Unit 4: Review Answers

Student Textbook pages 356–359

Answers to Understanding Concepts Questions

1. The following chart identifies the five organs of the digestive tract. It also summarizes the structural and functional characteristics of each organ.

Organ of the Digestive Tract	Structural Characteristics	Functional Characteristics
Mouth	■ teeth and tongue ■ mucus membranes ■ salivary ducts enter mouth	■ teeth and tongue for the physical digestion of food ■ mucus membranes add moisture to food ■ salivary glands (exocrine gland) secrete saliva; chemical digestion (amylase) of starch; add moisture to food
Esophagus	■ tube connecting mouth to stomach ■ circular and longitudinal muscles	■ tube transports bolus of food to stomach ■ muscles responsible for peristalsis
Stomach	■ muscular organ with numerous ridges and folded lining ■ exocrine glands secrete gastric juice	■ muscles and folds; physical digestion of food; increasing surface area ■ gastric juice includes the enzyme pepsinogen ■ gastric juice also contains HCl(aq), which activates pepsinogen; pepsin digests protein to polypeptides
Small Intestine	■ long tube ■ exocrine glands in lining ■ pancreatic and bile ducts enter upper portion (duodenum) ■ numerous villi and microvilli	■ the length of the small intestine ensures the maximum length of time for digestion and absorption ■ the exocrine glands lining the intestine plus the pancreatic enzymes digest proteins, carbohydrates, and fats ■ villi and microvilli increase the surface area for the absorption of nutrients; capillary and lymphatic vessels transport nutrients
Large Intestine	■ shorter, but wider, tube	■ absorption of water and dissolved minerals

2. The accessory organs of the digestive system are:

- Liver: responsible for producing bile salts from cholesterol. Bile emulsifies fat droplets; all monosaccharides (except glucose) are removed from the blood and converted into glycogen, which is stored in the liver until needed.
- Pancreas: a source of several enzymes that chemically digest carbohydrates, fats, and peptides (sub-units of proteins).
- Gall bladder: stores bile until required; bile emulsifies fats, increasing the surface area for chemical digestion.

3. The plural membranes surround the lungs. Each pleuron is made up of two layers separated by a thin film of lubricating fluid. One layer adheres to the rib cage and the diaphragm, while the other is fused to the lungs. The surface tension of water molecules in this fluid helps to keep the lungs inflated.
4. Sketches should show the following structures that air passes through:

   nose → pharynx → larynx → trachea → bronchus → bronchioles → alveolus
5. Use Figure 8.2: An internal view **(B)** of the human heart on page 269 of the student textbook as a guide for the first sketch. Figure 8.7 on page 274 is a good guide for the second sketch.
6. Urine follows the following path:

   kidney → ureters → urinary bladder → urethra
7. Ureters and the urinary bladder are made up of smooth muscles. Peristalsis moves urine within the ureters, and peristaltic contractions cause the urine to enter the bladder. The bladder is also a smooth muscle because it is under involuntary, nervous control.
8. Two possible answers are as follows.
   - Movement of muscles generates large amounts of heat, which helps to maintain normal body temperature. Shivering (muscle contractions) helps to produce more heat when you are cold.
   - The contraction of skeletal muscles helps to move blood in the veins back to the heart.
9. **(a)** The three major classes of macronutrients are: carbohydrates, proteins, and lipids (fats). Three similarities that these molecules share are:
   - all are classified as organic molecules (carbon, hydrogen, and oxygen atoms)
   - they are made of smaller sub-units that must be digested (broken down)
   - they supply the energy and the building blocks that are needed to synthesize cellular contents

