of water from the outside to the inside of the cell (3.5)

I

ileum the region of the small intestine that connects the jejunum and large intestine (9.1)

immune system a type of organ system consisting of all the cells in the body that protect us from disease, especially those caused by infectious agents; includes lymphocytes (8.2, 10.7)

immunity a condition where the body is protected from various threats, like pathogens, toxins, and cancer cells (10.7)

immunoglobulins (Ig) antibodies that are typically Y-shaped molecules with two arms made of polypeptide chains (10.7)

independent variable a factor of the experiment being tested; also referred to as experimental variable (1.2)

induced fit model when the enzyme undergoes a slight change in shape in order to accommodate the substrate (5.2)

inductive reasoning using creative thinking to combine isolated facts into a cohesive whole (1.2)

infertility failure of a couple to achieve pregnancy after one year of regular, unprotected intercourse (14.4)

inflammatory response tissue response to injury that is characterized by redness, swelling, pain, and heat (10.7)

initiation first step of protein synthesis, in which all the translation components are brought together (4.3)

innate immunity an immune response that does not require a previous exposure to the pathogen (10.7)

inspiration the active phase of ventilation in which the diaphragm and the external intercostal muscles contract (11.2)

insulin the hormone released by the pancreas that lowers blood glucose levels by stimulating uptake of glucose by cells, especially muscle and liver cells (9.2)

integration the summing up of excitatory and inhibitory signals by a neuron (12.2)

integumentary system a type of organ system that includes skin, nails, hairs, muscles that move hairs, oil and sweat glands, blood vessels, and nerves leading to sensory receptors; protects the body, synthesizes sensory input, assists in temperature regulation, and synthesizes vitamin D (8.2)

intermediate filaments fibrous polypeptides that play a structural role within a cell (3.3)

internal respiration the exchange of gases between the blood in systemic capillaries and the tissue fluid (11.3)

interneuron a type of neuron that receives input from sensory neurons and other interneurons, and then communicates with motor neurons (12.1)

interstitial cells cells of the male reproductive system that secrete the androgens (such as testosterone) (14.1)

interstitial cell-stimulating hormone (ICSH) a hormone secreted by the anterior pituitary in males; promotes the production of sperm; also called luteinizing hormone (LH) (14.1)

introns segments of DNA that are not part of the gene (4.3)

ionic bond the attraction between negatively and positively charged ions (2.2)

ions particles that are negatively or positively charged due to an electron transfer between atoms (2.2)

isotonic solutions solutions in which the solute concentration and the water concentration both inside and outside the cell are equal (3.5)

isotopes atoms of the same element that differ in the number of neutrons (2.1)

J

jejunum the middle section of the small intestine, located between the duodenum and ileum (9.1)

K

kidneys paired organs of the urinary system that regulate the chemical composition of the blood and produce a waste product called urine (13.1)

kidney stones hard granules that can form in the renal pelvis (13.4)

L

lacteals the small lymphatic capillaries contained within a villus (9.1)

large intestine part of the digestive system; includes the cecum, colon, rectum, and anal canal (9.1)

laryngitis an inflammation of the larynx with accompanying hoarseness, often leading to the inability to talk in an audible voice (11.4)

larynx a cartilaginous structure that serves as a passageway for air between the pharynx and the trachea (11.1)

law a theory generally accepted by an overwhelming number of scientists; also referred to as a principle (1.2)

light reactions (light-dependent reactions) reactions in photosynthesis that release oxygen and provide molecules for the Calvin cycle (7.1)

lipase a pancreatic enzyme that digests fat molecules after they have been emulsified by bile salts (9.3)

lipids molecules that contain more energy per gram than other biological molecules; include fats and oils (2.6)

liver the largest gland in the body; produces urea and bile, detoxifies blood, stores glycogen, and produces the plasma proteins, among other functions (9.2)

loop of Henle portion of a nephron between the proximal and distal convoluted tubules (13.2)

lung cancer uncontrolled cell growth that affects any component of the respiratory system (11.4)

lungs paired, cone-shaped respiratory organs that occupy the thoracic cavity (11.1)

