Study Unit

Muscles in Motion

By

John Fixl

Reviewed by

Mary Jo Gunning

About the Reviewer

Mary Jo Gunning, Ed.D., is Director of Athletics at Marywood University, Scranton, Pennsylvania. She received her doctorate in Sports Administration from Temple University, her master's degree in Exercise Physiology and Sports Medicine from the University of Maryland, and her bachelor's degree in Health and Physical Education from Marywood.

Preview

Welcome to this study unit about muscles in motion. Your first unit introduced you to the fast-growing field of fitness. You learned how to take charge of and manage your health and lifestyle, and you studied about trends in the fitness industry. You also received an overview of how fitness affects you and discovered what qualifications are needed for fitness leaders.

This unit will teach you the difference between the physiology and kinesiology of your muscles. Physiology is a branch of biology that deals with the functions and activities of living matter. Kinesiology is the study of the principles of mechanics and anatomy in relation to human movement. You'll also learn how the muscular system affects the cardiopulmonary/cardiorespiratory and skeletal systems.

After completing this study unit, you'll be able to

- Identify the different types of muscles and tell which are used for movement
- Define medical terminology that relates to the fitness industry
- Compare and contrast the different types of muscle motions
- Explain how conditioning affects the size and shape of the muscles
- Explain the effects of steroids on the muscular system and body
- Discuss the functions and structure of the cardiorespiratory support system
- Discuss the functions and structure of the skeletal system and the relationship of bones and joints to the muscular structure
- Explain how the conscious and unconscious minds control actions and form habits
- Describe how your muscles respond to various exercise activities
- Identify and suggest treatment for muscle soreness and injury

You can see that this unit will greatly expand your knowledge of the fitness field. So let's get started on this exciting adventure!

Contents

Muscles in Motion

INTRODUCTION

The alarm clock rings. You awaken (Figure 1).

FIGURE 1—Waking up involves a very complex series of actions directed by the brain to your muscles.

Is it really that simple?

Not really. Every movement you make is an amazing feat of coordination. When the alarm rings, the process it calls into action is very complex. It begins with the brain "taking in" sensory information. ("Oh no, it's time to get up!")

The brain then orders a series of body responses. You may open your eyes, yawn, stretch, and reach across the bed to turn off that irritating alarm. Although you may not realize, your body has made a complex series of actions.

1. First, you must have seen or at least been aware of the location of the alarm clock in relation to your bed.

2. You then ordered a coordinated effort of torso, upper-back, arm, and finger muscles to reach across and push, turn, or unplug the ringing mechanism.

Your brain's decisions form the thinking, reflecting, and action-directing part of life called *neural,* or *neuro,* processes. For these neural decisions to become "physical" actions, they must be transferred through the nervous system to the muscular system. When the transfer has happened, you're able to do things such as turn the page of a book, drive a car, put on clothes, climb mountains, hammer nails, or plant flowers. Every movement you make—however slight or forceful, delicate or powerful—comes about as the result of activity in the neuromuscular system, which combines the workings of the nervous and muscular systems.

Nature has been very thorough in designing the body and its systems. Sound theories of engineering and physics are found in the workings of your body's moving parts. While far from perfect, the body represents a marvelously intricate system with features allowing you to perform a vast range of feats.

Constantly receiving messages through the senses (touch, sight, smell, hearing, and taste), the brain acts like a chief executive officer interpreting its messages and determining whether the body should respond. This miraculous, all-encompassing organ is the central processing unit responsible for the organization of all behavior. Without the brain, you would be little more than a mass of undirected, meaningless activity.

The brain and the neural system work together with other organs and anatomical and physiological systems of the body. This study unit will explore those other body systems that make it possible for you to be the magnificent machine that you are. Later in this study unit, you'll explore how behavioral habits develop and why habits are sometimes useful but most often not. You'll also discover how students of body discipline learn to *program* their minds and muscles for outstanding performance.

Let's begin with the muscular system.

THE MUSCULAR SYSTEM

The muscular system is the anatomical system most directly affected by exercise. Although bones and joints form the body's framework, the activity of muscles is what makes movement possible. The body contains three types of muscle: skeletal, smooth, and cardiac. Skeletal and cardiac muscles are related to physical activity.

Skeletal Muscle

Skeletal muscle forms an elaborate system of individual muscles that fasten onto the skeleton, thus enabling the bones to move at the joints (Figure 2). Understanding the positions and functions of each skeletal muscle is important to a fitness leader as well as to the sports physician or team player.

Your ability to maintain an upright posture is due to well-conditioned skeletal muscle.

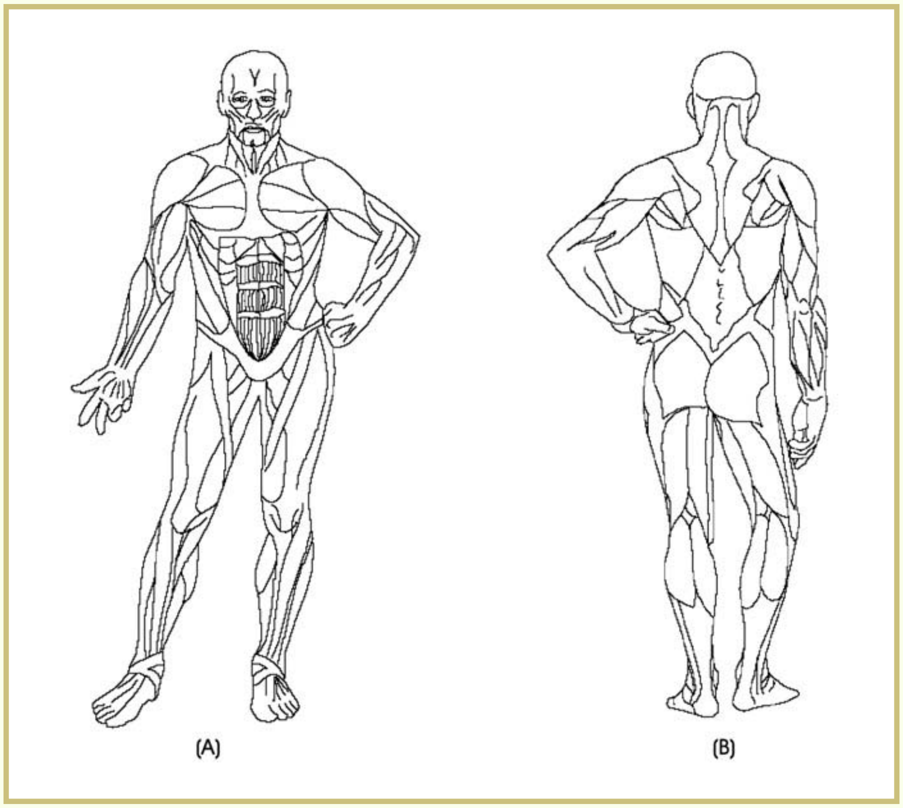


FIGURE 2—Skeletal Muscles: Anterior (Front) View (A) and Posterior (Back) View (B)

But skeletal muscle doesn't work alone. Its supportive companions are layers of connective tissue and *tendons.* Skeletal muscles are attached to the bones by tendons, and the location of the tendons normally determines their names. Tendons are located at the attachment points to the bones of the skeleton.

Skeletal muscles constitute a large portion of total body weight. Since you're able to consciously direct and control the movement of skeletal muscles, they're described as *voluntary* muscles. Therefore, you're able to strengthen skeletal muscle by exercise conditioning.

Smooth Muscle

Smooth muscle, on the other hand, is found only in the area of the organs. In the digestion of food, smooth muscle operates in a wavelike motion to guide the food slowly along the digestive canal, stopping at various "mixing" points on the way. It's smooth muscle that gently pumps food to the stomach, moves it to the intestinal tract, and then moves it to points of excretion. Smooth muscle is *involuntary,* meaning that your conscious mind doesn't control its operation. Since smooth muscle doesn't assist in generating physical motion, it won't be discussed in detail in this course.

Cardiac Muscle

The cardiac (heart) muscle is a muscle type all its own. The cardiac muscle incorporates properties of both smooth and skeletal muscles. Like smooth muscle, cardiac muscle is an involuntary muscle. Like skeletal muscle, cardiac muscle can be strengthened by exercise conditioning.

In cooperation with the other systems of the body, the heart and its circulatory system provide a filtering and distribution system for oxygen and nutrients.

Since both the skeletal muscle and the heart muscle are affected by exercise conditioning, we'll examine them more closely.

Close-up of a Skeletal Muscle

A skeletal muscle looks like a tightly bound bundle within which there are more tight bundles. This "bundles within a bundle" construction contributes to maximum strength and simplicity and is comparable to a super cable.

Another name for skeletal muscle is *striated muscle,* meaning muscle that appears "striped." This striping is due to protein band formations which can be seen when viewed under high magnification.

An individual skeletal muscle is separated from its neighboring muscles and held in place by layers of fibrous connective tissue called *fascia* (plural: *fasciae*). The entire skeletal muscle system is embedded and sheathed by various densities and types of fasciae. These fasciae act like envelope compartments to protect the muscle bundles. Nerve fibers, blood vessels, and other pathways permeate all levels of this fibrous tissue.

At each end, the skeletal muscle attaches to bones of the skeleton, either at a specific point or along a wider band. The "attachment point" is called a *tendon*. The more stationary end of a muscle is called its *point of origin;* the more movable end is called the *insertion* (Figure 3). The material forming the actual attachment is an extension of the sheath of fascia beyond the muscle. This tough cord of white fibers secures the attachment like a "body glue."

For example, skeletal muscles, such as the biceps (shown in Figure 3), contain tightly packed, cylindrical bundles called *fasciculi*. Within each *fasciculus* are smaller cylindrical bundles called *muscle fibers.* A muscle fiber represents a single cell and is the starting place for muscle movement (contraction), as you'll soon see. A single muscle fiber can extend the entire length of the muscle, often to a length of several inches.