   (b) The enzymes that act on each major category are:
   - carbohydrates are digested by carbohydrase enzymes to form simple sugars that move by diffusion into the capillary bed found in the villi
   - proteins are digested by protease enzymes to form amino acids that move by diffusion into the capillary bed found in the villi
   - lipids are digested by lipases to form fatty acid molecules and glycerol; these enter the cells of the villi and, within these cells, re-form as lipoprotein droplets before entering the lacteals
10. The three main nutrients are important for the following reasons:
    - Carbohydrates: the quickest and most readily available source of energy for the body is glucose. Carbohydrates are digested to simple sugars that can be converted to glucose.
    - Proteins: are digested to amino acids, which are transported to the tissues. Ordinarily, amino acids are not used as an energy source. Most are incorporated into structural proteins found in muscles, skin, hair, and nails. Others are used to synthesize such proteins as hemoglobin, plasma proteins, enzymes, and hormones.
    - Lipids: used for long-term nutrient and energy storage, insulation, cushioning of internal organs, and to form hormones that send messages around the body. Lipids are also the structural components of cell membranes.
11. Inhalation: nervous stimulation results in the contraction of the diaphragm and the intercostal muscles. This causes the diaphragm to lower and the rib cage to move up and out. The result is lower air pressure in the lungs, and air comes rushing in from the environment.

    Exhalation: due to a lack of nervous stimulus, the diaphragm relaxes and rises back to its normal, domed shape. At the same time, the intercostal muscles relax and the rib cage moves down and in. Air pressure in the lungs increases and the air moves from the higher pressure in the lungs to the lower pressure in the environment.
12. External respiration refers to the exchange of gases between air in the alveoli and blood in the pulmonary capillaries. Blood entering the pulmonary capillaries has a higher concentration of carbon dioxide than atmospheric air; therefore, most of the carbon dioxide diffuses out of the blood into the lungs. Blood entering the pulmonary capillaries has a lower concentration of oxygen than atmospheric air; therefore, oxygen gas diffuses across the alveoli into the plasma and then into the red blood cells in the lungs.
13. The right and left sides of the heart account for the name "double pump" because the right side of the heart pumps blood to the lungs and the left side of the heart pumps blood to the rest of the body.
14. **(a)** The following shows the movement of blood, starting from the right atrium:

    right atrium → right AV valve → right ventricle → pulmonary semilunar valve → pulmonary artery → lungs → pulmonary vein → left atrium → left AV valve → left ventricle → aortic semilunar valve → aorta → coronary artery → heart muscle capillaries → coronary vein → right atrium

    Coronary circulation serves the heart muscle itself.

    (b) The coronary pathway differs from the others in that it carries deoxgenated blood. Its circulation supplies metabolic needs of the heart muscle, whereas the systemic circulation supplies the needs of skeletal muscles and internal organs in the rest of the body. The pulmonary circulation (which is included in the above pathway), carries blood through capillaries in the lungs where it is oxygenated.

15. The many branching arteries in the coronary circulation system provide an efficient method of supplying the heart muscle with blood (nutrients and oxygen) and an efficient way to get rid of metabolic waste products produced by this vital organ. Another significant feature of the coronary arteries is their small size. Because they have such a small diameter, the coronary arteries may become clogged.

16.

Characteristic	Artery	Vein
Structure	■ wall has three layers ■ middle layer is thick, smooth muscle that can contract to regulate blood pressure	■ wall has three layers ■ walls are thinner, have less smooth muscle compared to an artery
Function	■ transports blood away from the heart	■ transports blood towards the heart
Oxygen Composition of Blood Carried	■ most arteries have a relatively high concentration of oxygen (oxygenated blood) ■ the exception is the pulmonary artery, which transports oxygen-poor blood (deoxygenated) to the lungs	■ most veins have a relatively high concentration of carbon dioxide and a low concentration of oxygen (deoxygenated) ■ the exception is the pulmonary vein, which transports oxygen-rich blood to the left atrium
Movement of Blood	■ blood is under pressure and moves in spurts that correspond to the contraction of the ventricles	■ blood is under less pressure ■ valves in veins keep blood flowing towards the heart ■ rely on the contraction of smooth muscles to help push blood toward the heart
Pressure Difference	■ blood is under pressure ■ pressure decreases the further away from the heart	■ blood is under lower pressure ■ rely on the contraction of smooth muscles to help push blood towards the heart

17. Capillaries (a) are only one cell thick, while arteries and veins have layers of tissue; (b) form vast networks, rather than individual hose-like tubes; and (c) are the site of gas and nutrient exchange between the blood and all the cells of the body.

