Answer Key

Unit 4  Animals: Structure and Function

Unit Preparation Questions (Assessing Readiness)
(Student textbook pages 396–9)

1. absorption, digestion, respiration, biosynthesis, excretion, egestion, secretion, movement, irritability, homeostasis, and reproduction

2. c

3. Students may suggest osmosis or diffusion. Some students may also suggest active transport (endocytosis, exocytosis). All of these answers are acceptable.

4. d

5. $6\text{CO}_2$, $6\text{H}_2\text{O}$

6. A is the cell membrane, which separates the inside of the cell from the environment within the body, and controls the flow of materials into and out of the cell. B is the cytoplasm, which includes the cytosol, organelles, and other life-supporting materials. C is a mitochondrion, from which energy is released from glucose to fuel cell activities.

7. e

8. a. Both processes move molecules across the cell membrane.
   b. Osmosis is the process whereby water moves through the cell membrane so that the numbers of water molecules on the inside and outside of a cell are the same. Diffusion is the movement of molecules from areas where there are higher concentrations of molecules to areas where there are lower concentrations of molecules.
   Sample answer:

9. Sweating is an example of osmosis. The gas exchange in our lungs is an example of diffusion.

10. a. A sperm cell requires the most food energy, because the sperm tail moves back and forth like a whip.
    b. Skin cells have the least number of mitochondria of the three types because they require the least amount of energy. Skin cell functions do not include movement, whereas muscle cells must provide energy for muscles to contract and relax.

11. e

12. In multicellular organisms, cell division is needed for tissue and organ growth, and to repair and replace cells in the organism.

13. Answers should include three of: blood cells, skin cells, muscle cell, nerve cell, bone cell

14.

15. a. D
    b. B
    c. C
    d. A

16. e

17. b

18. a

19. b

20. a. and b.
   Sample answer:

   Organ (heart)
   ---
   Tissue (cardiac muscle)
   ---
   Cell (cardiac muscle cell)
21. b

22. a. and b.

Answers should include any three of the following life functions, and the organs or systems associated with them.

<table>
<thead>
<tr>
<th>Organ or System Responsible</th>
<th>Life Function(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circulatory system</td>
<td>• transports blood, nutrients, gases, and wastes</td>
</tr>
<tr>
<td>Digestive system</td>
<td>• takes in food and breaks it down</td>
</tr>
<tr>
<td></td>
<td>• absorbs nutrients</td>
</tr>
<tr>
<td></td>
<td>• removes solid waste from body</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>• controls breathing</td>
</tr>
<tr>
<td></td>
<td>• exchanges gases in lungs</td>
</tr>
<tr>
<td>Excretory system</td>
<td>• removes liquid wastes from body</td>
</tr>
<tr>
<td>Immune system</td>
<td>• defends the body against infections</td>
</tr>
<tr>
<td>Muscular system</td>
<td>• works with the bones to move body parts</td>
</tr>
<tr>
<td>Endocrine system</td>
<td>• produces and releases hormones to keep body systems in balance</td>
</tr>
<tr>
<td>Reproductive system</td>
<td>• includes reproductive organs to produce offspring</td>
</tr>
<tr>
<td>Integumentary system</td>
<td>• includes skin, hair, and nails</td>
</tr>
<tr>
<td></td>
<td>• creates waterproof barrier around body</td>
</tr>
<tr>
<td>Nervous system</td>
<td>• detects changes in environment and signals changes to the body, which then responds</td>
</tr>
<tr>
<td>Skeletal system</td>
<td>• supports, protects, and works with muscles to move body parts</td>
</tr>
</tbody>
</table>

c. Students should be able to identify the corresponding organelles of an animal cell that carry out the same life function(s).

23. circulatory, digestive, respiratory, excretory, lymphatic, muscular, endocrine, reproductive, integumentary, nervous, skeletal

24. a

25. In the duodenum—where most digestion takes place—villi and microvilli maximize the surface area and are in close contact with blood to permit transfer of nutrients.

26. a. Examples include the nervous system and muscular system, or the digestive system and circulatory system, or the circulatory system and respiratory system.

b. Sample answer: The nervous system controls the body and directs the muscular system, which brings about movement.

27. The human digestive system is arranged vertically through the centre of the body. This way food can enter at the top of the system, with digestion taking place in the middle where nutrients are distributed, and then waste is expelled at the lower end of the system.

28. c

29. It was discovered that viruses, bacteria, and microscopic organisms cause diseases. This discovery was only possible because the microscope allowed scientists to study “germs”.

30. Improvements to images include:
   - The magnification of microscopes and the resolution of images have increased over time.
   - Colour and three-dimensional images of living and non-living specimens can be produced.
   - The introduction of staining techniques makes it easier to observe the details of an image.
   - Even molecules are now visible with the use of the scanning tunneling microscope.

Benefits to cell biology include:
   - Sub-cellular components have been identified.
   - Their structures and functions have been revealed.

31. a. Both imaging technologies transmit electromagnetic radiation through the body to create an image of the internal structure.

b. X rays produce a single image, whereas a CT scan produces multiple images (slices) that are reconstructed into a 3-D image by a computer. Sample answer:

![Diagram of X ray and CT scan]

X ray
- single image
- transmit electromagnetic radiation through the body to create an image of the internal structure

CT scan
- multiple images (slices) that are reconstructed into a 3-D image by a computer

32. compound light microscope (maximum 2000´)
transmission electron microscope (maximum 100 000´)
scanning electron microscope (maximum 300 000´)
scanning tunneling microscope (maximum 200 000 000´)
33. Sample answer:

<table>
<thead>
<tr>
<th>Type</th>
<th>How Image is Produced</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>X ray</td>
<td>electromagnetic radiation</td>
<td>broken arm</td>
</tr>
<tr>
<td>CT or CAT scan</td>
<td>electromagnetic radiation</td>
<td>internal trauma, tumours</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>high-frequency sound waves</td>
<td>pregnancy checkup</td>
</tr>
<tr>
<td>MRI scan</td>
<td>magnetism and radio waves</td>
<td>brain trauma</td>
</tr>
</tbody>
</table>

34. Ultrasound, endoscope, CT scanner—the ultrasound will have the least impact on the fetus, while the CT scanner will subject it to a small amount of radiation (which should be avoided if possible). Even though the endoscope is the most invasive technology, it would not harm the fetus and involves no radiation.

Chapter 10 The Digestive System

Learning Check Questions

(Student textbook page 406)

1. Carbohydrates serve as short-term or long-term energy storage in the body.

2. A monosaccharide is a single-ringed or single-unit sugar, such as glucose or fructose. A disaccharide is formed by a bond between two monosaccharides; examples of disaccharides are sucrose, maltose, and lactose.

3. Macromolecules are chemically broken down by enzymatic hydrolysis, which uses water and enzymes to disassemble large biological molecules into smaller molecules for absorption by body cells.

4. Carbohydrates are likely to be used first as a quick, short-term energy source.

5. Although carbohydrates can function in long-term energy storage, lipids would provide the greatest benefit because they store more energy per gram compared to carbohydrates.

6. Answers can include:
   - act as catalysts to speed up chemical reactions in the cells
   - provide immunity against infection and disease
   - transport ions in cell membranes
   - enable cells to respond to chemical stimuli

(Student textbook page 414)

7. Digestion of carbohydrates begins as soon as food enters the mouth when the salivary glands release saliva, which contains enzymes (e.g., amylase) that start the chemical digestion process.

8. Peristalsis is a form of mechanical digestion that involves a series of wave-like muscular contractions of longitudinal and circular muscles. The contractions move the bolus down the esophagus to the stomach for further digestion.

9. a. open, for air exchange and access to the trachea
   b. closed, to prevent food entering the trachea
   c. open, because coughing involves exhaling, which requires the trachea to be open
   d. open, until swallowing occurs

10. A doctor would examine the neck area under the jaw line on each side of the body to feel for swelling of the submandibular glands.

11. The doctor should find a lower pH in the lower part of the esophagus, due to stomach acid flowing into the esophagus (the condition known as acid reflux). Students should identify the esophageal sphincter in Figure 10.9 (student textbook page 413) as being the place where acid from the stomach could leak back into the esophagus.

12. Gastroesophageal pain may be due to high acid levels. Over-the-counter antacids are medicines that work by increasing the pH in the digestive tract due to a base, like calcium carbonate, acting to neutralize the pH level.

(Student textbook page 417)

13. Pancreatic fluid delivers enzymes for the breakdown of foods. It also produces bicarbonate to neutralize acidity, which increases enzymatic efficiency.

14. Before fats are digested, insoluble fat droplets are emulsified into smaller fat droplets by bile salts. This allows for a greater surface area to be exposed for digestive enzymes to break lipids down in the small intestine.
15. Answers should show an understanding that chyme first passes through the first part of the small intestine, the duodenum, where it receives digestive secretions from the pancreas, liver, and the gall bladder. Next, the chyme and digestive juice mixture moves into the lower part of the small intestine (jejunum and ileum), where more digestion occurs and nutrients are absorbed into the bloodstream.

16. The gall bladder stores the bile produced by the liver. Bile contains bile salts that digest the insoluble fats by breaking up the fat droplets so they are easier to digest and absorb.

17. The gall bladder stores the acidic bile between meals. Without the gall bladder to store the bile being produced, the highly acidic bile would be steadily released into the intestines, even when there is no food present to dilute it, thus causing chronic diarrhea.

18. Answers should show an understanding that a smooth small intestine would result in food passing through more quickly, and that fewer villi would result in lower nutrient absorption. This could result in malnutrition. Sample answer: This baby may have nutrient deficiencies as he grows because its body is not able to absorb nutrients efficiently. They may have to eat more frequently to make up for this.

(Student textbook page 422)

19. Helicobacter pylori are bacteria that prevent mucus production in the walls of digestive tract. Without mucus, the acids in the stomach come into contact with and destroy the lining of the stomach, causing the formation of an ulcer.

20. Losing weight, eating properly, and cutting down alcohol intake can all reduce the risk of developing a gallstone.

21. Diagnosis may be difficult because the symptoms of Crohn’s disease are similar to other intestinal bowel disorders, such as ulcerative colitis, and because Crohn’s disease can occur in any part of the very long alimentary canal.

22. Inflammatory bowel disease is a group of diseases that cause inflammation in the intestines. These diseases include Crohn’s disease and ulcerative colitis. Crohn’s disease is a form of IBD that can affect any part of the alimentary canal from the mouth to the anus. Ulcerative colitis is a form of IBD that specifically attacks the colon.

23. a. Constipation is a condition in which bowel movements are infrequent and strained; it can be caused by inadequate water intake, inadequate fibre in the diet, and lack of good muscle and nerve function in the bowel.

b. Hepatitis is an inflammation of the liver caused by contaminated drinking water (hepatitis A), infection through sexual contact (hepatitis B), or by contact with infected blood (hepatitis C).

c. Cirrhosis is a chronic disease in which scar tissue replaces healthy liver tissue and the liver ceases to function properly. The most common causes of cirrhosis are chronic alcoholism and hepatitis C.

24. Both coffee and citrus fruits are acidic, which would aggravate the ulcers.

Caption Questions

Figure 10.5 (Student textbook page 409): The cecum in a small herbivore is longer than that of a small carnivore because the cellulose walls in plant tissues are more difficult to digest than animal tissues. Food containing cellulose needs more time to digest than food that does not contain cellulose.

Section 10.1 Review Questions (Student textbook page 410)

1. The four macromolecules are carbohydrates, lipids, proteins, and nucleic acids. They are used to maintain the body’s metabolism, provide the energy that the body’s cells need to carry out cellular activities, and to build and repair body tissues.

2. Lipids build cell membranes, help protect vital organs from injury, insulate the body from cold, and function as energy storage molecules.
3. Answers should include characteristics of carbohydrates, lipids, proteins, and nucleic acids, and include their respective digestive enzymes, carbohydrases, lipases, proteases, and nucleases. Sample answer:

**Macromolecules**

- **Carbohydrates**
  - **Structure**: Two hydrogens and one oxygen for every carbon.
  - **Function**: Provide materials for building cell membranes, source of quick energy.
  - **Example**: Glucose
  - **Digestive Enzyme**: Carbohydrases

- **Lipids**
  - **Structure**: Glycerol molecule (three carbons and a fatty acid chain).
  - **Function**: Store energy reserves, cushioning and insulation for internal organs, materials to build cell membranes.
  - **Example**: Oils
  - **Digestive Enzyme**: Lipases

- **Proteins**
  - **Structure**: Hundreds of amino acids linked by peptide bonds.
  - **Function**: Structure and support for blood cells, tissues, and muscles, aid in contraction, catalysts for chemical reactions, immunity against infections and disease, transport ions.
  - **Example**: Insulin
  - **Digestive Enzyme**: Proteases

- **Nucleic Acids**
  - **Structure**: Double helix.
  - **Function**: Contain genetic information.
  - **Example**: DNA
  - **Digestive Enzyme**: Nucleases

4. Answers should show an understanding that all carbohydrates have the molecular formula CH₂O, and that most carbohydrates function in energy storage. The molecules of monosaccharides (single sugar), disaccharides (two sugars), and polysaccharides (many sugars) differ in size and in their number of sugar units. There are different types of each of these sugars in plants and animals.

5. Answers should show an understanding of why it takes longer to break down a polysaccharide into simple sugars, which the body is able to use quickly to release energy. For example, if there is a fire log available, you can create a fire quickly. However, if you have to first chop up a tree trunk into fire logs, it will take longer to get the fire going.

6. Maltose is a simple sugar carbohydrate, soybean oil is a lipid, and salt contains the mineral sodium.

7. Most macromolecules are too large to enter cells directly. Enzymatic hydrolysis disassembles large molecules into smaller molecules so that cells can absorb these smaller molecules for the body to use.

8. Amino acids are joined together by peptide bonds to form a polypeptide, and one or more polypeptides make up a protein.

9. Water is considered the most important molecule in the body because it makes up about two-thirds of the body's mass and performs vital functions such as transporting nutrients, eliminating toxins, and regulating body temperature.

10. Sample answer:

**Digestive Processes**

<table>
<thead>
<tr>
<th>Process</th>
<th>Definition</th>
<th>Part of Digestive Tract Where Process Occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical digestion</td>
<td>The breakdown of macromolecules by enzymes</td>
<td>Digestive tract</td>
</tr>
<tr>
<td>Mechanical digestion</td>
<td>The process of physical breakdown of food into smaller bits</td>
<td>Mouth (primarily)</td>
</tr>
</tbody>
</table>

11. a. vitamin D  
   b. vitamin A  
   c. vitamins A and D

12. Milk is a good source of the mineral calcium which is important for proper muscle function. Bananas are a good source of potassium which also functions in muscle contraction and may prevent muscle cramping.

13. a. fluid feeder  
    b. substrate feeder  
    c. bulk feeder  
    d. filter feeder

14. A large cecum not only has a larger surface area for better nutrient absorption of plant material, but it also has more room for hosting bacteria that help in the enzymatic breakdown of plant cellulose.

15. Answers should show an understanding that there are four stages of food processing and that the correct order of these processes is: ingestion, digestion, absorption, and elimination.

16. With such a variety of food sources, animals have evolved in terms of developing a variety of feeding mechanisms to minimize competition and maximize their reproductive success and survival.