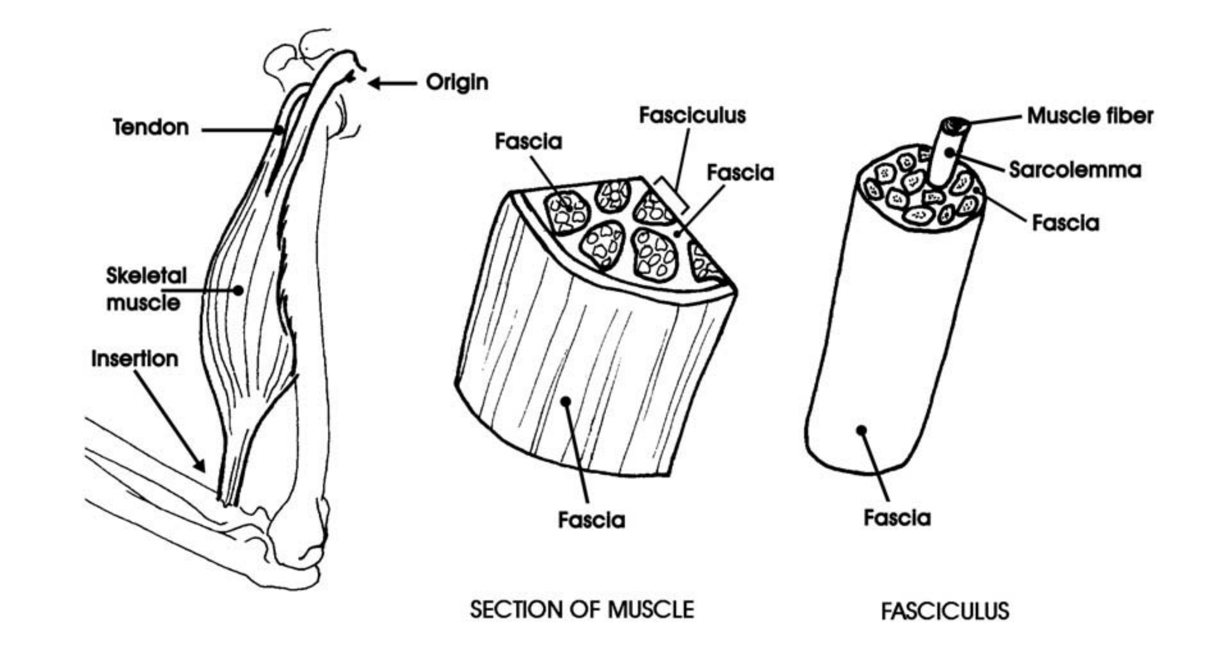
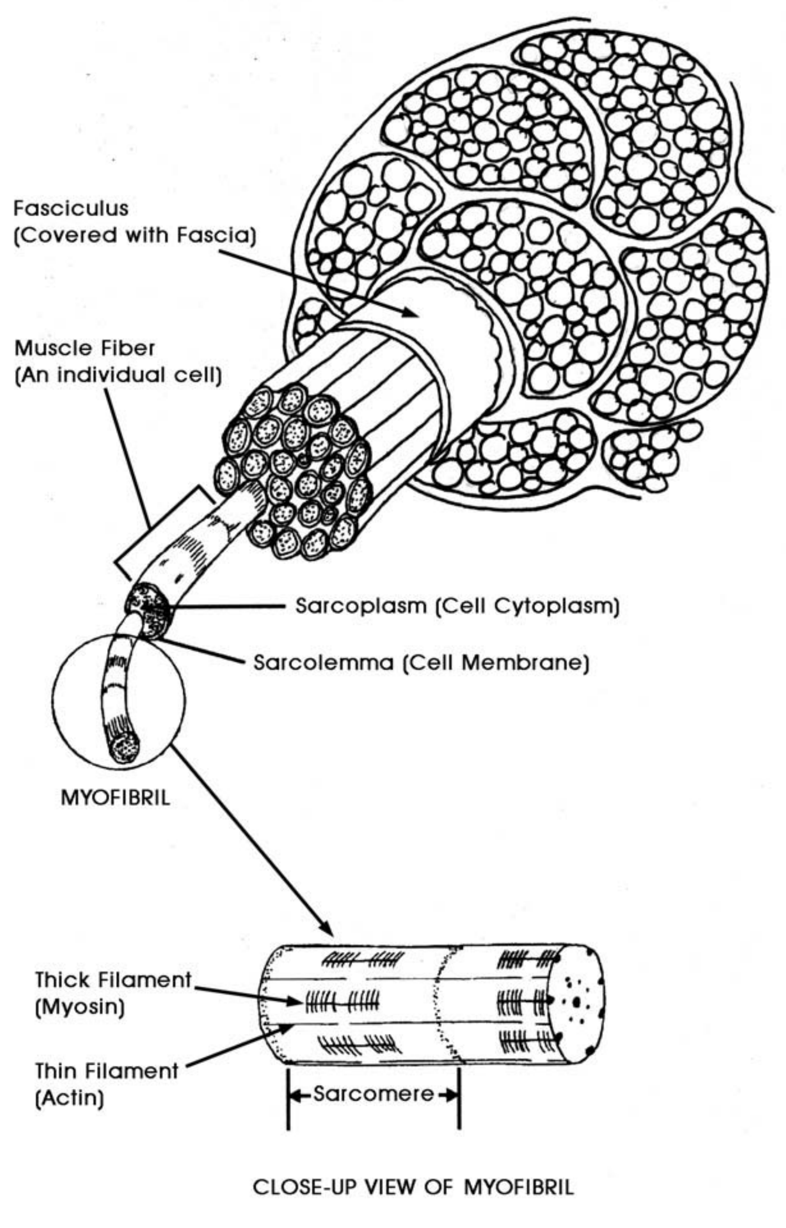


FIGURE 3—Fibrous connective tissue called fascia encloses skeletal muscles, such as the biceps brachii (shown at left). Fasciculi (individual bundles of muscle fibers) are also wrapped in fascia. Each muscle fiber (or muscle cell) is wrapped in this fibrous connective tissue as well. When the muscle fibers contract, they pull on the connective tissue network, which in turn pulls the tendon. This action moves the attached bone.

A muscle fiber is encased in a cell membrane, which is called the sarcolemma (Figure 4). The cell environment (cytoplasm) of the sarcolemma is called the *sarcoplasm.* The sarcoplasm houses all of the components of a normal body cell along with a feature unique to muscle cells—collections of tiny protein threads. These groupings of threads are called *myofibrils.* There are two proteins within the myofibrils: *myosin,* which represents about 65 percent of the muscle protein, and *actin.* The myofibril itself consists of smaller units called *sarcomeres.* Myosin protein is located in the middle of each sarcomere. Actin protein overlaps a portion of one end of the myosin and extends over into an adjacent sarcomere, where it overlaps one end of the myosin in that sarcomere.

When a nerve impulse tells the muscle to contract, tiny structures on the myosin molecules grab the actin molecules and cause the muscle fibers (cells) to contract. As the muscle fibers contract, they pull on the connective tissue network of the muscle. This action pulls the tendon, which in turn, pulls the attached bone.

FIGURE 4—Detail of Skeletal Muscle Structure



Take a few minutes now to review what you've just learned by completing *Health Check 1.*

Health Check 1

At the end of each section of *Muscles in Motion*, you'll be asked to check your understanding of what you've just read by completing a "Health Check." Writing the answers to these questions will help you review what you've studied so far. Please complete *Health Check 1* now.

Match the terms in Column 1 with their appropriate definitions in Column 2.

Column 1

_____ 1. tendon

_____ 2. actin and myosin

_____ 3. sarcomere

_____ 4. fascia

_____ 5. insertion

_____ 6. origin

_____ 7. myofibril

_____ 8. sarcoplasm

_____ 9. muscle fiber

Column 2

a. fibrous connective tissue that separates and holds muscle in place

b. single-point attachment of a muscle to skeletal bone

c. a single cell of a muscle

d. cell environment located within the sarcolemma

e. more stationary end of a muscle

f. more movable end of a muscle

g. a cluster of tiny protein threads

h. the proteins that make up the myofibrils

i. a unit of the myofibril

Check your answers with those on page 43.

WARNING: STRANGE WORDS AHEAD

In this section, you'll learn many new words that identify muscle parts or muscle action. On first reading—when each word is new to you—you may find it slow going. But if you keep referring to the figures as you go along, you'll find it becomes simple to understand.

The root, the prefix, and the suffix of a word can give you a clue about the definition of some complex and confusing words. For example, the word *arthritis* has the root *arthro,* which means "joint," and the suffix *-itis,* which means "inflammation" (Figure 5). *Arthritis* is therefore defined as an inflammation of a joint. Similarly, *dermatitis* is an inflammation of the skin *(derm-).*

Fitness leaders need a solid understanding of muscles and the medical terms that define and describe their actions in order to properly care for their students.

FIGURE 5—Breaking a word down by its root, prefix, and/or suffix can give you a clue to its meaning.

Arthritis	=	arthro (root)	+	itis (suffix)
Arthritis	=	joint	+	inflammation

Arthritis = inflammation of a joint

Now, the good news. Once you've mastered the information in Tables 1, 2, and 3, you'll have succeeded in accomplishing one of the toughest parts of your course. You can expect clear sailing ahead!

Table 1

COMMON PREFIXES AND THEIR MEANINGS

a-, ab-	away from
a-, an-	negative
ad-	toward
aer-	air
alge-, algio-, algo-	pain
amph-, amphi-, ampho-	around; on both sides
angi-, angio-	relating to blood or lymph vessels
ante-	before
anti-	against; opposing
apo-	derived from; separated
aut-, auto-	same; self
cephal-, cephalo-	relating to a head
contra-, counter-	against; opposed
cyst-, cysti-, cysto-	bag; bladder
dent-, denti-, dento-	relating to the teeth
derm-, derma-, dermato-, dermo-	the skin
dia-	through; completely
dis-	negative; double; absence of
dys-	difficult; bad
ecto-	out; on the outside
ex-, exo-	out
hemo-, hemato-	relating to the blood
holo-	all; a whole
homo-, homeo-	same; similar
hydra-, hydro-	relating to water
iso-	equal
kinesi-	movement
latero-	side
macro-	large; long; big
mal-	bad; poor; evil
mega-, megal-	large; great
melan-, melano-	black
meta-	beyond; over; between; change
micro-	small
myelo-	marrow
myo-	muscle
neuro-	nerve
non-, not-	no
ortho-	straight; normal
os-	a mouth; a bone
oste-, osteo-	a bone
path-	disease; suffering
peri-	around
pneu-	relating to the air or lungs

Table 2

COMMON SUFFIXES AND THEIR MEANINGS	
-aemia	blood
-algesia	suffering; pain
-ase	enzyme
-cele	a tumor; a cyst; a hernia
-cide	causing death
-cyte	a cell
-ectomy	a cutting out
-emesis	vomiting
-emia	blood
-esthesia	sensation
-gene, -genesis, -genetic, -geni	production; origin; formation
-gram	a tracing; a mark
-graphy	a writing; a record
-iasis	condition; pathological state
-itis	inflammation
-kinesis	motion
-logia, -logy	science of; study of
-osis	condition; disease
-path, -pathy	disease; suffering
-phobia	fear

Table 3

COMMON ROOTS AND THEIR MEANINGS	
arthro	joint
brachium	arm
cardio	heart
cephalo	head
dermo	skin
hemo	blood
myo	muscle

Take a few minutes now to complete *Health Check 2*.

Health Check 2

Define the following terms, referring to Tables 1, 2, and 3. *Hint:* Sometimes a prefix will function as a root.

1. Myocardiopathy

   ____

2. Hematocele

   ____

3. Cephalopathy

   ____

4. Melanemia

   ____

5. Osteoarthropathy

   ____

Check your answers with those on page 43.