luteinizing hormone (LH) a hormone secreted by the anterior pituitary; in males it controls the production of testosterone by the interstitial cells; in females it promotes the development of the corpus luteum in the ovary; also called interstitial cell-stimulating hormone (ICSH) in males (14.1)

lymph tissue fluid contained within lymphatic vessels (10.2, 10.6)

lymphatic capillaries collect excess tissue fluid called lymph (10.2, 10.6)

lymphatic system a type of organ system consisting of lymphatic vessels, lymph nodes, and other lymphatic organs; transports lymphs and lipids, and aids the immune system (8.2, 10.6)

lymphatic vessels a one-way system that carries lymph (10.6)

lymph nodes masses of lymphatic tissue located along the course of a lymphatic vessel (10.6)

lymphocytes have two major types: B lymphocytes produce antibodies, T lymphocytes can either regulate the responses of other cells or can kill other cells (10.2, 10.6)

lymphoid organs organs that contain large number of lymphocytes; can be primary or secondary lymphoid organs (10.6)

lysosomes membrane-bound vesicles produced by the Golgi apparatus; contain hydrolytic digestive enzymes (3.2)

M

macrophages large phagocytic cells derived from monocytes that ingest microbes and debris (10.2)

malignant occurs when additional mutations cause abnormal cells to fail to respond to inhibiting signals that control the cell cycle, meaning they are cancerous and may spread (4.4)

maltase an enzyme secreted by the surface cells of the small intestine villi; completes the digestion of starch to glucose (9.3)

mass number the number of subatomic particles in an atom (2.1)

mast cells a type of immune cell found especially in the skin, lungs, and intestinal tract (10.7)

matrix the inner fluid-filled space of mitochondria (3.2)

matter anything that takes up space and has mass (2.1)

medulla oblongata part of the brain stem that regulates vital functions like heartbeat, breathing, and blood pressure; also contains reflex centres for vomiting, coughing, sneezing, hiccuping, and swallowing (12.3)

memory B cells form during a primary immune response but enter a resting phase until a secondary immune response occurs (10.7)

memory T cells form during an initial infection and respond rapidly during subsequent exposure to the same antigen (10.7)

meninges (sing., **meninx**) protective membranes wrapping around both the spinal cord and the brain (12.3)

meningitis an infection of the meninges that surround the brain and spinal cord (12.5)

menopause period in a woman's life during which the ovarian and uterine cycles cease (14.3)

menstruation periodic shedding of tissue and blood from the inner lining of the uterus (14.3)

messenger RNA (mRNA) carries genetic information from DNA to ribosomes for protein synthesis (4.3)

metabolic pathway a series of linked reactions that begin with a particular reactant and terminate with an end product (5.2)

metabolism the sum of all the chemical reactions that occur in a cell (5.1)

metastasis process in which cancer cells invade new tissues and form tumours (4.4)

MHC (major histocompatibility complex) protein a protein marker on the surface of a cell that helps T cells recognize an antigen (10.7)

midbrain part of the brain stem that acts as a relay station for tracts passing between the cerebrum and the spinal cord or cerebellum; also has reflex centres for visual, auditory, and tactile responses (12.3)

microtubules small, hollow cylinders made of tubulin (3.3)

mitochondria (sing., **mitochondrion**) eukaryotic membranous organelles that break down carbohydrates to produce ATP molecules (3.2)

model a representation of an actual subject in a scientific experiment (1.2)

molecule the unit formed when two or more atoms bond together (2.2)

monocytes agranular leukocytes that are the largest of the white blood cells; differentiate into phagocytic dendritic cells and macrophages (10.2)

monomer a simple organic molecule that exists individually or can link with other monomers (2.4)

monosaccharide a carbohydrate with a low number of carbon atoms; a simple sugar (2.5)

motor molecules proteins that can attach, detach, and reattach farther along actin filament (3.3)

motor neuron a type of neuron that takes messages away from the central nervous system to an effector such as an organ, muscle fibre, or gland (12.1)

mouth the organ of the digestive tract where food is chewed and mixed with saliva (9.1)

multiple sclerosis a brain disorder that affects the myelin sheath of neurons in the white matter of the brain (12.5)

muscular tissue composed of cells called muscle fibres that contain actin filaments and myosin filaments; three types of muscle tissue are skeletal, smooth, and cardiac (8.1)

musculoskeletal system a type of organ system consisting of bones and muscle; bones help hold and protect body parts and provide a place for skeletal muscle attachment; muscles help with functions of the body (8.2)

mutagens environmental influences causing mutations in humans (4.4)

myasthenia gravis an autoimmune disorder in which antibodies are formed that react against the acetylcholine receptor at the neuromuscular junction of the skeletal muscles (12.5)

myelin sheath a protective covering on axons (12.1)