**Section 10.2 Review Questions**  
(Student textbook page 419)

1. a. A (mouth) and I (small intestine)  
    b. G (stomach) and I (small intestine)  
    c. I (most digestion and nutrient absorption occurs here and a large surface area facilitates these processes)  
    d. D (large intestine)
2. Answers should show an understanding of the following:
   - carbohydrates are digested in the mouth by the action of amylase and broken down further by pancreatic amylase in the small intestine
   - proteins are broken down by pepsin in the stomach and further hydrolyzed by pancreatic enzymes in the small intestine
   - nucleic acids are broken down by nucleases in the small intestine
   - fats are broken down by bile salts and pancreatic lipases in the small intestine
   - no chemical digestion occurs in either the esophagus (it is for transport and swallowing only) or in the large intestine (which functions to absorb water from undigested material)

3. The three different regions of the small intestine, and their structures and functions, are:
   - duodenum—U-shaped region immediately after the stomach, where food is combined with secretions from the pancreas and gall bladder as it passes through the digestive tract
   - jejunum—structure immediately following the duodenum; about 2.5 m long, it contains more folds than the duodenum; breaks down the remaining proteins and carbohydrates for absorption into the bloodstream
   - ileum—structure immediately following the jejunum; about 3 m long, it contains fewer and smaller villi than either the duodenum or jejunum; absorbs nutrients, and pushes the remaining undigested material into the large intestine

4. False. All foods are mechanically broken down in the mouth by chewing. Moreover, carbohydrates are chemically digested in the mouth due to salivary amylase.

5. Food moves through the esophagus due to rhythmic, wave-like muscle movements called peristalsis, that move food from the throat into the stomach. This involves involuntary smooth muscles that will contract and relax independent of gravity.

6. The wall of the stomach is protected by mucus that acts as a barrier to prevent the highly acidic gastric juices from damaging the stomach wall.

7. The walls of the small intestine are lined by folds which have finger-like projections called villi. The villi are surrounded by brush-like microvilli. The villi and microvilli greatly increase the surface area of the intestine so that nutrients can be more effectively absorbed.

8. Proteins are digested in the stomach. Hence, digestive enzymes, which are proteins, would be broken down by the acidity in the stomach.

9. Answers should show an understanding that there would be an even greater requirement for chemical digestion to occur, and more potent enzymes might be required without mechanical forces to break up food.

10. It is likely that the microbes were destroyed by the acidic conditions in the child's stomach.

11. The individual would require medications to replace the pancreatic enzymes necessary for digestion of carbohydrates, lipids, and proteins; they would also need regular insulin injections to replace the function of the pancreas.

12. Answers should show an understanding that there would be an even greater requirement for chemical digestion to occur and more potent enzymes might be required without mechanical forces to break up food. The small intestine might also have to be longer to allow more effective chemical digestion of food. The animal would also have few, if any, teeth for mechanical digestion.

13. It is possible that fluids could dilute digestive enzymes and change stomach acidity during feeding.

14. Answers should show an understanding that many of the products of digestion are absorbed through the villi into the small intestine and then into the bloodstream to deliver nutrients to body cells.

15. Water is absorbed from food matter passing through the large intestine.

16. Answers should show an understanding that the large intestine in humans is shorter and wider than the small intestine. The main function of the large intestine is to absorb water from the alimentary canal and to move feces into the rectum for storage and elimination.

Quirks and Quarks: Do You Really Need Your Appendix? Questions
(Student textbook page 426)

1. In developing countries, where health conditions and sanitation are very poor, diarrhea is extremely common, and is a leading cause of death. If the appendix functions to repopulate the intestines with beneficial bacteria after bouts of diarrhea, it may be enabling many of these people to recover from diarrhea, rather than die from it.
2. You may wish to direct students to the following websites to begin their search:
   • Education-Portal.com, Career in Holistic Nutrition: Job Duties and Responsibilities
     http://education-portal.com/career_in_holistic_nutrition.html
   • Education-Portal.com, Holistic Nutritionist: Education Needed for a Career in Holistic Nutrition
   • eHow.com, How to Become a Holistic Nutritionist
     http://www.ehow.com/how_4764495_become-holistic-nutritionist.html

Section 10.3 Review Questions
(Student textbook page 427)

1. A peptic ulcer is a sore or inflammation of the lining of the esophagus, stomach, or duodenum.

2. a. G
   b. anywhere in the digestive system (A to I), so all body parts are correct
   c. D
   d. B

3. Sample answer:

<table>
<thead>
<tr>
<th>Digestive System Disorder</th>
<th>Cause</th>
<th>Symptoms</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulcer</td>
<td>Helicobacter pylori</td>
<td>abdominal pain, bloating, nausea, loss of appetite</td>
<td>antibiotics; medications to reduce acidity; lifestyle changes, such as quitting smoking, avoiding alcohol, and reducing weight</td>
</tr>
<tr>
<td>Inflammatory bowel disease</td>
<td>chronic disease</td>
<td>loose and bloody stools, cramps, abdominal pain</td>
<td>medication; special diet; surgery</td>
</tr>
<tr>
<td>Cirrhosis</td>
<td>chronic disease (alcoholism, hepatitis C)</td>
<td>blood tests can reveal a fatty liver</td>
<td>transplant</td>
</tr>
<tr>
<td>Gallstones</td>
<td>obesity, alcohol, heredity</td>
<td>hard masses and crystal formation</td>
<td>medications; ultrasound shockwaves</td>
</tr>
</tbody>
</table>

4. The green tint in her vomit indicates that bile is being thrust up from the small intestine. Enough pressure in the abdominal cavity pushes the digestive contents out of the stomach, and even the small intestine.

5. Students may suggest asking questions about things such as:
   • alcohol intake
   • smoking habits
   • amount of fibre eaten daily
   • amount of fatty foods eaten daily
   • stool colour
   • location of pain
   • weight
   • blood pressure
   • family history of disorders
   • other lifestyle choices that impact health and body systems

6. The liver is responsible for performing many functions that are essential for life, such as breaking down toxins that can harm the body and making bile and glycogen. A malfunctioning liver would encounter problems digesting fats and regulating blood sugar levels.

7. The traditional endoscope consists of an eyepiece and a light source attached to a flexible tube that can be inserted into the mouth or anus. The capsule endoscope is a small capsule-sized camera that isn’t attached to a wire as in a traditional endoscope, and it travels like food through a patient’s digestive tract, rather than being pushed through it like the traditional endoscope.

8. An endoscope is a flexible tube that can be inserted into the mouth or anus and that allows for a non-invasive alternative to surgery for foreign object removal from the alimentary canal.

9. Answers should show an understanding of the similarities and differences between the two technologies. Sample answer:

   Capsule endoscopy
   • easier to move through small intestine
   • may take longer to obtain images

   Traditional (tube) endoscopy
   • easy to obtain soft-tissue images
   • relatively painless
   • may be able to biopsy at the same time
10. The three types of hepatitis are:
   • hepatitis A, contracted by drinking contaminated drinking water
   • hepatitis B, contracted through sexual contact with an infected person
   • hepatitis C, contracted by contact with infected blood

11. Organs that are vital to digestion and therefore could not be removed include the liver and pancreas.

12. Answers should show an understanding that the pump can automatically monitor blood glucose levels and deliver precise amounts of insulin into the blood. By controlling sugar fluctuations so precisely, long-term complications are reduced. However, some disadvantages of a computerized insulin pump include cost and some discomfort associated with wearing it.

13. No. The capsule endoscope was developed to travel the digestive tract and take pictures, in particular, of the small intestine. Because the pancreas is an accessory organ found next to the stomach, the capsule endoscope would not pass through the pancreas.

14. The symptoms are typical of constipation. Good advice would consist of drinking more water, eating more fibre-containing foods like fruits and vegetables, taking fibre supplements, and seeing a doctor if the symptoms get worse.

15. She should follow a low-cholesterol diet, with an increase of omega-3 fatty acids.

16. As we age, the function of various body secretions is altered and the pancreas is no exception. The diet of the elderly is often poorer and this may trigger large fluctuations in blood glucose levels, with which the pancreas is not able to keep up due to decreased insulin secretion.

Chapter 10 Review Questions
(Student textbook page 435–7)

1. d
2. a
3. d
4. c
5. b
6. c
7. a
8. a
9. Chyme enables nutrients to be absorbed during digestion because it undergoes both mechanical digestion (churning) and chemical digestion, enabling the nutrients to be absorbed more readily into the blood via the intestinal capillaries.

10. a. False. After surgical removal of an infected gall bladder, a person must be especially careful to minimize fat intake.
b. True
c. False. A substance that decreases water reabsorption in the large intestine can lead to constipation.

11. This is prevented by mucus secretion, by gastric juices being secreted only when food is present, and by pepsin being secreted in an inactive form until HCl is present.

12. Chewing is a form of mechanical digestion, which is essential to break food up into smaller pieces so that there is a larger surface area for chemical digestion. Chewing also moistens the food to assist in swallowing, and it mixes the food with amylase-rich saliva.

13. The esophagus transports each bolus of food to the stomach by wave-like muscular contractions called peristalsis. Glands in the lining of the esophagus also produce mucus, which keeps the passage moist and aids in swallowing.

14. The liver produces bile, which contains bile salts that break up insoluble fats into smaller fat droplets so they are easier to digest and absorb. Lipids are a source of energy for the body, and this source of energy would be unavailable without the bile salts for breaking up fats into smaller, more digestible units.

15. a. True
   b. False. Food matter is digested and nutrients are absorbed before entering the colon.
   c. True
d. True
e. True

16. Gallstones are small, hard masses that develop in the gall bladder, which is an organ that stores and releases bile. If they are not removed, gallstones can cause an obstruction that would block the flow of bile in the ducts between the liver and gall bladder, and between the gall bladder and the intestines.
17. People may believe that turning off enzyme production in the stomach would help them reduce weight by reducing the amount of digestion that would occur. However, such a pill may also prevent the absorption of nutrients, minerals, and vitamins. This would disrupt the healthy functioning of the body, leading to severe health consequences.

18. Answers could include: inflammation of the esophagus due to acid damage and the development of ulcers; ulcer damage to tissue and subsequent bleeding; coughs and asthma due to nerve damage in the esophagus; inflammation of the throat and larynx; lung inflammation and infection; fluid in the sinuses and middle ear; narrowing of the esophagus due to scar tissue; and development of pre-cancerous and cancerous tissue in the esophagus.

19. If the pancreas is dysfunctional, pancreatic enzymes will not be produced. Glucose and other nutrients will then build up in the bloodstream, eventually to dangerous levels.

20. Sample answer:

**Interaction of the Digestive System and Other Body Systems**

<table>
<thead>
<tr>
<th>System</th>
<th>Interconnection with Digestive System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integumentary</td>
<td>Vitamin D in the skin plays a role in the absorption of calcium.</td>
</tr>
<tr>
<td>Skeletal</td>
<td>Teeth aid in mechanical digestion.</td>
</tr>
<tr>
<td>Muscular</td>
<td>Aids in chewing, swallowing, and peristalsis</td>
</tr>
<tr>
<td>Nervous</td>
<td>This influences digestive system activity.</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Nutrients are absorbed into the blood in the small intestines.</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Structures overlap such as epiglottis and oral cavity.</td>
</tr>
</tbody>
</table>

21. a. After eating a carbohydrate-rich meal, blood glucose levels increase as the carbohydrates are broken down into simpler sugars such as glucose. As blood glucose levels increase, insulin is released in response to help move glucose from the blood into body cells.

b. This implies that there must be time delays or lags in the body’s feedback response to blood glucose levels. This time delay can cause sugar cravings because blood sugar levels are normal while insulin levels are still elevated in the blood, which in turn can produce a desire for sweet foods.

22. a. Meals seem to occur every 4 to 5 hours, the time it takes for food to pass out of the stomach.

b. It takes a day or so for food to pass through the colon, which explains daily bowel movements for many people.

23. They are at risk of contracting hepatitis C.

24. In birds, digestion does not start in the mouth, as there are no teeth to grind up food. Unless birds have special powerful enzymes to start digestion in the mouth, it is highly likely that digestion must occur in another organ further down the digestive tract.

25. Answers should show an understanding of how the esophageal and pyloric sphincters compartmentalize the digestive system and provide an environment where the pH can be very different than that found in any other parts of the body. For example, the sphincters allow enzymes secreted in the stomach to work at maximum efficiency by preventing these highly acidic materials from physically damaging other parts of the digestive system.

26. Answers should show an understanding of the process of macromolecule breakdown. Students should examine all four macromolecules (carbohydrates, lipids, proteins, and nucleic acids) in their scripts.

27. Answers should show an understanding that sugars are converted to glucose and move directly into the circulatory system to be absorbed by body cells. Lipids, however, need to be broken down by bile salts and reassembled to move into the lymphatic system before being transported to the circulatory system. Both are absorbed in the small intestine.

28. Sample answer:
29. Answers should include information on the causes and symptoms of the disorder, how the disorder is diagnosed and treated (including the technologies used), and any new advances in treatment of the disorder. Pamphlets should be well-organized, concise, and accurate.

30. Answers should show an understanding that both Crohn's disease and colitis are types of inflammatory bowel disease, yet they differ because Crohn's disease is a form of IBD that can affect any part of the alimentary canal from the mouth to the anus, whereas ulcerative colitis is a form of IBD that specifically attacks the colon.

31. Answers should include a comprehensive comparison of both insulin injections and insulin pump therapies, and outline the costs and benefits of both. Handouts should be well-organized, concise, and accurate.

32. Answers should show an understanding of all Key Terms and Key Concepts from the Chapter 10 Summary on student textbook page 434.

33. Sample answer:

The Nutritional Value of Pizza

<table>
<thead>
<tr>
<th>Food in Pizza</th>
<th>Nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheese</td>
<td>fat (energy), protein, calcium, sodium</td>
</tr>
<tr>
<td>Meat</td>
<td>protein and sodium</td>
</tr>
<tr>
<td>Crust</td>
<td>carbohydrates (energy)</td>
</tr>
<tr>
<td>Broccoli</td>
<td>vegetable (vitamins, fibre, and water)</td>
</tr>
<tr>
<td>Tomato sauce</td>
<td>fruit (vitamins and fibre) and water</td>
</tr>
</tbody>
</table>

34. If scientists can trigger stem cells to develop into insulin-producing cells, such an advance could contribute to new treatments for diabetes.

35. a. Yes. Women with gestational diabetes are more likely to develop type 2 diabetes later in life.
   b. Yes. Being overweight and eating a diet high in fat can affect the body's ability to respond to insulin.
   c. No. This is associated with type 1 diabetes.
   d. Yes. A diet high in sugars can affect the body's ability to respond to insulin.
   e. Yes. This is associated with type 2 diabetes.

36. Excess blood glucose can dehydrate cells in people with diabetes, because water is moving from a place of higher concentration in body cells to a place of lower concentration in the blood-bathing body cells.

37. Answers should show an understanding that one potential danger is the blocking of the bolus and important food nutrients from entering the stomach.

