

A VISUAL GUIDE TO

Anatomy & Physiology


The Unity of Form and Function

Before you begin a chapter, it is important to have a broad overview of what it covers. This is provided by an outline on the first page of each chapter, page-referenced to facilitate your later review and study.

Icons at the beginning of each chapter encourage you to use the interactive CD-ROM that accompanies your textbook. The *Essential Study Partner* is packed with hundreds of animations and learning activities. The quizzing will help you to reinforce difficult topics. The animations will bring to life those concepts that are difficult to envision.

Knowledge doesn't come in little compartments that you can forget as soon as an exam is completed. In the health professions, you must have a comprehensive understanding of the entire body, and as you begin each new book chapter, you will need to remember concepts covered in earlier ones.

Brushing Up boxes list major concepts (with chapter references) that students should be familiar with before continuing. This feature demonstrates the interrelatedness of each chapter to the student, and helps give instructors the flexibility to present topics in a different order than the book does.



CHAPTER 11

The Muscular System

Muscles of the thigh and upper leg (MRI).

Chapter Outline

The Structural and Functional Organization of Muscles 2

- The functions of muscles 2
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- Muscles acting on the head 19

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Study with Your ESP CD-ROM

Refer to your ESP Tutorial CD-ROM for helpful animations, activities, and quizzes related to the material covered in this chapter. The following are suggested areas to go to on the CD and are presented according to "Unit/Topic/Subtopic/Screen":

- Support and Movement/Muscular System

Brushing Up

To understand this chapter, it is important that you understand or brush up on the following concepts:

- Gross anatomy of the skeleton (chapter 9)
- Movements of synovial joints (chapter 10)

Each chapter has three to five *Insights*, intended as diversionary readings for enjoyment. These essays illuminate the clinical relevance of a concept, give short historical sketches of the personalities and events behind the facts and findings in anatomy and physiology, and explore evolutionary insights into the body's structure and function.

Each section ends with a few self-testing questions called *Before You Go On*. These questions help you test your progress at frequent intervals. Use the questions as a test of your memory and ability to explain an idea.

There's no escaping the fact that human anatomy and physiology encompasses a lot of information, but you don't have to swallow it all in one bite. Each chapter is divided into five or six digestible sections. Each section begins with a short list of objectives. This makes it easier for you to break down the subject matter and plan your goals for a study session.

11-32 Part Two Support and Movement

Clinical Insight 11.3

Hernias

A hernia is any condition in which the viscera protrude through a weak point in the muscular wall of the abdominopelvic cavity. The most common type to require treatment is an *inguinal hernia*. In the male fetus, each testis descends from the pelvic cavity into the scrotum by way of a passage called the *inguinal canal* through the muscles of the groin. This canal remains a weak point in the pelvic floor, especially in infants and children. When pressure rises in the abdominal cavity, it can force part of the intestine or bladder into this canal or even into the scrotum. This also sometimes occurs in men who hold their breath while lifting heavy weights. When the diaphragm and abdominal muscles contract, pressure in the abdominal cavity can soar to 1,500 pounds per square inch—more than 100 times the normal pressure and quite sufficient to produce an inguinal hernia, or "rupture." Inguinal hernias rarely occur in women.

Two other sites of hernia are the diaphragm and navel. A *hiatal hernia* is a condition in which part of the stomach protrudes through the diaphragm into the thoracic cavity. This is most common in overweight people over 40. It may cause heartburn due to the regurgitation of stomach acid into the esophagus, but most cases go undetected. In an *umbilical hernia*, abdominal viscera protrude through the navel.

Before You Go On

Answer the following questions to test your understanding of the preceding section.

- Which muscles are used more often, the external intercostals or internal intercostals? Explain.
- Explain how pulmonary ventilation affects abdominal pressure and vice versa.
- Name a major superficial muscle and two major deep muscles of the back.
- Define *perineum*, *urogenital triangle*, and *anal triangle*.
- Name one muscle in the superficial perineal space, one in the urogenital diaphragm, and one in the pelvic diaphragm. State the function of each.

Muscles Acting on the Shoulder and Upper Limb

Objectives

When you have completed this section, you should be able to

- Name and locate the muscles that act on the pectoral girdle, shoulder, elbow, wrist, and hand;
- Relate the actions of these muscles to the joint movements described in chapter 10; and
- Describe the origin, insertion, and innervation of each muscle.