N

NAD^+ (nicotinamide adenine dinucleotide) a coenzyme used as an electron carrier during cellular respiration (6.1)

$NADP^+$ (nicotinamide adenine dinucleotide phosphate) a coenzyme that carries hydrogen atoms from the light reactions to the Calvin cycle reactions (7.1)

natural killer (NK) cells large, granular, lymphocyte-like cells that kill some virus-infected and cancer cells by cell-to-cell contact (10.7)

natural selection the ability of individuals of a species that are better adapted to their environment to live longer and produce more offspring than other individuals (1.1)

negative feedback the primary homeostatic mechanism that keeps a variable close to a particular value, or set point (8.3)

nephrons microscopic kidney units made up of a glomerular capsule, the proximal convoluted tubule, the loop of Henle, the distal convoluted tubule, and the collecting duct (13.2)

nerve fibres axons that occur in nerves (12.4)

nerve impulse a type of impulse used by the nervous system to convey information (12.2)

nerves fibres bound by connective tissue; found outside the brain and spinal cord (8.1, 12.4)

nervous system a type of organ system consisting of the brain, spinal cord, and associated nerves; allows us to respond to external and internal stimuli (8.2, 12.1)

nervous tissue contains nerve cells called neurons; present in the brain and spinal cord (8.1)

neuroglia cells that support and nourish neurons, maintain homeostasis, form myelin, and may aid in signal transmission (12.1)

neuron a specialized cell that transmits nerve impulses between parts of the nervous system; contained within nervous tissue (8.1, 12.1)

neurotransmitters molecules that carry out communication between the two neurons at a chemical synapse (12.2)

neutrons uncharged subatomic particles located within the nucleus of an atom (2.1)

neutrophils granular leukocytes with a multilobed nucleus joined by nuclear threads; able to phagocytize and digest bacteria (10.2)

nodes of Ranvier gaps in the myelin sheath covering the axon (12.1)

noncyclic electron pathway light-dependent photosynthetic pathway that is used to generate ATP and NADPH; because the pathway is noncyclic, electrons must be replaced by the splitting of water (7.2)

nuclear envelope a double membrane separating the nucleus from the cytoplasm in a cell (3.2)
nuclear pores units that permit bidirectional transport of proteins and ribosomal subunits across the nuclear envelope (3.2)
nucleolus region of the nucleus where rRNA is produced and joins with proteins to form subunits of ribosomes (3.2)
nucleoplasm semifluid medium within a cell's nucleus (3.2)
nucleotide a molecular complex of three subunits: phosphate, a pentose sugar, and a nitrogen-containing base (2.8)
nucleus unit that stores DNA within a eukaryotic cell (3.2)

O

observations using the five senses or instruments to gather data about nature; the initial step of the scientific process (1.2)
oils lipids that tend to be of plant origin and are liquid at room temperature; energy storage molecules; e.g., corn oil, soybean oil (2.6)
oligodendrocytes a type of neuroglia that produce myelin in the central nervous system (12.1)
oocyte the female gamete; also called an egg (14.2)
oogenesis the production of an egg, the female gamete (14.2)
organ several tissues joined together to perform a common function (1.1)
organelle a well-defined subcellular structure that performs a particular function (3.2)
organic molecules units of life that always contain carbon (C) and hydrogen (H) (2.4)
organ system a group of organs that work together (1.1)
osmoregulation the maintenance of the appropriate balance of water and salt in the blood (13.1)
osmosis the diffusion of water across a selectively permeable membrane due to concentration differences (3.5)
osmotic pressure the pressure that develops in a system due to osmosis (3.5)
otitis media inflammation of the middle ear (11.4)
ovarian cancer form of cancer that affects the ovary; often difficult to diagnose due to a lack of symptoms (14.4)
ovarian cycle monthly changes occurring in the ovary that determine the level of sex hormones in the blood (14.3)
ovaries female sex organs that produce oocytes and sex hormones (14.2)
oviducts transport the oocyte (egg) from the ovary to the uterus; location of fertilization; also called the oviducts or fallopian tubes (14.2)
ovulation in females, the process by which an oocyte bursts from an ovary and usually enters an oviduct (14.2)
oxidizing agent a molecule that accepts electrons during a redox reaction (6.1)
oxyhemoglobin (HbO_2) compound formed when oxygen combines with hemoglobin (11.3)
oxytocin hormone released by the posterior pituitary that stimulates uterine contraction (14.3)