MORE ABOUT MUSCLES

Contractions: Where Movement Begins

Physical movement comes from a series of chemical processes triggered by the brain. The message sent to your muscles leads to a minute action or contraction. The different types of contractions depend upon the relationship of muscle tension or force to muscle length.

Isotonic Contractions

The term *isotonic* means "same" or "equal" *(iso-)* "tone," or "tension." In simple terms, an *isotonic contraction* involves a muscle shortening against a force.

The contraction of a sarcomere, the tiniest unit of a muscle fiber, is the body's first effort toward physical motion. Coordinated, similar contractions among sets of muscles produce both large body movements, such as the flutter kick and arm stroke for swimming, and very fine motor movements like the blink of an eye. The amount of muscular force changes throughout an exercise. For example, if you use a 10-pound dumbbell for a biceps curl, the weight is constant, but the biceps muscle doesn't generate a constant 10 pounds of force throughout its full contraction. Because this is an example of contraction, the muscle shortens as it develops tension.

Another name for isotonic contractions is *concentric contractions*. In concentric contractions, the muscle shortens against a resistance as it contracts. For example, in the biceps curl example mentioned earlier, the biceps muscle contracts concentrically in the up phase with a dumbbell. The force of the biceps overcomes the force of the resistance.

Eccentric Contractions

Eccentric contractions are the opposite of concentric contractions. The muscle lengthens against a resistance while producing force. For example, as the muscle returns to its resting place in the biceps curl down phase, the biceps muscle contracts eccentrically.

Isokinetic Contractions

Isokinetic contractions resemble isotonic contractions with one important difference: tension within the muscle doesn't undergo change, even though the length of the muscle changes. Swimming is a good example of an activity involving isokinetic contractions. The water provides both a positive and negative force that keeps a constant tension within the muscles. Special equipment such as hydraulic machines also involve isokinetic contractions as the machinery makes you pull and push to keep tightness going both ways.

Isometric Contractions

Isometric means "same length." *Isometric contractions* occur when there's no muscle shortening taking place. An example would be holding a weight at arm's length or trying to move a very heavy object.

A Guide to Muscle Talk

The Tongue Twisters

Muscles tend to have tongue-tangling names. Look at the road maps of the muscles in Figures 6 and 7. The names generally convey some sort of information unique to the particular muscle. Consider the following helpful hints.

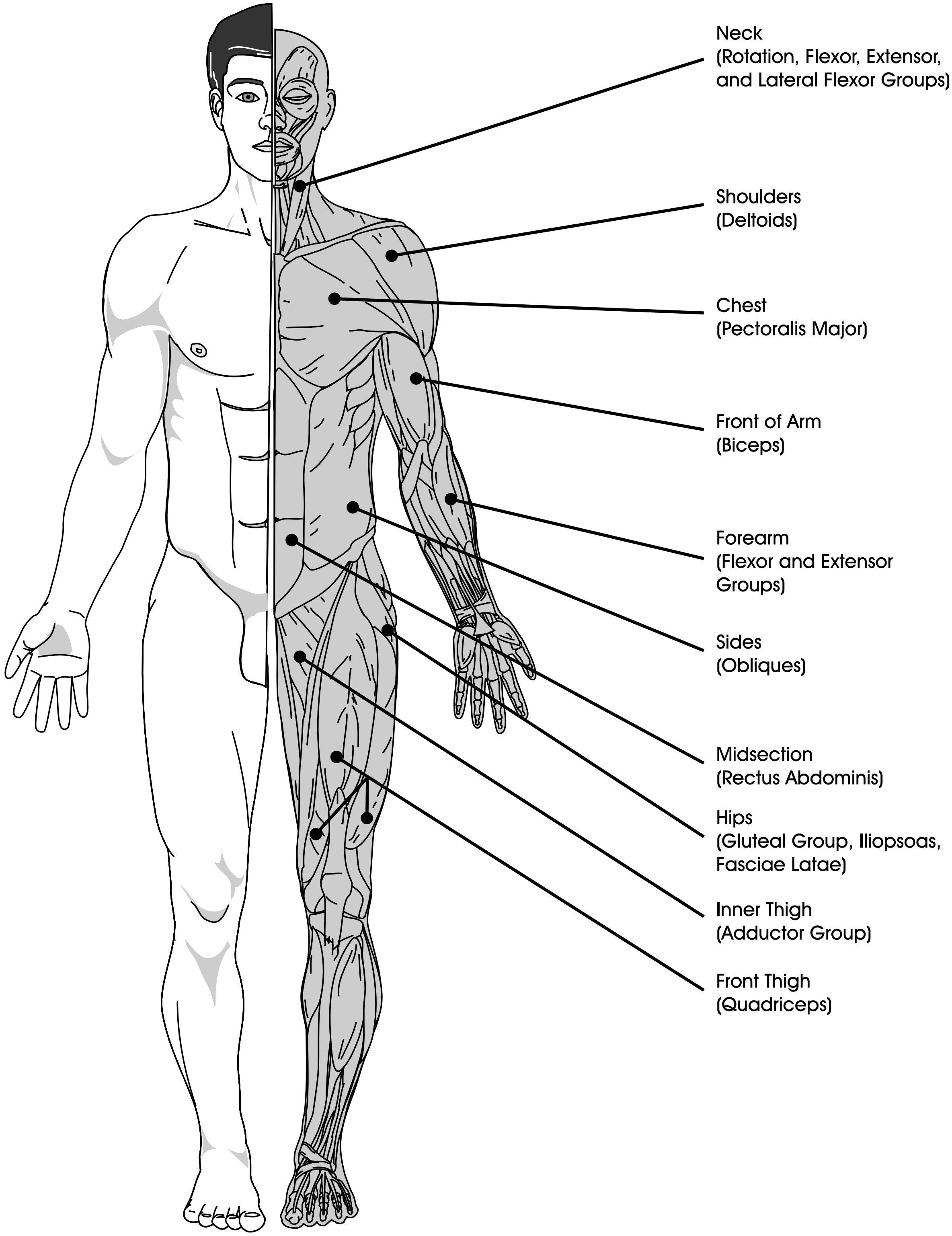


FIGURE 6—A Road Map of the Muscles (Front)

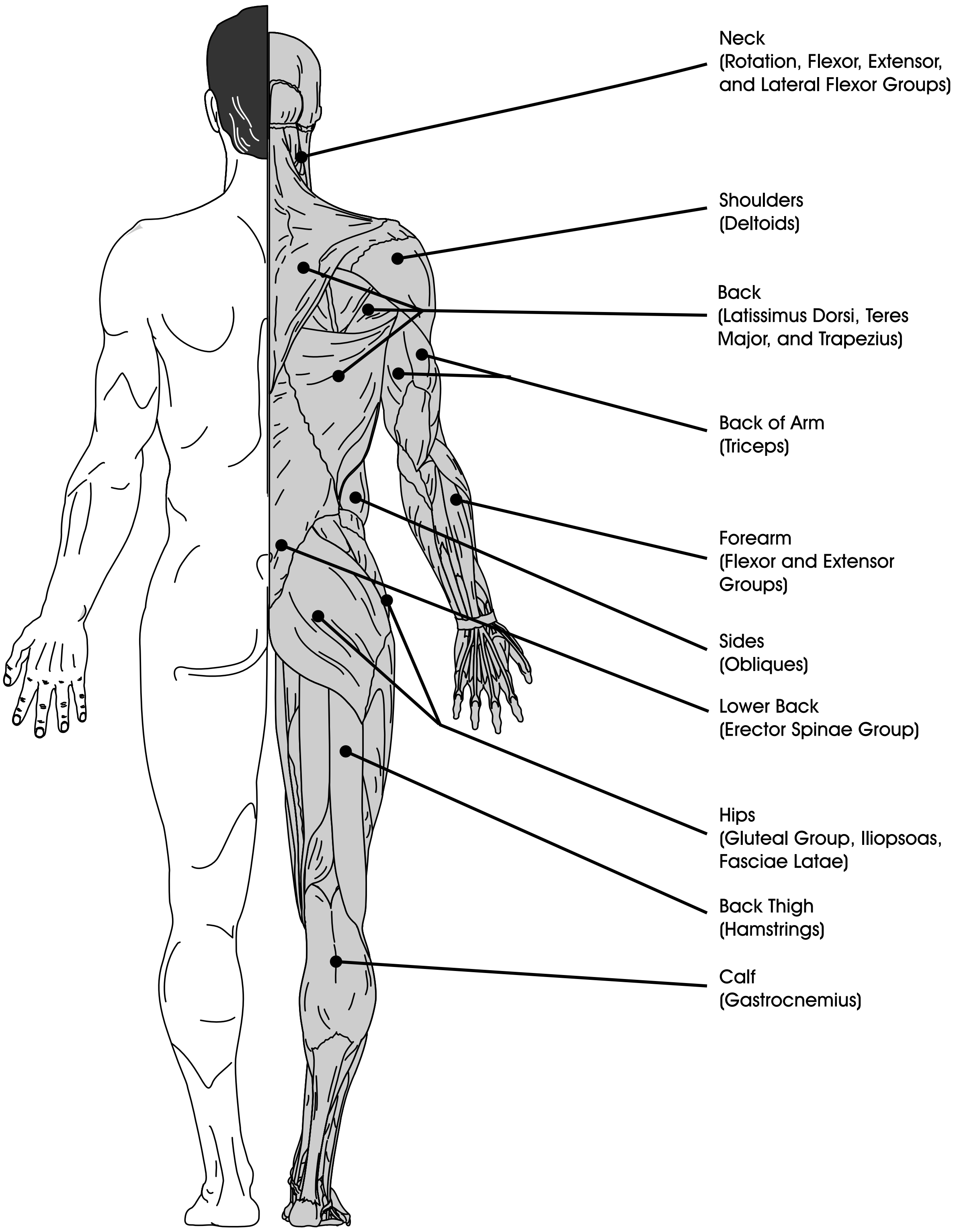


FIGURE 7—A Road Map of the Muscles (Back)

Direction of fibers. Sometimes the name of the muscle tells you about the grain of a muscle; that is, which way the muscle is aligned for its particular action.

Example: *rectus* ("straight") *abdominis*—the narrow, flat muscle on the anterior of the abdominal wall whose fibers run vertically from the pubis to the rib cage

Location. The place a muscle can be found in relation to other muscles or to other parts of the body can be revealed in its name.

Example: *external* ("on the outside") *oblique*

Point of attachment. The muscle name can also tell you the place at which the muscle physically attaches to the bone.

Example: *brachioradialis*—a muscle lying on the side of the radius (a forearm bone)

Number of heads. Many muscles have a number of attachments, rather than just the origin and insertion points. These multiple attachment points are known as heads, and their number may be expressed in the muscle name.

Examples: *biceps brachii*—a muscle of the upper arm having two heads; *triceps brachii*—a muscle of the upper arm having three heads

Size. Size is also considered a way to classify muscles.