Figure 11.21 Actions of Some Thoracic Muscles on the Scapula. Note that an individual muscle can contribute to multiple actions, depending on which fibers contract and what synergists act with it.

Lateral rotation
 Trapezius (superior part)
 Levator scapulae
 Serratus anterior

Elevation
 Levator scapulae
 Trapezius (superior part)
 Rhomboides major
 Rhomboides minor

Medial rotation
 Levator scapulae
 Rhomboides major
 Rhomboides minor

Depression
 Trapezius (inferior part)
 Serratus anterior

Retraction
 Rhomboides major
 Rhomboides minor
 Trapezius

Protraction
 Pectoralis minor
 Serratus anterior

Actions of the Shoulder	
Table 11.11 (Humeroscapular) Joint	
Boldface indicates prime movers; others are synergists. Parentheses indicate only a slight effect.	
Flexion	Extension
Anterior deltoid Pectoralis major Coracobrachialis Biceps brachii	Posterior deltoid Latissimus dorsi Teres major
Abduction	Adduction
Lateral deltoid Supraspinatus	Pectoralis major Latissimus dorsi Coracobrachialis Triceps brachii Teres major (Teres minor)
Medial Rotation	Lateral Rotation
Subscapularis Teres major Latissimus dorsi Deltoid Pectoralis major	Infraspinatus Teres minor Deltoid

terior surface of the scapula. The other three originate on the posterior surface. The supraspinatus and infraspinatus occupy the corresponding fossae above and below the scapular spine, and the teres minor lies inferior to the infraspinatus. The tendons of these muscles merge with the joint capsule of the shoulder as they pass it en route to the humerus. They insert on the proximal end of the humerus, forming a partial sleeve around it. The rotator cuff reinforces the joint capsule and holds the head of the humerus in the glenoid cavity. These muscles act as synergists in shoulder movements. The rotator cuff, especially the tendon of the supraspinatus, is easily damaged by strenuous circumduction.

Since the humeroscapular joint is capable of such a wide range of movements and is acted upon by so many muscles, its actions are summarized in table 11.11.



Think About It

Since a muscle can only pull, and not push, antagonistic muscles are needed to produce opposite actions at a joint. Reconcile this fact with the observation that the deltoid muscle both flexes and extends the shoulder.

Success in the health professions requires far more than memorization. More important is your insight and ability to apply what you remember to new cases and problems. *Think About It* questions, which can be found strategically distributed throughout each chapter, encourage you to stop and think more deeply about the meaning or broader significance of what you have just read.

The human organ systems do not exist in isolation from each other. Diseases of the circulatory system can lead to failure of the urinary system and aging of the skin can lead to weakening of the skeleton. For each organ system, a page called *Connective Issues* shows how it affects other systems of the body and is affected by them. These pages will help you get the big picture and appreciate the body as an integrated whole.

The muscular system consists of about 600 skeletal muscles—striated muscles that are usually attached to bone. (The term does not include smooth or cardiac muscle.) The form and function of the muscular system occupy a place of central importance in several fields of health care and fitness. Physical and occupational therapists must be well acquainted with the muscular system to design and carry out rehabilitation programs. Nurses and other health-care providers often move patients who are physically incapacitated, and to do this safely and effectively requires an understanding of joints and muscles. Even to give intramuscular injections safely requires a knowledge of the muscles and the nerves and blood vessels associated with them. Coaching, movement science, sports medicine, and dance benefit from a knowledge of skeletal-muscular anatomy and mechanics.

Myology,¹ the study of muscles, is closely related to what we have covered in the preceding chapters. It relates muscle attachments to the bone structures described in chapter 9 and muscle function to the joint movements described in chapter 10. In this chapter, we consider the gross anatomy of the muscular system and how it relates to joint movements. In the following chapter, we examine the mechanisms of muscle contraction at the cellular and molecular levels.