P

pacemaker referring to the sinoatrial node because it usually keeps the heartbeat regular (10.3)
pancreas a digestive organ with both endocrine and exocrine functions (9.2)
pancreatic amylase a pancreatic enzyme that digests starch (9.3)
pancreatic cancer a form of cancer that originates in the pancreas; one of the more fatal forms of cancer (9.4)
pancreatic islets clusters of at least three types of endocrine cells: alpha cells, beta cells, and delta cells (9.2)
pancreatitis an inflammation of the pancreas (9.4)
parasympathetic division division of the autonomic system that is active under normal conditions; uses acetylcholine as a neurotransmitter (12.4)
parathyroid glands glands embedded behind the thyroid gland; produce parathyroid hormones (5.3)
parathyroid hormone (PTH) hormone produced by the parathyroid glands; causes the blood phosphate level to decrease and the blood calcium level to increase (5.3)
Parkinson's disease a disorder of the brain in which the basal nuclei function improperly because of a degeneration of the neurons in the brain that release the neurotransmitter dopamine (12.5)
pathogens disease-causing agents such as viruses and bacteria (10.6)
penis the male organ of sexual intercourse (14.1)
pentose a 5-carbon sugar (2.5)
pepsin an enzyme that acts on proteins to produce peptides (9.3)
peptidases enzymes secreted by the surface cells of the small intestine villi; complete the digestion of protein to amino acids (9.3)
peptide bond a type of bond that joins amino acids together in a polypeptide (2.7)
peripheral nervous system (PNS) lies outside the central nervous system and is composed of nerves and ganglia (12.4)
peristalsis rhythmic muscular contractions that push food along the digestive tract (9.1)
peroxisomes membrane-bound vesicles that enclose enzymes (3.2)
phagocytes a type of white blood cells that destroy pathogens using phagocytosis (10.7)
phagocytosis a way to transport large substances, such as viruses, into cells (3.5)
pharyngitis an inflammation of the throat usually because of an infection (11.4)
pharynx a funnel-shaped passageway that connects the nasal and oral cavities to the larynx (9.1, 11.1)
phenomena observable natural events or facts (1.2)
phospholipids fatty acids that contain a phosphate group (2.6)
photosynthesis a process that uses solar energy to reduce carbon dioxide to carbohydrates (3.2, 7.1)
photosystem a system consisting of a pigment complex (molecules of chlorophyll *a*, chlorophyll *b*, and the carotenoids) and an electron acceptor within the thylakoid membrane (7.2)
pH scale indicates the acidity or basicity (alkalinity) of solutions; ranges from 0 to 14 (2.3)
pineal gland a gland in the third ventricle of the brain that produces melatonin (12.3)
pinocytosis a way to transport small substances, such as macromolecules, into cells (3.5)
pituitary gland small gland that lies just inferior to the hypothalamus; consists of the anterior and posterior pituitary, both of which produce hormones (14.1)
placenta an organ that functions in gas, nutrient, and waste exchange between the embryonic (later fetal) and maternal circulatory systems (10.5, 14.3)
plasma a component of blood making up about 55 percent of the volume and containing a variety of inorganic and organic substances dissolved or suspended in water (8.1, 10.2)
plasma cells cells that are specialized for the secretion of antibodies (10.7)
plasma membrane a living boundary that separates the living contents of the cell from the surrounding environment (3.2)
plasmids small accessory rings of DNA from bacteria that are not part of the bacterial chromosome and are capable of self-replicating (4.5)
platelets a component of blood; fragments of large cells present only in bone marrow, involved in the process of clotting (8.1, 10.2)
pneumonia an infection of the lungs in which the bronchi or alveoli fill with thick fluid (11.4)
polymer monomers linked together (2.4)
polymerase chain reaction (PCR) creates billions of copies of a segment of DNA (4.5)
polypeptide a chain of amino acids that are joined to one another by a peptide bond (2.7)
polyps small growths arising from the epithelial lining (9.4)
polyribosomes several ribosomes associated simultaneously with a single mRNA molecule (3.2)
polysaccharides long polymers that contain many glucose subunits; e.g., starch, glycogen, cellulose (2.5)