38. Sample answer:

<table>
<thead>
<tr>
<th>Organ</th>
<th>What Happens Here</th>
</tr>
</thead>
<tbody>
<tr>
<td>A salivary glands (answers may include parotid glands, accessory parotid gland, sublingual gland, and submandibular gland)</td>
<td>• glands secrete a watery fluid called saliva that begins chemical digestion of food</td>
</tr>
<tr>
<td>B gall bladder</td>
<td>• stores bile between meals</td>
</tr>
<tr>
<td>C small intestine</td>
<td>• macromolecules are broken down into their component molecules</td>
</tr>
<tr>
<td></td>
<td>• nutrients are absorbed through membranes of the cells lining the small intestine</td>
</tr>
<tr>
<td>D appendix</td>
<td>• possible storage site for “good” bacteria</td>
</tr>
<tr>
<td>E esophagus</td>
<td>• transports each bolus of food from the mouth to the stomach</td>
</tr>
<tr>
<td>F stomach</td>
<td>• food is temporarily stored while further chemical and mechanical digestion takes place</td>
</tr>
<tr>
<td></td>
<td>• gastric glands secrete gastric juice which mixes with food to produce chyme</td>
</tr>
<tr>
<td>G pancreas</td>
<td>• secretes pancreatic fluid that contains numerous enzymes to chemically digest carbohydrates, lipids, and proteins</td>
</tr>
<tr>
<td>H colon</td>
<td>• temporarily holds undigested material that comes from the small intestine</td>
</tr>
<tr>
<td></td>
<td>• absorbs water from alimentary canal back into blood</td>
</tr>
<tr>
<td></td>
<td>• bacteria in colon break down undigested matter further</td>
</tr>
<tr>
<td></td>
<td>• leftover matter in the colon forms feces</td>
</tr>
<tr>
<td>I rectum</td>
<td>• stores feces until eliminated at the anus</td>
</tr>
</tbody>
</table>

39. Gastrointestinal disorders that might stimulate the contraction of the diaphragm and the abdominal muscles include ulcers and gallstones. Other things that may initiate vomiting include overeating, coughing, and stress (the nervous system's influence on vomiting).

40. This is possible because the genetic code is universal and thus both humans and bacteria share, through common evolutionary ancestry, the same “language” of genes for making proteins.
Chapter 10 Self-Assessment Questions
(Student textbook page 438–9)

1. b  
2. c  
3. a  
4. d  
5. c  
6. d  
7. a  
8. b  
9. d  
10. a

11. Answers should show an understanding of the main functions of proteins in the body, as in Table 10.1 on student textbook page 403.

12. a. Answers should show an understanding of the hydrolysis process, including the role of enzymes in the breakdown of a disaccharide molecule into two monosaccharide molecules. See Figure 10.2 on student textbook page 404.
   b. simple sugars (monosaccharide molecules)
   c. carbohydrates
   d. small intestine

13. They all contain fats. Fat droplets are first broken down into smaller fat droplets in combination with gall bladder-derived bile salts. Fat droplets are further digested by lipases in the small intestine.

14. Macromolecules are also known as essential nutrients because they cannot be made by the body, and must therefore be obtained from food.

15. Diagrams should show the flow of food from the mouth to the esophagus to stomach to the small intestines to the large intestine to the rectum. The liver, gall bladder, and pancreas are the important accessory organs.

16. Peristalsis consists of wave-like muscular contractions that move food down the esophagus. This involves involuntary smooth muscles that will contract and relax independent of body position.

17. Ulcers are sores in the lining of the stomach or duodenum that form because the protective mucus that covers the lining has weakened due to a bacterial infection.

18. Answers should show an understanding of what diabetes is and how each of these types of diabetes occurs. The most important difference is that type 1 diabetes occurs when the insulin-producing cells of the pancreas are destroyed by the immune system and therefore no longer produce insulin. Type 2 diabetes occurs when either the body does not make enough insulin or it is unable to properly use the insulin it makes. Handouts should be well-organized, concise, and accurate.

19. Students may suggest ulcerative colitis, but may also discuss some symptoms of Crohn's disease. Either answer is acceptable.

20. a. Answers should show an understanding that a digestive enzyme appears to work more optimally at a low pH. Graph titles should show an understanding of the relationship between rate of reaction and pH (e.g., “Enzyme Reaction by pH”).
   b. The digestive enzyme is likely to be pepsin (which breaks down proteins) because it is known to work optimally under acidic pH conditions.
   c. in the stomach
   d. Answers should show an understanding that the pH can affect the rate at which an enzyme functions to break down complex molecules. This may be due to changes in pH affecting the shape of an enzyme, or changing properties of the substrate.

21. The stomach does not digest the proteins that make up its own cells because the stomach secretes little gastric juice and active enzyme until food and acid is present. Also, stomach cells secrete mucus, which prevents gastric juice from harming the cells of the stomach lining.

22. Since Crohn's disease can affect any part of the alimentary canal, this can make it difficult for the intestine to absorb enough nutrients to keep a person nourished. This results in poor muscle development since the newly forming muscle cells are poorly nourished.

23. Fat-soluble vitamins, such as vitamin A and vitamin E, do not dissolve in water, and so excess amounts are not carried out of the body. Instead, high levels of the vitamins can be stored in the fatty parts of the body, and this may be toxic to the body.

24. Answers should show an understanding of Banting and Best’s discovery of insulin and how insulin injections for people with diabetes can prolong their lives. There should be some attempt to use accessible vocabulary for younger students.
25. You can infer that the organism probably eats mostly plant material because:
- a larger cecum indicates that the food must spend a long time in the alimentary canal to fully break down; and
- plant eaters require the help of specialized bacteria (or microbes) to break down the plant cellulose.

Chapter 11 The Respiratory System
Learning Check Questions
(Student textbook page 444)
1. oxygen and carbon dioxide
2. Breathing involves inspiration and expiration. Inspiration occurs when breathing in, or inhaling, and expiration occurs when breathing out, or exhaling.
3. Cellular respiration is the series of energy-releasing chemical reactions that takes place within the cells, which provides energy for all cellular activities.
4. The two main requirements of respiration are: (1) a large enough respiratory surface to meet the body’s needs; and (2) a moist surface so that oxygen and carbon dioxide can dissolve.
5. outer skin (examples are earthworms, some amphibians); gills (fish, clams, mussels, crayfish, crabs); lungs (mammals, birds, reptiles, and most amphibians); and trachea (insects)
6. Gas exchange would not be as efficient because the gases would have to diffuse through larger amounts of tissue.

(Student textbook page 447)
7. Two adaptations are: (1) gills; and (2) a counter-current exchange mechanism, which allows a greater diffusion of oxygen from the water to the animal’s bloodstream.
8. Land animals must keep their respiratory surfaces moist so that oxygen can move from the lungs into the bloodstream as a dissolved gas.
9. Inspiration is considered the active phase of ventilation because this is the phase in which the diaphragm and the external intercostal muscles contract. Expiration is considered the passive phase because the intercostal muscles and diaphragm relax.
10. the diaphragm and the intercostal muscles
11. The diaphragm, and the external and internal intercostal muscles help breathing. A tear in the muscles would mean that those muscles would not be able to relax and contract as smoothly as they would normally do. This would likely result in ragged breathing as the other intact muscles try to compensate.
12. During inhalation, the intercostal muscles contract, lifting the rib cage up and out. Simultaneously, the diaphragm contracts and pulls downward. With an increased volume in the thoracic cavity, air pressure decreases, and the lungs are drawn outward in the chest cavity and expand. This greater volume causes the pressure within the lungs to be lower than the air pressure outside the body and air rushes into the lungs.

(Student textbook page 452)
13. Nasal passages warm, moisten, and filter the inhaled air.
14. Inhaled air is warmed by the blood flowing through the dense network of capillaries in the membrane covering the turbinates, so that it does not damage the structures in the lower respiratory tract.
15. Movements of the vocal cords are controlled by muscle contractions and by nerve signals. Vibrations are modified by the length, size, and tension of the vocal cords. The longer the vocal cords, the less the tension, and therefore the lower the voice.
16. When an individual’s trachea collapses, the passage of air to the bronchi of the lungs would be blocked and the individual would be unable to breathe.
17. The patient would be unable to talk because the doctor would be cutting into the region below the larynx, and therefore air would not pass through the larynx over the vocal cords. Instead, air would exit the trachea through the tube below the larynx.
18. The epiglottis covers the glottis to prevent food from entering the trachea and moving into the lungs when swallowing food. If the epiglottis did not work properly, food would enter the trachea and lungs. This would cause coughing and choking, and possibly lead to infections in the lungs.

(Student textbook page 458)
19. The tonsils trap bacteria and other harmful substances, preventing them from entering the respiratory tract.
20. She might have laryngitis. Laryngitis can be caused by an inflammation of the larynx due to strain. The swollen vocal cords cannot vibrate as usual, causing a loss of voice.
21. (1) Pneumonia is the inflammation of the alveoli, usually caused by a bacterial infection, which causes the alveoli to fill with fluid. (2) Bronchitis describes the condition in which the bronchi are inflamed and filled with mucus, or when the cilia lining the bronchi are destroyed. (3) Asthma is caused by an inflammation of the bronchi and bronchioles that reduces the air passages and thus the airflow into the lungs. (4) Emphysema occurs when alveolar walls lose their elasticity, causing the airways to collapse and the alveoli to deteriorate.

22. Cystic fibrosis is caused by the mutation of the single gene responsible for producing the protein that regulates salt and water balance.

23. Bronchitis occurs when the bronchi become red, inflamed, and filled with mucus due to destruction of the cilia lining the bronchi. The mucus accumulates in the bronchi, affecting the person’s ability to breathe.

24. A person who smokes is inhaling irritants into the lungs, which reduces the capacity of the lungs to take in oxygen. Smoking can damage important structures in the respiratory tract, which in turn reduces the surface area over which gas exchange occurs. Therefore, a smoker’s lungs are not as efficient at allowing oxygen diffusion as the lungs of a non-smoker.

(Student textbook page 462)

25. Metastasis is the spread of cancer from its original body site.

26. A carcinogen is a cancer-causing agent.

27. A CT scan takes multiple X-ray images of soft tissue, bone, and blood vessels through 360° and assembles the images to show thin cross-sections of the body.

28. Bronchoscopy can be used to visually examine the patient’s respiratory tract and the bronchoscope allows doctors to take tissue samples for further examination.

29. (1) avoid smoking altogether, or quit smoking if they already smoke; (2) avoid exposure to other air-borne carcinogens such as second-hand smoke, air pollution, radon gas, and asbestos

30. TPM uses photons that penetrate the tissue samples and fluorescent markers to create a three-dimensional image of a point inside a biological sample. Traditional microscopy produces a two-dimensional image of the surface of the tissue sample.

Caption Questions

Figure 11.2 (Student textbook page 445): In a counter-current system, blood flows in the direction opposite to the flow of oxygen-containing water. This system maintains a high diffusion gradient, allowing gases to diffuse across the entire respiratory surface.

Section 11.1 Review Questions
(Student textbook page 449)

1. The respiratory system:
   - ensures that oxygen is brought into the body and made available to each cell that needs it; and
   - ensures that carbon dioxide can leave each cell and be removed from the body.

2. Answers should include the following steps:
   (1) Oxygen-carrying water comes into contact with gills.
   (2) The oxygen in the water diffuses into the blood circulating through the capillaries in the gill tissue.
   (3) Carbon dioxide diffuses out of the blood, across the gill tissue, into the water.

3. As a land animal, the rabbit’s respiratory surface must be large enough to accommodate the animal’s activity level, its size, and the lower moisture of its environment. An earthworm uses its entire outer skin as a respiratory surface and must stay in a moist area to survive. Fish use gills as their respiratory surface area. Insects use a system of branching tracheal tubes; they do not use their circulatory system for gas exchange.

4. No, this is not the expected result. Although inhaled air contains CO₂, the concentration is too small to react significantly with limewater.

5. The fish gill is able to obtain oxygen more efficiently because the counter-current arrangement maintains a high oxygen diffusion gradient between the continuously flowing oxygen-rich water and the blood. In the human lung however, the oxygen diffusion gradient decreases as oxygen diffuses across the lung tissue during each breath.

6. All respiratory surfaces need to be kept moist. Because woodlice have gills under their body, the gills are more exposed to the environment than are human lungs. Therefore, woodlice are probably restricted to cool, damp areas because their gills are at greater risk of drying out.
7. Breathing through your mouth would result in the cold, dry air entering your lungs more quickly. This would reduce the effectiveness of the gas exchange as the respiratory surface would then be cooled and dried. Air entering through your nose would be warmed and take on more moisture as it would spend more time in the nasal cavity, which in turn would improve the efficiency of the gas exchange within the lungs.

8. Cycle charts should include the following steps:

**Inhalation**
1. The external intercostal muscles contract, lifting the rib cage up and out.
2. At the same time, the diaphragm contracts and pulls downward.
3. The muscular contractions increase the volume of the thoracic cavity.
4. The increase in thoracic cavity volume reduces air pressure within the cavity, causing the lungs to expand. Lower air pressure in the lungs causes air from the atmosphere to move into the lungs.

**Exhalation**
5. The external intercostal muscles relax and the internal intercostal muscles contract, pulling the rib cage down and in.
6. The diaphragm relaxes and moves upward into its domed shape.
7. The muscular relaxation shrinks the volume of the thoracic cavity.
8. The reduction in thoracic cavity volume increases air pressure in the lungs, causing air to move out through the trachea into the atmosphere.

9. The percentage of oxygen breathed out is less than that breathed in because some of the oxygen has diffused into your circulatory system. The percentage of carbon dioxide breathed out is higher than that breathed in because waste carbon dioxide has been expelled from the body.

10. The initial deep exhalation will reduce the residual volume that is comprised of air with a depleted amount of oxygen, and increase the inspiratory capacity. The subsequent deep inhalation will replace part of the residual volume with oxygen-enriched air, thus increasing the vital capacity.

11. a. inspiratory reserve volume, tidal volume, and expiratory reserve volume
   b. Residual volume is the amount of gas that remains in the lungs and the respiratory passages. This gas prevents the lungs and respiratory passages from collapsing.

12. by adding together the vital capacity and the residual volume

13. Sample answer:

```
cellular respiration
  requires
  respiration
    consists of
      inspiration
      expiration
  provides
    gas exchange
```

14. Removing the air from the thoracic cavity would reduce the pressure against the outside of the lung wall and allow the lung to re-expand within the chest cavity.

Section 11.2 Review Questions
(Student textbook page 454)

1. a. Mucus helps to moisten inhaled air and trap particles of dust, bacteria, and other foreign matter.
   b. Cilia move any trapped foreign particles into the nose or throat where they can be expelled by sneezing or coughing.

2. Singers would produce a high note by increasing the tension in their vocal cords. The air passing over the vocal cords would cause the cords to vibrate faster and produce a high note.

3. Answers should be in the form of flow charts indicating the pathway through the respiratory system in the following order: nasal passages, pharynx, glottis, larynx, trachea, bronchus, bronchiole, alveolus.

4. Each lung is surrounded by a thin, flexible, double-layered sac called the pleural membrane. The outer layer of this membrane is attached to the inside of the chest wall, and the inner layer covers the lungs. The thin space between these two layers contains a lubricating fluid that allows the layers to slide easily against each other during the movements of breathing.
5. Two characteristics are:
   - the arrangement of the bronchioles and alveoli is kept in a relatively permanent position by elastic connective tissue that fills the space between them; and
   - the alveoli are lined with a lubricating film that helps to keep them from collapsing and prevents their sides from sticking together and closing.

