



The Muscular System

Muscles, the specialized tissues that facilitate body movement, make up about 40% of body weight. Most body muscle is the voluntary type, called skeletal muscle because it is attached to the bony skeleton. Skeletal muscle contributes to body contours and shape, and composes the organ system called the muscular system. These muscles allow you to grin, frown, run, swim, shake hands, swing a hammer, and to otherwise manipulate your environment. The balance of body muscle is smooth and cardiac muscles, which form the bulk of the walls of hollow organs and the heart. Smooth and cardiac muscles are involved in the transport of materials within the body.

Study activities in this chapter deal with microscopic and gross structure of muscle, identification of voluntary muscles, body movements, and important understandings of muscle physiology.

OVERVIEW OF MUSCLE TISSUES

1. Nine characteristics of muscle tissue are listed below and on page 90. Identify the muscle tissue type described by choosing the correct response(s) from the key choices. Enter the appropriate term(s) or letter(s) of the key choice in the answer blank.

Key Choices

A. Cardiac B. Smooth C. Skeletal

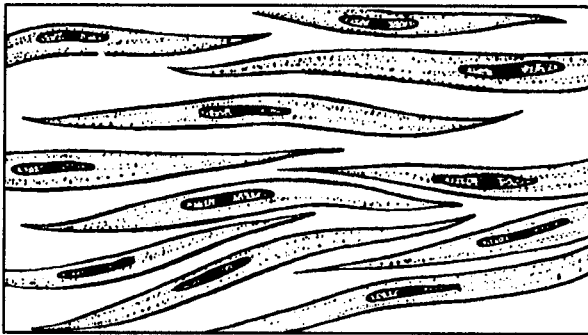
- _____ 1. Involuntary
- _____ 2. Banded appearance
- _____ 3. Longitudinally and circularly arranged layers
- _____ 4. Dense connective tissue packaging
- _____ 5. Figure-8 packaging of the cells
- _____ 6. Coordinated activity to act as a pump

Key Choices

- A. Cardiac B. Smooth C. Skeletal

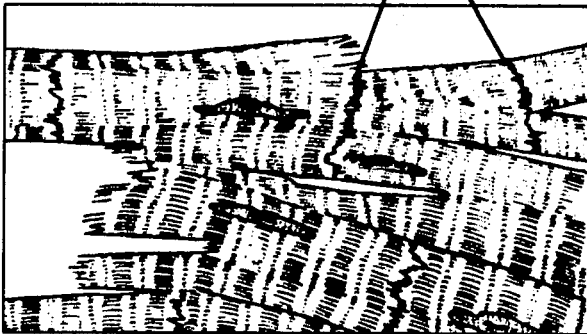
- _____ 7. Moves bones and the facial skin
 _____ 8. Referred to as the muscular system
 _____ 9. Voluntary

2. Identify the type of muscle in each of the illustrations in Figure 6-1. Color the diagrams as you wish.



A _____

Intercalated disks



B _____

Figure 6-1

3. Regarding the functions of muscle tissues, circle the term in each of the groupings that does not belong with the other terms.

- | | | | |
|-----------------------|------------------------|-----------------|-----------------------------|
| 1. Urine | Foodstuffs | Bones | Smooth muscle |
| 2. Heart | Cardiac muscle | Blood pump | Promotes labor during birth |
| 3. Excitability | Response to a stimulus | Contractility | Action potential |
| 4. Ability to shorten | Contractility | Pulls on bones | Stretchability |
| 5. Maintains posture | Movement | Promotes growth | Generates heat |

MICROSCOPIC ANATOMY OF SKELETAL MUSCLE

4. First, identify the structures in Column B by matching them with the descriptions in Column A. Enter the correct letters (or terms if desired) in the answer blanks. Then, select a different color for each of the terms in Column B that has a color-coding circle and color the structures in on Figure 6-2.

Column A

- _____ 1. Connective tissue surrounding a fascicle
- _____ 2. Connective tissue ensheathing the entire muscle
- _____ 3. Contractile unit of muscle
- _____ 4. A muscle cell
- _____ 5. Thin connective tissue investing each muscle cell
- _____ 6. Plasma membrane of the muscle cell
- _____ 7. A long, filamentous organelle found within muscle cells that has a banded appearance
- _____ 8. Actin- or myosin-containing structure
- _____ 9. Cordlike extension of connective tissue beyond the muscle, serving to attach it to the bone
- _____ 10. A discrete bundle of muscle cells

Column B

- A. Endomysium ○
- B. Epimysium ○
- C. Fascicle
- D. Fiber ○
- E. Myofilament
- F. Myofibril ○
- G. Perimysium ○
- H. Sarcolemma
- I. Sarcomere
- J. Sarcoplasm
- K. Tendon ○

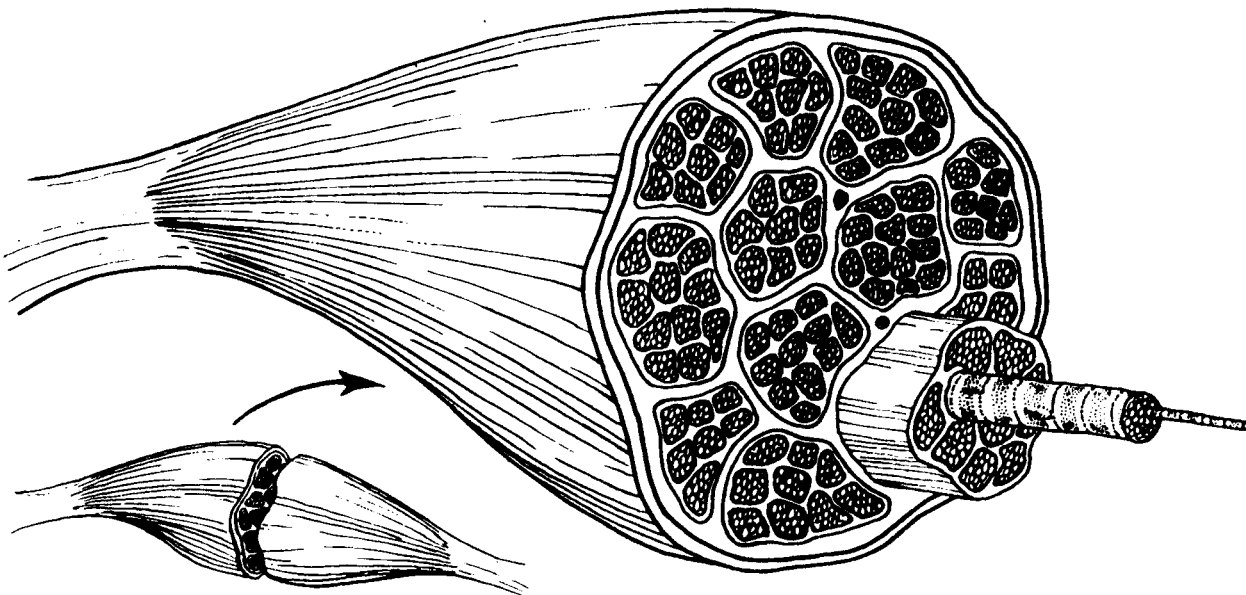


Figure 6-2

5. Figure 6-3 is a diagrammatic representation of a small portion of a relaxed muscle cell (bracket indicates the portion enlarged). First, select different colors for the structures listed below. Use them to color the coding circles and corresponding structures on Figure 6-3. Then bracket and label an A band, an I band, and a sarcomere. When you have finished, draw a contracted sarcomere in the space beneath the figure and label the same structures.