- **Movement.** Most obviously, the muscles enable us to move from place to place and to move individual body parts. Muscular contractions also move body contents in the course of respiration, circulation, digestion, defecation, urination, and childbirth.
- **Stability.** Muscles maintain posture by resisting the pull of gravity and preventing unwanted movements. They hold some articulating bones in place by maintaining tension on the tendons.
- **Communication.** Muscles are used for facial expression, other body language, writing, and speech.
- **Control of body openings and passages.** Ringlike *sphincter muscles* around the eyelids, pupils, and mouth control the admission of light, food, and drink into the body; others that encircle the urethral and anal orifices control elimination of waste; and other sphincters control the movement of food, bile, and other materials through the body.
- **Heat production.** The skeletal muscles produce as much as 85% of our body heat, which is vital to the functioning of enzymes and therefore to all of our metabolism.

Some of these functions are shared by skeletal, cardiac, and smooth muscle. The remainder of this chapter, however, is concerned only with skeletal muscles.

Connective Issues

Interactions Between the MUSCULAR SYSTEM and Other Organ Systems

- ➔ Ways in which other systems affect the muscular system
- ➔ Ways in which the muscular system affects other systems

Integumentary System

- ➔ Covers and protects superficial muscles; initiates synthesis of calcitriol, which promotes absorption of calcium needed for muscle contraction; dissipates heat generated by muscles
- ➔ Facial muscles pull on skin to provide facial expressions

Skeletal System

- ➔ Provides levers that enable muscles to act; stores calcium needed for muscle contraction
- ➔ Muscles move and stabilize joints and produce stress that affects ossification, bone remodeling, and shapes of mature bones

Nervous System

- ➔ Stimulates muscle contraction; monitors and adjusts muscle tension; adjusts cardiopulmonary functions to meet needs of muscles during exercise
- ➔ Muscles give expression to thoughts, emotions, and motor commands that arise in the central nervous system

Endocrine System

- ➔ Hormones stimulate growth and development of muscles and regulate levels of glucose and electrolytes important for muscle contraction
- ➔ Exercise stimulates secretion of stress hormones; skeletal muscles protect some endocrine organs

Circulatory System

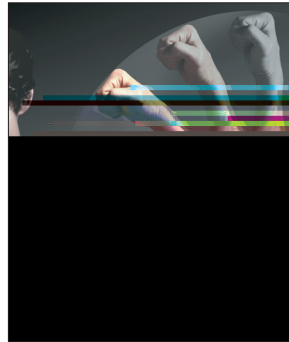
- ➔ Delivers O₂ and nutrients; carries away wastes and heat generated by muscles; cardiovascular efficiency, RBC count, hemoglobin level, and density of blood capillaries in muscle greatly affect muscular endurance
- ➔ Muscle contractions help to move blood through veins; exercise stimulates growth of new blood vessels

Lymphatic/Immune Systems

- ➔ Lymphatic system drains fluid from muscles; immune system protects muscles from pathogens and promotes tissue repair
- ➔ Muscle contractions promote lymph flow; exercise elevates level of immune cells and antibodies; excess exercise inhibits immune responses

Respiratory System

- ➔ Provides O₂ and removes CO₂; respiratory efficiency greatly affects muscular endurance
- ➔ Muscle contractions ventilate lungs; muscles of larynx and pharynx regulate air flow; CO₂ generated by exercise stimulates respiratory rate and depth



Urinary System

- ➔ Eliminates wastes generated by muscles; regulates levels of electrolytes important for muscle contraction
- ➔ Muscles control voluntary urination; muscles of pelvic floor support bladder

Digestive System

- ➔ Absorbs nutrients needed by muscles; liver regulates blood glucose levels and metabolizes lactic acid generated by anaerobic muscle metabolism
- ➔ Muscles enable chewing and swallowing; control voluntary defecation; abdominal and lumbar muscles protect lower digestive organs

Reproductive System

- ➔ Gonadal steroids affect muscular growth and development
- ➔ Muscles contribute to erection and ejaculation; abdominal and pelvic muscles aid childbirth