6. During external respiration, the walls of the alveoli and capillaries allow gases to diffuse through their cell membranes easily. Answers should include diagrams similar to Figure 11.9(A) on student textbook page 452.

7. Like a tree, the bronchi start from a single “trunk”, the trachea. The bronchi then branch into a great number of secondary bronchi that eventually lead to bronchioles. Also similar to a tree, gas exchange occurs in the “leaves” or alveoli of the lungs.

8. Sketches should illustrate and name the following structures: A – nasal passages; B – nostril; C – pharynx; D – epiglottis; E – glottis; F – larynx; G – bronchus; H – lung; I – bronchioles; J – diaphragm; K – thoracic cavity

9. Arterial blood has been recently oxygenated after passing through the lungs. When hemoglobin and oxygen combine, the red blood cell appears red. Venous blood has had its oxygen depleted and therefore the red blood cells no longer have the bright red colour. Blood oozing from a cut is exposed to oxygen in the air that binds with the hemoglobin to produce the bright red colour.

10. In birds, the air sacs permit a unidirectional flow of air through the lungs. This system might be considered more efficient than the mammalian lung because unidirectional flow means that air moving through bird lungs is largely “fresh” air and has a higher oxygen content. Therefore, in bird lungs, more oxygen is available to diffuse into the blood.

11. Oxygen is transported in the blood by binding to the iron-containing pigment in hemoglobin that is found in the red blood cells.

12. (1) bound to hemoglobin, and (2) dissolved in blood fluids

13. The blood sample that is brighter red is likely carrying more oxygen than the other sample of blood.

14. Sample answer:

   Carbon dioxide diffuses out of the blood into capillaries
   Carbon dioxide diffuses out of the capillaries into the air in the alveoli
   Carbon dioxide is exhaled into the air

Section 11.3 Review Questions
(Student textbook page 464)

1. Answers should demonstrate an understanding that tonsils trap harmful substances before they enter the respiratory system. Therefore, the removal of the tonsils allows harmful substances to enter the respiratory system and cause infections later in life. However, under certain conditions, the removal of part or all of the tonsils may be medically warranted.

2. Adults who are responsible for children, individuals with sensitive respiratory systems, and those with respiratory system disorders need to pay the most attention to this forecast so that they can take the necessary precautions. Children are more susceptible to air pollution than healthy adults because children have a higher rate of respiration and because the lungs of very young children are still developing. Adults with respiratory disorders or respiratory system issues are also at risk because many of these conditions are aggravated when air pollutants are inhaled.

3. Sample answer:

   cilia in lining of bronchi are destroyed
   bronchi become inflamed
   bronchi become vulnerable to infection

4. Emphysema is an obstructive respiratory disorder in which the walls of the alveoli break down and lose their elasticity. This reduces the surface area for gas exchange and causes oxygen shortages in the tissues. A low-flow oxygen system provides concentrations of oxygen that vary with the individual’s rate of breathing.

5. A metered-dose inhaler would likely be recommended because it is a pressurized canister that propels the medication deep into the lungs when triggered without the patient having to take a sharp deep breath, as would be needed with a dry powder inhaler.
6. A spiral CT scanner rotates continuously around the body producing clear, detailed views of blood vessels and internal tissues. It can also provide cross-sections that can be computer rendered into 3-D images of organs and tissues, allowing for detection of very small carcinomas.

7. The word “Future” in the slogan is appropriate because CF is a genetic condition, which means the condition is present at birth and affects the individual’s future.

8. Sample answer:

   Cells in the lungs multiply rapidly and develop into a tumour.

   Cells from the tumour separate and enter the blood or lymph. They are now known as metastatic cells.

   Metastatic cells leave the blood and enter the tissues and other parts of the body.

   A metastatic cell establishes itself in the new location and grows into a tumour.

9. Symptoms of asbestosis (pulmonary fibrosis) include:
   (1) shortness of breath – scarring has caused reduced respiratory surface, which means reduced gas-exchange capability;
   (2) a persistent and productive cough (a cough that expels mucus) – cilia lining the bronchi have been gradually destroyed, the bronchi have become inflamed, and mucus accumulates; and
   (3) chest tightness – scar tissue in the lungs prevents them from expanding.

10. X rays can’t penetrate lead so the lead apron serves as a shield that minimizes your body’s exposure to X ray radiation which, in sufficiently high doses, may cause cancer.

11. Because lung tissues are located deep within the thoracic cavity, lung cancer is difficult to detect in its early stages. Once lung cancer progresses to later stages, it becomes more difficult to treat.

12. Using lasers to destroy lung tumours helps reduce damage to the lungs, minimizes scarring, and speeds up the healing process. A laser emits a high-energy beam of light that can be precisely focused on a tumour with minimal impact on surrounding tissues. The heat of the laser also seals blood vessels and reduces blood loss and swelling. Traditional surgery involves opening up the chest wall and exposing the lungs, which poses major risks including infection and injury to healthy tissues.

13. Sample answer:

   Computer axial tomography scanner

   Can confirm the presence of a tumour, its size, location, and relationship to surrounding tissue

   Spiral scanning allows 3-D view of tissues and organs

   Faster scanning provides clearer images

   Produces cross-sectional images of the body

   The use of contrasting agents helps locate areas of infection or injury

   Carcinomas as small as 2–3 mm across can be detected

14. The drugs used in chemotherapy attack cells that are dividing rapidly. Because of this, the drugs kill some normal cells as well as cancer cells, especially the rapidly-dividing cells in the skin and digestive tract. As a result, chemotherapy can cause side effects such as loss of hair, nausea, and mouth sores.

15. It is often not possible to be sure that every cancerous cell has been removed during surgery for many different reasons. Radiation therapy and chemotherapy are used after such surgeries to make sure that any cancerous cells that were not removed by the surgery will be destroyed.

16. Doctors could increase the drug concentration to target the cells or organs that need it most.

Chapter 11 Review Questions
(Student textbook pages 471–3)

1. c
2. d
3. e
4. b
5. e
6. c
7. e
8. b
9. First, the surface area, or respiratory surface, must be large enough for the exchange of oxygen and carbon dioxide to occur at fast enough rates to meet the body's needs. Second, respiration must take place in a moist environment, so that the oxygen and carbon dioxide are dissolved in water.

10. Inhalation begins when the external intercostal muscles and the diaphragm contract. Exhalation begins when the diaphragm and the intercostal muscles relax, reducing the volume of the thoracic cavity.

11. emphysema

12. Breathing becomes extremely difficult because the inflammation of the pleural membrane prevents the membranes from sliding past each other smoothly.

13. Inhaled air is warmed before it enters the alveoli, which prevents shocking the blood with cold air. The air is also moistened, which improves the efficiency of diffusion of oxygen across the moist, thin walls into the capillaries.

14. A is inspiratory reserve volume
   B is tidal volume
   C is expiratory reserve volume
   D is residual volume
   E is vital capacity
   F is total lung volume

   This spirogram represents typical values for human vital capacity: the maximum volume of air that can be moved into and out of the lungs during a single breath.

15. The residual volume of air of a person with a collapsed lung would be significantly reduced as compared to that of a healthy individual.

16. The mucus in the lungs normally traps pathogens and then is expelled from the body by coughing. In people who have cystic fibrosis, the mucus is so thick that the pathogens are trapped but cannot be expelled. As a result, the lungs get repeated infections that reduce lung function, and the individual has trouble breathing.

17. The lack of mucus would mean that foreign particles such as dust and bacteria, which would normally be trapped by the mucus, would now move further into the respiratory tract and even the lungs. This may stimulate coughing or sneezing as the cilia lining the bronchi force these materials back out of the body. Another side effect might be that the nasal passages start to feel dry and sore because of the lack of moisture that is normally provided by the mucus.

18. Both carbon dioxide and water are waste products of cellular respiration. This water moves out of the cells into the blood. When it reaches the lungs, the water diffuses out of the blood and across the walls of the alveoli to be exhaled by the lungs.

19. Answers should show an understanding that the condition is a shortness of breath induced by sustained aerobic exercise, and that the athletes may have to resort to inhalers and alter their training program to control the attacks.

20. Sample answer: Use vital capacity as a good indicator of fitness. Divide your subjects into two groups each, with a similar numbers of males and females who are also similar in age. One group should be made up of individuals who do not exercise regularly (Group A) and the other a group of individuals who do exercise regularly (Group B). Measure each person's resting breathing rate and their vital capacities, then have them all do the same exercise and measure how long it takes each person's breathing rate to return to normal. Then see if there is any significant relationship between vital capacity, which is a measure of fitness, and the time it takes a person's breathing rate to return to normal after exercise.

21. Students may suggest experimental designs that involve scanning something similar to a steak, into which they prescribe inserting pieces of bone or tissues of different densities that are at least 2 mm across and larger.

22. The student in Experiment B would have a higher respiration rate and would be trying to breathe deeply. This is because the student has more carbon dioxide in his bloodstream than the student in Experiment A, who was allowed to breathe.

23. a. Viral pharyngitis affects the nasal passages, nostrils, and pharynx.
   b. The nasal passages, which serve to warm, moisten, and clean the incoming air, become inflamed and irritated. Excess mucus is created and the ciliated cells move the foreign particles back up into the nose and throat. The mucus and foreign particles are then expelled by coughing or sneezing. Pharyngitis can result in very large tonsils, which causes trouble swallowing and breathing.
24. Sample answer:

Lung cancer can be treated with:
- radiation therapy to kill cancer cells
- chemotherapy to kill cancer cells
- traditional surgery
- laser surgery

but the side effects are that:
- there is hair loss and nausea
- surrounding cells are also killed
- but all of the cancer may not have been removed; and patient needs time to recover and may be at risk of infection

25. Answers should include a compelling argument detailing the benefits and advantages of TPM, particularly in the case of treating children. Students should include the use of scientific evidence to support their ideas.

26. Sample answer:

The respiratory centres would trigger an increased breathing rate to bring more oxygen into the body.

The oxygen would be transported to the cells for cellular respiration.

Increased amounts of carbon dioxide would be released into the blood.

Rising amounts of carbon dioxide would combine with water in the blood to form carbonic acid (H₂CO₃). Carbonic acid molecules quickly break down to form bicarbonate ions and hydrogen ions (H⁺).

At the lungs, the carbon dioxide would reform and diffuse out of the blood and into the alveoli.

Excess carbon dioxide would be exhaled.

27. Answers should demonstrate an understanding that: external respiration is the exchange of oxygen and carbon dioxide between the air and the blood (occurs in the lungs between alveoli and capillaries and involves diffusion along a concentration gradient); and internal respiration is the exchange of oxygen and carbon dioxide between the body’s tissue cells and the blood. Oxygen diffuses from the blood into the oxygen-poor tissues while carbon dioxide diffuses from the tissues into the blood. Most of the oxygen is carried by hemoglobin, and most of the carbon dioxide is carried in the blood fluids.

28. Graphs should show that the non-smoker rate of decline is about five times less than the rate of the decline for the smoker. This is due to the deterioration of the smoker’s lung. It is estimated that the peak flow rate drops at a rate of 1% per year for a non-smoker and at a rate of 5% per year for a smoker.

29. True:
- gills, like lungs, have structural changes that increase the surface area of the body part involved in gas exchange
- a mechanism has evolved that enables the animal to ventilate this surface
- gills, like bronchioles and alveoli, are feathery tissue structures that consist of numerous delicate branches
- gases are exchanged over the gill membranes, as in lungs

False:
- ventilation mechanisms either require movement on the part of the organism or are combined with other functions (e.g., feeding)
- lungs require moistening, while gills do not

To summarize: A lung is an inside-out gill that must be kept moist and requires a pressure differential to work.

30. Answers should show an understanding of all Key Terms and Key Concepts from the Chapter 11 Summary on student textbook page 470.

31. Different types of organisms have different mechanisms for gas exchange. Unicellular organisms have a large surface area to volume ratio, so they are particularly efficient at exchanging gases through the cell membrane. Multicellular organisms are bigger than unicellular organisms, making diffusion of gases more difficult. However, many multicellular animals are small enough that they don’t require a specialized gas exchange system. Even relatively large animals, such as flatworms, can have adaptations that eliminate the need for a complex respiratory system. Platyhelminths are very dorsoventrally flattened—“flatworms.” This flattening makes them very thin and gives them a large ratio of surface area to volume. The flatworm’s respiratory surface area is large enough to service its relatively low volume.

32. The person was likely a smoker, as evidenced by the discoloration of the lungs. It is also likely that the person suffered from emphysema, given the deterioration of the structure of the alveoli.

33. Sharks that use ram ventilation to ventilate their gills keep their mouths open as they swim forward so that oxygen-rich water flows into their mouths, over their gills, and out through their gill slits. If they stopped moving, there wouldn’t be any new oxygen to diffuse into their bodies, without which they would not survive for long; therefore, the statement is true as these sharks must keep moving to continue to get the oxygen that they need.
34. A closed stuffy room likely has a lower concentration of oxygen. Without appropriate levels of oxygen, our cells are less able to provide the energy that we need to conduct any activity, including our ability to concentrate.

35. a. If water enters the airways of a conscious victim, the victim will try to cough up the water or swallow it, thus inhaling more water involuntarily. Upon water entering the airways the larynx or the vocal cords in the throat constrict and seal the air tube. This prevents water from entering the lungs. Because of this, water enters the stomach in the initial phase of drowning and very little water enters the lungs. With continued lack of oxygen in the brain, hypoxia will quickly render a victim unconscious.

   b. Artificial resuscitation restarts breathing by simulating respiration, which provides for the overall exchange of gases in the body by pulmonary ventilation, external respiration, and internal respiration.

36. a. When a smoker inhales tobacco smoke, the respiratory system tries to protect itself by producing mucus and stimulating coughing. Normally, the cilia that line the trachea and bronchi beat outward to sweep harmful substances out of the lungs. Chemicals in smoke paralyze the sweeping action of the cilia. As a result, some of the toxins remain in the lungs and mucus remains in the airways. While the smoker sleeps, some cilia recover and start functioning again. On waking, the smoker coughs because the lungs are trying to get rid of the toxins from the previous day’s smoking.

   b. Emphysema: Eventually, after long-term exposure to tobacco smoke, the cilia stop functioning completely. If that happens, the tar left in the lungs can cause the alveoli to become brittle, leading to the respiratory disorder known as emphysema.

37. A—bronchiole; B—alveoli, C—capillaries.

   Answers should show an understanding that gas exchange occurs where the capillary network is in contact with the alveoli.

38. More frequent shallow breaths are preferable, as this means you are using only your tidal volume and not inhaling smoke into the inspiratory reserve volume of the lung. Once through the smoke, you can then exhale strongly and replace the slightly smoky air with fresh air.

39. a. The hyperventilation removes carbon dioxide from the lungs. This reduces the stimulus for breathing.

   b. The divers may feel that they do not need to breathe even when their blood oxygen levels get so low that they are in danger of fainting.

40. The individual was unable to breathe for a period of time. The high levels of oxygen are needed to replenish the oxygen in the bloodstream to minimize tissue damage.

41. The carbon dioxide that you have exhaled has to be removed from the air and the oxygen that you have used has to be replaced in the appropriate concentrations.