18. Refer to the graph included with question 23, page 303. As blood flows from arteries into capillary networks, the diameter of the vessels decreases, but the total cross-sectional area of the vessels increases. This increases the frictional resistance between the blood cells and the walls of the vessels, thereby decreasing blood pressure and the speed at which it flows.

19. The top layer would be the liquid portion of the blood—the plasma. Plasma is mainly water. You would find plasma proteins, salts, gases, nutrients, and nitrogenous waste products in this component of the blood.

The middle layer would contain the white blood cells, while the lowest layer contains the red blood cells. White blood cells fight infection and are part of the immune system.

Red blood cells do not have a nucleus. Hemoglobin, the oxygen-carrying pigment, is found in the red blood cells. Red blood cells transport oxygen and help to transport carbon dioxide.

20. Renal artery → glomerulus → capsule (Bowman's) → proximal tubule → loop of the nephron (or Henle) → distal tubule → collecting duct → renal pelvis

21.
- ■ Filtration: water, salts, nutrient molecules, and waste molecules move under pressure from the glomerulus to the inside of the capsule. These small molecules are called glomerular filtrate. Large molecules normally remain in the blood.
- ■ Reabsorption: nutrient and salt molecules are actively reabsorbed from the proximal tubule into the capillary network surrounding the nephron. Water flows passively.
- ■ Secretion: certain molecules are actively secreted from the capillary network into the distal tubule.

22. (a)

Filtrate Components that are Reabsorbed at the Proximal Tubule	Filtrate Components that are not Reabsorbed at the Proximal Tubule
most water	some water
nutrients	much nitrogenous waste
necessary salts	excess salts

(b) Molecules that are not reabsorbed become part of the urine and are removed from the body.

23. (a) Water: approximately 180 L of water is filtered every day. Normally, 99% of the water is reabsorbed from the filtrate as it passes through the remainder of the tubule.

(b) Ions (salts): the kidneys regulate salt balance in blood by controlling the excretion and reabsorption of various ions. For example, sodium (Na^+) is an important ion in plasma that must be regulated. Approximately 630 g of salts are filtered each day. Only 3.2 g are excreted in the urine. Over 99% of the sodium ions are actively reabsorbed in the proximal and distal tubules.

(c) pH: the bicarbonate (HCO_3^-) buffer system and the process of breathing work together to maintain the pH of the blood. Only the kidneys, however, can rid the body of a wide range of acidic and basic substances. The kidneys are slower acting than the buffer/breathing mechanism, but they have a more powerful effect on pH. The kidneys reabsorb bicarbonate ions and excrete hydrogen ions as needed to maintain the normal pH of the blood.

24. The steps in the sliding filament model are as follows.

- neuromuscular impulses trigger the release of calcium from the sarcoplasmic reticulum
- the calcium causes the troponin protein that is blocking the actin attachment sites to bind with tropomyosin and make the actin attachment sites available to the myosin heads
- the heads of the myosin myofilament bend backward and inward and attach to the pairs of actin myofilaments enveloping it
- pairs of actin myofilaments are pulled along with the myosin heads as they flex, dragging the Z lines of the actin myofilaments in the direction of the flex, towards the myosin core
- as one after another myosin head flexes, the myosin "walks" along the pairs of actin myofilaments and the Z lines move closer together as the muscle fibre contracts

25. Enzymes are specific. Each kind can cleave (or digest) only a certain type of molecule. Enzymes do not have the right molecular shape to attack themselves. As well, many enzymes are secreted in an inactive form and are only activated when they enter a region of the digestive tract with a specific pH.

26. (a) The first curve (on the left) is the one that would take place in the human. This enzyme is active at normal body temperature (37 °C). The enzyme of the right is most active at a temperature that would be fatal to humans!