pons part of the brain stem that contains bundles of axons travelling between the cerebellum and the rest of the central nervous system; functions with the medulla oblongata to regulate the breathing rate (12.3)

portal system a pathway of blood flow that begins and ends in capillaries (10.4)

positive feedback a homeostatic mechanism that brings about an ever greater change in the same direction (8.3)

posterior pituitary portion of the pituitary gland that stores and secretes oxytocin and antidiuretic hormone produced by the hypothalamus (13.3)

prediction the step in the scientific process that follows the formulation of a hypothesis and assists in creating the experimental design (1.2)

preparatory (prep) reaction a reaction that produces the molecule that can enter the citric acid cycle (6.4)

pressure filtration part of urine formation; occurs when whole blood enters the afferent arteriole and the glomerulus (13.2)

primary lymphoid organs organs where lymphocytes develop and mature; includes red bone marrow and thymus (10.6)

principle a theory generally accepted by an overwhelming number of scientists; also referred to as a law (1.2)

prions infectious agents that are responsible for several brain diseases of humans and animals (12.5)

products in a chemical reaction, the substances that form as a result of a reaction (5.1)

progesterone female sex hormone that helps maintain sexual organs and secondary sex characteristics (14.3)

prolactin a hormone secreted by the pituitary needed for lactation to begin (14.3)

promoter a region of DNA that contains a special sequence of nucleotides (4.3)

prostate cancer cancer of the prostate gland (14.4)

prostate gland a gland that produces a slightly basic secretion to help buffer the acidic environment of the vagina (14.1)

proteins polymers composed of amino acid monomers (2.7)

proteomics the study of the structure, function, and interaction of cellular proteins (4.7)

protons positively charged subatomic particles located in the nucleus of an atom (2.1)

proximal convoluted tubule portion of a nephron following the glomerular capsule where tubular reabsorption of filtrate occurs (13.2)

pulmonary arteries blood vessels that transport oxygen-poor blood from the heart to the lungs (10.3)

pulmonary circuit part of the circulatory system that circulates blood through the lungs (10.4)

pulmonary fibrosis a disease restricting the ability of the lungs to expand during inhalation, reducing vital capacity and other lung volumes (11.4)

pulmonary tuberculosis a bacterial infection that invades the lung tissue (11.4)

pulmonary veins blood vessels that transport oxygen-rich blood from the lungs to the heart (10.3)

pulse a wave effect that passes down the walls of arteries when the aorta expands and then recoils with each ventricular contraction; the arterial pulse can be used to determine heart rate (10.3)

purines nucleotides with a double-ring structure; e.g., adenine, guanine (4.1)

pyelonephritis infection of the kidneys (13.4)

pyramidines nucleotides with a single-ring structure; e.g., thymine, cytosine (4.1)