- Myosin Actin filaments Z disc

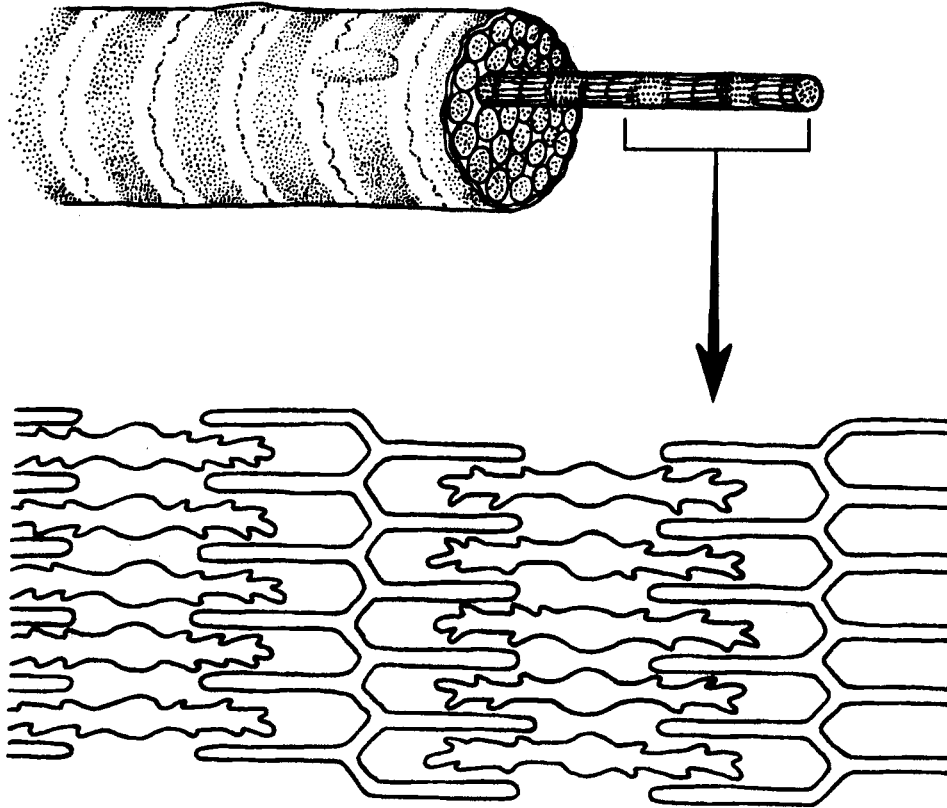


Figure 6-3

SKELETAL MUSCLE ACTIVITY

6. Complete the following statements relating to the neuromuscular junction. Insert the correct answers in the numbered answer blanks.

- _____ 1. A motor neuron and all of the skeletal muscle cells it stimulates is called a (1). The axon of each motor neuron has numerous endings called (2). The actual gap between an axonal ending and the muscle cell is called a (3).
- _____ 2. _____ 3. Within the axonal endings are many small vesicles containing a neurotransmitter substance called (4).
- _____ 4. _____ 5. When the (5) reaches the ends of the axon, the neurotransmitter is released, and it diffuses to the muscle cell membrane to combine with receptors there. Binding of the neurotransmitters with muscle membrane receptors causes the membrane to become permeable to sodium, resulting in the influx of sodium ions and (6) of the membrane. Then contraction of the muscle cell occurs.
- _____ 6.

7. Figure 6-4 shows the components of a neuromuscular junction. Identify the parts by coloring the coding circles and the corresponding structures in the diagram. Add small arrows to indicate the location of the ACh receptors and label appropriately.

- | | | |
|---|--------------------------------------|---------------------------------|
| <input type="radio"/> Mitochondrion | <input type="radio"/> T tubule | <input type="radio"/> Sarcomere |
| <input type="radio"/> Synaptic vesicles | <input type="radio"/> Synaptic cleft | |

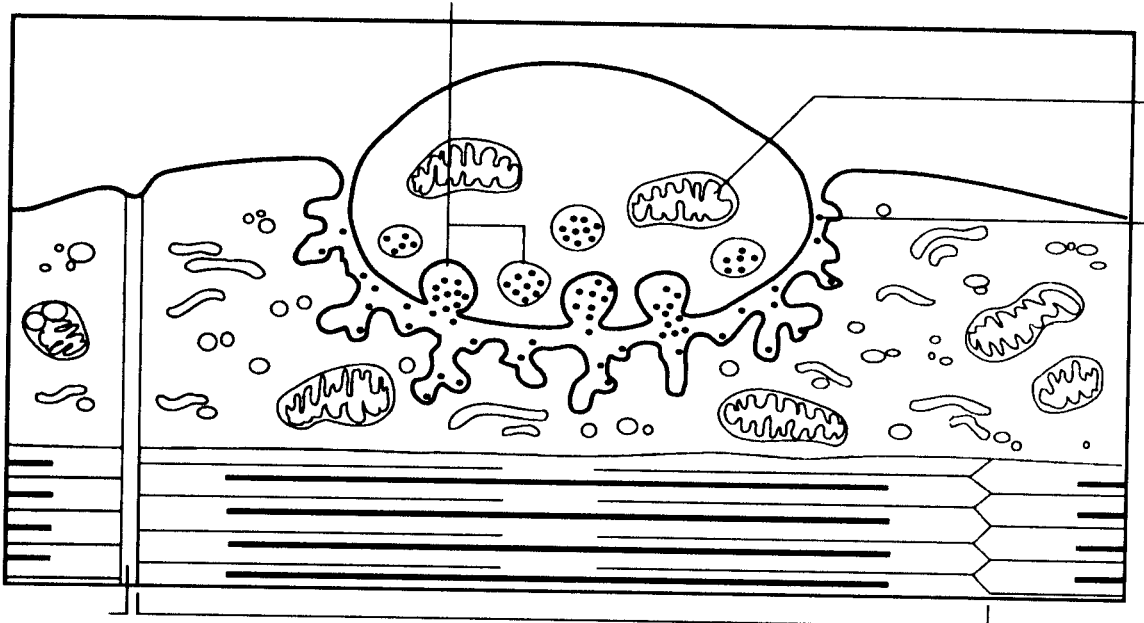


Figure 6-4

8. Number the following statements in their proper sequence to describe the contraction mechanism in a skeletal muscle cell. The first step has already been identified as number 1.

