

**A. Short Answer**

1. Action potentials are propagated to the interior of a muscle fiber by extensions of the sarcolemma called the \_\_\_\_\_.
2. The \_\_\_\_\_ serves as a reservoir of calcium ions in skeletal muscle.
3. The thick myofilaments are composed of the protein \_\_\_\_\_.
4. Cardiac and some smooth muscle tissue do not require direct stimulation by the nervous system; thus they are said to be \_\_\_\_\_.
5. The synapse where a motor nerve fiber and muscle fiber meet is called a(n) \_\_\_\_\_.
6. Motor nerve fibers stimulate skeletal muscle fibers with a neurotransmitter called \_\_\_\_\_.
7. When a muscle fiber is excited, its membrane produces a brief, self-propagating voltage change called a(n) \_\_\_\_\_.
8. Our best current understanding of how muscle contracts is called the \_\_\_\_\_ theory.
9. Myosin cannot bind to actin until calcium binds to \_\_\_\_\_ and the complex slides out of the way to expose active sites called \_\_\_\_\_ on the actin.
10. When a muscle is stimulated so frequently it can't completely relax between twitches, the successive twitches become stronger and stronger. This is called \_\_\_\_\_.
11. In \_\_\_\_\_ contraction, a muscle develops or maintains tension even as it is being stretched, thus preventing it from relaxing too quickly and producing abrupt, uncoordinated actions.
12. The difference between one's normal rate of oxygen consumption and the rate seen at the end of a strenuous exercise is called \_\_\_\_\_.

**B. Matching**

- |                   |                          |                 |                          |
|-------------------|--------------------------|-----------------|--------------------------|
| A. troponin       | G. isotonic contraction  | M. glycogen     | S. complete tetanus      |
| B. calmodulin     | H. carbon dioxide        | N. power stroke | T. myoglobin             |
| C. T tubules      | I. Z discs/Z line        | O. myosin       | U. calsequestrin         |
| D. twitch         | J. tropomyosin           | P. treppe       | V. recovery stroke       |
| E. synaptic cleft | K. isometric contraction | Q. A band       | W. eccentric contraction |
| F. creatine       | L. phosphagen system     | R. lactic acid  | X. synaptic vesicles     |

- \_\_\_\_\_ 1. Structures that define the limits of a sarcomere.
- \_\_\_\_\_ 2. End product of anaerobic fermentation partly responsible for muscle fatigue.
- \_\_\_\_\_ 3. Calcium-binding protein of the thin myofilament.
- \_\_\_\_\_ 4. Calcium-binding protein of the sarcoplasmic reticulum.
- \_\_\_\_\_ 5. Source of energy for muscle contraction.
- \_\_\_\_\_ 6. Location of acetylcholinesterase.
- \_\_\_\_\_ 7. Movement of thin filament past thick filament in sarcomere.
- \_\_\_\_\_ 8. Sustained muscle contraction at a high stimulus frequency.
- \_\_\_\_\_ 9. Shortening of a muscle while maintaining constant tension.

**C. True or False (if false, cross out the incorrect portion and write in the correction).**

1. When a muscle contracts, each thin myofilament gets shorter.
2. Skeletal muscle cannot contract unless it is stimulated by a motor neuron or artificially stimulated.
3. Tropomyosin is part of the thin filaments of the sarcomeres.
4. A "large" motor unit is one with many nerve fibers per muscle fiber.
5. Muscles need ATP in order to contract, but not to relax.
6. When ATP is unavailable, creatine phosphate can bind to myosin and serve in place of ATP.
7. A muscle cell's resting membrane potential is maintained by the  $\text{Na}^+ - \text{K}^+$  pump.
8. To record a resting potential from a cell, one electrode is inserted into the cytoplasm, the other outside the cell.
9. Muscles engage in anaerobic respiration when mild exercise lasts more than about 10 minutes.
10. The A-bands of skeletal muscle contain only myosin.