R

radioactive isotopes isotopes that decay and release various types of energy in the form of rays and subatomic particles (2.1)

reactants in a chemical reaction, the substances that participate in a reaction (5.1)

receptor-mediated endocytosis a form of pinocytosis that uses a receptor protein shaped so a specific molecule can bind to it (3.5)

receptor proteins types of proteins that allow a specific molecule to bind to them and change their shape to bring about a cellular response (3.4)

recombinant DNA (rDNA) contains DNA from two or more different sources (4.5)

red blood cells a component of blood that transports oxygen; small, biconcave, disk-shaped cells without nuclei; also called erythrocytes (8.1, 10.2)

red bone marrow a primary lymphoid organ where lymphocytes begin their development; contains a network of connective tissue fibres, along with stem cells that are able to divide and produce blood cells (10.6)

reduced hemoglobin (HHb) a compound formed when the globin portion of hemoglobin combines with excess hydrogen ions (11.3)

reducing agent a molecule that donates its electrons during a redox reaction (6.1)

reflex actions automatic responses to a stimulus (12.4)

refractory period in nonmyelinated axons, a period in which sodium gates are unable to open following an action potential (12.2)

renin an enzyme that changes angiotensinogen into angiotensin (13.3)

repeatable describes an experiment for which any scientist can repeat the experiment and get the same results (1.2)

reproduction the act of an organism making more of itself (1.1)

reproductive system a type of organ system differing in males and females; in males it consists of the testes, other glands, and various ducts that conduct semen to and through the penis; in females it consists of the ovaries, oviducts, uterus, vagina, and external genitals (8.2, 14.1)

respiratory centre located in the medulla oblongata of the brain; controls the rhythm of ventilation (11.2)

respiratory system a type of organ system consisting of the lungs and tubes that take air to and from them; brings oxygen into the body and removes carbon dioxide, restoring pH (8.2, 11.1)

responding variable the result or change that occurs due to the experimental variable; also referred to as dependent variable (1.2)

resting potential the membrane potential of an inactive neuron (12.2)

restriction enzyme cleaves vector DNA in order to introduce foreign DNA into it (4.5)

reticular activating system (RAS) the area of the brain that contains the reticular formation; acts as a relay for information to and from the peripheral nervous system and higher processing centres of the brain (12.3)

ribosomal RNAs (rRNAs) structural form of RNA found in the ribosomes (4.3)

ribosomes responsible for the synthesis of proteins using mRNA as a template; composed of two subunits (3.2)

RNA (ribonucleic acid) a type of nucleic acid, including messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA) (2.8, 4.3)

RNA polymerase an enzyme that binds tightly to a promoter during transcription (4.3)

RuBP carboxylase an enzyme that speeds up carbon dioxide fixation in the Calvin cycle (7.3)

S

salivary amylase an enzyme in saliva that digests starch to maltose (9.3)

salivary glands glands that produce saliva to keep the mouth moist and to begin the process of digesting starch (9.1)

saltatory conduction occurs in myelinated axons when the action potential "jumps" from node to node (12.2)

sample size the number of organisms or objects being studied or tested in an experiment (1.2)

saturated fatty acid a fatty acid that has no double covalent bonds between carbon atoms; holds all possible hydrogens (2.6)

Schwann cells a type of neuroglia that form a myelin sheath around axons in the peripheral nervous system (12.1)

scientific method the process by which scientists formulate a hypothesis, gather data by observation and experimentation, and come to a conclusion (1.2)