- 1. Acetylcholine is released into the neuromuscular junction by the axonal terminal.
- 2. The action potential, carried deep into the cell, causes the sarcoplasmic reticulum to release calcium ions.
- 3. The muscle cell relaxes and lengthens.
- 4. Acetylcholine diffuses across the neuromuscular junction and binds to receptors on the sarcolemma.
- 5. The calcium ion concentration at the myofilaments increases; the myofilaments slide past one another, and the cell shortens.
- 6. Depolarization occurs, and the action potential is generated.
- 7. As calcium is actively reabsorbed into the sarcoplasmic reticulum, its concentration at the myofilaments decreases.

9. The following incomplete statements refer to a muscle cell in the resting, or polarized, state just before stimulation. Complete each statement by choosing the correct response from the key choices and entering the appropriate letter in the answer blanks.

Key Choices

- | | |
|---|--|
| A. Na ⁺ diffuses out of the cell | G. Relative ionic concentrations on the two sides of the membrane during rest |
| B. K ⁺ diffuses out of the cell | H. Electrical conditions |
| C. Na ⁺ diffuses into the cell | I. Activation of the sodium-potassium pump, which moves K ⁺ into the cell and Na ⁺ out of the cell |
| D. K ⁺ diffuses into the cell | J. Activation of the sodium-potassium pump, which moves Na ⁺ into the cell and K ⁺ out of the cell |
| E. Inside the cell | |
| F. Outside the cell | |

- 1. There is a greater concentration of Na⁺ (1), and there is a greater concentration of K⁺ (2). When the stimulus is delivered, the permeability of the membrane is changed, and (3), initiating the depolarization of the membrane. Almost as soon as the depolarization wave begins, a repolarization wave follows it across the membrane. This occurs as (4).
- 2. Repolarization restores the (5) of the resting cell membrane. The (6) is (are) reestablished by (7).
- 3. _____
- 4. _____
- 5. _____
- 6. _____ 7. _____

10. Complete the following statements by choosing the correct response from the key choices and entering the appropriate letter or term in the answer blanks.

Key Choices

- | | | |
|-------------------------|--------------------------|---------------------|
| A. Fatigue | E. Isometric contraction | I. Many motor units |
| B. Isotonic contraction | F. Whole muscle | J. Repolarization |
| C. Muscle cell | G. Tetanus | K. Depolarization |
| D. Muscle tone | H. Few motor units | |

- _____ 1. _____ is a continuous contraction that shows no evidence of relaxation.
- _____ 2. A(n) _____ is a contraction in which the muscle shortens and work is done.
- _____ 3. To accomplish a strong contraction, _____ are stimulated at a rapid rate.
- _____ 4. When a weak but smooth muscle contraction is desired, _____ are stimulated at a rapid rate.
- _____ 5. When a muscle is being stimulated but is not able to respond due to "oxygen debt," the condition is called _____.
- _____ 6. A(n) _____ is a contraction in which the muscle does not shorten but tension in the muscle keeps increasing.

11. The terms in the key refer to the three ways that muscle cells replenish their ATP supplies. Select the term(s) that best apply to the conditions described and insert the correct key letter(s) in the answer blanks.

Key Choices

- | | |
|-----------------------------------|------------------------|
| A. Coupled reaction of CP and ADP | C. Aerobic respiration |
|-----------------------------------|------------------------|

- B. Anaerobic glycolysis

- _____ 1. Accompanied by lactic acid formation
- _____ 2. Supplies the highest ATP yield per glucose molecule
- _____ 3. Involves the simple transfer of a phosphate group
- _____ 4. Requires no oxygen
- _____ 5. The slowest ATP regeneration process
- _____ 6. Produces carbon dioxide and water
- _____ 7. The energy mechanism used in the second hour of running in a marathon
- _____ 8. Used when the oxygen supply is inadequate over time
- _____ 9. Good for a sprint

12. Briefly describe how you can tell when you are repaying the oxygen debt.

13. Which of the following occur within a muscle cell during oxygen debt? Place a check (✓) by the correct choices.

- | | | | |
|-------|--------------------------|-------|-----------------------------|
| _____ | 1. Decreased ATP | _____ | 5. Increased oxygen |
| _____ | 2. Increased ATP | _____ | 6. Decreased carbon dioxide |
| _____ | 3. Increased lactic acid | _____ | 7. Increased carbon dioxide |
| _____ | 4. Decreased oxygen | _____ | 8. Increased glucose |

MUSCLE MOVEMENTS, TYPES, AND NAMES

14. Relative to general terminology concerning muscle activity, first label the following structures on Figure 6-5: insertion, origin, tendon, resting muscle, and contracting muscle. Next, identify the two structures named below by choosing different colors for the coding circles and the corresponding structures in the figure.