Chapter 11 Self-Assessment Questions
(Student textbook pages 474–5)

1. e
2. d
3. d
4. d
5. c
6. c
7. d
8. c
9. a
10. b
11. Epiglottis—ii; Larynx—i; Bronchiole—iii; Diaphragm—iv
12. The pharynx, commonly known as the throat, is the passageway for air into the respiratory system, as well as the passageway for food and water into the digestive system. The epiglottis is a flap of cartilage that lies behind the tongue and in front of the larynx. The epiglottis closes over the opening to the trachea, the glottis, when a person swallows. This prevents food and drink from entering the trachea and passing into the bronchi of the lungs. When the epiglottis is at rest, it is upright and allows air to pass unobstructed into the lower respiratory tract. The larynx, or voice box, is made from cartilage and contains the vocal cords. After passing through the larynx, air moves down the flexible tube of the trachea, also known as the windpipe. The trachea is strengthened by semicircular, cartilaginous arches that prevent it from collapsing. The open part of the semicircle faces the esophagus and allows the esophagus to expand when food is being swallowed.
13. Carbon monoxide gas will bond to the hemoglobin molecule in preference to the oxygen molecule, effectively blocking oxygen from being transported in the blood at the levels needed. If maintained for long enough, inhalation of carbon monoxide gas can cause death as organs are quickly damaged when deprived of oxygen.

14. During gas exchange, oxygen and carbon dioxide are transported in different ways. Approximately 99 percent of the oxygen that reaches cells is carried by an oxygen transporting molecule called hemoglobin, which is only in red blood cells. This is hemoglobin's most important function. The rest is dissolved in the blood plasma. Slightly less than one-quarter (23 percent) of carbon dioxide is carried in the blood by hemoglobin; the remainder is dissolved and carried in the blood fluids.

15. Sample answers:
   - bronchitis, in which the airways are inflamed due to infection (acute) or due to an irritant (chronic), and coughing brings up mucus; or
   - emphysema, an obstructive respiratory disorder in which the walls of the alveoli break down and lose their elasticity, reducing the surface area for gas exchange and causing oxygen shortages in the tissues. Exhaling becomes difficult because of the loss of elasticity, so breathing is laboured.

16. Sample answer:
   To design a device that could model an artificial lung, you would need a housing of some type to enclose the entire mechanism, a membrane through which diffusion could take place, and a pump to pump blood through an oxygen source and return the oxygenated blood to the body. The device would contain bundles of hollow fibre membranes that function as the alveoli to facilitate diffusion for gas exchange. The device would require sensors to measure air inflow and outflow as well as the levels of oxygen and carbon dioxide, and mechanism to help stimulate the inhalation and exhalation functions.

17. Because smoking decreases the effectiveness of cilia to sweep out the lungs, other harmful substances (e.g., air pollutants) remain in the lungs. When this happens, the pollutants can cause further damage.

18. Cases of pneumonia would increase with rising temperature and relative humidity because warm, moist conditions allow pneumonia-causing bacteria to thrive and spread easily from person to person.

19. When you hold your breath carbon dioxide builds up in your lungs. When too much carbon dioxide builds up in your lungs, your brain tells you to breathe. Specifically, chemoreceptors in the brain and major blood vessels detect this shift and stimulate the breathing centre of the brain (the medulla oblongata). Hence, as CO₂ levels build up and the blood becomes more acidic, we involuntarily breathe, thus lowering CO₂ levels and stabilizing blood pH.

20. Asthma medications work to reduce inflammation in the airways and relax the bronchiole muscles, both of which open up the airways. However, the medications do not address the root cause of asthma, which is an extreme sensitivity to a wide range of triggers such as pollen, dust, cigarette smoke, and other air pollutants. As the triggers act in different ways, it is not possible to develop a cure that works for all causes.

21. Sample answer:

**Emphysema**
- is most commonly caused by smoking
- occurs when walls of the alveoli lose their elasticity, causing airways to collapse
- is a progressive disease that worsens as time passes

**Asthma**
- is caused by sensitivity to certain triggers (e.g., pollen, dust, smoke)
- is a chronic respiratory disease
- causes a blockage in airways, resulting in reduced airflow
- cannot be cured, but symptoms can be managed

Results in overproduction of mucus, which blocks airways.
22. a. Sample answer:

**Common Respiratory Disorders and Their Symptoms**

<table>
<thead>
<tr>
<th>Respiratory Disorder</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>• alveoli in lungs become inflamed and fill with fluids</td>
</tr>
<tr>
<td></td>
<td>• inflammation in one or both lungs</td>
</tr>
<tr>
<td>Chronic bronchitis</td>
<td>• bronchi become red, inflamed, and filled with mucus</td>
</tr>
<tr>
<td></td>
<td>• coughing expels mucus</td>
</tr>
<tr>
<td></td>
<td>• persistent cough in the case of chronic bronchitis</td>
</tr>
<tr>
<td>Asthma</td>
<td>• inflammation of the bronchi and bronchioles</td>
</tr>
<tr>
<td></td>
<td>• reduced airflow resulting in wheezing, coughing, tightness in the chest,</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• during an attack, muscles around the airways contract and cells may</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Emphysema</td>
<td>• exhaling is difficult</td>
</tr>
<tr>
<td>Cystic fibrosis (CF)</td>
<td>• thick build-up of mucus in the lungs</td>
</tr>
<tr>
<td></td>
<td>• infections common</td>
</tr>
<tr>
<td></td>
<td>• inflamed and damaged lung tissue</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>• persistent cough</td>
</tr>
<tr>
<td></td>
<td>• difficulty breathing</td>
</tr>
<tr>
<td></td>
<td>• chest pain</td>
</tr>
<tr>
<td></td>
<td>• loss of appetite</td>
</tr>
</tbody>
</table>

b. Given the symptoms, there is more than one possible disorder. Coughing that brings up mucus could be caused by pneumonia, chronic or acute bronchitis, asthma, and cystic fibrosis.

You could determine what is in the mucus (lab tests), determine the lung capacity (spirometry), determine if there is any lung damage (X ray, CT scan, bronchoscopy, listen to the lungs, conduct genetic tests for CF).

23. a. the trachea

b. This procedure would allow inspiration directly into the trachea, circumventing any blockages in the mouth or throat.

24. Respiratory efficiency is the rate at which oxygen can be transferred into the bloodstream for transport to the rest of the body. Vital capacity is the volume of gas that can be expelled from the lungs from a position of full inspiration, with no limit to duration of inspiration. Vital capacity is how much air the lungs hold, whereas respiratory efficiency is how well the oxygen is transferred from the lungs to the blood stream.

25. Advantages:

- air is easier to move over the respiratory surface
- air has a higher concentration of oxygen than water

Disadvantage:

- Compared to obtaining dissolved oxygen from water, breathing air makes it more difficult to keep the respiratory surface moist.

**Chapter 12 The Circulatory System**

**Learning Check Questions**

(Student textbook page 481)

1. Main functions of the circulatory system:
   (1) transport gases (from the respiratory system), nutrient molecules, and waste materials (from the digestive system); (2) regulate the internal temperature and transport chemical substances that are vital to health from one part of the body to the other; (3) protect against blood loss from injury and against disease-causing microbes or toxic substances introduced into the body.

2. In an open circulatory system, vessels open into the animal’s body cavity, whereas in a closed circulatory system the circulating blood is contained within vessels and kept separate from the interstitial fluid.

3. In an open circulatory system such as that of an insect, hemolymph is pumped through a single vessel by tubular hearts, and is then pushed from one open space or chamber to the next by muscle contractions.

4. Since the right ventricle sends blood to the lungs and the left ventricle sends blood into the rest of the body, an improperly working left ventricle would not have any effect on the lungs.

5. right atrium: O₂-poor; right ventricle: O₂-poor; left atrium: O₂-rich; left ventricle: O₂-poor

6. right atrium: blood going to right ventricle
   right ventricle: blood going to lungs
   left atrium: blood going to left ventricle
   left ventricle: blood going to body

(Student textbook page 486)

7. Veins have valves to allow blood to flow only toward the heart when open, and to prevent the backward flow of blood when closed. (Valves are found in the veins that carry blood to the extremities, such as fingers and toes, against the force of gravity.)
8. Because blood in the pulmonary arteries is oxygen-poor, but blood in the pulmonary veins is oxygen-rich, it is incorrect to say that all arteries carry blood high in oxygen and all veins carry blood low in oxygen.

9. Arteries carry oxygen-rich blood away from the heart. Veins carry oxygen-poor blood towards the heart. Capillaries allow for the exchange of materials between the circulatory system and the cells of the body.

10. As the muscles work, they use up energy and generate waste products, such as carbon dioxide. At the same time, there is a greater need for oxygen to generate the needed energy. The increased blood flow helps the lungs exchange more oxygen and release the carbon dioxide carried by the blood.

11. Arteries have thicker walls than do veins; veins are less elastic than arteries; veins have a larger inner circumference than arteries.

12. The three main components of blood are: plasma; white blood cells and platelets; and red blood cells. Plasma, the liquid portion of blood, consists of water with dissolved gases, proteins, sugars, vitamins, minerals, and waste products. Plasma makes up about 55% of blood volume. The solid component of blood that comprises the other 45% consists of red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes).

(Student textbook page 491)

13. Regular exercise helps keep arteries elastic, which ensures normal blood flow and normal blood pressure.

14. Stenosis is a narrowing in the opening of the heart valves or arteries that can result in the non-smooth (or turbulent) flow of blood.

15. The SA node is a nerve bundle that stimulates atrial contraction and controls the heartbeat. It acts as the heart's natural pacemaker because its self-firing mechanism generates electrical signals at regular intervals, which automatically repeats a cycle of firing, relaxing, and firing.

16. The ratio of 2.3 is quite dissimilar to the normal 3:2 ratio for systolic/diastolic. The 80 reading might indicate that the maximum pressure is not being achieved when the ventricles contract, meaning that not enough blood is being pumped from the heart. This individual might experience dizziness and a feeling of being cold. The 120 reading might indicate that the heart has not completely relaxed and has not yet reached its lowest point. This individual might experience hyperactivity and a feeling of being overheated.

17. The voltage increase at R causes the ventricles to contract.

18. Answers could include any two of the following: genetics, activity, stress, body temperature, diet, and medications. Treatments could include exercise, better diet, or blood pressure medications.

(Student textbook page 498)

19. When arteries supplying blood to the brain are clogged with plaque (fatty deposits), this cuts off the flow of oxygen and nutrients to brain tissue, increasing the risk of a stroke.

20. Blood pressure causes the aneurysm to grow larger over time, with an increasing risk of bursting. If the aneurysm bursts, there will be internal bleeding that can quickly lead to death.

21. In aortic stenosis, the volume of blood ejected from the left ventricle is reduced. As a result, the heart's ability to pump blood decreases and blood backs up into the lungs.

22. (1) Angioplasty is a surgical procedure used to open a clogged artery and to place a stent in the artery to prevent further blockage. (2) Coronary bypass surgery is used to re-route the blood flow by creating new pathways for the blood to flow between the aorta and the blocked arteries. (3) Valve replacement is the use of animal or human sources, or synthetic materials, to either repair or replace fused or damaged valves.

23. An ischemic stroke is caused by a clot in a blood vessel. A hemorrhagic stroke occurs when a blood vessel in the brain ruptures and the blood flows into the surrounding brain tissue. Using an MRI scan, a clot in a blood vessel (ischemic stroke) could easily be distinguished from a rupture (hemorrhagic stroke) because the excess blood could be identified.

24. An exercise cardiogram is also known as a cardiac stress test. An exercise ECG is usually performed to diagnose the cause of chest pain, irregular heartbeats, dizziness, or fatigue.

Caption Questions

Figure 12.4 (Student textbook page 482): The black arrows indicate the direction of blood flow.

Figure 12.11 (Student textbook page 485): Students should be able to name any two of the following factors: clotting prevents excessive blood loss after injury; it helps protect the injury site; it begins repair of the injury.

Figure 12.12: Students should be able to name any two of the following factors: high/low body core temperature; high/low blood pressure; increased metabolic activity, such as during exercise; high/low external temperature; certain substances such as alcohol and nicotine.
Section 12.1 Review Questions
(Student textbook page 488)

1. The body cavity in an insect is very small, which means that the blood does not have far to circulate. As the respiratory and circulatory systems are separate, even a very active insect can meet its oxygen requirements despite its relatively slow circulation.

2. d. vena cava; b. right atrium; c. right ventricle; and a. pulmonary arteries

3. Sample answer:

4. Answers should include any three key functions of plasma proteins, and all three functions of salts in plasma, as listed in Table 12.1 on student textbook page 484.

5. The biconcave shape of an erythrocyte increases the surface area available for gas exchange, and the lack of a nucleus makes these cells smaller and more flexible as they travel through the body tissues.

6. Men are usually taller and weigh more than the average woman. Since men's bones are therefore longer and bigger, more red blood cells could be manufactured in the bone marrow.

7. The heart has to work harder to compensate for the backflow of blood through the valve, so having a leaky heart valve could result in heart failure in some patients.

8. A: Neutrophils are found in tissues and blood; B: Eosinophils are found in the mucous lining of the digestive and respiratory tracts; C: Monocytes are found in the bloodstream; D: Macrophages act to engulf pathogens encountered; E: Basophils act at the sites of infection and secrete anti-clotting factor

9. An artery has three different structural layers. The outer layer is a covering of connective tissue mixed with a few elastic fibres. The thickest middle layer is composed of alternating bands of elastic fibres and smooth muscle. The inner layer, only one single cell thick, reduces the friction of the blood as it flows through. The elasticity of the walls of the artery allows expansion and contraction as blood flows through and also adds to the pumping motion that forces the blood through the vessels, as is evidenced in your pulse.

10. Answers should indicate an understanding that blood flowing through veins in the legs and the lower part of the body has to move against the force of gravity to return to the heart, and this further reduces the pressure. There are two mechanisms in the veins that give blood flow a boost as blood pressure drops. Firstly, small muscles surrounding the veins contract and relax to squeeze blood along the veins. Secondly, one-way valves inside the veins prevent blood from flowing backward due to the pull of gravity.

11. Some of the basic functions of a mammal's circulatory system are: (1) it transports gases (from the respiratory system), nutrient molecules, and waste materials (from the digestive system); (2) it regulates internal temperature and transports chemical substances that are vital to health from one part of the body to the other; (3) it protects against blood loss from injury and against disease-causing microbes or toxic substances introduced into the body.

12. Plasma contains proteins such as albumin, globulins, and fibrinogen that have many vital functions that include resisting infections, helping blood to clot, maintaining a slightly alkaline pH in the blood, and adjusting the body's fluid balance. The plasma also contains organic substances and inorganic ions such as sodium, potassium, chloride, and bicarbonate that are essential for nerve conduction, muscle contraction and maintaining the body's fluid balance.

13. Sample answer:
14. Since the artificial blood is unable to transport carbon dioxide, the concentration of carbon dioxide in the body and blood vessels will increase. This will cause an increase in acidity, forming carbonic acid, which in turn increases the concentration of hydrogen atoms—this could build up to toxic levels that can be harmful to the person.

15. Assuming the person has a heart rate of 75 beats per minute, then the volume pumped in one minute is $75 \times 70 \text{ mL} = 5250 \text{ mL}$. Since 14% of the blood volume is oxygen, then $5250 \times 0.14 = 735 \text{ mL}$. Arterial blood contains 20% oxygen by volume, or $1050 \text{ mL}$ of oxygen. Therefore, the blood absorbs $1050 - 735 = 315 \text{ mL}$ of oxygen.