scientific theories concepts that join together well-supported and related hypotheses (1.2)
scrotum a saclike structure outside the abdominal cavity of a male that houses the testes (14.1)
secondary lymphoid organs organs in which some lymphocytes become activated; includes lymph nodes and spleen (10.6)
secretion the act of secretory vesicles discharging their contents across the plasma membrane (3.2)
selective reabsorption part of urine formation; occurs as molecules and ions are both passively and actively reabsorbed from the nephron into the blood of the peritubular capillary network (13.2)
selectively permeable a membrane that allows certain substances to move across it but not others (3.5)
semen combination of sperm and seminal fluid (14.1)
semilunar valves the two valves between the ventricles and their attached vessels (10.3)
seminal fluid nutrient-rich fluid in which sperm leave the penis (14.1)
seminal vesicles paired glands that lie at the base of the bladder, each with a duct that joins with a vas deferens (14.1)
seminiferous tubules long, coiled structures contained within chambers of the testis where sperm are produced (14.1)
sensory neuron a type of neuron that takes messages to the central nervous system (12.1)
Sertoli cells cells that support, nourish, and regulate the spermatogenic cells (14.1)
short tandem repeat (STR) a type of DNA profiling used to amplify target sequences of DNA (4.5)
sinusitis an inflammation of the cranial sinuses (11.4)
skeletal muscle a type of muscular tissue usually attached by tendons to the bones of the skeleton; contracted by voluntary control (8.1)
small intestine the portion of the digestive tract that precedes the large intestine; consists of the duodenum, jejunum, and ileum (9.1)
smooth muscle a type of muscular tissue found in the walls of viscera and blood vessels; under involuntary control (8.1)
sodium-potassium pump a carrier protein that moves sodium ions to the outside of a cell and potassium ions to the inside; especially in nerve and muscle cells (3.5, 12.2)
solutes the dissolved substances contained in a solution (2.3, 3.5)
solvent part of a solution, usually a liquid, that contains solutes (3.5)
somatic system a subdivision of the peripheral nervous system that serves the skin, skeletal muscles, and tendons (12.4)
somatostatin a growth hormone inhibiting hormone produced by the pancreas, and cells in the stomach and small intestine (9.2)
sperm male gamete having a haploid number of chromosomes and the ability to fertilize an egg, the female gamete (14.1)
spermatogenesis the production of sperm in males (14.1)
spinal cord the nerve cord that is continuous with the base of the brain and housed within the vertebral column (12.3)
spinal nerves nerves that arise from the spinal cord (12.4)
spleen a secondary lymphoid organ that removes old and defective blood cells, as well as reacts to foreign invaders (10.6)
starch a large storage form of glucose found in plants and animals (2.5)
stem cells cells that are ever capable of dividing and producing new cells that go on to differentiate into particular types of cells (10.2)
steroids type of lipids that have a backbone of four fused carbon rings; e.g., cholesterol (2.6)
stomach an organ that receives food from the esophagus, starts the digestion of proteins, and moves food into the small intestine (9.1)
stomach ulcers open sores in the stomach wall caused by a gradual disintegration of tissue (9.4)
stomata (sing., **stoma**) small openings in a leaf in which carbon dioxide enters (7.1)
stroke a cerebrovascular accident resulting when an arteriole in the brain bursts or is blocked by an embolus (10.8, 12.5)
stroma a fluid-filled space within a chloroplast (3.2)
substrate-level ATP synthesis a process in which ATP is formed by transferring a phosphate from a metabolic substrate to ADP (6.2)
substrates reactants in an enzymatic reaction (5.2)
sympathetic division division of the autonomic system that is active when an organism is under stress; activates the adrenal medulla to secrete the hormones epinephrine and norepinephrine (12.4)
synapse the region of close proximity between an axon terminal and the dendrite or cell body of another neuron or muscle cell (12.2)
synaptic cleft a tiny gap separating two neurons at a synapse (12.2)
systemic circuit part of the circulatory system that circulates blood to body tissues (10.4)
systole contraction of the heart muscle (10.3)

T

T cells lymphocytes that migrate from bone marrow to the thymus where they mature and differentiate (10.6)
telomeres sequences at the ends of chromosomes that keep them from fusing with each other (4.4)
termination third and final step of protein synthesis, in which the polypeptide and the assembled components that carried out protein synthesis are separated from one another (4.3)
testable hypothesis a tentative explanation for a natural event (1.2)
testes (sing., **testis**) part of the male reproductive system; produce sperm and sex hormones (14.1)
testicular cancer one of several forms of cancer that affect the testes of males; usually characterized by abnormal tenderness or lumps in one of the testicles (14.4)
testosterone main sex hormone in males that helps maintain sexual organs and secondary sex characteristics (14.1)
thalamus two masses of grey matter that receive all sensory input except for smell (12.3)
thrombin converted plasma protein that acts as an enzyme during the process of blood clotting (10.2)
thymine (T) one of four nitrogen-containing bases in nucleotides composing the structure of DNA; pairs with adenine (2.8)
thymus a primary lymphoid organ that secretes the hormone thymosins, which aids in the differentiation of T cells (10.6)
thyroid gland a large gland in the neck that produces several important hormones, including triiodothyronine, thyroxine, and calcitonin (5.3)
thyroxine (T_4) a hormone produced by the thyroid gland that increases metabolic rate (5.3)
tissue a group of similarly specialized cells that work together to perform the same function (1.1, 8.1)
tissue fluid the fluid between the body's cells; also called interstitial fluid (10.2)
tonsillitis occurs when the tonsils become inflamed and enlarged (11.4)
trachea a tube connecting the larynx to the primary bronchi, commonly called the windpipe (11.1)
tracts bundles of myelinated axons in white matter in the central nervous system (12.1)
transcription the first stage of gene expression; process in which a portion of DNA serves as a template for mRNA formation (4.3)
trans-fats fatty acids that are often produced by hydrogenation (2.6)
transfer RNA (tRNA) molecules that bring amino acids to the ribosomes, the site of protein synthesis (4.3)
transgenic organisms organisms with foreign DNA or genes inserted into them (4.5)
translation during gene expression, the process in which the sequence of mRNA bases determines the sequence of amino acids in a polypeptide (4.3)