Examples: *pectoralis major* ("the larger"); *gluteus maximus* ("biggest"); and *adductor longus* ("long")

Shape. The shape of a muscle (often resembling geometric design) can be part of its name.

Example: *trapezius* ("trapezoid")

Action. A muscle's movement or action is often part of its name.

Example: *extensor* ("extending") *digitorum*

Unless you've studied some Latin or had previous training in physiology, you won't necessarily be able to identify these key words right away. But as you notice how certain words are repeated frequently, you'll start to become familiar with them.

Muscle Motions

You may wonder why it's necessary to use a long word to describe a simple action—such as *supination* for turning your hand palm up. The reason is that there are so many possible actions and directions of movement, that it's necessary to be very specific to avoid confusion. Table 4 contains key words describing motions.

Table 4

MOTION KEY WORDS
Flexion—bending at the joint to decrease the angle between two bones
Extension—straightening at a joint to increase the angle between two bones; the opposite of *flexion*
Adduction—movement of a part toward the midline of the body; that is, toward the plane that splits the body into two equal halves, left and right
Abduction—movement away from the midline of the body; that is, from the plane that splits the body into equal left and right halves. Abduction is the opposite of *adduction*.
Rotation—movement of a part around an axis
Pronation—the rotation of the forearm and hand to palms down
Supination—rotation of the forearm and hand to palms up; opposite of *pronation*
Inversion—twisting the foot inward at the ankle
Eversion—twisting the foot outward at the ankle

Growing and Shrinking Muscles

The skeletal muscles are very responsive to use and disuse. Through training, muscles undergo an actual enlargement of the muscle fibers, and an increase in the number of protein filaments in the myofibrils. This process is called *hypertrophy.* Aerobic exercise will produce slight enlargement. A weight training program with isotonic and isometric exercise will induce full muscular enlargement.

By the same token, neglect of muscular conditioning will result in a gradual decrease in size and strength of the skeletal muscles. This process is called *atrophy*. In an extreme case (such as when a limb is in a cast for a very long time), the muscle fibers disintegrate and are replaced by connective tissues.

Steroids and Muscle Building

Many people have heard of bodybuilders using steroids and ask fitness leaders whether this is a safe way to increase muscle size (Figure 8).

Steroids are a controversial subject, and the fitness leader has a responsibility to provide sound information.

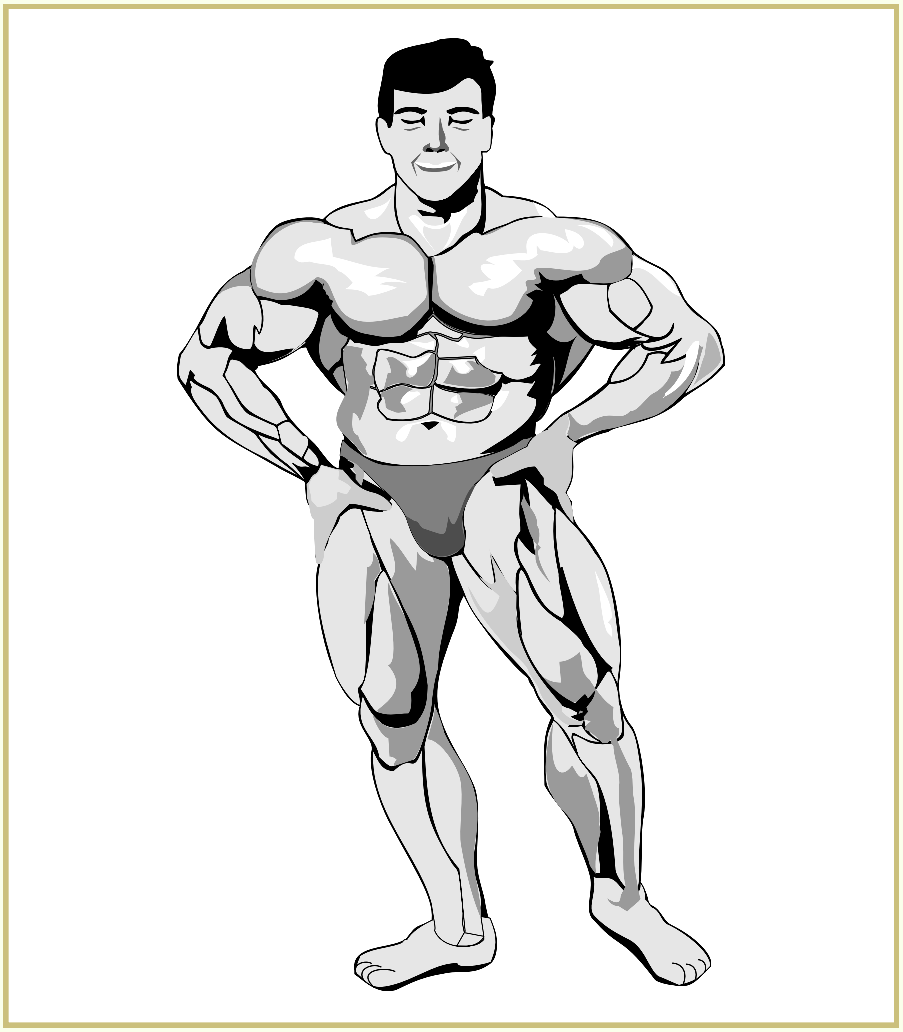


FIGURE 8—Steroids usually enhance muscle mass and strength but can cause physical and psychological damage.

Anabolic-androgenic steroids are synthetic derivatives of testosterone—the male sex hormone secreted by the testicles. *Anabolic* refers to the building of body tissue; *androgenic* relates to the development of male secondary sex characteristics. Steroids do indeed usually enhance muscle mass and strength, but from a health standpoint their track record is poor. They often produce both physical and psychological damage. This damage far outweighs any benefits that may result from their use. Some of the dangerous effects of prolonged use of steroids include the following:

- Decrease in levels of HDL cholesterol
- Increase in blood pressure
- Sterility
- Breast size reduction
- Shrinking of the uterus
- Atrophy of the testicles
- Decrease in sperm production
- Liver cancer

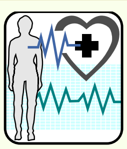
- Unexpected mood swings, such as depression

According to the American College of Sports Medicine, short-term use of steroids, in either small or extremely large doses, hasn't been shown conclusively to either aid or hinder athletic performance. It has also concluded that the use of anabolic steroids doesn't result in significant improvement in strength, body weight, endurance, or lean body mass. Medical opinions suggest that the use of steroids should be discouraged altogether as part of an exercise plan. Patience and consistency in an exercise program will deliver greater rewards in the long run.

The Muscle Monitor

A *Golgi Tendon Organ* is neither a tendon nor a true organ. It's a receptor mechanism that's located within the tendons of a muscle and serves as a monitor.

When a muscle contracts, its tendon and the tendon's resident Golgi Tendon Organ are stretched. This sends information from the Golgi Tendon Organ back to the central nervous system, describing the strength of the contraction. If the muscle contraction is so strong as to possibly induce injury, the central nervous system sends back a message for the muscle to relax. The Golgi Tendon Organ thus acts as a protective mechanism by which the body can avoid harmful exertion.



Health Check 3

Indicate whether each statement is True or False.

_____ 1. In a biceps curl down phase, the muscles contract concentrically (shorten).

_____ 2. Muscles attach to the bone at the *point of attachment.*

_____ 3. The word *maximus* in *gluteus maximus* refers to the shape of the muscle.

_____ 4. Abduction is the movement of a part toward the midline of the body.

_____ 5. Pronation involves the rotation of the foot inward at the ankle.

_____ 6. Hypertrophy is enlargement of the muscles.

Check your answers with those on page 43.

Whew! You've certainly learned a lot about your muscles. Take a few minutes now to review this section by completing *Health Check 3.*

THE CARDIORESPIRATORY (CARDIOPULMONARY) SUPPORT SYSTEM

For muscular endurance and strength, muscles need a constant supply of oxygen and nutrients. Think in terms of a transportation system. Your body's transportation system allows for the delivery of nutrients and oxygen and for the elimination of waste. Two body systems work together to meet these needs: (1) the cardiovascular system, consisting of the heart and its circulatory tract; and (2) the respiratory tract, consisting of the lungs and alveoli (tiny air sacs) (Figure 9).

Together, the cardiovascular and respiratory systems form an elaborate yet precise transportation network called the *cardiorespiratory system.* Blood is the means by which this transportation works. Blood delivers oxygen and necessary nutrients, such as carbohydrates, amino acids, and fat, to the body cells where they're needed. It also serves as the carrier for the elimination of waste products, such as carbon dioxide and lactic acid.

The Heart

Nestled between the right and left lungs, the heart contains two receiving chambers (the *atriums,* or *atria*) and two outgoing chambers (the *ventricles*). The heart acts as a double pump. It takes in *deoxygenated* (stripped of oxygen) blood that's returning from the body tissues, and sends *oxygenated* (oxygen-rich) blood back into the network of arteries. The heart (cardiac muscle) constantly pumps blood throughout the body. Ongoing circulation is vital to the body for survival. Without it, waste products quickly build up and become toxic, and the blood is stripped of its oxygen supplies. This spells death to a living organism.

In this system's *pulmonary circuit*, the blood passes through capillaries (microscopic blood vessels) next to an outlying region of the lungs. In this region are the alveoli. In an exchange process, the oxygen in an alveolus passes into the capillary, and carbon dioxide waste leaves the capillary and enters the alveolus (Figure 10). All blood returning to the heart must pass through the pulmonary circuit in order to be reoxygenated. The rest of the body is part of the heart's *systemic circuit,* a circulatory path bringing "fresh" (oxygenated) blood to all organs and muscles (Figure 11).