- Movable bone
- Immovable bone

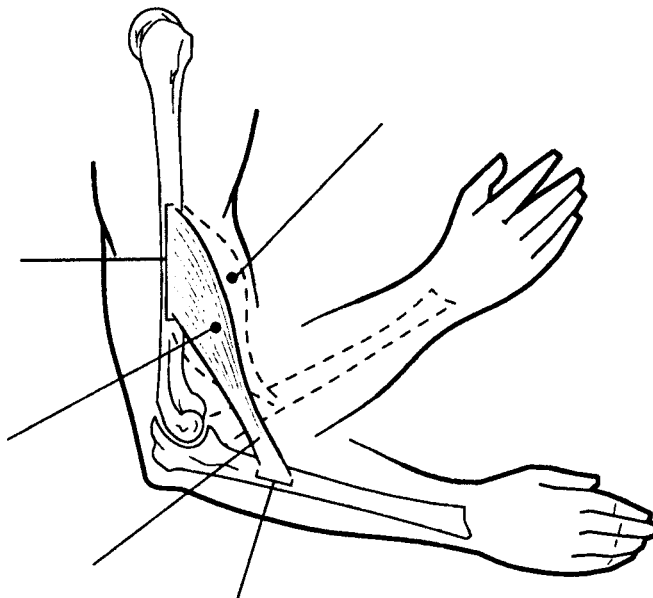


Figure 6-5

15. Complete the following statements. Insert your answers in the answer blanks.

- _____ 1. Standing on your toes as in ballet is (1) of the foot. Walking on your heels is (2).
- _____ 2. _____
- _____ 3. Winding up for a pitch (as in baseball) can properly be called (3). To keep your seat when riding a horse, the tendency is to (4) your thighs.
- _____ 4. _____
- _____ 5. In running, the action at the hip joint is (5) in reference to the leg moving forward and (6) in reference to the leg in the posterior position. When kicking a football, the action at the knee is (7). In climbing stairs, the hip and knee of the forward leg are both (8). You have just touched your chin to your chest; this is (9) of the neck.
- _____ 6. _____
- _____ 7. _____
- _____ 8. Using a screwdriver with a straight arm requires (10) of the arm. Consider all the movements of which the arm is capable.
- _____ 9. One often used for strengthening all the upper arm and shoulder muscles is (11).
- _____ 10. _____
- _____ 11. Moving the head to signify "no" is (12). Action that moves the distal end of the radius across the ulna is (13). Raising the arms laterally away from the body is called (14) of the arms.
- _____ 12. _____
- _____ 13. _____
- _____ 14. _____

16. The terms provided in the key are often used to describe the manner in which muscles interact with other muscles. Select the key terms that apply to the following definitions and insert the correct letter or term in the answer blanks.

Key Choices

- A. Antagonist B. Fixator C. Prime mover D. Synergist

- _____ 1. Agonist
- _____ 2. Postural muscles for the most part
- _____ 3. Stabilizes a joint so that the prime mover can act at more distal joints
- _____ 4. Performs the same movement as the prime mover
- _____ 5. Reverses and/or opposes the action of a prime mover
- _____ 6. Immobilizes the origin of a prime mover

17. Several criteria are applied to the naming of muscles. These are provided in Column B. Identify which criteria pertain to the muscles listed in Column A and enter the correct letter(s) in the answer blank.

Column A	Column B
_____ 1. Gluteus maximus	A. Action of the muscle
_____ 2. Adductor magnus	B. Shape of the muscle
_____ 3. Biceps femoris	C. Location of the muscle's origin and/or insertion
_____ 4. Abdominis transversus	D. Number of origins
_____ 5. Extensor carpi ulnaris	E. Location of muscle relative to a bone or body region
_____ 6. Trapezius	F. Direction in which the muscle fibers run relative to some imaginary line
_____ 7. Rectus femoris	G. Relative size of the muscle
_____ 8. External oblique	

GROSS ANATOMY OF THE SKELETAL MUSCLES

Muscles of the Head

18. Identify the major muscles described in Column A by choosing a response from Column B. Enter the correct letter in the answer blank. Select a different color for each muscle described and color in the coding circle and corresponding muscle on Figure 6-6.

Column A	Column B
<input type="radio"/> _____ 1. Used in smiling	A. Buccinator
<input type="radio"/> _____ 2. Used to suck in your cheeks	B. Frontalis
<input type="radio"/> _____ 3. Used in winking	C. Masseter
<input type="radio"/> _____ 4. Used to form the horizontal frown crease on the forehead	D. Orbicularis oculi
<input type="radio"/> _____ 5. The "kissing" muscle	E. Orbicularis oris
<input type="radio"/> _____ 6. Prime mover of jaw closure	F. Sternocleidomastoid
<input type="radio"/> _____ 7. Synergist muscle for jaw closure	G. Temporalis
<input type="radio"/> _____ 8. Prime mover of head flexion; a two-headed muscle	H. Trapezius
	I. Zygomaticus

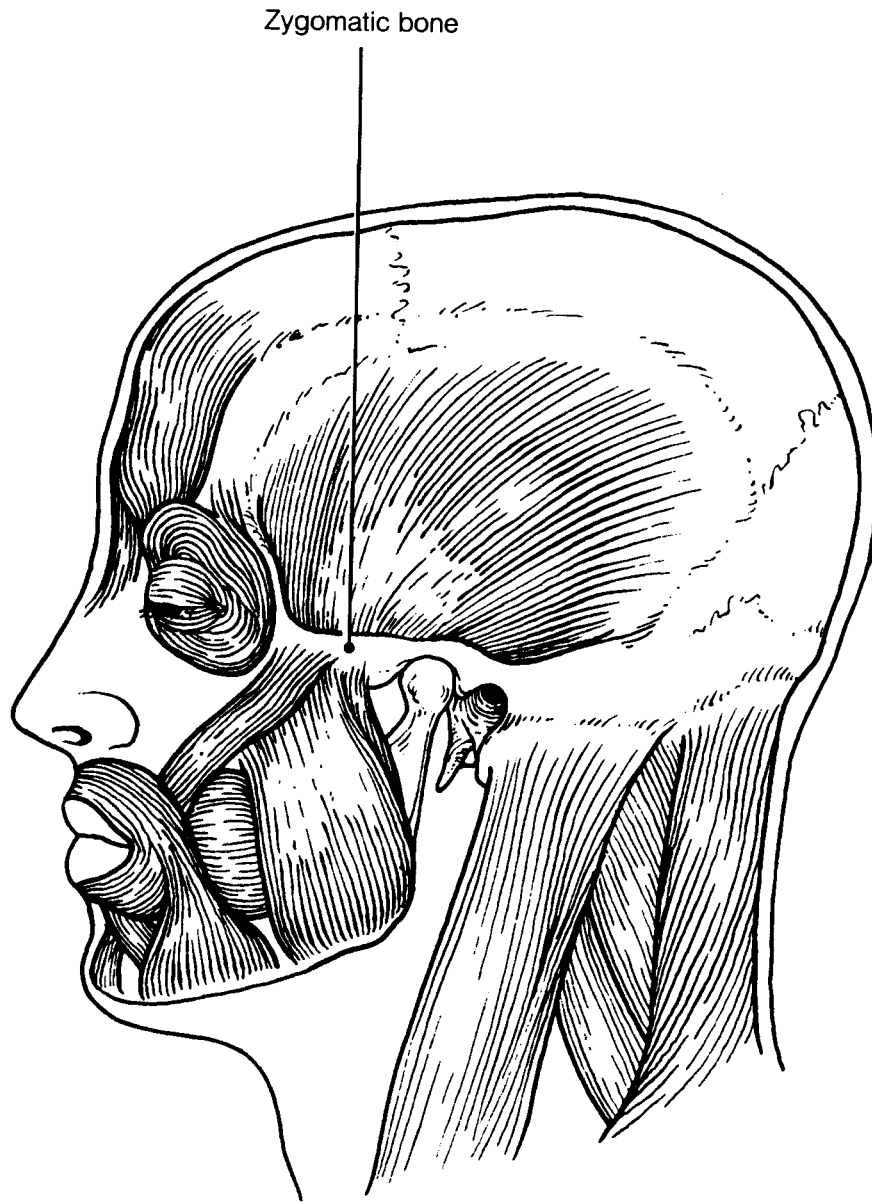


Figure 6-6

Muscles of the Trunk

19. Identify the anterior trunk muscles described in Column A by choosing a response from Column B. Enter the correct letter in the answer blank. Then, for each muscle description that has a color-coding circle, select a different color to color the coding circle and corresponding muscle on Figure 6–7.