16. Answers should show an understanding of the role of blood and the circulatory system in the following systems:
   a. the digestive system: works closely with the circulatory system to transport absorbed nutrients throughout the body; circulatory system transmits chemical messages that control the speed of digestion
   b. the respiratory system: supplies the blood with oxygen, which the circulatory system then delivers to other parts of the body; carbon dioxide is carried by the circulatory system back to the lungs, where it is exhaled from the body

Section 12.2 Review Questions
(Student textbook page 493)

1. Students should be able to identify these areas of the heart as shown in Figure 12.14 on student textbook page 489.

2. If no signal is received from the SA node, then the ventricles will not contract and no blood can flow from the heart to the body tissues.

3. The P wave begins when the SA node fires and the atria contract. The QRS complex occurs as the ventricles contract. The T wave occurs as the ventricles relax. The typical “lub-DUB” sounds can be heard. If the distance between these adjacent gaps is consistent, then the overall health of the individual can be determined.

4. The fittest individual is C, because they pump more blood with each heartbeat even though their resting heart rate is lower. Cardiovascular fitness is determined by the capacity of the heart, lungs, and blood vessels to deliver oxygen to working muscle tissues so that they can maintain prolonged physical work.

5. frequency, strength, and duration.

6. Correct sequence: a, e, i, c, h, f, b, g, d, j

7. Systolic blood pressure occurs when the left ventricle contracts, forcing blood out of the heart; it is the highest pressure in the cardiac cycle. Diastolic is the lowest blood pressure, and it occurs immediately before another contraction of the ventricle.

8. The graphs will both have positive slopes for the individual's normal readings, and the highs and lows will have definite fluctuations. The overall trend is that the individual's blood pressure increases the longer the person does not exercise regularly and continues to eat fatty foods.

9. The “lub-DUB” sound is a repeated double beat, which is made as different heart valves close. The first, “lub”, is the sound of the closing of the atrioventricular valves. The second, “DUB”, is the sound of the semilunar valves closing.


11. Circulation in the extremities is poor in extreme cold because the blood goes to the internal organs to protect them.

12. No, it cannot. Although an ECG can be used to determine heart rate, it does not provide an indication of stroke volume, which is needed to calculate cardiac output. Two people with the same heart rate but with different stroke volumes would have different cardiac outputs.

13. It is a form of hypotension in which there is a sudden fall in blood pressure. The sudden fall in blood pressure leads to a diminished blood circulation in the brain area, and may cause a temporary loss of vision.

14. by dilating or relaxing the arteries

Section 12.3 Review Questions
(Student textbook page 503)

1. Arteriosclerosis is the hardening of the arteries, which causes them to lose their elasticity. It can be caused by poor diet, smoking, lack of exercise, and lifestyle choices.

2. After the plaque has been compressed against the arterial wall, a stent or wire mesh device is permanently placed in the artery to keep the vessel open and to reduce the possibility of further blockage.

3. Hemophilia: a person with hemophilia bleeds for a long time and is at risk of dying from internal bleeding that may occur as a result of a minor injury.
4. Coronary angiography, or mapping the coronary arteries, is done by injecting a liquid dye into an artery and then taking X rays as the dye moves through the blood vessels. By mapping the flow of dye, a doctor can determine where the circulation is blocked.

5. Arrhythmia is an irregular speed or rhythm of the heartbeat. The artificial pacemaker is a small device that only transmits electrical impulses when the heartbeat is abnormal. The pacemaker can send electrical signals to the atria, the ventricles, or to both.

6. Sample answer: Draw a blood sample for a complete blood count. This test checks your hemoglobin levels. Hemoglobin is the iron-rich protein in red blood cells that carries oxygen to the body. A low level of hemoglobin is a sign of anemia.

7. Magnetic resonance imaging (MRI) uses powerful magnets and radio waves instead of X rays. An MRI machine produces a strong magnetic field that forces hydrogen atoms in the body to line up in the direction of the field. A burst of radio waves sent toward the field causes the hydrogen atoms in the brain tissue to briefly alter their alignment, creating a signal that can be detected by the scanner. Computer analysis of these signals generates detailed three-dimensional images of the body's internal structures.

8. The doctor would likely recommend a tissue valve, as it does not require that the patient take blood thinners, something that a hemophiliac must avoid so they do not bleed to death.

9. Students might name and describe any three of the following diagnostic tests: chest X ray; angiography; cardiac catheterization; electrocardiogram (ECG); echocardiogram (ECHO); exercise ECG (stress test); Holter monitoring or event monitoring; stethoscope; Doppler ultrasound; CT scan; cardiac MRI.

10. Advantages: readily available; no need for immunosuppressive drugs; artificial heart restores hemodynamic stability, raising blood pressure and helping vital organs recover; persons who are not heart transplant candidates have prolonged time with family and friends, and time to enjoy desired activities. Disadvantages: can wear out or the electrical motor can fail; infection, and the need to take blood thinners to prevent clotting. Stroke and bleeding are also possible complications with the artificial heart; not all patients have a body size that allows the device to be implanted into the chest cavity, making small persons unable to receive the device.

11. Normally, the aorta carries oxygen-rich blood to the body, and the pulmonary artery carries oxygen-poor blood to the lungs. If the aorta and the pulmonary artery are transposed, the pulmonary artery pumps blood to the rest of the body instead of to the lungs, and the aorta pumps blood to the lungs instead of to the rest of the body. When this happens, oxygen-rich blood is circulated in an endless loop through the lungs, and the oxygen-poor blood from the body recirculates through the body, without ever reaching the oxygen-rich environment of the lungs.

Sample answer:

12. An ischemic stroke is caused by a clot in a blood vessel. This differs from a hemorrhagic stroke, which occurs when a blood vessel in the brain ruptures and blood flows into the surrounding brain tissue.

13. The person may be experiencing arteriosclerosis. Treatments for this condition include: making healthy lifestyle choices, taking clot-reducing medicines such as Aspirin, taking a clot-busting medication such as urokinase, and surgical treatment, such as angioplasty.

14. Some safety and environmental concerns related to the use of medical nanotechnologies involve unintended effects on human health and/or the environment, such as biological or chemical contamination through leakage, spillage, circulation, inhalation, or accumulated concentrations of nanoparticles in the human body or natural ecosystems.

15. Sample answer: Manufacturers would have to create a device that would not wear out for at least the length of a person's normal lifespan. In addition, battery power would also have to last a lifetime because you can't stop a person's heart to replace the batteries.
16. Answers should show an understanding of how lifestyle choices such as smoking, diet, and level of exercise affect health both positively and negatively.

Chapter 12 Review Questions
(Student textbook pages 513–5)

1. e
2. a
3. c
4. c
5. d
6. a
7. a
8. b
9. the diastolic pressure from the recoil of the arteries

10. Answers should show an understanding of the following concepts:

   Similarities:
   - some sort of pumping device helps to move blood through the body
   - some of the circulation of blood is a result of body movements
   - all tissues come in close contact with the circulating body fluid so that the exchange of nutrients and wastes can occur

   Differences:
   - blood is contained within vessels and separate from body tissues
   - blood is separate from interstitial fluid

11. Diagrams should be labelled as shown in Figure 12.15 on student textbook page 490.

12. Graphic organizers or tables should identify at least three of the following disorders and their associated diagnostic technologies:

<table>
<thead>
<tr>
<th>Circulatory System Disorder</th>
<th>Diagnostic Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angina</td>
<td>• chest X ray</td>
</tr>
<tr>
<td></td>
<td>• angiography</td>
</tr>
<tr>
<td></td>
<td>• cardiac catheterization</td>
</tr>
<tr>
<td></td>
<td>• electrocardiogram (ECG)</td>
</tr>
<tr>
<td></td>
<td>• echocardiogram (ECHO)</td>
</tr>
<tr>
<td></td>
<td>• exercise ECG (stress test)</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>• electrocardiogram (ECG)</td>
</tr>
<tr>
<td></td>
<td>• exercise ECG (stress test)</td>
</tr>
<tr>
<td></td>
<td>• chest X ray</td>
</tr>
<tr>
<td></td>
<td>• echocardiogram (ECHO)</td>
</tr>
<tr>
<td></td>
<td>• Holter monitoring or event monitoring</td>
</tr>
<tr>
<td>Atherosclerosis</td>
<td>• angiography</td>
</tr>
<tr>
<td></td>
<td>• chest X ray</td>
</tr>
<tr>
<td></td>
<td>• echocardiogram (ECHO)</td>
</tr>
<tr>
<td></td>
<td>• CT scan</td>
</tr>
<tr>
<td></td>
<td>• exercise ECG (stress test)</td>
</tr>
<tr>
<td></td>
<td>• Doppler ultrasound (similar to echocardiography)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>• chest X ray</td>
</tr>
<tr>
<td></td>
<td>• stethoscope</td>
</tr>
<tr>
<td></td>
<td>• electrocardiogram (ECG)</td>
</tr>
<tr>
<td></td>
<td>• echocardiogram (ECHO)</td>
</tr>
<tr>
<td></td>
<td>• exercise ECG (stress test)</td>
</tr>
<tr>
<td></td>
<td>• Holter monitoring or event monitoring</td>
</tr>
<tr>
<td>Congenital heart defects</td>
<td>• chest X ray</td>
</tr>
<tr>
<td></td>
<td>• electrocardiogram (ECG)</td>
</tr>
<tr>
<td></td>
<td>• echocardiogram (ECHO)</td>
</tr>
<tr>
<td></td>
<td>• cardiac catheterization</td>
</tr>
<tr>
<td></td>
<td>• angiography</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>• angiography</td>
</tr>
<tr>
<td></td>
<td>• electrocardiogram (ECG)</td>
</tr>
<tr>
<td></td>
<td>• echocardiogram (ECHO)</td>
</tr>
<tr>
<td></td>
<td>• exercise ECG (stress test)</td>
</tr>
<tr>
<td></td>
<td>• CT scan</td>
</tr>
<tr>
<td></td>
<td>• cardiac catheterization</td>
</tr>
<tr>
<td>Heart valve disease</td>
<td>• chest X ray</td>
</tr>
<tr>
<td></td>
<td>• electrocardiogram (ECG)</td>
</tr>
<tr>
<td></td>
<td>• echocardiogram (ECHO)</td>
</tr>
<tr>
<td></td>
<td>• cardiac catheterization</td>
</tr>
<tr>
<td></td>
<td>• exercise ECG (stress test)</td>
</tr>
<tr>
<td></td>
<td>• cardiac MRI</td>
</tr>
</tbody>
</table>
13. The heart pumps the hemolymph through vessels into sinuses/body cavities, and body movements squeeze the sinuses, forcing hemolymph through the body. When the heart relaxes, hemolymph is drawn back in through the small pores.

14. An open circulatory system is one in which vessels open into the animal’s body cavity, as in the circulatory systems of earthworms and insects.

15. Sample answer:
A Comparison of Pulmonary and Systemic Circulation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pulmonary circulation</th>
<th>Systemic circulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side of heart</td>
<td>Right side</td>
<td>Left side</td>
</tr>
<tr>
<td>Type of blood pumped</td>
<td>Deoxygenated</td>
<td>Oxygenated</td>
</tr>
<tr>
<td>Destination</td>
<td>Lungs and the arteries, veins, and capillaries that serve the lungs</td>
<td>Rest of the body and the arteries, veins, and capillaries that serve the body</td>
</tr>
<tr>
<td>Pathway of carbon dioxide</td>
<td>Blood that flows from the heart to the lungs carries waste carbon dioxide</td>
<td>The blood returns to the heart carrying waste carbon dioxide from the body tissues</td>
</tr>
<tr>
<td>Pathway of oxygenated blood</td>
<td>Pumped from the heart to the rest of the body</td>
<td>Pumped to the heart and then re-enters the pulmonary circulation</td>
</tr>
<tr>
<td>Movement of blood</td>
<td>Heart → Lungs → Heart</td>
<td>Body tissues → Heart → Pulmonary circulation → Body tissues</td>
</tr>
</tbody>
</table>

16. Angioplasty is used to treat arteriosclerosis. During angioplasty, the surgeon inserts a tube with a narrow balloon inside it into a clogged artery. When the tube reaches the site where the artery is clogged, the balloon is inflated to widen the vessel. After the balloon is removed, a permanent tube may be left in place to keep the vessel open.

17. Approximately every minute of every day someone in Canada needs blood. About 52% of Canadians say they, or a family member, have needed blood or blood products for surgery or medical treatment.

18. Systolic blood pressure gradually increases during exercise, while diastolic blood pressure remains about the same. Diastolic pressure may even decrease due to vasodilation, or the slight dilation of blood vessels caused by the heart pumping harder to spread more oxygen throughout the body. Since systolic pressure is directly connected to how the heart operates, it is affected the most by exercise.

19. Sample answer:
A Comparison of Pulmonary and Systemic Circulation

<table>
<thead>
<tr>
<th>Part of Heartbeat</th>
<th>Diastole Begins</th>
<th>Diastole Is Complete</th>
<th>Systole Begins</th>
<th>Systole Is Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are the AV valves open or closed?</td>
<td>open</td>
<td>open</td>
<td>closed</td>
<td>closed</td>
</tr>
<tr>
<td>Are the semilunar valves open or closed?</td>
<td>closed</td>
<td>closed</td>
<td>closed</td>
<td>open</td>
</tr>
<tr>
<td>Are the atria relaxed or contracted?</td>
<td>relaxed</td>
<td>contracted</td>
<td>relaxed</td>
<td>relaxed</td>
</tr>
<tr>
<td>Are the ventricles relaxed or contracted?</td>
<td>relaxed</td>
<td>relaxed</td>
<td>contracted</td>
<td>contracted</td>
</tr>
<tr>
<td>Where is the highest pressure during this phase?</td>
<td>atria</td>
<td>atria</td>
<td>ventricles</td>
<td>ventricles</td>
</tr>
</tbody>
</table>

20. The QRS complex would not occur because the AV node has not stimulated the ventricles to contract and the AV valves would not close, which is what produces the “lub” sound. The drawing will only include P waves and perhaps intermittent QRS complexes and T waves as the arrhythmia patterns change.

21. Hypertension causes the heart to work harder for extended periods of time, increasing the risk of heart attack, stroke, and kidney failure.

22. a. a centrifuge
b. top layer—plasma 55%; middle layer—white blood cells and platelets 1%; bottom layer—red blood cells 44%
c. A blood sample for a patient suspected of suffering from anemia would have a lower relative volume of red blood cells than that of a healthy person.
d. Answers should show an understanding that anemia is a blood disorder in which the blood contains fewer than normal healthy red blood cells.

23. a. red blood cells—B; white blood cells—D
b. C (lowest rbc count)
c. E (highest wbc count)
24. Answers should show an understanding that regular exercise reduces the resting heart rate while improving the stroke volume. Students should use simple diagrams that are appropriate for grade 1 learners.

25. Students should include in their answers summaries of some of the following technologies: MRI, X rays, artificial hearts, gene therapy and the transfusion of clotting factors for hemophilia, ECG, biomarkers, nanovalves, artificial blood, and blood substitutes.