(b) Two other factors that influence enzyme activity are pH and enzyme concentration. All enzymes are only active in a very narrow range of pH values. A higher concentration of enzyme will speed up the rate of the chemical reaction.

27. (a) (Interpretation 1)

- Upon release, calcium ions bind to tropinin, exposing the myosin binding sites.
- ATP is hydolyzed (ADP + phosphate) when the myosin head is unattached.
- ADP + P are bound to myosin as the myosin head attaches to the actin myofilament.
- ADP + P release causes the myosin head to change position and the actin myofilament to move.
- Binding of another ATP causes the myosin head to return to its resting position.

(Interpretation 2)

ATP produced previous to strenuous exercise only lasts a few seconds, and then muscles acquire new ATP in three ways: creatine phosphate breakdown, fermentation, and cellular respiration.

- Creatine phosphate provides enough energy for 8 seconds of intense activity, and then it is spent. Creatine phosphate is rebuilt when a muscle is resting by transferring a phosphate group from ATP to creatine.
- Fermentation also supplies ATP without consuming oxygen. During fermentation, glucose is broken down to lactate (lactic acid). The energy released by this reaction is used to attach a phosphate group to ADP to make ATP.
- Cellular respiration occurring in the mitochondria usually provides most of the muscle's ATP. The breakdown of glucose to carbon dioxide and water releases energy to attach a phosphate group to ADP to make ATP. Students may remember that the energy in one glucose molecule is sufficient to make 36 ATP.

(b) The different sources of acquiring ATP are interrelated because:

- all are called into action during strenuous exercise that last more than just a few seconds;
- all involve the chemical breakdown of high energy compounds; and

- the energy released from these high energy compounds is used to bond a phosphate group (P) to ADP to form ATP.

28. The following are examples of one function of blood in relation to each body system listed below.

(a) Digestive system: blood in capillaries in each villus of the small intestine absorbs nutrients (glucose and amino acids) and transport these to the tissues.

(b) Respiratory system: capillaries surround the alveoli and are the site of gas exchange. Carbon dioxide diffuses from the blood into the alveoli, while oxygen diffuses from the alveoli into the blood.

(c) Excretory system: blood transports nitrogenous (metabolic) wastes to the kidneys. The kidneys filter the blood, reabsorb water/nutrients, and excrete the wastes. The kidneys also help to maintain the pH balance of the blood by actively secreting H^+ ions and absorbing HCO_3^- ions.

(d) Muscular system: blood transports oxygen (red blood cells) and glucose to the muscle cells. Glucose and oxygen combine in the mitochondria of muscle cells to produce ATP (cellular respiration). Blood is also responsible for transporting waste products [carbon dioxide, lactate (lactic acid), and metabolic wastes] away from the muscles to the excretory system.

(e) Immune system: white blood cells fight infection and play a role in the development of immunity (the ability to resist disease).

29. Some students might answer quantitatively by constructing a comparison chart such as the one below. Other students might answer qualitatively by describing how the composition of filtrate and urine differ from each other and from plasma. For example, plasma and filtrate carry equal amounts of glucose; plasma contains all of the blood proteins; all three fluids carry comparable amounts of sodium ions; and most of nitrogenous wastes to be removed from the body are in the urine, with negligible amounts in the plasma and filtrate.

Component	Plasma (g/L)	Glomerular Filtrate (g/L)	Urine (g/L)
glucose	1.0	1.0	0.0
protein	44.0	0.0	0.0
sodium ions	3.0	3.0	3.8
nitrogenous wastes	0.3	0.3	31.3

30. The concentration gradient established by the difference in solution concentration (some students might say, more precisely, osmostic pressure) between the interior of the tubule and the interstitial fluid surrounding it allows for the active transport of sodium ions and the passive transport of potassium and chloride ions, as well as the diffusion of water, between these two regions.

31. The interstitial fluid does not become diluted through water reabsorption because sodium ions are constantly being reabsorbed from the tubule and the collecting duct at the same time that water is being reabsorbed.