Column A

- _____ 1. The name means “straight muscle of the abdomen”
- _____ 2. Prime mover for shoulder flexion and adduction
- _____ 3. Prime mover for shoulder abduction
- _____ 4. Part of the abdominal girdle; forms the external lateral walls of the abdomen
- _____ 5. Acting alone, each muscle of this pair turns the head toward the opposite shoulder
- _____ 6. and 7. Besides the two abdominal muscles (pairs) named above, two muscle pairs that help form the natural abdominal girdle
- _____ 8. Deep muscles of the thorax that promote the inspiratory phase of breathing
- _____ 9. An unpaired muscle that acts with the muscles named immediately above to accomplish inspiration

Column B

- A. Deltoid
- B. Diaphragm
- C. External intercostal
- D. External oblique
- E. Internal intercostal
- F. Internal oblique
- G. Latissimus dorsi
- H. Pectoralis major
- I. Rectus abdominis
- J. Sternocleidomastoid
- K. Transversus abdominis

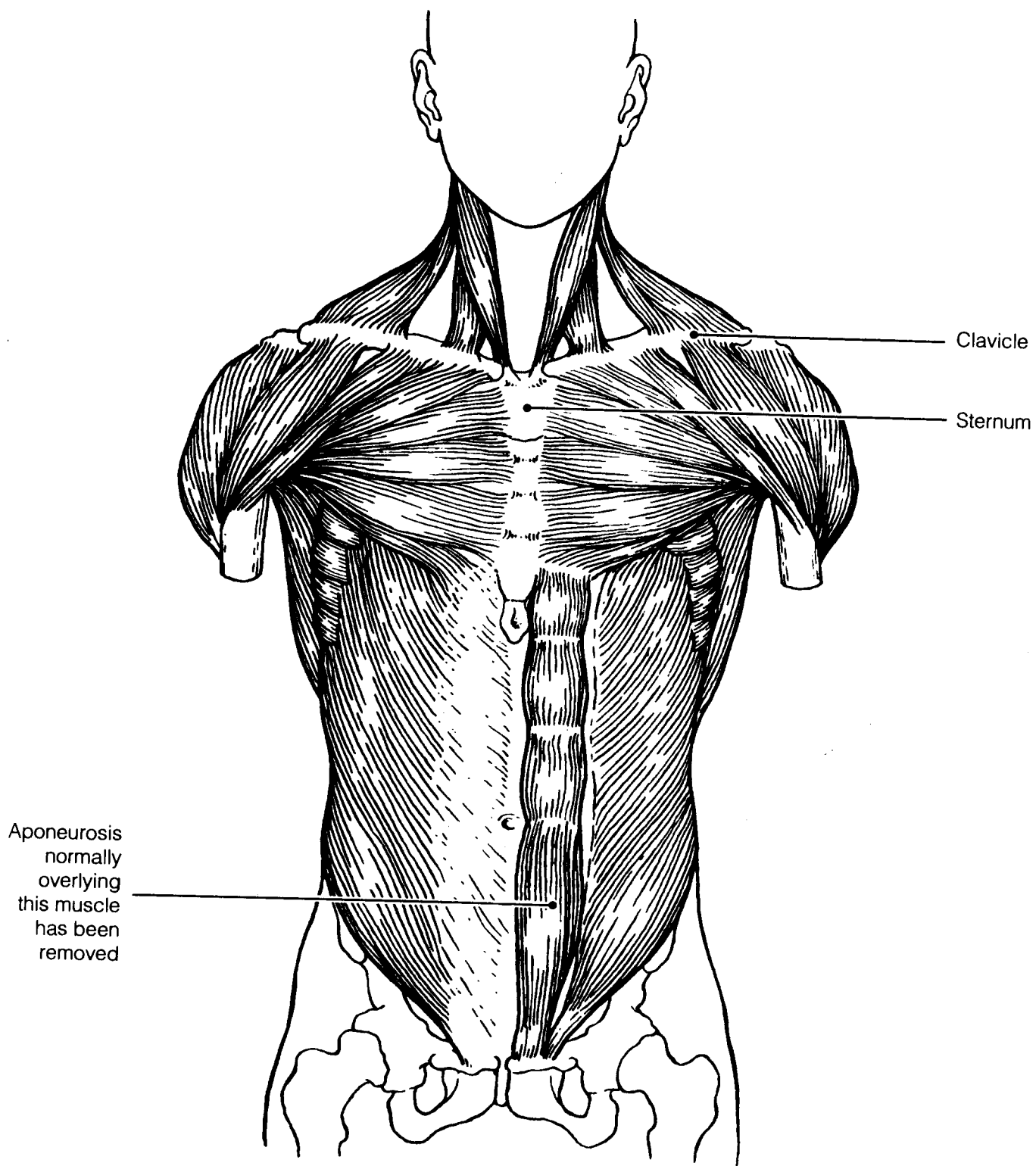


Figure 6-7

20. Identify the posterior trunk muscles described in Column A by choosing a response from Column B. Enter the correct letter in the answer blank. Select a different color for each muscle description with a coding circle and color the coding circles and corresponding muscles on Figure 6–8.

Column A

- _____ 1. Muscle that allows you to shrug your shoulders or extend your head
- _____ 2. Muscle that adducts the shoulder and causes extension of the shoulder joint
- _____ 3. Shoulder muscle that is the antagonist of the muscle just described
- _____ 4. Prime mover of back extension; a deep composite muscle consisting of three columns
- _____ 5. Large paired superficial muscle of the lower back

Column B

- A. Deltoid
- B. Erector spinae
- C. External oblique
- D. Gluteus maximus
- E. Latissimus dorsi
- F. Trapezius