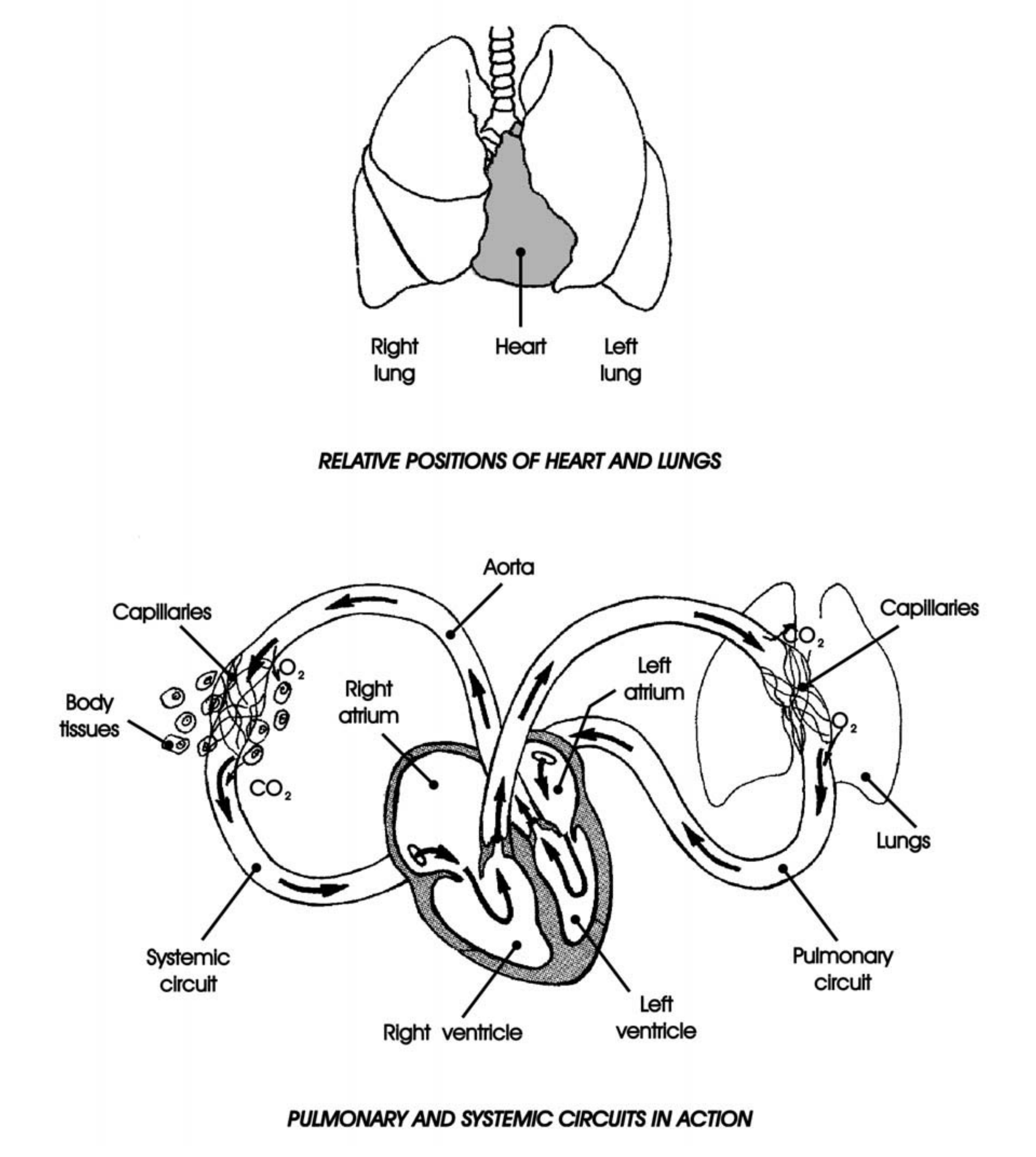


FIGURE 9—The heart and lungs work together to deliver nutrients and oxygen and to eliminate waste.

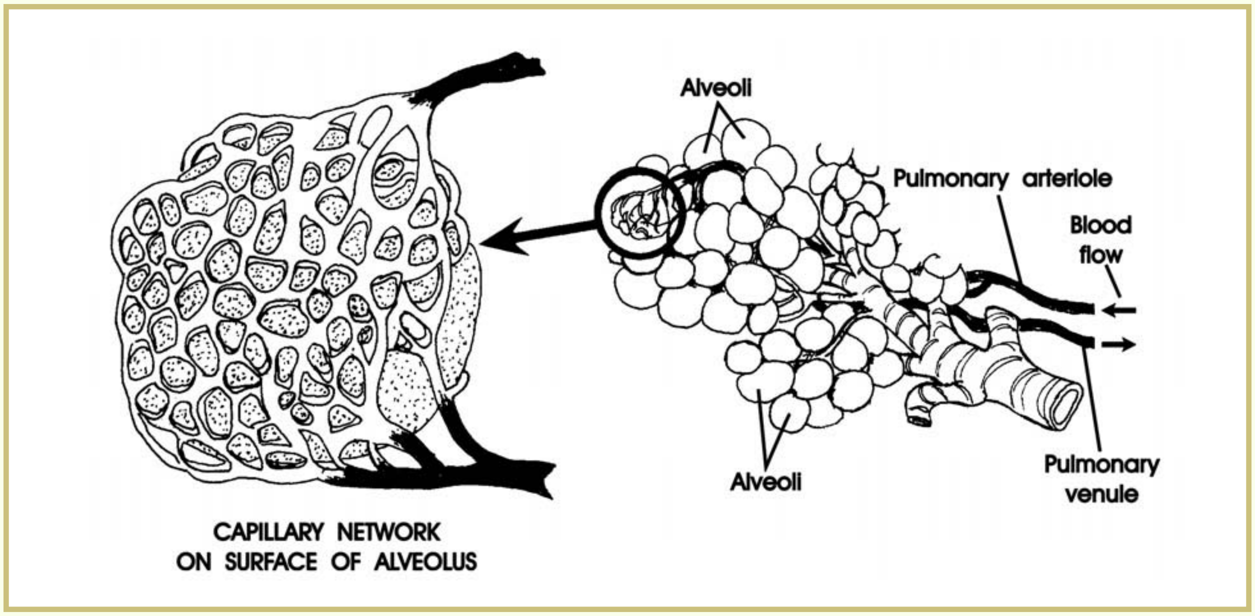
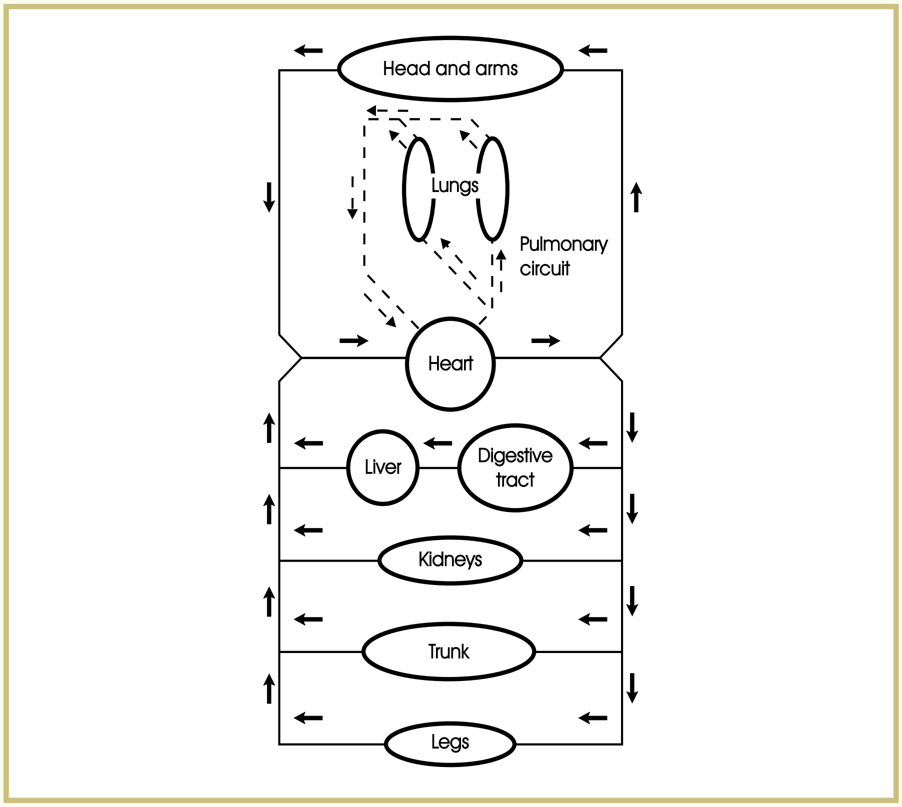


FIGURE 10—This is a close-up view of an alveolus and the capillary network surrounding it. Oxygen enters the capillary from the alveolus, and carbon dioxide waste passes from the capillary into the alveolus to be exhaled.

FIGURE 11—The pulmonary circuit carries blood solely between the heart and the lungs. The systemic circuit handles all other blood circulation in the body.



Blood Vessels

There are three kinds of blood vessels:

1. Arteries
2. Capillaries
3. Veins

The *arteries* carry blood and fresh oxygen away from the heart to the cells and tissues of the body. They're strong, elastic vessels that can withstand the pressure of the pumped blood leaving the heart. As blood moves further along the system of arteries, these vessels diminish in size, becoming *arterioles* (Figure 12).

As arterioles approach the level of the cells, they become microscopic in size and are called *capillaries.* Their walls are membranes through which the oxygen diffuses into the fluid surrounding the body cells. Life is maintained as the cells use what nutrients and oxygen they need.

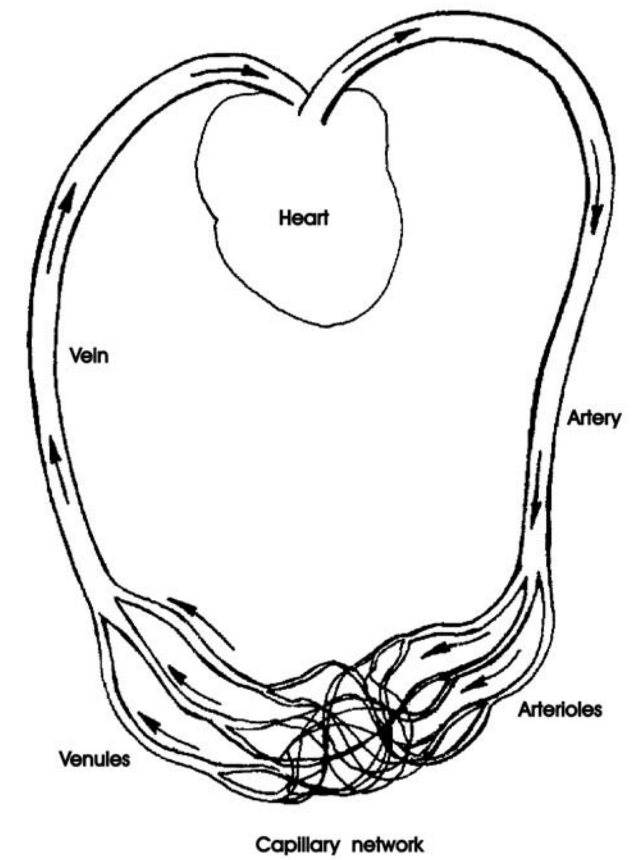


FIGURE 12—Blood travels away from the heart through arteries and arterioles. It returns to the heart through venules and veins.

The capillaries are very thin and narrow. Their primary function is the exchange of gases, nutrients, and waste between the cells and the blood. After passing through the capillaries, the blood enters the veins.

The capillaries continue, eventually hooking up into *venules,* the smaller counterpart of veins. Venules and veins are the vessels that carry blood back to the heart and pulmonary circuit for reoxygenation. Veins aren't as elastic as arteries. This is because the further the distance from the heart, the less pumping pressure is exerted upon the blood vessel system.