32. The blood's role in absorbing heat and carrying it to the skin to be dissipated helps the body maintain a constant internal temperature (homeostasis). Blood vessels near the surface of the skin can either dilate (vasodilation) to increase heat loss or constrict (vasoconstriction) to preserve body heat, but no materials are exchanged.

33. Fast-twitch fibres provide explosions of energy. Fast-twitch fibres are rich in glycogen a good source of gluese, but they have fewer mitochondria, little or no myoglobin, and fewer blood vessels than slow-twitch fibres. Fast-twitch fibres can develop maximum tension more rapidly than slow-twitch fibres, and the maximum tension is greater; however, their dependence on anaerobic energy leaves them vulnerable to an accumulation of lactate (lactic acid) that causes them to fatigue quickly.

34. The churning action of the stomach mixes the food with gastric juice and physically breaks the food down.

Physical digestion increases the surface area of the food, which increases the efficiency of the enzymes responsible for chemical digestion.

35. (a) Physical processing takes place in the mouth (teeth and tongue grinding the food), the stomach (muscle contractions squeeze food in between the folds of the stomach lining), and the small intestine (bile from the gall bladder enters the duodenum and emulsifies fat).

Chemical digestion takes place in the mouth (salivary amylase begins the digestion of starch), the stomach (pepsin begins the digestion of proteins), and in the small intestine (most chemical digestion takes place in the small intestine).

(b) Physical digestion is required to break large pieces of food into small pieces. This increases the surface area for chemical digestion. Chemical digestion involves the use of enzymes to break down (hydrolyze) macromolecules to small organic molecules that can be absorbed. Each enzyme has a particular job to do.

36.
- Carbohydrates are digested by a number of enzymes that are collectively called carbohydrases. The end products of carbohydrate digestion are simple sugars (monosaccharides). Simple sugars, such as glucose, are absorbed into the cells of the intestinal villi by active transport.
- Proteins are digested by a number of enzymes that are collectively called proteases. The end products of protein digestion are amino acids. Amino acids are absorbed into the villi in the small intestine by active transport.

- Lipids (fats) are digested by a number of enzymes that are collectively called lipases. The end products of lipid digestion are fatty acids and glycerol. These end products are absorbed into the cells of the villi by simple diffusion.

37. Muscle fibre, which is responsible for muscle contractions, is made up of the following major parts:

myoglobin	stores oxygen for use during muscle contractions
sarcolemma	surrounds the muscle fibre and regulates the entry and exit of materials
sarcoplasm cytoplasm	the site of metabolic processes for normal cell activities; contains myoglobin and glycogen (which stores energy for muscle contractions)
sarcoplasmic reticulum	stores calcium ions needed for muscle contractions
Myofibrils	contain myofilaments that are responsible for muscle contractions
thick filament	binds to actin and causes muscle contractions
thin filament	binds to myosin and causes muscle contractions

38. The lymphatic system consists of a network of lymphatic vessels, associated glands (nodes), and fluid called lymph.

Similarities between the lymphatic system and the cardiovascular system include:

- both circulate fluids
- both have capillaries to absorb materials;
- lymph vessels and veins have valves in them to keep fluid moving in one direction
- lymph vessels and veins both rely on the contraction of skeletal muscles to move fluids
- both systems produce cells that are responsible for fighting off pathogens

The key difference is that blood arrives at and leaves the heart in a continuous circuit of cardiovascular vessels, while lymph forms in closed-ended tubes in capillary beds. Lymph is mixed back into the general blood circulation after it is delivered to the heart through ducts that empty into large veins near the heart.

39. Lymph forms from interstitial fluid that has been collected and absorbed by lymphatic capillaries.

40. Midway along the capillary, solutes diffuse out of the capillary and wastes diffuse into the capillary. Substances that leave a capillary contribute to interstitial fluid (also called tissue fluid, the fluid between the body's cells). Tissue fluid tends to contain all the components of plasma, except lesser amounts of protein. The lymphatic capillaries always collect excess tissue fluid, which circulate it as lymph that is eventually returned to the systemic venous blood when the major lymphatic vessels enter the veins in the shoulder region.