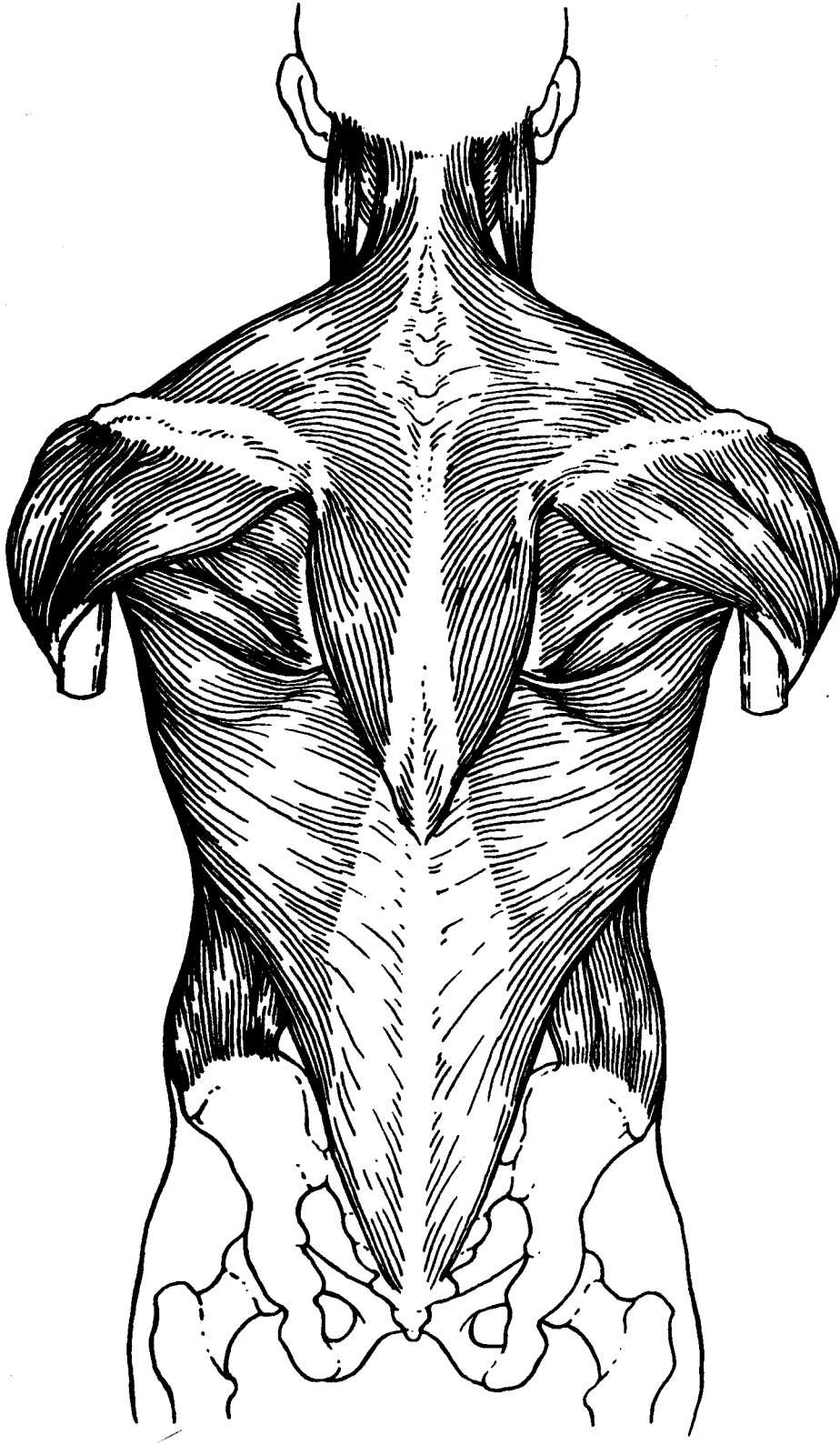


Figure 6-8

Muscles of the Hip, Thigh, and Leg

21. Identify the muscles described in Column A by choosing a response from Column B. Enter the correct letter in the answer blank. Select a different color for each muscle description provided with a color-coding circle, and use it to color the coding circles and corresponding muscles on Figure 6–9. Complete the illustration by labeling those muscles provided with leader lines.

Column A

- _____ 1. Hip flexor, deep in pelvis; a composite of two muscles
- _____ 2. Used to extend the hip when climbing stairs
- _____ 3. “Toe dancer’s” muscle; a two-bellied muscle of the calf
- _____ 4. Inverts and dorsiflexes the foot
- _____ 5. Muscle group that allows you to draw your legs to the midline of your body, as when standing at attention
- _____ 6. Muscle group that extends the knee
- _____ 7. Muscle group that extends the thigh and flexes the knee
- _____ 8. Smaller hip muscle commonly used as an injection site
- _____ 9. Muscle group of the lateral leg; plantar flex and evert the foot
- _____ 10. Strap-like muscle that is a weak thigh flexor; the “tailor’s muscle”
- _____ 11. Like the two-bellied muscle that lies over it, this muscle is a plantar flexor

Column B

- A. Adductors
- B. Biceps femoris
- C. Fibularis muscles
- D. Gastrocnemius
- E. Gluteus maximus
- F. Gluteus medius
- G. Hamstrings
- H. Iliopsoas
- I. Quadriceps
- J. Rectus femoris
- K. Sartorius
- L. Semimembranosus
- M. Semitendinosus
- N. Soleus
- O. Tibialis anterior
- P. Vastus intermedius
- Q. Vastus lateralis
- R. Vastus medialis