transposons specific DNA sequences that are able to move within and between chromosomes (4.4)

triglyceride a fat molecule made up of a three-part structure; typically involved in energy storage (2.6)

triiodothyronine (T_3) a hormone produced by the thyroid gland that increases metabolic rate (5.3)

trypsin a pancreatic enzyme that digests protein (9.3)

tubular excretion part of urine formation; a way by which substances are removed from blood in the peritubular network and added to the tubular fluid (13.2)

U

unsaturated fatty acids fatty acids that have double bonds between carbon atoms; hold less than the total possible number of hydrogens (2.6)

uracil (U) one of four nitrogen-containing bases in nucleotides composing the structure of RNA; pairs with adenine (2.8)

urea a by-product of amino acid metabolism (13.1)

ureters small, muscular tubes that conduct urine from the kidneys to the bladder (13.1)

urethra a small tube that extends from the urinary bladder to an external opening that removes urine from the body; in the male reproductive system, it connects to the ejaculatory ducts (13.1, 14.1)

uric acid produced by the breakdown of nucleotides (13.1)

urinary bladder part of the urinary system that stores urine until it is expelled from the body (13.1)

urinary system a type of organ system containing the kidneys, the urinary bladder, and the tubes that carry urine; eliminates metabolic wastes from the body and helps regulate the fluid balance and pH of the blood (8.2, 13.1)

urine liquid waste produced by the kidneys and excreted from the body (13.1)

uterus a thick-walled, muscular organ in which an embryo develops and is nourished before birth (14.2)

V

vacuole a large membranous sac found within cells that stores substances (3.2)

vagina component of the female reproduction system that serves as the birth canal; receives the penis during sexual intercourse (14.2)

vas deferens storage location for mature sperm before they pass into the ejaculatory duct (14.1)

vector a piece of DNA that can be manipulated such that foreign DNA can be added to it (4.5)

veins types of blood vessels that return blood from the capillaries to the heart (10.1)

venae cavae the largest veins; include the superior vena cava and the inferior vena cava, both of which deliver oxygen-poor blood into the heart (10.1)

ventilation another term for breathing; encompasses both inspiration and expiration (11.1)

ventricles (brain) hollow interconnecting cavities in the brain; produce and serve as a reservoir for cerebrospinal fluid (12.3)

ventricles (heart) the two lower, thick-walled chambers of the heart (10.3)

venules small veins that drain blood from the capillaries and then join to form a vein (10.1)

verniform appendix a small projection from the cecum (9.1)

vesicles tiny membranous sacs within the endomembrane system of a cell (3.2)

villi (sing., **villus**) fingerlike projections of the inner small intestinal wall (9.1)

vitamins relatively small organic molecules that are required in trace amounts in diets for synthesis of coenzymes that affect health and physical fitness (5.2)

vocal cords mucosal folds supported by elastic ligaments, housed within the larynx (11.1)

vulva external genital organs of the female (14.2)

W

white blood cells components of blood that fight infection; larger than red blood cells, contain a nucleus, and lack hemoglobin; also called leukocytes (8.1, 10.2)

white matter a type of nervous tissue making up the central nervous system; contains myelinated axons that run together in bundles called tracts (12.1)

Z

zygote cell formed by the union of two gametes; the product of fertilization (14.2)

INDEX

D

H

I

J

K

L

M

N

O

P

Q

R