The *veins* serve the network to transport the now-oxygen-deficient, carbon-dioxide-richer blood back to the heart to complete the cycle.

You've been working very hard. Take a few moments now to review the material in this section by completing *Health Check 4.*

Health Check 4

Indicate whether each statement is True or False.

_____ 1. The cardiorespiratory system is an elaborate network that gives our muscles a constant supply of oxygen and nutrients.

_____ 2. Deoxygenated blood is overloaded with oxygen.

_____ 3. Arteries carry blood away from the heart, whereas veins carry the blood back to the heart.

_____ 4. Veins carry blood away from the heart.

_____ 5. Carbon dioxide enters the capillaries.

Check your answers with those on page 43.

THE SKELETAL SYSTEM

The network of bones, joints, and connective tissues is collectively known as the *skeletal system.* Besides the basic skeleton of bones, the body provides mechanisms to connect and protect the skeletal structure.

Functions of Bones

The skeletal system works with the muscles of the body to support you in your upright posture. When the muscles are kept conditioned, they function well with the contour of the bones to keep you—and your assorted organs—standing tall. The skeletal system plays an important role in four areas.

Posture. If muscles aren't exercised, the support system gives in to the pull of gravity and excess body weight. The result is often rounded shoulders, twisted hips, and a sagging abdominal area. Years of neglect can emphasize these distortions, but years of care and conditioning can yield a youthful body at any age.

Organ protection. The lungs and heart, two delicate and vital organs, receive protection from the sternum and rib cage. Other vital organs protected by bones are the kidneys and the spinal cord.

Blood formation. Certain bones are also responsible for the formation of blood. The red marrow of some bones helps to produce red blood cells, some types of white blood cells, and platelets.

Mineral storehouse. Bones also act as storehouses for calcium and phosphorus, as well as potassium, sodium, and other minerals. They then regulate the release of minerals into the bloodstream. It's because of their high mineral content that bones survive long after death.

Composition of Bones

To carry out their tasks, bones must be both lightweight and strong. Therefore, bones are constructed of two layers: an outer layer that's very dense and ivorylike in appearance, and an inner layer that's spongy, with numerous caverns that serve as a storehouse.

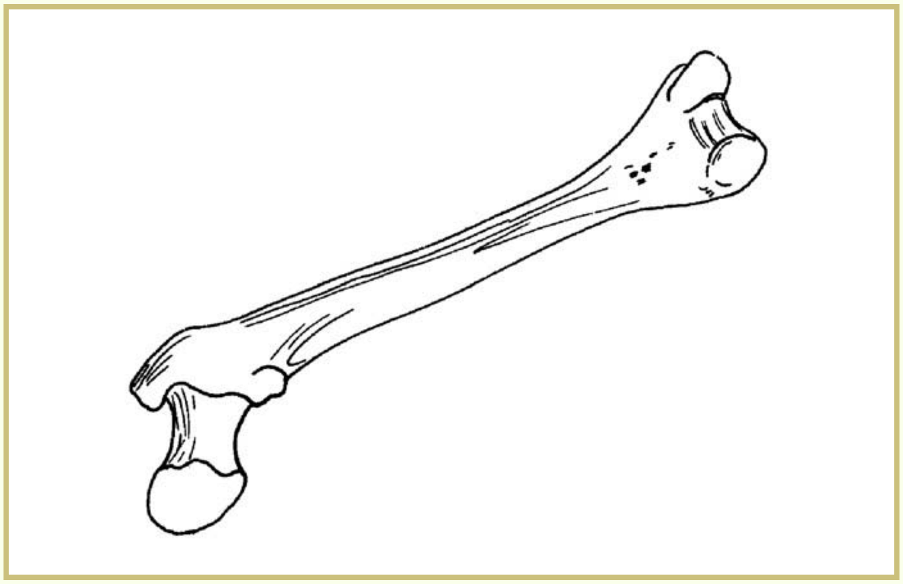
People tend to think of bones as nonliving objects that are just "there to hold everything in place." This is probably because the only bones they ever see are usually prepared (cleaned, treated, and dried). What they're seeing is similar to the shells that wash up on shore; merely the empty remains of once pliable, living structures. In fact, the bones in a living person are "living," and like other cells in the body, they undergo constant growth and maintenance. For example, in the fetus, bones begin to form from cartilage—a tough, white, fibrous tissue. Bones continue to develop, strengthen, and grow throughout the adolescent years. They stabilize in a person's late teens or early 20s.

Types of Bones

Bones come in different sizes and shapes and are classified simply by appearance.

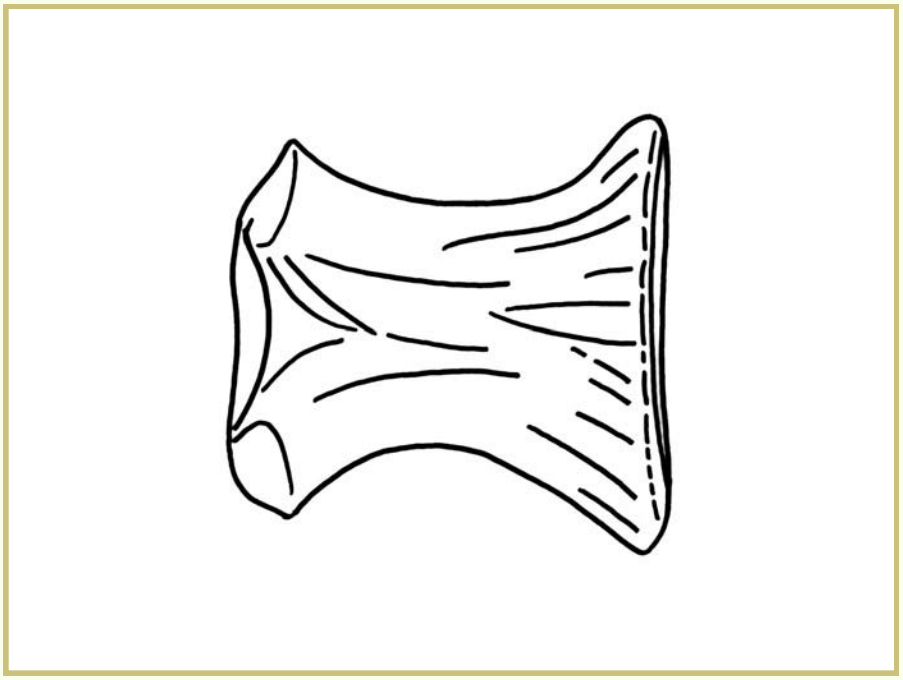
Long bones. Bones that are longer than they're wide are called *long bones* (Figure 13). They include the arm bones (humerus, radius, ulna, and metacarpals) and leg bones (femur, tibia, fibula, and metatarsals).

FIGURE 13—Long Bone



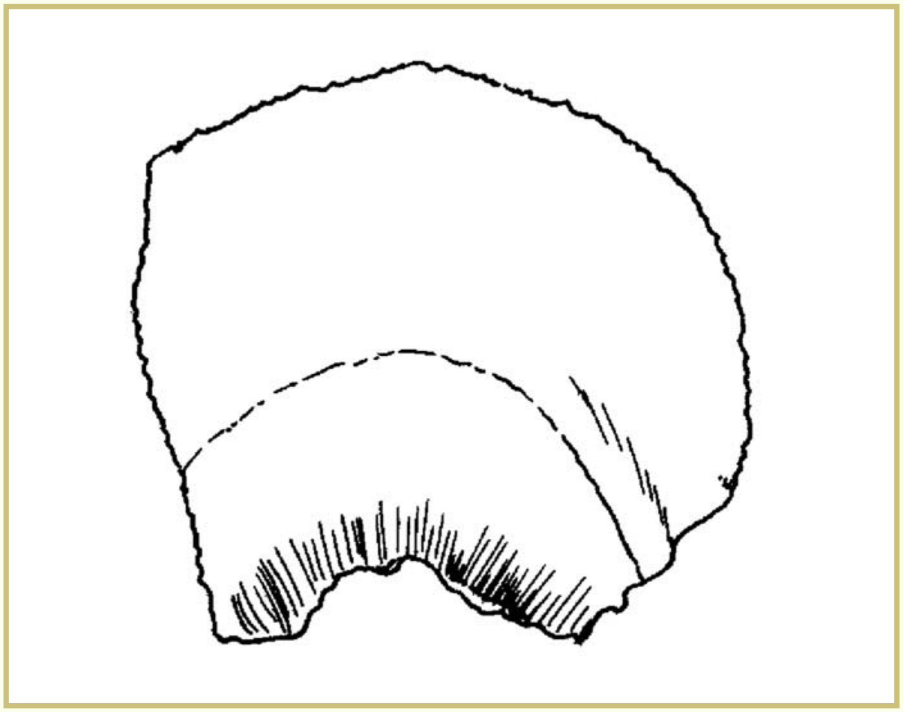
Short bones. These bones can be found in the wrists (carpals) and ankles (tarsals). They have no long axis and are approximately equal in length and in width (Figure 14).

FIGURE 14—Short Bone



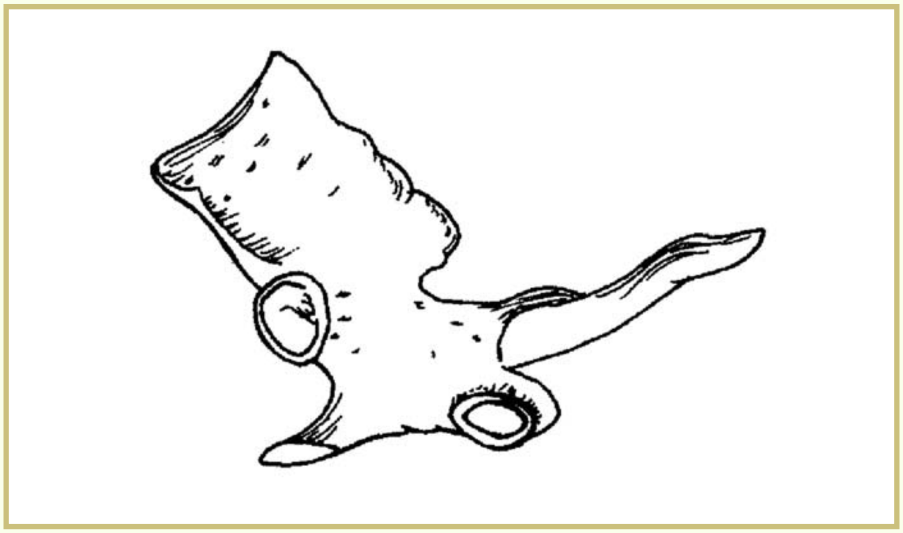
Flat bones. These bones are thin and usually curved (Figure 15). Examples of flat bones include the ribs, the sternum, bones of the skull, and the shoulder blade.

