Chapter 10: Review Answers

Student Textbook page 352–353

Answers to Understanding Concepts Questions

1. The chart below identifies the three types of muscle tissue illustrated and includes a brief description of each type.

Cell	Type	Description
A	Skeletal muscle	■ are striated and tubular ■ cells (fibres) each have many nuclei ■ contract voluntarily ■ are usually attached to bones of the skeleton
B	Smooth muscle	■ are non-striated ■ cells each have one nucleus ■ contract involuntarily ■ are found in the walls of internal organs
C	Cardiac muscle	■ are striated, tubular, and branched ■ cells each have one nucleus ■ contract involuntarily ■ are found in the walls of the heart

2. Skeletal muscle supports the body, allows movement, stabilizes joints, protects internal organs, creates body form, and helps to maintain body temperature.

3. Student illustrations should show that a muscle fibre is made of myofibrils that are in turn composed of myofilaments composed of the proteins actin and myosin. Sketches will be similar to right half of Figure 10.3 on page 335.

4. The key events in a muscle fibre from contraction to relaxation are as follows:

- The heads of myosin myofilaments move first, bending backward and inward.
- Calcium ions bind to troponin to cause the troponin-tropomyosin complex to be shifted away from the attachment sites for the myosin heads on the actin.
- The myosin attaches to the actin and pulls it along as the myosin heads flex. As each myosin flexes, the myosin "walks along" the actin. The Z lines are pulled closer together.
- One molecule of ATP provides the energy to reposition the myosin head before each flex.

5. Creatine phosphate and ATP regenerate each other through the process of contracting and relaxing muscle tissue. To start contracting, muscle tissue breaks down creatine phosphate, releasing a phosphate group that binds to ADP, producing ATP. Creatine phosphate provides enough energy (generates enough ATP) for about 8 s of intense activity, and then it must be regenerated through the transfer of phosphate groups from ATP to creatine.

6. Oxygen is supplied to skeletal muscle through a high concentration of blood vessels in the muscles.

7. When muscle cells are functioning anaerobically, as they do during glycolysis, the reduced NADH that starts to accumulate reduces pyruvate. This reaction produces lactate and oxidized NAD+. The NAD+ is regenerated, allowing the reactions of glycolysis to continue and thus continuing to generate ATP. At the same time, lactate accumulates in the muscle cells. Some lactate is removed by the bloodstream and carried to the liver. Remaining lactate requires oxygen to be in the reactions that break it down and remove it from the body. The period immediately following exertion, when the body needs oxygen to break down the lactate, is the period when the body is considered to have an oxygen deficit.

8. Muscles fatigue because of the depletion of glycogen and the build-up of lactic acid. A person's physical condition can affect tolerance to fatigue because people who are more physically fit have muscle fibres with a greater aerobic capacity. Physically fit people also tend to have a greater proportion of intermediate-twitch muscle fibres and a higher proportion of hypertrophied muscle fibres as compared with atrophied muscle fibres.

9. If body temperature drops, then skeletal muscles will contract involuntarily. This creates shivering, which produces body heat to try to raise body temperature.

10. Students may suggest examples such as the following: conservation of body heat (through constriction of blood vessels near skin); generation of body heat (through shivering); continual heart contraction and relaxation; interaction of diaphragm and rib muscles in breathing. Accept any answer that clearly shows a connection between the action of muscle tissue (skeletal, smooth, and cardiac) and homeostasis.

11. Myoglobin is an oxygen-binding pigment (similar to hemoglobin) found in skeletal muscle fibres. It provides a ready supply of oxygen in the muscle that supports aerobic cellular respiration during exercise.

12. The initial supply of ATP in skeletal muscles supports strenuous exercise for only about eight seconds. After that, new ATP is supplied by the breakdown of creatine phosphate, through aerobic cellular respiration, and by fermentation.

13. Graph A: Muscle Twitch (single stimulus)

Region 1: Latent period—the time between stimulation and initiation of muscle contraction (during this time calcium ions are leaving the sarcoplasmic reticulum and penetrating the myofibrils)

Region 2: Contraction period—the time during which a muscle shortens (Z lines are pulled closer together)

Region 3: Relaxation period—the time when the muscle returns to its normal length (actin and myosin myofilaments slide past each other to their resting position)

14. Graph B: Summation and Tetanus (multiple stimuli applied)

Region 4: Summation—occurs when a muscle receives a rapid series of threshold stimuli and responds to each stimulus before completely relaxing from the previous one. Successive twitches blend together, creating a cumulative response called summation.