26. a. The atrioventricular (AV) valves separate the atria from the ventricles.
   b. The aorta is the main artery of the heart, taking oxygenated blood to the other body systems.
   c. In counter-current exchange, a diffusion gradient keeps oxygenated and deoxygenated blood separate.
   d. All veins except the pulmonary veins carry oxygen-poor blood and all arteries except the pulmonary arteries carry oxygen-rich blood.
   e. Fibrinogen is a blood protein involved in the blood clotting mechanism.

27. Students should list some of the following common disorders: arteriosclerosis, atherosclerosis, aneurysm, arrhythmia, heart murmur, stroke, heart attack, hypertension, blood clots, plaques.

28. The average cardiac output is 4900 ml/min—about 8 times less than these elite athletes—and their heartbeat is almost twice as great. Elite athletes train using cardiovascular techniques that enable them to dramatically improve their cardiac output by making increased demands upon their circulatory system on a daily basis. As well, their diets and schedules are carefully supervised to ensure overall athletic success.

29. Answers should show an understanding of some of the factors in maintaining a healthy heart, including: avoiding smoking and illegal drug use; maintaining a healthy weight; eating a diet high in unsaturated fats and antioxidants, including fresh fruits and vegetables; and getting regular exercise.

30. Answers should show include some of the consequences of quadruple bypass surgery, which can be:
   - development of blockages in other arteries
   - damage to the aorta
   - abnormal heart rhythm
   - high or low blood pressure
   - depression or severe mood swings
   - blood clots leading to heart attack or stroke
   - kidney failure
   - recurrence of angina

31. Answers should show an understanding of the risks associated with eating a poor diet, smoking, and getting little or no exercise. Plans should clearly communicate how maintaining a healthy lifestyle contributes to a healthy circulatory system by reducing the risk of circulatory system disorders, such as arteriosclerosis and strokes.

32. a. The circulatory system has the following main functions:
   - transports gases (from the respiratory system), nutrient molecules (from the digestive system), and waste materials (from the excretory system)
   - regulates internal body temperature and transports hormones
   - protects against blood loss from injury and against disease-causing microbes or toxic substances introduced into the body
   b. The superior vena cava carries blood from the upper half of the body to the heart, and the inferior vena cava carries blood from the lower half of the body to the heart.
   c. Answers should show an understanding that the heart has to work harder to compensate for the back flow of blood through the valve and having a leaky heart valve could result in heart failure in some patients.

33. Answers should show an understanding of all Key Terms and Key Concepts from the Chapter 12 Summary on student textbook page 512.
34. **a.** damage to the mitral valve: listen through stethoscope for unusually loud tapping sound caused by the force of closing of the mitral valve (this could indicate stenosis); listen for a high-pitched snap upon the opening of the mitral valve (also indicating stenosis); stretched valve flaps can make a clicking sound when they shut; if valve is leaking blood back into the atrium (regurgitation), this may produce a murmur or whooshing sound

**b.** damage to the tricuspid valve: listen through stethoscope for heart murmur caused by blood moving through a stenotic or leaky valve (indicating regurgitation); listen to lungs to determine if they are retaining fluid, which indicates the heart is not pumping as well as it should

**c.** damage to the aortic valve: listen through stethoscope for heart murmur caused by blood moving through a stenotic or leaky valve (indicating regurgitation)

**d.** damage to the pulmonary valve: listen through stethoscope for heart murmur, which may indicate aortic valve stenosis

**e.** damage to the AV node: listen with stethoscope for an irregular heartbeat; a premature or abnormal heartbeat (a “skipped” beat) can indicate arrhythmia

35. Sample answer:

![Diagram](image)

36. Your heart rate and blood pressure are both elevated from the strenuous activity and your cardiac output is high. The temperature in the hot tub will artificially elevate these levels even higher due to vasodilation and vasoconstriction. During the activity the body was probably attempting to conserve heat (vasoconstriction) if the weather was cold, or it was attempting to reduce body temperature (vasodilation) if the weather was warm. In either case, extended stays in the hot tub might lead to irregular heart rhythms or palpitations.

37. Common misconceptions may include:
- it is unsafe to donate blood
- not all donated blood is tested
- a blood transfusion is not safe
- 10% of the Canadian population donates blood (in reality this number is 3%)
- blood donation is harmful to the donor
- one can only accept a blood donation from a blood relative
- if I have a tattoo I cannot donate blood
- money is provided for blood donations

38. A healthy person has a strong heart, which has a larger stroke volume and a slow heart rate. When the person stands up, gravity pulls blood from their brain towards their feet and blood does not return to the brain until the next heartbeat. For a healthy person with a slow pulse, this takes a second or two and that is enough time to feel the lack of oxygen in the symptom of lightheadedness or dizziness.

39. **a.** The defect in the baby’s heart essentially creates a single ventricle, as is found in a frog’s heart.

**b.** A baby with a small ventricular septal defect may have no problems at all. A baby with a larger ventricular septal defect may have a telltale bluish tint to the skin due to oxygen-poor blood; this is often most visible in the lips and fingernails. These implications do not apply to the frog because amphibians also respire through their skin; therefore, the reduced efficiency of the frog’s three-chambered heart is not a factor.

40. Anemia occurs when there is insufficient hemoglobin in the blood and there are too few red blood cells. The body needs iron in order to produce hemoglobin, which carries oxygen to all parts of the body. Anemia can be caused by inadequate iron in the diet, or poor absorption of iron. It can also be caused by long-term blood loss due to peptic ulcers, hemophilia, heavy menstrual periods, long-term use of aspirin, or uterine cancer. Other factors include lead poisoning, and lesions or injuries to the gastrointestinal tract (as in the case of ulcerative colitis and colon cancer). The decreased number of red blood cells often results in pallor of the skin. Anemia also causes fatigue because the heart has to work harder to provide oxygen-rich blood to the body.
Chapter 12 Self-Assessment Questions
(Student textbook pages 516–7)
1. b
2. e
3. d
4. d
5. a
6. d
7. e
8. c
9. b
10. a

11. a. Cardiac output = heart rate × stroke volume = 70 bpm × 75 mL/stroke = 5250 mL (or 5.25 L)
   b. 365 days × 24 hours/day × 60 min/hour × 5.25 L/min = 2 759 400 L

12. Synthetic blood substitutes can carry out some of the functions of real blood for a short time (until matching donated blood can be found), but there is currently no real substitute for human blood for transfusion. Researchers are working to develop fluids that can carry oxygen to tissues, but as yet they have been unable to replace many of the functions of human blood, such as defending the body from disease, and the blood clotting process.

13. Diagrams and labels should be similar to Figure 12.7 on student textbook page 483.

14. If the right ventricle cannot pump blood properly, the lungs will receive a reduced blood flow and less oxygen-rich blood will be available for the body.

15. The blood vessels in the penguin’s feet are constricted to reduce the amount of blood flow to them. This reduces the amount of heat lost from the feet.

16. Answers should show an understanding of the components of blood and their respective proportions in a blood sample of a healthy person, and the possible disorders of the blood that could be identified, such as anemia and leukemia.

17. When reattaching a severed finger, blood from the veins can pool in the appendage and threaten its survival. Leech saliva dilates blood vessels and prevents blood clotting. This would improve blood supply and circulation to the tissues, resulting in a better surgical outcome.

18. Students should be able to identify the four main valves in the diagram as the bicuspid atrioventricular valve, the tricuspid atrioventricular valve, the pulmonary semilunar valve, and the aortic semilunar valve. The two atrioventricular valves are between the atria and the ventricles, and they keep blood flowing in one direction. The semilunar valves are between each ventricle and the large arteries that carry blood away from the heart. The two atria contract simultaneously, pushing blood through the valves into the ventricles. When the ventricles contract simultaneously, the blood is pumped out of the heart.

19. a. A: atrial fibrillation; B: arrhythmia
   b. An artificial pacemaker is a small device that emits electrical impulses to control the rate of the heartbeat. It is attached just under the skin of the chest and usually includes a sensor that monitors the heart. The pacemaker only transmits an electrical impulse to the heart when the heartbeat is abnormal. Depending on the nature of the problem, the pacemaker may send electrical signals to the atria, or the ventricles, or to both.

20. The stress test helps determine the heart’s response to the stress of exercise. This test is usually performed to determine the cause of unexplained chest pain, or if the person is experiencing irregular heartbeats, excessive dizziness, or fatigue.

21. The duration of heart relaxation is much shorter. For an average heart rate of 70 beats per minute, the duration of a heartbeat is 60 s/70 beats, or 0.86 s per beat. In addition, assuming that the duration of contraction and relaxation are equal, each lasts 0.43 s. At 200 beats per minute (or 0.30 s per beat), the relaxation phase of the cardiac cycle is 0.15 s. Therefore, the heart has only 0.15 s to fill with blood. A shorter relaxation phase results in a smaller stroke volume, since the heart does not have enough time to fill completely.

22. (1) Coronary bypass surgery: surgeons bypass blocked arteries using vessels from another part of the body.
   (2) Angioplasty: surgeons thread a catheter into an artery in the groin or upper part of the arm and guide it through the major blood vessels toward the heart. Where there is plaque a balloon is inflated, forcing open the vessel. Stents may also be inserted. (3) Drug treatment: drugs that include an enzyme (tPA) that work with the body to dissolve blood clots.
23. Varicose veins can be caused by prolonged pressure on the veins due to pregnancy, obesity, aging, long periods of standing, leg injury, or abdominal straining. If the condition is severe, the doctor may recommend surgical removal of all or part of the affected vein, or non-surgical treatments such as keeping the legs elevated, taking pain relievers, getting moderate exercise, or laser therapy to make the vein contract.

24. If the heart rhythm is abnormal but a faulty signal is sent to the computer that it is OK, then the pacemaker will not direct the generator to send electrical pulses to the heart. The person might feel dizziness and/or fatigue. If the heart is functioning properly but a faulty signal is interpreted by the computer that the heart needs stimulation, then the heart could be forced to beat erratically (similar to atrial fibrillation).

25. Through osmosis, salt causes body tissues to retain water and it promotes thirst. Excessive salt keeps the circulatory volume higher than it should be, exerting excess fluid pressure on blood vessel walls. The blood vessel walls react to this stress by thickening and narrowing, leaving less space for the fluid already cramped in the blood compartment, raising “resistance” and requiring higher pressure to move blood to the organs. The heart has to pump against this high pressure system.

Unit 4 Review Questions
(Student textbook pages 521–5)

1. c
2. b
3. b
4. e
5. d
6. c
7. c
8. b
9. d
10. d
11. e

12. Answers should show an understanding of the difference between physical and chemical digestion in the stomach. In physical digestion, peristalsis pushes food against the bottom of the stomach, churning it backward, breaking it into smaller pieces, and mixing it with gastric juice to produce a thick liquid called chyme. In chemical digestion, gastric juice is responsible for the further breakdown of food in the stomach.

13. a. Inflammatory bowel disease is the general name for diseases that cause inflammation in the intestines (bowels). Crohn's disease usually affects the ileum of the small intestine, but it can affect any part of the digestive tract from the mouth to the anus. Colitis is the inflammation and ulceration of the lining of the colon.

b. Cirrhosis is a chronic disease of the liver that occurs when scar tissue replaces healthy liver tissue and prevents the liver from functioning properly. Chronic alcoholism and hepatitis C are the most common causes of cirrhosis of the liver.

c. A peptic ulcer forms when the thick layer of mucus that protects the lining of the stomach from the acids in the digestive juices is eroded.

d. Constipation is a common disorder in which bowel movements are reduced to three per week or less. It can be caused by inadequate water intake, lack of good nerve and muscle function of the bowel, poor diet and lack of physical activity.

e. Hepatitis is an inflammation of the liver. There are three types of hepatitis: A, B, and C. Hepatitis A is usually contracted from drinking contaminated water. Hepatitis B is spread by sexual contact but there is a vaccine to protect against it. Hepatitis C is usually contracted by contact with infected blood; there is no vaccine for hepatitis C.

f. Gallstones are hard masses that form in the gall bladder when cholesterol in the bile causes crystals to grow and accumulate.

14. The main digestion-related secretion of the liver is bile, a greenish-yellow fluid mixture that is made up of bile pigments and bile salts. Bile salts act like detergent, physically breaking up the fat droplets into smaller fat droplets, and suspending the smaller fat droplets so they can disperse throughout the chyme. The many smaller fat droplets create a greater surface area to be exposed for digestive enzymes to chemically break down the fats in the small intestine: this makes it easier for the intestinal cells to absorb the fats.
15. (1) **Inspiration** moves air from the external environment to the lungs inside the body.
(2) **Expiration** moves air from the lungs back to the external environment.
(3) **External respiration** is the exchange of oxygen and carbon dioxide between the air and the blood. Internal respiration is the exchange of oxygen and carbon dioxide between the body's tissue cells and the blood.
(4) **Cellular respiration** is the series of energy releasing chemical reactions that take place inside the cells.

16. Lung cancer is a disease in which uncontrolled cell growth and division occurs in the lungs. As the lung cells continue to grow and divide, uncontrolled, they create a rapidly growing mass of cells that form a tumour, or carcinoma. Metastatic cells can break away from the tumour and be carried throughout the body, spreading the cancer.

17. e. nasal cavity; b. pharynx; a. glottis; f. larynx; d. bronchiole; c. alveoli

18. Bronchitis is a disorder that causes the bronchi to become inflamed and filled with mucus, which is expelled by coughing. Emphysema is an obstructive respiratory disorder in which the walls of the alveoli break down and lose their elasticity. This reduces the surface area for gas exchange and causes oxygen shortages in the tissues. Exhaling becomes difficult because of the loss of elasticity, so breathing is laboured.

Cystic fibrosis is caused by an abnormal gene that disrupts the function of the cells lining the passageways of the lungs. When these cells do not function properly, the homeostatic balance of salt and water cannot be maintained, causing the thin mucus and liquid coating on the insides of the lungs to become very thick and sticky. The mucus in the lungs normally traps pathogens and then is expelled from the body by coughing.

19. Depolarization from the SA node proceeds across the atria from the top; depolarization from the AV node is carried to the bottom of the ventricles before it emanates over ventricular tissue.

20. The ventricle in the amphibian heart has channels that reduce the mixing of blood, whereas the mammalian heart has two separate ventricles.

21. A sphygmomanometer has a cuff that is wrapped around the upper arm and inflated to exert pressure on a large artery in the arm. This temporarily stops the flow of blood. As air is slowly let out of the cuff, the blood begins to flow again, and the pressure of the blood against the walls of the artery is measured.

22. Fat digestion occurs in the small intestine, and the digestion of proteins and carbohydrates occurs in the stomach.

23. Answers should show an understanding that the removal of all or part of the large intestine results in reduced absorption of water from undigested food material that comes from the small intestine. This results in a change in the osmotic balance within the body. The production and absorption of vitamins B12 and K are also affected since bacteria that live in the large intestine produce these vitamins. Answers should include a description of any dietary and lifestyle changes that the patient would have to make after the recovery from surgery.

24. Whereas mammalian dentition is adapted to process different food types, birds are able to process different types of food by breaking up food particles in the gizzard. Bird diets are comparably diverse to mammalian diets; some birds are carnivores, others are insectivores or frugivores, still others omnivores.

25. a. The sandwich contains carbohydrates (bread), protein (chicken), and fat (mayonnaise).

b. The breakdown of carbohydrates begins with salivary amylase in the mouth. The breakdown of proteins begins in the stomach with pepsinogen, and the emulsification of fats begins in the duodenum with the introduction of bile. So, it is the chicken that will begin its breakdown in the stomach.