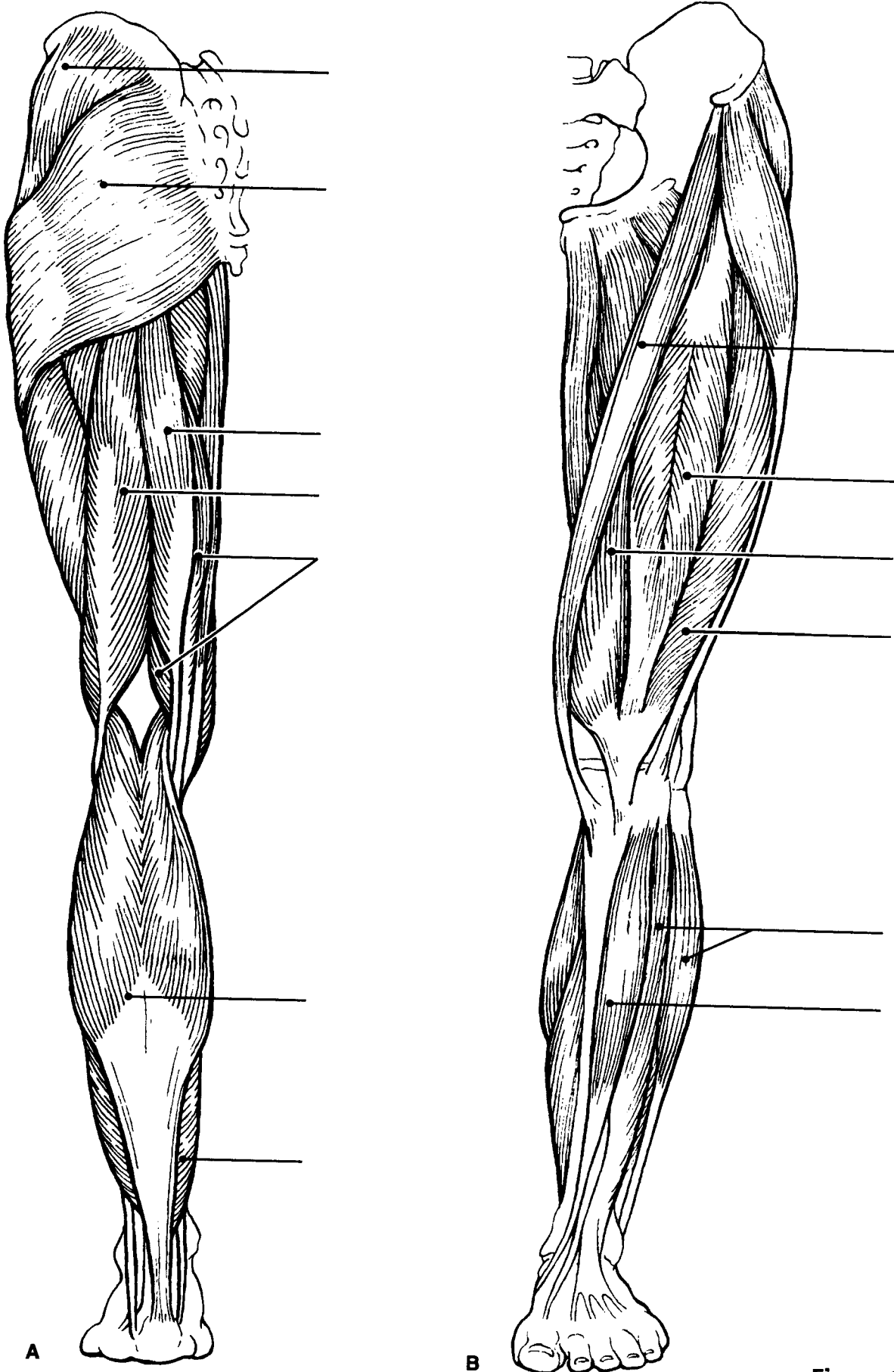


Figure 6-9

Muscles of the Arm and Forearm

22. Identify the muscles described in Column A by choosing a response from Column B. Enter the correct letter in the answer blank. Then select different colors for each muscle description provided with a color-coding circle and use them to color in the coding circles and corresponding muscles on Figure 6–10.

Column A

- _____ 1. Wrist flexor that follows the ulna
- _____ 2. Muscle that extends the fingers
- _____ 3. Muscle that flexes the fingers
- _____ 4. Muscle that allows you to bend (flex) the elbow
- _____ 5. Muscle that extends the elbow
- _____ 6. Powerful shoulder abductor, used to raise the arm overhead

Column B

- A. Biceps brachii
- B. Deltoid
- C. Extensor carpi radialis
- D. Extensor digitorum
- E. Flexor carpi ulnaris
- F. Flexor digitorum superficialis
- G. Triceps brachii



Figure 6–10

General Body Muscle Review

23. Complete the following statements describing muscles. Insert the correct answers in the answer blanks.

- _____ 1. Three muscles— (1), (2), and (3)—are commonly used for intramuscular injections in adults.
- _____ 2.
- _____ 3. The insertion tendon of the (4) group contains a large sesamoid bone, the patella.
- _____ 4. The triceps surae insert in common into the (5) tendon.
- _____ 5. The bulk of the tissue of a muscle tends to lie (6) to the part of the body it causes to move.
- _____ 6.
- _____ 7. The extrinsic muscles of the hand originate on the (7).
- _____ 8. Most flexor muscles are located on the (8) aspect of the body; most extensors are located (9). An exception to this generalization is the extensor-flexor musculature of the (10).
- _____ 9.
- _____ 10. The pectoralis major and deltoid muscles act synergistically to (11) the arm.
- _____ 11.

24. Circle the term that does not belong in each of the following groupings.

1. Vastus lateralis Vastus medialis Knee extension Biceps femoris
2. Latissimus dorsi Pectoralis major Shoulder adduction Antagonists
3. Buccinator Frontalis Masseter Mastication Temporalis
4. Vastus medialis Rectus femoris Iliacus Origin on coxal bone

25. Identify the numbered muscles in Figure 6–11 by placing the numbers in the blanks next to the following muscle names. Then select a different color for each muscle provided with a color-coding circle and color the coding circle and corresponding muscle in Figure 6–11.

- _____ 1. Orbicularis oris
- _____ 2. Pectoralis major
- _____ 3. External oblique
- _____ 4. Sternocleidomastoid
- _____ 5. Biceps brachii
- _____ 6. Deltoid
- _____ 7. Vastus lateralis
- _____ 8. Frontalis
- _____ 9. Rectus femoris
- _____ 10. Sartorius
- _____ 11. Gracilis
- _____ 12. Adductor group
- _____ 13. Fibularis longus
- _____ 14. Temporalis
- _____ 15. Orbicularis oculi
- _____ 16. Zygomaticus
- _____ 17. Masseter
- _____ 18. Vastus medialis
- _____ 19. Tibialis anterior
- _____ 20. Transversus abdominus
- _____ 21. Rectus abdominis