41. **(a)** Lymph capillaries are closed-ended tubes that collect interstitial fluid (that is, lymph) for eventual transport to the circulatory system, while blood capillaries are open-ended tubes that connect the arterial circulatory system with the venous circulatory system.

(b) Lymph vessels differ from veins of the circulatory system in that the walls of lymph vessels are thinner and the interior space is, therefore, more voluminous.

(c) Lymph is essential interstitial fluid that has been collected and channeled back to the circulatory system. Lymph also carries white blood cells, so, unlike interstitial fluid, it functions as part of the body's defence system.

42. The pathway of lymph, in general terms, can be summarized as follows.

- Lymph capillaries branch and interconnect freely and extend into almost all regions of the body except bone marrow, the central nervous system, and tissues such as the epidermis.
- Lymph capillaries join to form larger vessels called lymph veins.
- At certain locations, lymph veins enter lymph nodes.
- Lymphatic vessels from all over the body, except the upper right quadrant, drain into the thoracic duct. This vessel delivers the lymph into the base of the left subclavian vein in the shoulder area. In this way, lymph is continuously emptied into the blood where it mixes with the plasma.

43. T cells are lymphocytes (cells of the lymphatic system) that mature in the thymus gland (near the heart). There are several types of T cells. The key ones (and their specific functions) are:

- helper T cells, which secrete chemicals that activate macrophages, B cells, and other T cells when a foreign antigen is detected
- killer T cells, which bind with infected cells and destroy them by puncturing a hole in their cell membranes
- suppressor T cells, which slow/suppress the cellular immunity process to make sure normal tissue/healthy cells are not destroyed during a defence by the immune response
- memory T cells, which remain in the bloodstream after a successful encounter with a foreign antigen, in order to trigger a faster response the next time the same foreign antigen appears

44. Memory cells in both B cell and T cell lymphocyte defenders are created after the first successful defence of the body against foreign antigens. Memory cells remain in the bloodstream, ready to detect the foreign antigen and trigger a successful immune response the next time it invades.

45. The following is a summary of the body's immune response, triggered by the entry of pathogens at the site of an infection.

- Non-phagocytic leucocytes arrive at the site of the infection. These cells release histamine, which causes blood vessels at the site to dilate and become more permeable to fluid and leucocytes. The increased blood flow and accumulation of fluid makes the area swollen and hot.
- Phagocytic macrophages engulf and destroy invading bacteria.
- The antigens from the pathogen protrude from the cell membrane of the macrophage.
- Receptor sites on the surface of the helper T cells bind to the antigens on the surface of the macrophage. This union triggers the release of chemical messengers from both cells. The messengers cause T cells to multiply. Some of these T cells destroy infected tissue cells, breaking the reproductive cycle of the pathogen.
- The antibodies on B cells bind to the antigens, contributing to the destruction of the pathogens.
- T cells bind to the B cell antibody-antigen complex. This union of T and B cells activates the B cell, causing it to enlarge and divide, which produces plasma cells and memory cells.
- The plasma cells produce antibodies and release them into the bloodstream. Antibodies and memory B cells remain in the blood, ready to fight a new infection by the same pathogen.

Answers to Applying Concepts Questions

46. **(a)** The small intestine has a large surface area due to the presence of villi and microvilli in the intestinal lining.

(b) The small intestine has a large surface area to increase the rate of absorption of nutrients needed by the body.

47. Her blood potassium level will continue to be about 4 mmol/L because homeostatic mechanisms operate to absorb and maintain it at that level. The excess potassium she is ingesting will be excreted.

48. Since the identity of Substance X is not given, it is not reasonable to infer it should have been filtered (that is, removed) prior to passing from the glomerulus to the Bowman's capsule. If Substance X is something that should not pass into the nephron (e.g., glucose or red blood cells), then its presence in the urine would signal a problem. If Substance X is something that should be a component of urine (e.g., urea, sodium ions), then its presence would suggest proper nephron/kidney function (at least with respect to the excretion of these particular substances). Students' reasoning is more important for assessment here than the correctness of their answers.