## D. Multiple Choice

- \_\_\_\_\_ 1. Muscle contraction and relaxation require ATP for all of the following processes **except**:
- A. flexion of the head of a myosin molecule
  - B. maintaining the excitability of the sarcolemma
  - C. releasing  $\text{Ca}^{2+}$  from terminal cisternae
  - D. reabsorption of  $\text{Ca}^{2+}$  from the sarcoplasm
  - E.  $\text{Na}^+$  -  $\text{K}^+$  pumps used to restore the resting membrane potential
- \_\_\_\_\_ 2. In contrast to slow oxidative muscle fibers, fast glycolytic fibers:
- A. contract more slowly
  - B. contain more mitochondria
  - C. fatigue more quickly
  - D. have more capillaries
  - E. contain more myoglobin
- \_\_\_\_\_ 3. When a muscle develops tension but does not shorten, it is said to exhibit:
- A. treppe
  - B. fatigue
  - C. twitch
  - D. isometric contraction
  - E. isotonic contraction
- \_\_\_\_\_ 4. Endurance training has the **least** effect on:
- A. the thickness of muscle fibers
  - B. the number of mitochondria in a fiber
  - C. the amount of glycogen in a muscle fiber
  - D. the red blood cell count
  - E. the density of capillaries
- \_\_\_\_\_ 5. In skeletal and cardiac muscle actin and myosin overlap in the \_\_\_\_\_ of a sarcomere.
- A. Z disc/Z line
  - B. H band
  - C. dark band
  - D. light band
  - E. triads
- \_\_\_\_\_ 6. A skeletal muscle fiber has more \_\_\_\_\_ than any of these other features.
- A. myofibers
  - B. sarcomeres
  - C. motor end plates
  - D. synaptic vesicles
  - E. Z discs/Z lines
- \_\_\_\_\_ 7. When there is not enough oxygen to produce ATP by aerobic respiration, a muscle fiber can produce some ATP by borrowing phosphate groups from:
- A. adenosine triphosphate
  - B. creatine phosphate
  - C. creatine kinase
  - D. myoglobin
  - E. acetylcholine

\_\_\_\_\_ 8. When calcium ions are released by the sarcoplasmic reticulum, they bind to:

- A. the T tubules
- B. the Z discs/Z lines
- C. F actin
- D. tropomyosin
- E. troponin

\_\_\_\_\_ 9. Which of the following events occurs **first** at a neuromuscular junction?

- A. Myosin heads bind to receptor sites of G actin.
- B. Acetylcholine is released into the synaptic cleft.
- C.  $\text{Ca}^{2+}$  enters the synaptic knob of the motor neuron.
- D.  $\text{Ca}^{2+}$  is released from the sarcoplasmic reticulum
- E.  $\text{Na}^+$  -  $\text{K}^+$  gates open in the sarcolemma.

\_\_\_\_\_ 10. The term *motor unit* refers to:

- A. a neuromuscular junction
- B. the distance from one Z disc to the next
- C. one thick filament and all the thin filaments with which it forms cross-bridges
- D. one nerve fiber and all the muscle fibers it innervates
- E. one myofibril of a muscle fiber

\_\_\_\_\_ 11. Actin is lacking from the \_\_\_\_\_ of a relaxed sarcomere.

- A. H band
- B. I band
- C. A band
- D. thin filaments
- E. myofibrils

\_\_\_\_\_ 12. Based on the sliding filament theory, we would expect the \_\_\_\_\_ during muscle contraction.

- A. A and H bands to disappear
- B. I bands to get shorter and A bands to remain the same length
- C. A bands to get shorter and I bands to remain the same length
- D. A and I bands to both get shorter
- E. H bands and Z discs to disappear

\_\_\_\_\_ 13. Which of the following correctly represents the correct order in which the events of the sliding filament theory occur (noting that some events are omitted)?

- I.  $\text{Ca}^{2+}$  enters the synaptic knob
- II.  $\text{Ca}^{2+}$  is released by the sarcoplasmic reticulum
- III.  $\text{Ca}^{2+}$  enters the sarcoplasmic reticulum
- IV.  $\text{Ca}^{2+}$  binds to troponin
- V. troponin slides away to expose tropomyosin on F actin filament

- A. I-II-III-IV-V
- B. V-IV-III-II-I
- C. II-I-IV-V-III
- D. III-II-I-IV-V
- E. I-II-IV-V-III

\_\_\_\_\_ 14. In which of these would you expect there to be a greater ratio of fast glycolytic muscle fibers?