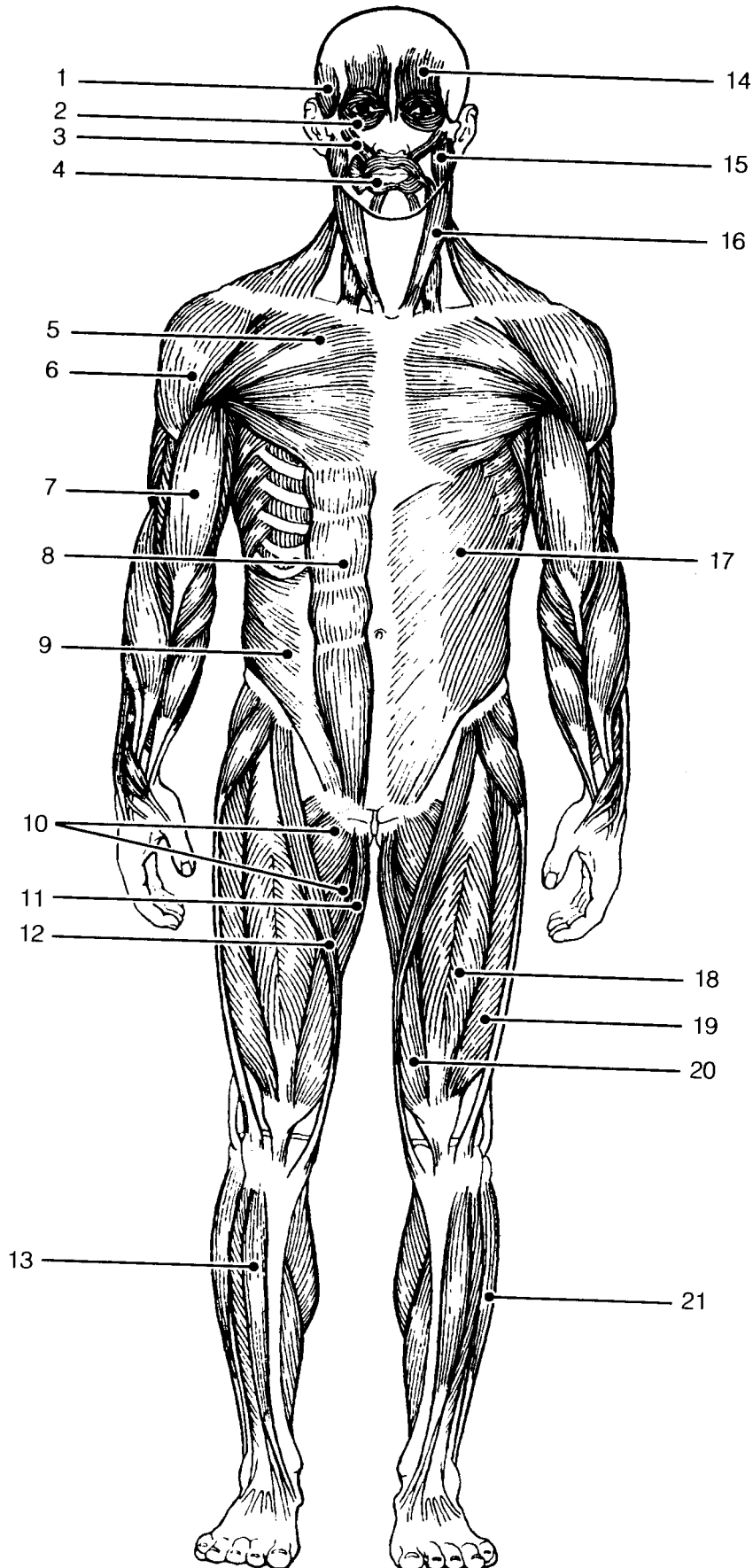


Figure 6-11

26. Identify each of the numbered muscles in Figure 6-12 by placing the numbers in the blanks next to the following muscle names. Then select different colors for each muscle and color the coding circles and corresponding muscles on Figure 6-12.

- ____ 1. Adductor muscle
- ____ 2. Gluteus maximus
- ____ 3. Gastrocnemius
- ____ 4. Latissimus dorsi
- ____ 5. Deltoid
- ____ 6. Semitendinosus
- ____ 7. Soleus
- ____ 8. Biceps femoris
- ____ 9. Triceps brachii
- ____ 10. External oblique
- ____ 11. Gluteus medius
- ____ 12. Trapezius

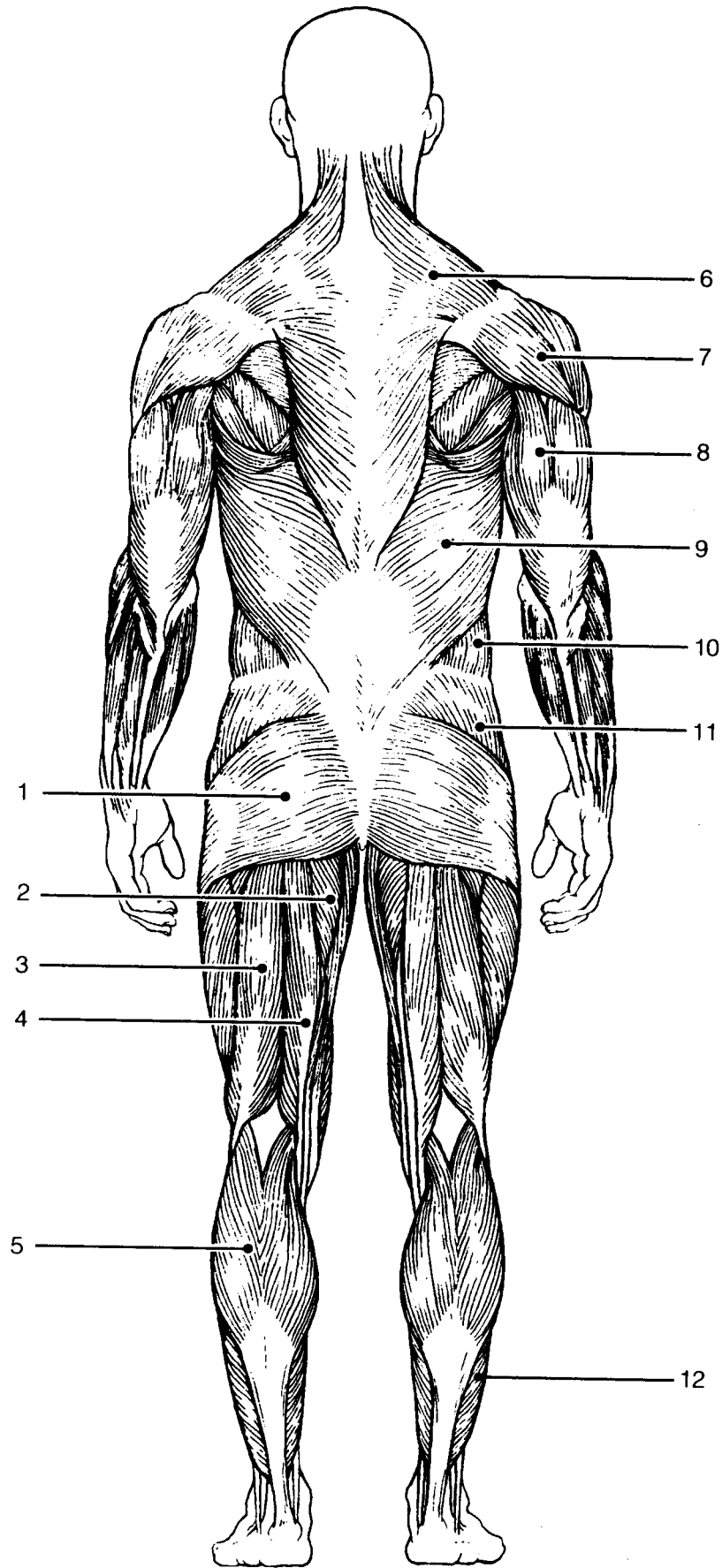


Figure 6-12