Region 5: Tetanus—the muscle remains contracted in a state of tetanus that continues until neural stimulation stops or until the muscle fatigues due to depletion of energy reserves. (Tetanus allows us to maintain the skeletal positions through sustained contractions, such as in the action of holding a glass of water.)

Region 6: Fatigue—tetanus ends due to depletion of energy reserves; fatigue is apparent when a muscle relaxes even though stimulation continues as shown in this graph.

Answers to Applying Concepts Questions

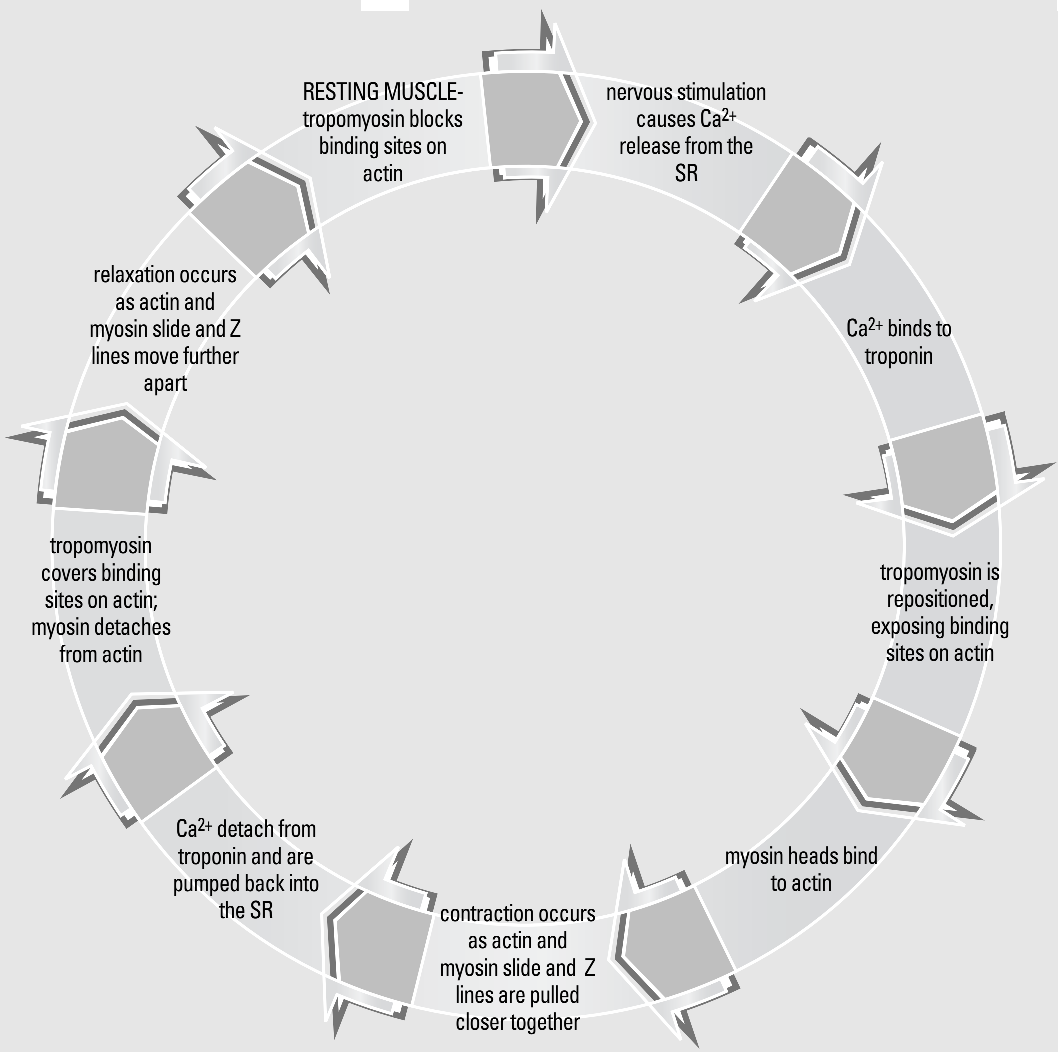
15. The esophagus contains smooth muscle. This is supported by the fact that swallowing is a slow involuntary action.