Connective Tissues of a Muscle

A skeletal muscle is composed of both muscular tissue and connective tissue (fig. 11.1). A skeletal muscle cell (muscle fiber) is about 10 to 100 μm in diameter and up to 30 cm long. It is surrounded by a sparse layer of areolar connective tissue called the **endomysium**² (EN-doo-MIZ-ee-um), which allows room for blood capillaries and nerve fibers to reach each muscle fiber. Muscle fibers are grouped in bundles called **fascicles**³ (FASS-ih-culs), which are visible to the naked eye as parallel strands. These are the "grain" in a cut of meat; tender meat is easily pulled apart along its fascicles. Each fascicle is separated from neighboring ones by a connective tissue sheath called the **perimysium**⁴, usually somewhat thicker than the endomysium. The muscle as a whole is surrounded by still another connective tissue layer, the **epimysium**⁵. The epimysium grades imperceptibly into connective tissue

- 2. endo = within + mys = muscle
- 3. fasc = bundle + icle = little
- 4. peri = around
- 5. epi = upon, above

Key terms are set off in boldface when they first appear in the narrative and are compiled and page-referenced at the end of each chapter. Frequently, when a new term is introduced, a footnote is provided that gives you the derivation of the word. You will soon recognize that such elements as *hypo-*, *natri-*, *-cyte*, and *-itis* occur over and over in the book. As their meanings become more familiar, you will approach pronunciation, spelling, and comprehension with more confidence and proficiency.

The **web address** located within the Chapter Review is a reminder to you that additional study questions and links to anatomy and physiology related topics appear on the website.

Each **chapter ends with** a chapter review. Part of this is a *study outline* that can be used as a basis for organizing your work.

The **boldface terms** in a chapter are listed in a page-referenced vocabulary checklist.

Testing Your Recall contains ten multiple-choice and ten short answer questions you can use to check your knowledge.

Each **chapter has five** *Testing Your Comprehension* questions that go beyond memorization to require a deeper level of analysis.

Chapter Review

Online Learning Center

Study resources for this chapter are available at <http://www.mhhe.com/saladin/>

Study Outline

The Structural and Functional Organization of Muscles (p. 2)

- Functions of muscles
 - Movement
 - Stability
 - Communication
 - Control of body openings and passages
 - Heat production
- Connective tissues of a muscle
 - Endomysium
 - Perimysium
 - Epimysium
 - Deep fascia
- Muscle-bone attachments
 - Direct (fleshy)
 - Indirect (via tendon)
 - Aponeuroses
 - Retinacula
- General anatomy of muscles
 - Origin, insertion, and belly
 - Fascicle orientation
- Coordinated action of muscles
 - Prime movers
 - Synergists

c. Antagonists

- Fixators
- Intrinsic and extrinsic muscles
- Muscle innervation
 - By size
 - By shape
 - By location
 - By number of heads
 - By orientation
 - By action

Muscles Acting on the Shoulder and Upper Limb (p. 32)

- Muscles acting on the scapula (table 11.9)
- Muscles acting on the humerus (table 11.10)
- Muscles acting on the forearm (table 11.12)
- Muscles acting on the wrist and hand (table 11.14)

Muscles Acting on the Hip and Lower Limb (p. 48)

- Muscles acting on the hip and femur (table 11.17)
- Muscles acting on the knee (table 11.18)
- Muscles acting on the foot (table 11.19)

Muscles of the Head and Neck (p. 10)

- Muscles of facial expression (table 11.2)
- Muscles of chewing and swallowing (table 11.3)
- Muscles acting on the head (table 11.4)

Muscles of the Trunk (p. 21)

- Muscles of respiration (table 11.5)
- Muscles of the abdomen (table 11.6)
- Muscles of the back (table 11.7)
- Muscles of the pelvic floor (table 11.8)

Selected Vocabulary

To review the names of individual muscles, see the tables cited in the Study Outline.

muscular system 2
myology 2
endomysium 2
fascicle 2
perimysium 2
epimysium 2
deep fascia 3
superficial fascia 3
direct attachment 3
indirect attachment 3
tendon 3
aponeurosis 4

retinaculum 4
origin 4
head of a muscle 4
insertion 4
belly 4
fusiform muscle 4
parallel muscle 4
convergent muscle 4
pennate muscle 4
circular muscle 4
sphincter 4
action of a muscle 5
prime mover 5
synergist 5
antagonist 5
antagonistic pair 5