49. Antony van Leeuwenhoek was observing lymph vessels containing lymph.

50. There would be a minimal effect because the pancreas also releases amylase that would digest the starch into maltose in the small intestine.

51. Without bile salts, fat digestion would be significantly reduced. Without bile, emulsification would not occur. Enzymes could only hydrolyze the lipid molecules on the outside of the fat globule.

52. Myosin can't bond to actin when a muscle is relaxed because the myosin binding sites on the actin are blocked by the troponin-tropomyosin complex. Calcium is needed to rearrange the complex so that the myosin binding sites become uncovered.

Answers to Making Connections Questions

53. Possible student inferences are outlined.

- Esophagus: since no digestion takes place in this organ, food spends very little time in it; peristalsis may delay the passage of larger boluses slightly, accounting for the 10 s figure
- Stomach: food needs time for physical digestion via churning as well as the chemical digestion of proteins
- Small intestine: the digestion of macromolecules and the absorption of nutrients requires a fair amount of time
- Large intestine: the absorption of water and salts and the anaerobic breakdown of solid matter by intestinal bacteria require a significant amount of time
- Rectum: the storage process may time a great amount of time before there is sufficient quantity of feces to stimulate the elimination process

54. Energy from aerobic respiration of skeletal muscle fibres that does not go into contraction is released to the body as heat. (Some students may also suggest that waste heat through inefficient conversion of chemical energy to kinetic energy also contributes to body heat.)

55. The breast muscle (meat) of a bird is made up of fast-twitch fibres that are used for the rapid, powerful contractions needed for flight. They probably are of intermediate type, as they can sustain long periods of repeated contractions without fatiguing.

56. The student in experiment B would have the higher respiration rate because carbon dioxide levels would have increased significantly, stimulating a higher breathing rate, while the breath was held.

57. (a) In order to answer this question, students need to understand the six steps in the contraction of a muscle. These steps are:

1. The influx of calcium ions from the sarcoplasmic reticulum triggers the exposure of binding sites on actin.
2. ATP is hydrolyzed when myosin head is unattached.
3. ADP + P are bound to myosin as myosin head attaches to actin.
4. ADP + P release causes myosin head to change position and the actin filament to move.
5. Binding of ATP causes myosin head to return to resting position.
6. Calcium ions are actively transported back into the sarcoplasmic reticulum, and the muscle relaxes.

If a muscle is in rigor mortis, the membranes of muscle cells become more permeable to calcium ions; however, the muscle will quickly run out of ATP. Muscles need ATP in order to release from a contracted state (it is used to pump the calcium out of the cells so the fibres can unlatch from each other). ATP reserves are quickly exhausted from the muscle contraction and other cellular processes; this means that the actin and myosin myofilaments will remain linked until the muscles themselves start to decompose.

So, if a muscle has a continual supply of ATP, students could predict that the calcium ions would be pumped back into the sarcoplasmic reticulum and the muscle would relax.

(b) If the sarcoplasmic reticulum (endoplasmic reticulum in muscle cells) wasn't intact, students could predict that this muscle could stay contracted longer. The reason that the muscle would stay contracted is that in a living muscle, the membranes of the sarcoplasmic reticulum contain active transport proteins that pump calcium ions back into the sarcoplasmic reticulum. If this membrane is not intact, then the calcium ions cannot be pumped out and the actin, and myosin myofilaments will remain linked until the muscles themselves start to decompose

58. As exercise intensity is increased:

- In the circulatory system, heart rate increases and blood vessels dilate to provide more oxygen and glucose to body cells and remove wastes (carbon dioxide) that are being produced. Blood vessels also dilate to increase loss of heat.
- In the respiratory system, breathing rate increases to increase the rate of gas exchange, providing more oxygen and eliminating carbon dioxide.
- The digestive system decreases activity.
- Increased blood pressure leads to increased glomerular filtration in the kidney and increased urine production. Since the body will be warm, some of the water will be lost as sweat, so increased urine production may not be as noticeable.