The heart contains cardiac muscle that is found only in this organ. This muscle type is involuntary, resistant to fatigue and does not undergo tetanus.

16. Myofibrils are cylindrical in shape and run the length of the muscle fibre. These fibres have light and dark bands called striations. The striations are formed by the placement of myofilaments (actin and myosin) within contractile units of myofibrils called sarcomeres. The myofilaments have a fixed length. When the muscle fibre contracts, the sarcomeres within the myofibrils shorten. When a sarcomere shortens, the actin myofilaments (thin) slide past the myosin myofilaments (thick) and approach one another. During the sliding process, the sarcomere shortens; however, the myofilaments (actin and myosin) themselves remain the same length.

17. (a) The scheme below is one way to represent muscle contraction as a cyclic pathway. (Note: SR refers to the sarcoplasmic reticulum)

(b) Two factors that can modify the activity of this cycle are the amounts of ATP and calcium available.



18. Warming up stretches muscles and increases blood flow to provide oxygen and nutrients for energy production.

19. Heat would cause vasodilation and an increased blood flow to the area. This would speed up removal of lactic acid and decrease the pain.

20. A skeletal muscle can maintain a moderate level of tension for long periods of time because different fibres contract at different times.

21. **Hypertrophy:** Regular, moderate exercise strengthens the muscles and enables them to use energy more efficiently. During the first few months of training, skeletal muscles increase in size. This is called hypertrophy and is due to an increased mass of individual skeletal muscle fibres.

Physical training causes other changes to muscles as well. The enzymes within muscle fibres become more active and numerous and the mitochondria become more abundant. A trained athlete's muscles withstand far more exertion than the muscles of an untrained person before fermentation begins. An athlete's muscles also receive more blood and store more glycogen than those of an untrained person.

Atrophy: Muscles may be impaired simply from a lack of use. This condition is referred to as atrophy. Atrophy is a reduction in the size, tone, and power of a muscle. If a skeletal muscle experiences reduced stimulation, its fibres decrease in size and become weaker.

Answers to Making Connections Questions

22. This question requires students to search for, and recognize, patterns and trends in the data represented by the graphs. In the first set of data, for 0–30 min of exercise, blood glucose remains fairly constant, while the percentage of blood-free fatty acids decreases with the level of exercise. Muscle triglyceride increases from mild to moderate exercise but decreases from moderate to heavy; meanwhile, the percentage of muscle glycogen, not detected at all during mild exercise, plays a significant role in providing energy during moderate exercise and nearly doubles as the exercise level increases to heavy. Based on these trends, students might reasonably predict a similar pattern for the second set of data, representing 90–120 min of exercise. That is, their bar graph for heavy exercise could show blood glucose remaining at roughly 10% blood-free fatty acids at a decreased percentage compared to the percentage for moderate exercise (e.g., 30%) decreased muscle triglyceride (e.g., 10%), and increased muscle glycogen (perhaps 50%). Some students might suggest that the people involved in the experiment that provided these data were well-trained athletes, which is a fair assumption given the percentages for aerobic energy sources in the mild exercise column and the pronounced muscle glycogen usage in the moderate and heavy exercise columns.

23. **(a)** The muscle tissue of someone who does the 100-m dash would contain lots of fast-twitch muscle fibres for a rapid generation of power.

(b) A weight lifter would also have lots of fast-twitch fibres, again, to generate power.

(c) A 10 000-m runner would have lots of slow-twitch fibres that resist fatigue and provide more endurance.

24. When the biceps muscle contracts, it shortens and flexes (bends) the elbow joint. The elbow is not extended (straightened) by the relaxation of the biceps because no force is exerted as a muscle lengthens. Instead the contraction of an opposing muscle, the triceps, straightens the elbow joint. The biceps and the triceps are one example of an antagonistic pair of muscles. As the bicep contracts, the triceps is relaxed and vice versa. If the rugby player tears the biceps muscle, then the player would be unable to flex the elbow joint. The ability to straighten the arm at the elbow would be unaffected.

25. The person with MD might have trouble breathing if the breathing muscles (diaphragm and intercostal muscles) are affected. Upon contraction, healthy skeletal muscles increase the volume of the thoracic cavity, decreasing air pressure in the lungs so that atmospheric pressure pushes air into the alveoli. If these muscles are not contracting with sufficient force to maintain normal breathing patterns, then a respirator (a machine that forces air into the lungs) would be required.