fixator 5
intrinsic muscle 6
extrinsic muscle 6
innervation 6
galea aponeurotica 12
suprahyoid group 14
infrahyoid group 14
anterior triangle 14
posterior triangle 19
central tendon of diaphragm 21
tendinous intersections of rectus abdominis 23
rectus sheath 23
linea alba 23
inguinal ligament 25

serratus posterior 27
lumbodorsal fascia 27
perineum 29
urogenital triangle 29
anal triangle 29
superficial perineal space 29
central tendon of perineum 29
urogenital diaphragm 29
pelvic diaphragm 29
rotator cuff 37
flexor retinaculum 40
extensor retinaculum 40
carpal tunnel 40
thenar group 45
hypothenar group 45
midpalmar group 45

lateral rotators 51
fascia lata 51
iliotibial band 51

Testing Your Recall

- Which of the following muscles is the prime mover in spitting out a mouthful of liquid?
 - platysma
 - buccinator
 - risorius
 - masseter
 - palatoglossus
- Each muscle fiber has a sleeve of areolar connective tissue around it called
 - the deep fascia.
 - the superficial fascia.
 - the perimysium.
 - the epimysium.
 - the endomysium.
- Which of these is *not* a suprahyoid muscle?
 - genioglossus
 - geniohyoid
 - stylohyoid
 - mylohyoid
 - digastric
- Which of these muscles is an extensor of the neck?
 - external oblique
 - sternocleidomastoid
 - splenius capitis
 - iliocostalis
 - latissimus dorsi
- Which of these muscles of the pelvic floor is the deepest?
 - superficial transverse perineus
 - bulbospongiosus
 - ischio cavernosus
 - deep transverse perineus
 - levator ani
- Which of these actions is *not* performed by the trapezius?
 - extension of the neck
 - depression of the scapula
 - elevation of the scapula
 - rotation of the scapula
 - adduction of the humerus
- Both the hands and feet are acted upon by a muscle or muscles called
 - the extensor digitorum.
 - the abductor digiti minimi.
 - the flexor digitorum profundus.
 - the abductor hallucis.
 - the flexor digitorum longus.
- Which of the following muscles does *not* extend the hip joint?
 - quadriceps femoris
 - gluteus maximus
 - biceps femoris
 - semitendinosus
 - semimembranosus
- Both the gastrocnemius and _____ muscles insert on the heel by way of the calcaneal tendon.
 - semimembranosus
 - tibialis posterior
 - tibialis anterior
 - soleus
 - plantaris
- Which of the following muscles raises the upper lip?
 - levator palpebrae superioris
 - orbicularis oris
 - zygomaticus minor
 - masseter
 - mentalis
- The _____ of a muscle is the point where it attaches to a relatively stationary bone.
- A bundle of muscle fibers surrounded by perimysium is called a/an _____.
- The _____ is the muscle primarily responsible for a given movement at a joint.
- The three large muscles on the posterior side of the thigh are commonly known as the _____ muscles.
- Connective tissue bands called _____ prevent flexor tendons from rising like bowstrings.
- The anterior half of the perineum is a region called the _____.
- The abdominal aponeuroses converge on a midsagittal fibrous band on the abdomen called the _____.
- A muscle that works with another to produce the same or similar movement is called a/an _____.
- A muscle somewhat like a feather, with fibers obliquely approaching its tendon from both sides, is called a/an _____ muscle.
- A circular muscle that closes a body opening is called a/an _____.

Answers in appendix B

Testing Your Comprehension

- Radical mastectomy, once a common treatment for breast cancer, involved removal of the pectoralis major along with the breast. What functional impairments would result from this? What synergists could a physical therapist train a patient to use to recover some lost function?
- Removal of cancerous lymph nodes from the neck sometimes requires removal of the sternocleidomastoid on that side. How would this affect a patient's range of head movement?
- In a disease called tick paralysis, the saliva from a tick bite paralyzes skeletal muscles beginning with the lower limbs and progressing superiorly. What would be the most urgent threat to the life of a tick paralysis patient?
- Women who habitually wear high heels may suffer painful "high heel syndrome" when they go barefoot or wear flat shoes. What muscle(s) and tendon(s) are involved? Explain.
- A student moving out of a dormitory kneels down, in correct fashion, to lift a heavy box of books. What prime movers are involved as he straightens his legs to lift the box?

Answers at the Online Learning Center