- A. swimmers
- B. marathon runners
- C. cyclists
- D. cross-country skiers
- E. sprinters

\_\_\_\_\_ 15. Which of these is/are true about cardiac and smooth muscle?

- 1. They both have gap junctions through which action potentials are carried.
  - 2. They have pacemakers.
  - 3. They use  $\text{Ca}^{2+}$  to initiate the contraction process.
  - 4. They are innervated by somatic motor nerve fibers.
- A. 1 & 3
  - B. 2 & 4
  - C. 1, 2, & 3
  - D. 4 only
  - E. All of the above

\_\_\_\_\_ 16. Which of these is/are true about muscle disorders?

- 1. Myasthenia gravis can be treated with acetylcholinesterase inhibitors.
  - 2. Myositis is often confused with fibromyalgia.
  - 3. In muscular dystrophy, muscles become weak and are replaced by fibrous and adipose tissues.
  - 4. Most muscular dystrophies are caused by autosomal dominant genes.
- A. 1 & 3
  - B. 2 & 4
  - C. 1, 2, & 3
  - D. 4 only
  - E. All of the above

**E. Word Origins: Identify the meaning of the portion of the words in their context or as a pre/suffix.**

- 1. In the word **sarcoplasmic**, *sarco* means \_\_\_\_\_.
- 2. In the word **sarcomere**, *mer* means \_\_\_\_\_.
- 3. In the word **isometric**, *iso* means \_\_\_\_\_.
- 4. In the word **isometric**, *metr* means \_\_\_\_\_.
- 5. In the word **isotonic**, *ton* means \_\_\_\_\_.
- 6. In the word **dystrophy**, *dys* means \_\_\_\_\_.
- 7. In the word **myoglobin**, *myo* means \_\_\_\_\_.
- 8. In the word **acetylcholinesterase**, *ase* means \_\_\_\_\_.
- 9. In the words **temporal summation**, *tempor* means \_\_\_\_\_.
- 10. In the word **phosphagen**, *gen* means \_\_\_\_\_.
- 11. -lemma means \_\_\_\_\_.
- 12. mortis means \_\_\_\_\_.

13. -troph means \_\_\_\_\_.

14. auto- means \_\_\_\_\_.

15. -blast means \_\_\_\_\_.

F. Which One Does Not Belong? Identify which option does NOT fit with the others, then write a SHORT explanation of why. There may be a couple of acceptable answers, depending on your reply.

1. a) junctional folds b) acetylcholine c) sarcoplasmic reticulum d) motor end plate