26. Answers should demonstrate an understanding of the steps in the clotting process. Following an injury to a vessel, vasoconstriction is followed by the accumulation of platelets at the site of injury and the subsequent formation of a platelet plug. This triggers a positive feedback enzyme cascade, attracting more platelets, clotting factors, and other chemicals, each of which continually attract additional clotting molecules until the clot is formed. The enzyme cascade also causes fibrinogen to come out of solution as fibrin, forming a fibrin clot that will eventually replace the platelet plug.
27. a. Since air no longer passes through the vocal chords, talking is not possible. Additionally, the air is no longer moistened before it enters the lungs. It is necessary to ensure humidification of the air.

b. The tracheal cover should have a filter to prevent excess dust or particulates entering, especially when the person is going outside. The cover should permit you to put a wet gauze pad to assist in humidification.

28. “Food that goes down the wrong way” is food that manages to get past the epiglottis and enter the trachea. This could be dangerous, because if food becomes lodged in the trachea, the person could choke and suffocate.

29. The SA node acts as a natural pacemaker. If it is malfunctioning, one would expect a slow or irregular heartbeat or irregular electrical activity between the atria and the ventricles. This could indicate the need to have a mechanical pacemaker surgically implanted.

30. The delay following auricular contraction allows the atrioventricular valves to close prior to ventricular contraction. Without that delay, the contraction of the ventricles would force blood back up through the valves into the atria.

31. a. Answers should show an understanding of the relationship between obesity and higher blood pressure (hypertension). Students should cite reliable sources for their findings.

b. No, people can develop high blood pressure due to a number of causes, such as kidney disease.

32. a. The duration of heart relaxation is much shorter. For an average heart rate of 70 beats per minute, the duration of a heartbeat is 60 s/70 beats, or 0.86 s per beat. In addition, assuming that the duration of contraction and relaxation are equal, each lasts 0.43 s. At 200 beats per minute (or 0.30 s per beat), the relaxation phase of the cardiac cycle is 0.15 s. Therefore, the heart has only 0.15 s to fill with blood.

b. A shorter relaxation phase results in a smaller stroke volume, since the heart does not have enough time to fill completely.

33. The most important factor to consider is the amount of energy being taken in compared with the amount of energy being used. As well, the weight-loss diet must be balanced. All six essential nutrients must be represented. To remove one or more of these nutrients upsets the homeostasis of the body and therefore is unsustainable. The proportions of carbohydrates, fats, and proteins should be adjusted, not the kinds of nutrients.

34. Answers that support the student’s opinion are acceptable, provided they include justification. Answers should include an understanding that alcoholism is a chronic, often progressive disease with symptoms that include a strong need to drink despite negative consequences, such as serious health problems. Like many other diseases, it has a generally predictable course, has recognized symptoms, and is influenced by both genetic and environmental factors that are being increasingly well defined. Recommendations may include getting counselling and/or attending AA meetings, as a part of any treatment plan.

35. a. Answers should include information about possible new infectious agents from the transplant animal, the relative size of the organs, and rejection, which is a concern with human-to-human transplants as well. A good article for teachers to gain some background on the issues is at:

- eMedicine, Medscape, article entitled Xenotransplation (by Lesley A. Taylor, MD)

You may wish to direct students to the following websites to begin their search:

- Health Canada, Drugs and Health Products, Xenotransplation

- Health Canada, Science and Research, Xenotransplation

b. Answers should include students’ own opinions as well as the ethics behind using animal donors, and the issue of having people used as experimental subjects and agreeing to lifetime monitoring.

c. Sample answer: Animals are used as food in our society, but we have not raised them specifically as organ donors. Many people would find this practice distasteful and inhumane for the animals. The people receiving the transplants may also not be accepted.

36. Answers should show an understanding of pulmonary, systemic, and cardiac circulation. Graphic organizers should include the information shown in Figure 12.7 on student textbook page 483.
37. Students should be able to estimate the length of the esophagus based on Figure 10.6 on student textbook page 411. The lengths of the large and small intestines are included in the caption to the figure.

Sample answer:

- **esophagus**
  - shortest length, as esophagus is used for transport of food to stomach only

- **large intestine**
  - medium length, as large intestine's function is primarily water absorption

- **small intestine**
  - longest length, as this is where digestion is completed and nutrients absorbed

38. a. Students may include in their answers some of the following ethical concerns:

- ethical issues surrounding the donor source, such as deceased donors, living donors (adults, mentally disabled, minors), anencephalic infants, or human fetuses
- ethical issues involving the organ recipient, such as lung transplants for people who smoke, or liver transplants for people with cirrhosis that is caused by alcoholism
- ethical issues involving allocation of limited resources, such as criteria for selection, using animals as donors, artificial or alternate substitutes for tissues and organs (such as coral), or high costs, universality, and fairness
- ethical issues involving procurement of organs and tissues, such as buying and selling human organs and tissues, media publicity, types of consent (voluntary or expressed, family, presumed, required request, routine inquiry), or fears, confusion, and the need for education

b. and c. Answers that support the student's opinion are acceptable, provided they include justification.

39. Answers should include information about the cause and symptoms of cystic fibrosis, the current state of research into the disease, and some current Canadian statistics. Information should be well-organized, concise, and accurate.

Sample answer: Cystic fibrosis is an often fatal genetic disease that causes severe breathing problems, intestinal disturbances, and frequent lung infections. In Canada, 60 percent of people with cystic fibrosis are diagnosed within the first year of life, and 90 percent are diagnosed by the age of 10. In the 1960s, most children with cystic fibrosis did not live long enough to attend kindergarten. Today, however, half of all Canadians with the disease are expected to live into their 40s and beyond. There is no cure for cystic fibrosis, but researchers are looking at different types of gene therapy for a possible treatment or cure.

40. Sample answer:

![Graph of Blood Glucose Concentration](image)

41. Answers should show an understanding of the effects of a healthy lifestyle on the circulatory system, such as decreased blood pressure, reduces risk of stroke, and arteriosclerosis.

42. Answers should include the information shown in Table 12.2 on student textbook page 486.

43. Sketches should be similar to Figure 12.4 for healthy arteries, veins, and capillaries. In their answers, students should compare the cross-sections of these healthy vessels to diseased blood vessels, which would likely show signs of arteriosclerosis—plaque deposits on the artery walls, causing a narrowing of the vessels.

44. Answers should show an understanding of the effects of exercise on respiratory volume, from their results of Activity 11.2: Measuring Respiratory Volumes.

Sample answer:

**Breathing during Exercise**

- **Inhalation**
  - lung pressure decreases
  - diaphragm and intercostal muscles contract

- **Exhalation**
  - lung pressure increases
  - diaphragm and intercostal muscles contract

45. A—salivary glands; B—esophagus; C—stomach; D—liver; E—gall bladder; F—pancreas; G—small intestine; H—large intestine.

46. Natural materials are recommended, as synthetic materials like Teflon® and Dacron® are only helpful for large vessels like the aorta. They do not work for narrower vessels like the coronary arteries because at smaller diameters they readily cause blood clots.
47. There would be some effect on the digestion of starch. When starches are heated, they swell and become easier for the body to break down. In the mouth, the enzyme amylase, which is contained in saliva, mixes with food products and breaks some starches into smaller units. However, once the carbohydrates reach the acidic environment of the stomach, the amylase is inactivated. After the carbohydrates have passed through the stomach and into the small intestine, key digestive enzymes are secreted from the pancreas and the small intestine, where most digestion and absorption occurs. Pancreatic amylase breaks starch into disaccharides and small polysaccharides, and enzymes from the cells of the wall of the small intestine break any remaining disaccharides into their monosaccharide components.

48. a. Students may suggest that they will need to collect data on each subject’s heart rate, blood pressure, family history, and lifestyle (diet, exercise).

b. Sample answer: should have a physical examination by a medical doctor to determine their heart rate, including an ECG, and blood pressure (with a sphygmomanometer). For lifestyle and family history, would fill out a detailed questionnaire.

c. Student answers should present a coherent and testable hypothesis.

49. a. Individual C, because they have a slow heart rate and a high stroke volume. These factors allow Individual C to maintain the same level of oxygen delivery to the muscles (cardiac output) as both Individuals A and B, but with less work done by the heart muscles.

b. Cardiovascular fitness is the capacity of the heart, lungs, and blood vessels to deliver oxygen to working muscle tissues so that they can maintain prolonged physical work. A good indicator of cardiovascular fitness is the length of time it takes the heart to recover its resting heart rate after strenuous exercise. The more fit the heart is, the shorter the time it takes to return to the resting heart rate.

c. Individual B could improve their cardiovascular fitness by doing cardiovascular exercises such as running, which provides health benefits by enlarging the ventricles, increasing their elasticity, and strengthening the ventricle walls. These changes produce an increase in the stroke volume.

50. No, it is not a good position for recovery. When the athletes are bent over their intercostal muscles cannot fully contract and their diaphragm cannot fully contract. As a result the athletes are not able to fully inflate their lungs, which is needed to recover

51. Answers should include a description of the stomach walls being folded like an accordion to permit expansion of the stomach. They should also note that the stomach walls are coated with mucus to protect it from the acids in gastric juice.

52. Answers should show an understanding that the pancreas is connected to the gall bladder and that both are accessory organs.

53. The gall bladder stores and releases bile, which is produced in the liver. The liver continues to produce bile to digest fats, whether or not the gall bladder is removed. However, without the gall bladder, bile is not as efficiently secreted into the body and it may result in discomfort after eating foods that are high in fat. A doctor may recommend minor dietary changes, such as eating smaller meals spaced throughout the day and reducing dietary intake of fat.

54. Answers should include a formal lab structure, and lists of materials appropriate to the investigation.

55. a. and b. Sample answer:

<table>
<thead>
<tr>
<th>Disorder</th>
<th>External Environmental Triggers</th>
<th>Steps to Reduce Chance of Developing Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronchitis</td>
<td>• exposure to air pollutants, cigarette smoke, dust, chemical compounds</td>
<td>• avoid contact with people known to have the bacterial (acute) form of bronchitis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• quit smoking, avoid second-hand smoke, avoid dusty locations</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>• no known environmental causes</td>
<td>• avoid contact with people known to be carrying the bacteria or virus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• get preventive vaccine for bacterial (lobular) form of pneumonia</td>
</tr>
<tr>
<td>Asthma</td>
<td>• exposure to pollen, air pollutants, dust, cigarette smoke</td>
<td>• usually develops in childhood and cannot be cured, but can be managed: monitor lung capacity for advance warning of attack</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• monitor daily pollen counts and avoid being outdoors when count is high</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• quit smoking, avoid second-hand smoke, avoid dusty locations</td>
</tr>
<tr>
<td>Emphysema</td>
<td>• most common cause is long-term exposure to cigarette smoke</td>
<td>• quit smoking, and avoid second-hand smoke</td>
</tr>
</tbody>
</table>
56. Some of the reasons why children are more susceptible than adults to respiratory disorders caused by air pollution (particularly asthma) are: (1) they have smaller airways, breathe more rapidly, and inhale more air per breath for their body weight compared to adults; and (2) children generally spend more time outdoors than adults, meaning that they are more exposed to vehicle exhaust and other pollutants that are at their highest levels during the day.

57. The small intestine is lined with folds and villi, increasing its surface area.

58. It speeds up the process of digestion.

59. a. Flowcharts should summarize the following steps in the blood centrifuge process: put blood (which consists of red blood cells suspended in plasma) in a test tube → place test tube in the blood centrifuge and spin at high speed → blood components separate out with plasma at top of tube and red blood cells at the bottom

b. Salad spinners mimic the same structure and motion as a motorized centrifuge.

Unit 4 Self-Assessment Questions
(Student textbook pages 526–7)

1. e
2. c
3. b
4. d
5. e
6. c
7. d
8. b
9. e
10. d

11. It has a very large surface area that allows extended exposure to food.

12. The effect on an insect’s respiratory system would be greater. This is because the respiratory surface in insects is in close contact with all of the living cells. This results in the pollutants diffusing more readily throughout the insect body.

13. Answers should show an understanding that fat digestion occurs in the small intestine, and that the digestion of proteins and carbohydrates occurs in the stomach.

14. Disadvantages:
   • the new technologies are difficult to create and therefore very costly
   • additional research into their effectiveness has not been done, due to the newness of the technology; therefore potential side-effects of using nanotechnologies are unknown

15. The cells and tissues of a one-way digestive system are specialized such that ingestion, digestion, and elimination can happen concurrently, making it more efficient in terms of food processing and energy utilization. One example that students may use to illustrate this is the digestive tract of the earthworm, which is shown in Figure 10.3 on student textbook page 408.

16. The lamellae, found within a fish’s gill filaments, facilitate this process by allowing water to flow in only one direction, counter to the blood flow within the capillary network in the gill.

17. Birds that live or fly at high altitudes are subjected to lower oxygen partial pressure and thus have evolved a respiratory system that is capable of maximizing the diffusion and retention of oxygen in the lungs. Efficient oxygen exchange is crucial during flight as flying is more energetically taxing than most forms of locomotion.

18. Diagrams should indicate an understanding that, in emphysema, alveolar walls break down and alveoli increase in size, effectively reducing the surface area for gas exchange. This then reduces the diffusion of gases.

19. If your heart rhythm is abnormal, but a faulty signal is sent to the computer that it is OK, then the pacemaker will not direct the generator to send electrical pulses to the heart. You might feel dizziness and/or fatigue. If the heart is functioning properly, but a faulty signal is interpreted by the computer that the heart needs stimulation, then the heart could be forced to beat erratically, similar to atrial fibrillation.
20. Putting pressure on the wound closes the blood vessels. This slows the blood flow and allows the plasma components such as fibrinogen and thrombin to perform their blood clotting function.

21. Diagrams should demonstrate an understanding of the various stages of clot formation. Following an injury to a vessel, vasoconstriction is followed by the accumulation of platelets at the site of injury and the subsequent formation of a platelet plug. This triggers a positive feedback enzyme cascade, attracting more platelets, clotting factors, and other chemicals, each of which continually attract additional clotting molecules until the clot is formed. The enzyme cascade also causes fibrinogen to come out of solution as fibrin, forming a fibrin clot that will eventually replace the platelet plug.

22. When the insect heart contracts, it forces hemolymph out through the vessels and into the body cavities. When it relaxes, the resulting negative pressure gradient, combined with muscular contractions in the body, draws the blood back to the heart.

23. Breathing rate is regulated to ensure ample oxygen is available to the body. However, the heart rate must be regulated to ensure efficient delivery of the available oxygen to the body cells and tissues. During exertion, respiratory rates will increase in order to increase oxygenation and allow for increased aerobic cellular respiration. Simply increasing the oxygen availability is not enough—the heart rate must also increase so that the additional oxygen can be quickly delivered to the muscles undergoing cellular respiration.

24. Biomarkers are molecules that indicate the presence of a particular disease or condition in the body. Testing kits can provide biomarker readings that assist the health care specialists to diagnose heart disease within 30 minutes from the time that the blood sample was taken. Expensive scans are usually not necessary. This decreased cost is of great benefit to both the individual and to medical costs in Canada's universal health care system.

25. See the ECG readings in Figure 12.15 on student textbook page 490.