59. The decreased blood pressure is due to loss of fluids while vomiting. If there aren't fluids to be absorbed, blood volume and blood pressure will drop. The heart rate is elevated to try to increase blood pressure.

60. The head injury may have affected the person's ability to produce or release ADH. Without ADH, the nephrons are not reabsorbing water into the blood, and the person is thirsty.

61. The risks and benefits of Aspirin™ use are:

Risks:

- Gastrointestinal bleeding, which could lead to anemia.
- Children or teens with risk factors should not take Aspirin™, due to the risk of Reye's Syndrome.
- Some people are allergic to Aspirin™.
- Birth defects have been found in babies of women who took high doses of Aspirin™ during the last trimester of their pregnancies.
- Liver damage or stomach bleeding might occur in people who drink three or more glasses of alcohol per day.
- Since Aspirin™ thins the blood, it wouldn't be suitable for people with blood clotting disorders.

Benefits:

- It reduces headache pain and inflammation due to injury or arthritis.
- It reduces the risk of cardiovascular disease (heart attack and stroke).
- It is associated with the prevention of breast, stomach, esophageal, ovarian and prostate cancer, and leukemia.
- It reduces the risk of gastrointestinal tumours forming.

62. Students are to select two body systems from the following table for their answer.

Body System	Possible Disorders (students are to identify one per system)	Description of how Technology is used to Address the Disorder
Excretory System	Kidney Failure	Dialysis Machine: very successful. Keeps patients alive until a kidney comes available. Kidney transplant and the use of the immunosuppressant Cyclosporin–Cyclosporin has significantly increased the success of transplants.
	Kidney Stones	Ultrasound: used to break kidney stones into fragments that are eliminated with the urine.
Digestive System	Stomach Ulcers, Crohn's Disease, Colitis, Colorectal Cancer, Polyps	Endoscopes: successfully used to look at the lining of either the upper or lower digestive tract. They allow biopsies to be taken, which allows accurate diagnosis of the disorder. X-rays and CAT (CT) Scans: also successful diagnostic technologies.
Respiratory System	Emphysema, Asthma, Lung Cancer	Spirometers: used to measure lung capacities. CAT (CT) Scans and X-rays: can detect lung abnormalities.
Musculoskeletal System	Bone fractures, Ligament and Tendon Tears, Cartilage Damage	X-rays, MRIs, and CAT (CT) Scans: successfully detect the location and severity of the fracture or tear. Arthroscopic Surgery: successfully used for joint injuries.
	Severe Arthritis	Artificial Joints: can replace hips, elbows, knees and wrists, providing patients with mobility and freedom from pain Medications: can reduce the pain.
Circulatory System	Heart Arrhythmias	ECGs: successfully detect abnormalities in the heart cycle. Pacemakers can be inserted to normalize the electrical activity in the heart.
	Hypertension	Sphygmomanometers: used by physicians and can be used at home to help people monitor their blood pressure
	Heart Stoppage	Defibrillators: can sometimes shock the heart into beating again if applied at the right time in the cycle

63. (a) Nitrogenous wastes are removed from the blood by simple diffusion. The concentration of urea and uric acid is higher in the patient's blood than in the dialyzing fluid, so diffusion through the dialysis membrane into the dialyzing fluid occurs. Fresh fluid washes over the dialysis membranes continuously, removing the nitrogenous wastes as they diffuse out of the blood.

(b) In a healthy kidney, most nutrient molecules are returned to the blood in the proximal tubule, with the remainder being reabsorbed in the distal tubule. During dialysis, nutrients are not replaced since they are never removed from the blood. However, the dialyzing fluid is formulated to contain higher concentrations of certain nutrients than are found in the blood, so during dialysis, these nutrients enter the blood by simple diffusion, adding to nutrients already present.