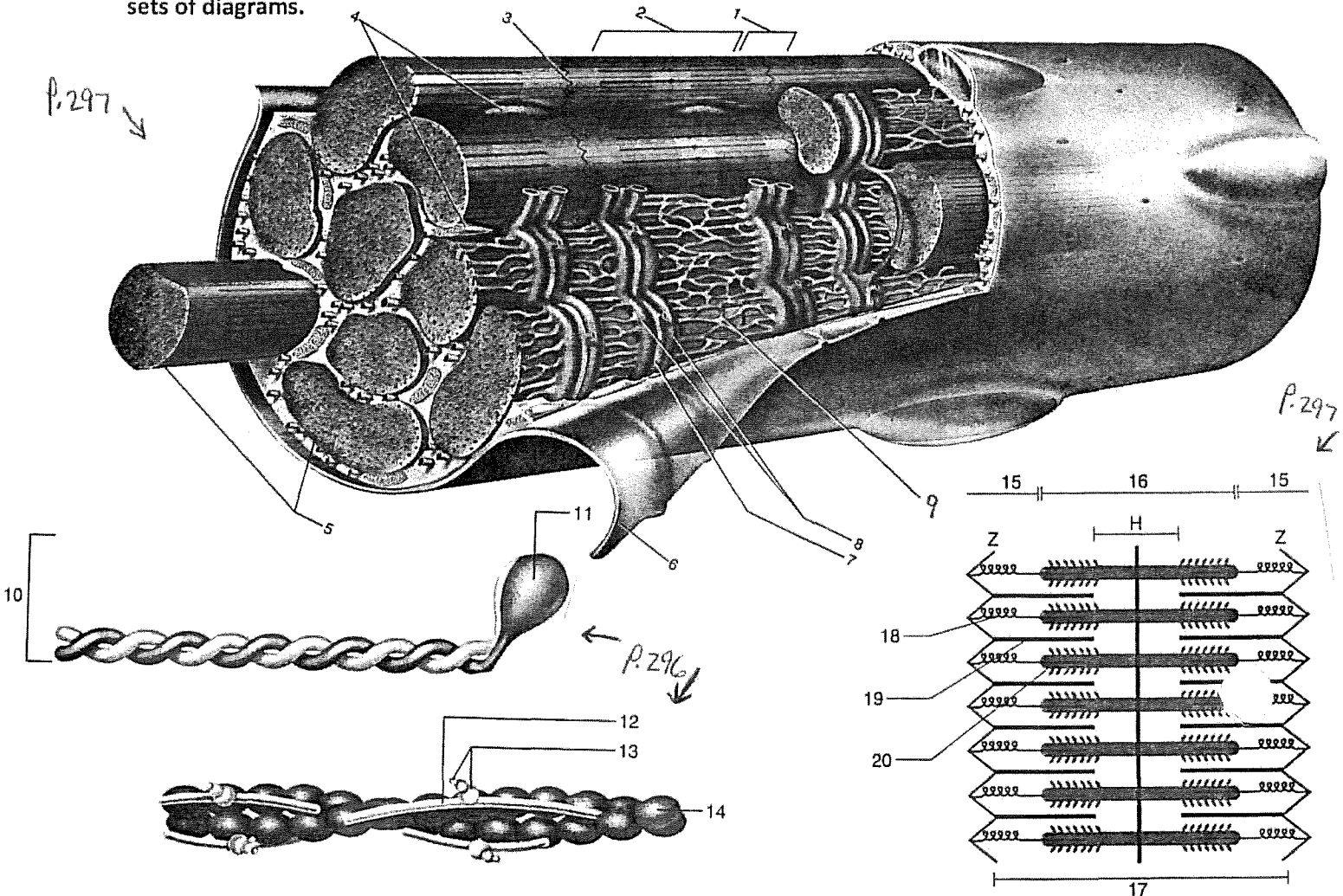
2. a) conductivity b) excitability c) elasticity d) autorhythmicity

3. a) tropomyosin b) troponin c) calmodulin d) calsequestrin

4. a) myosin kinase b) phosphagen system c) aerobic respiration d) anaerobic respiration

5. a) striation b) calmodulin c) branched cells d) intercalated discs

G. Figure Exercise: Answer the following questions about muscle cell structure and functions using all sets of diagrams.



\_\_\_\_\_ 1. Which of these are capable of carrying an electrical current or action potential?

- A. 3, 5
- B. 5, 6
- C. 6, 7
- D. 7, 9
- E. 9, 10

\_\_\_\_\_ 2. What structure stores calcium ions in resting muscle?

- A. 3
- B. 6
- C. 7
- D. 8
- E. 10

\_\_\_\_\_ 3. Sarcomeres laid end to end make up these.

- A. 3
- B. 5
- C. 2
- D. 8
- E. 9

\_\_\_\_\_ 4. Between two of these lies a sarcomere.

- A. 3
- B. 2
- C. 1
- D. 5
- E. 10

\_\_\_\_\_ 5. Which of these binds calcium ions before a muscle can contract?

- A. 7
- B. 8
- C. 11
- D. 12
- E. 13

\_\_\_\_\_ 6. Which of these binds to active sites on actin during muscle contraction?

- A. 12
- B. 14
- C. 11
- D. 18
- E. 20

\_\_\_\_\_ 7. The area marked 17 is called \_\_\_\_\_.

- A. a sarcomere
- B. a thin filament
- C. connectin
- D. a neuromuscular junction
- E. the dark band

\_\_\_\_\_ 8. When a muscle contracts which of these occur?

- A. 20 slides past 19
- B. 18 relaxes
- C. the length of 17 increases
- D. 11 attaches to and pulls on 14
- E. calcium binds 19 and shortens 17

\_\_\_\_\_ 9. The entire structure shown in 1-9 is a portion of a(n):

- A. myofibril
- B. muscle filament
- C. muscle fiber
- D. myoblast
- E. thick filament

\_\_\_\_\_ 10. Which of these is the dark band?

- A. 7 & 8
- B. 19
- C. 10
- D. 15
- E. 16