FIGURE 15—Flat Bone



Irregular bones. The irregular bones are those bones that don't fit into any other category (Figure 16). This group includes the vertebrae, the hip bones, and many of the bones which make up the skull.

FIGURE 16—Irregular Bone



When studying a bone separately from the rest of the skeleton, keep in mind that the sometimes-odd appearance of a bone end is actually the place another bone attaches. Where two bones come together, there will usually be a rounded surface on one bone end met by a pocket on the next bone (Figure 17).

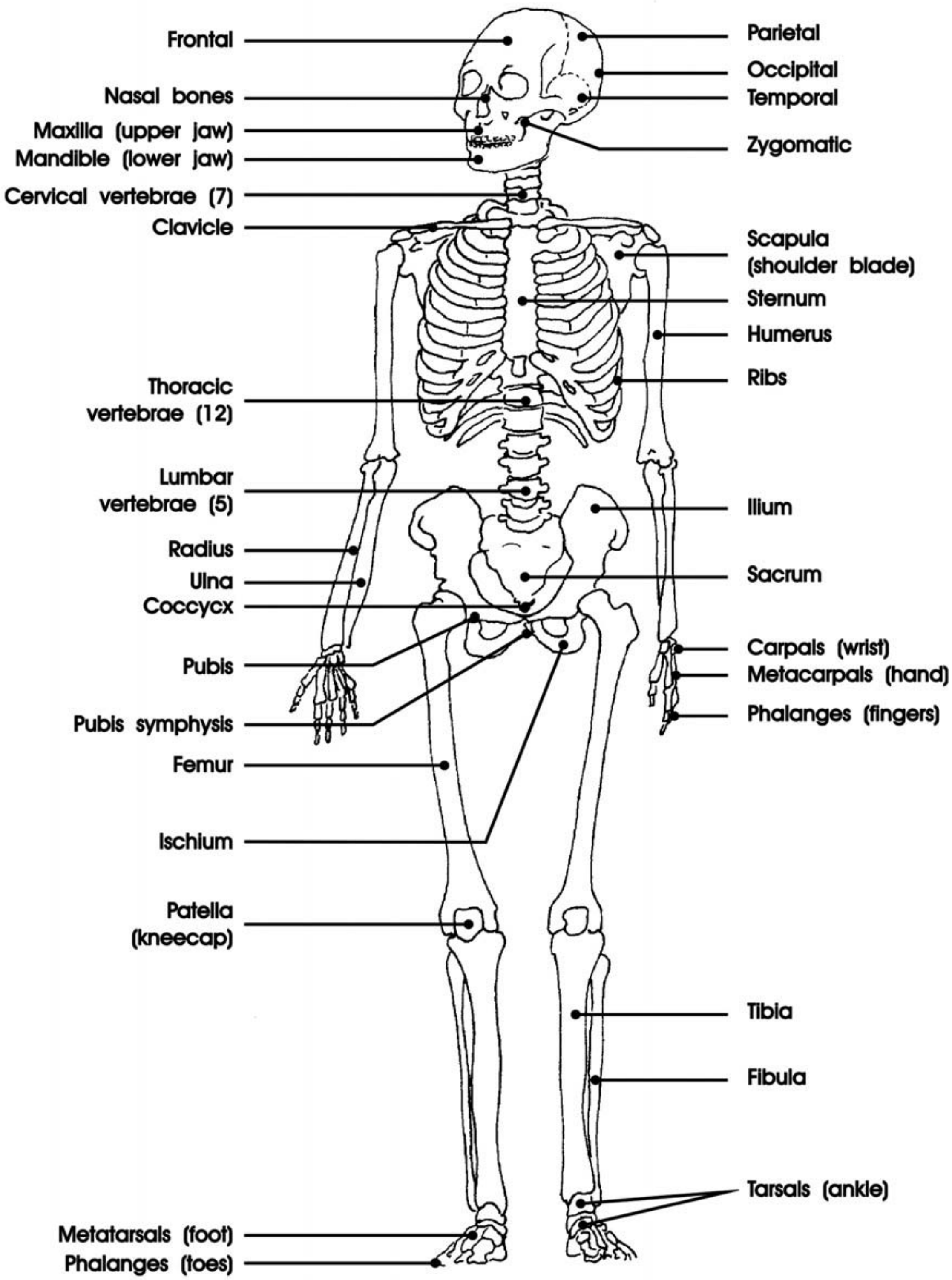


FIGURE 17—Although the ending of a bone may look odd in appearance, this is actually the place where it attaches to another bone. Bones connect to each other to form our skeleton.

Joints

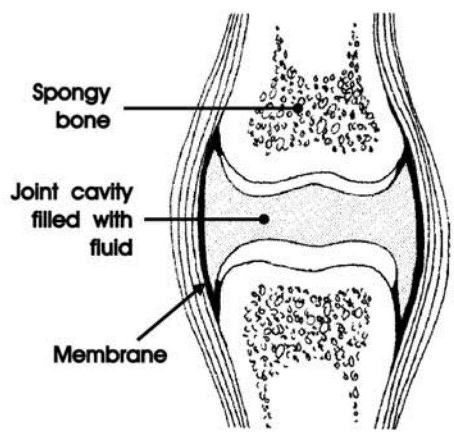
Without the joints, bones would have no way to fasten together in a movable fashion. A *joint* is a connection or a point of contact between bones, or between bones and cartilage. Joints and their connective tissue ease the working of the skeletal system at a level far below that of our conscious control. Joints can be structurally classified into three categories.

Fibrous joints. Fibrous joints contain no joint cavity. They include all joints in which the bones are bound by fibrous connective tissues or ligaments. Since there's very little room at the ends of the bones of these joints, very little movement is possible. They're essentially immovable. The joints between the bones in the skull, between the tibia and the fibula (bones of the leg), and between the radius and ulna (bones of the arm) are fibrous joints.

Cartilaginous joints. Cartilage unites cartilaginous joints. There's little or no motion because there's no joint cavity. These joints can be described as slightly movable. The joints that connect the rib cage to the sternum (breastbone) and the cartilages that separate the vertebrae in the spinal column are examples of cartilaginous joints.

Synovial joints. The term *synovial* refers to the lubricating fluid of the joints. Synovial joints have a space between the bones that form the joint (Figure 18). Movement of these joints is limited only by the shapes of the bones and the ligaments, tendons, or muscles that surround them.

FIGURE 18—Synovial joints are freely movable joints.



There are six types of freely movable (synovial) joints (Figure 19).

1. Gliding or plane joints allow gliding and sliding movements and can be found in the carpal (wrist) bones.
2. Hinge joints are found at the elbow and in the interphalangeal joints of the fingers and perform flexion and extension movements.
3. Pivot joints permit rotation such as the joint between the first and second cervical vertebrae. A projection from one bone is encircled by a ring on a second bone.
4. Condyloid, or ellipsoidal, joints allow flexion, extension, abduction, and adduction at such joints as the metacarpophalangeal (knuckle) joints of the hand.

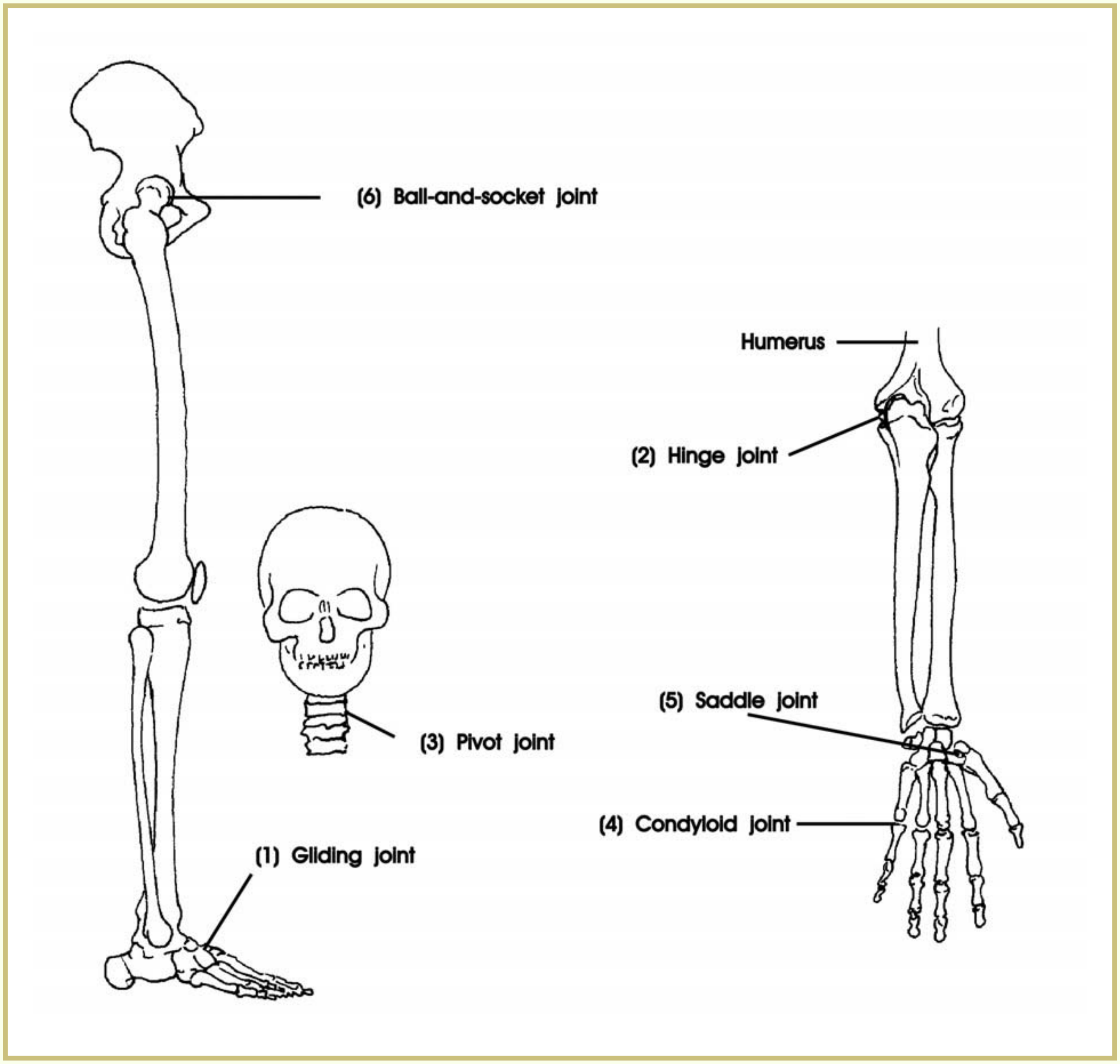


FIGURE 19—There are six types of freely movable joints.

5. Saddle joints, such as the carpometacarpal joint of the thumb, allow some flexion and extension and limited rotation. A saddle joint consists of two opposed curved surfaces, the surface of one bone being concave and the surface of the other being convex.
6. Ball-and-socket joints offer the greatest degree of movement. In this kind of joint, a rounded head on one bone fits into a cuplike depression of a second bone. Examples include the hip and shoulder joints.

It's important that these freely movable joints receive protection at junction points, as well as constant lubrication for smooth motion. For protection, cartilage "pads" buffer each bone end at the location of contact with the next bone. Fluid lubricants, secreted by the tissues surrounding a joint, also help.

Ligaments

Ligaments are links or bands within joints that help to secure the bones to one another. They're similar in nature to the tendons that attach a muscle to a bone. Ligaments often travel in several directions, securing the joint at a variety of angles and locations. Often torn through overexertion, ligaments can only be repaired with surgery.

Muscles, tendons, and bones are what people are made of. While you study muscular and skeletal processes in this study unit, don't forget how important it is for people to keep these body parts fit. People need to take charge of their bodies for a better life.

Take a few minutes now to complete *Health Check 5.*

Health Check 5

1. What are the four major functions of the skeletal bones?

   ____

2. What are the four types of bones contained in the human skeleton?

   ____

3. What are ligaments?

   ____

4. What are the three structural classifications of joints?

   ____

5. *True or False?* The outer layer of a bone is spongy and contains numerous caverns.

Check your answers with those on page 43.

MUSCLE MOVEMENT

Leverage

Do you remember learning about the principle of leverage in a physics class? If not, think back to your childhood when you played on a seesaw. Remember how you used your weight to raise your friend in the air at the other end of the seesaw? Your body uses the same principle to carry out its movements.

When muscles contract to move a body part, that movement is confined to an area ending at a joint. The movement is further confined to a direction allowed by the joint. The action itself can be compared to that of a lever.

Lever systems fall into three classifications of efficiency. They're ranked according to how much force must be exerted to overcome the resistance encountered.

1. A first-class lever is the most efficient, making large amounts of resistance easily movable with only slight force exerted (Figure 20).
2. A second-class lever is fairly efficient but requires additional force to counter the same resistance (Figure 21).
3. A third-class lever is the least efficient (Figure 22). A lot of force must be exerted to overcome the applied resistance.

FIGURE 20—First-Class Lever

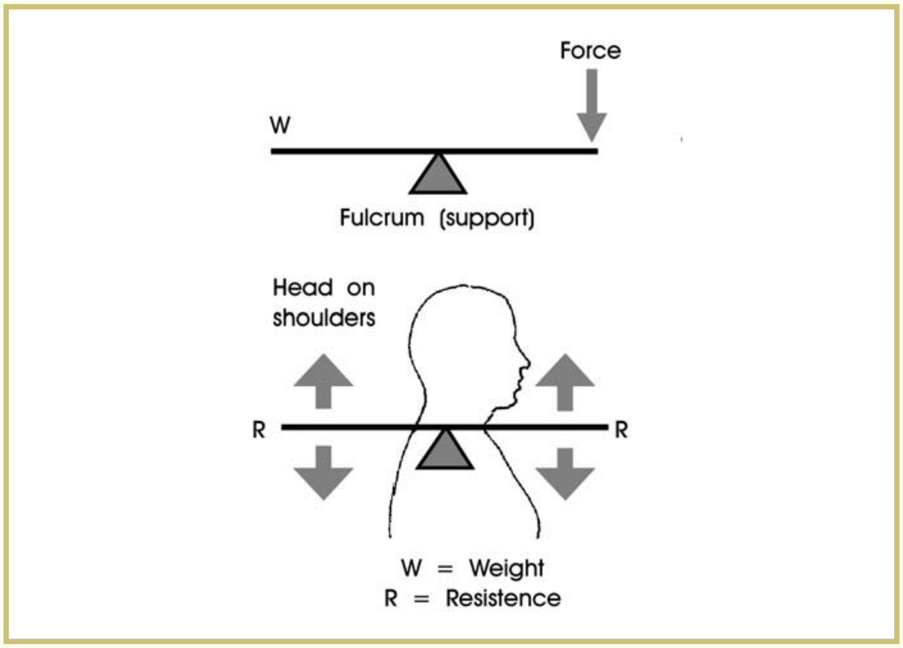


FIGURE 21—Second-Class Lever

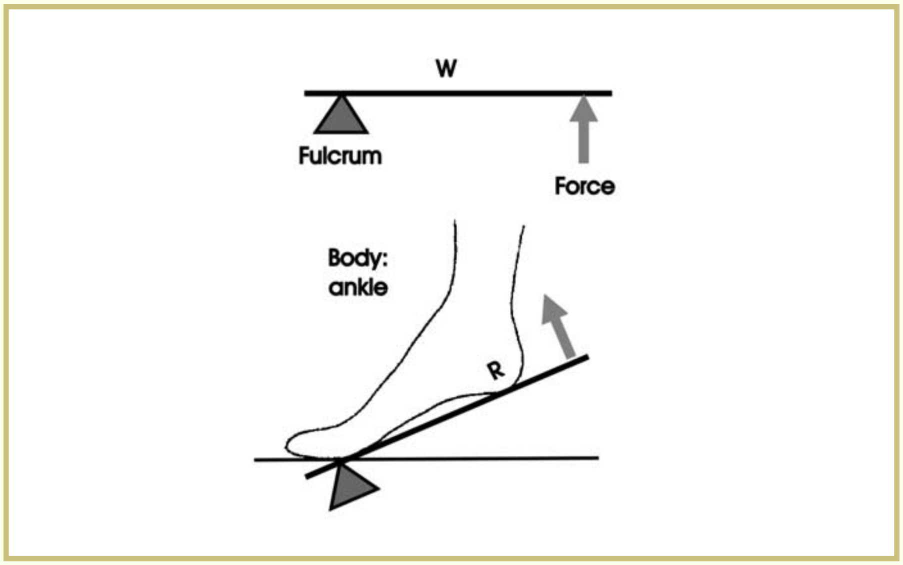
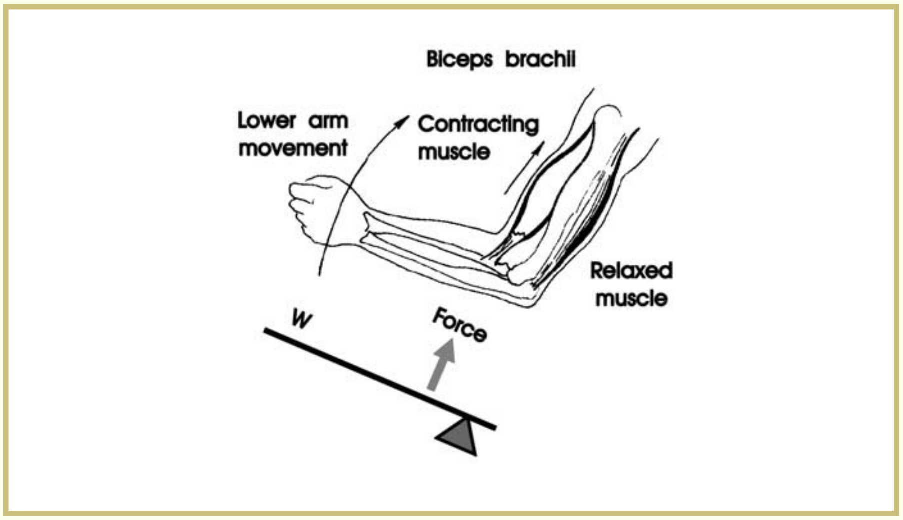


FIGURE 22—Third-Class Lever



The human body is based predominantly upon third-class levers. The body's movement capability is far more complex than just the up-and-down or back-and-forth operation of simple levers. Parts of our bodies can move within many planes and axes simultaneously. Timing and direction of muscle movements add innumerable possibilities to human motion.

Bending, lifting, twisting, chewing, grasping, somersaulting, vaulting, and climbing are some of the actions made possible by our bodily components in combination. It's a blend of simple muscle contractions that creates the graceful, fluid motion so normal to most of us in performing these coordinated movements.

Muscles on Automatic Pilot

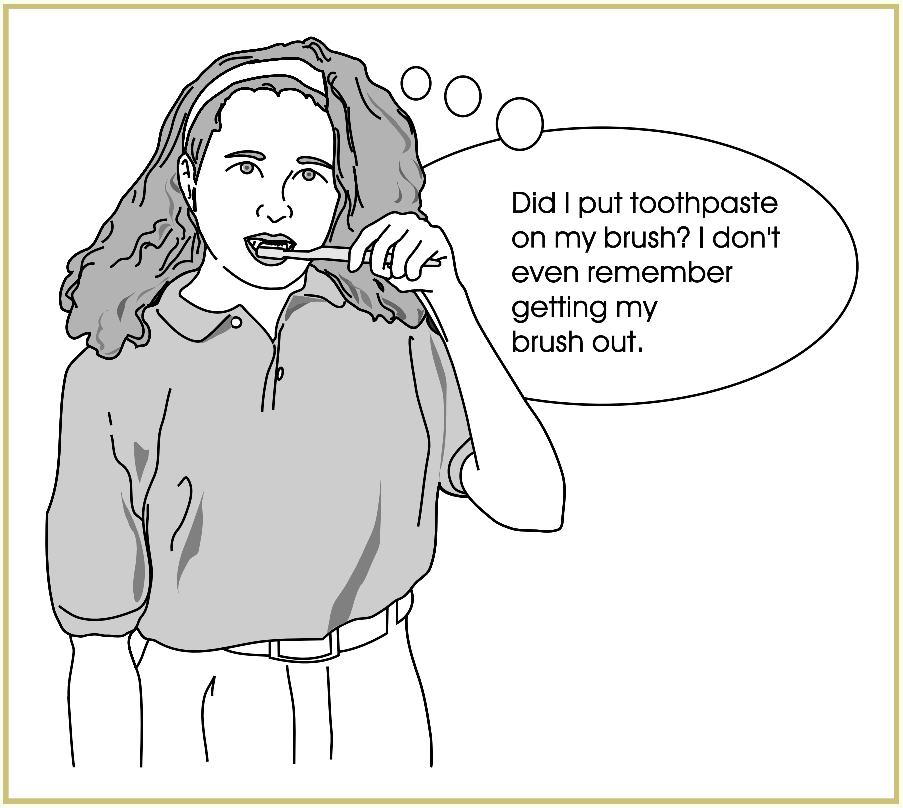
Have you ever prepared to go somewhere, jumped into your car, driven to your destination, and then realized that you didn't recall the drive?

Many daily actions have become habits and routines. When you experience something brand new, such as a new sport, your mind focuses and concentrates on learning how to coordinate the new movements. After a period of time and repetition, the action becomes so familiar and comfortable that the conscious mind no longer considers every step in the sequence. Remember when you were learning to ride a bicycle? You felt alert—almost nervous—as you practiced. And yet, once you learned how to do it, the mechanics of the act moved out of your conscious mind, and you were able to think about other things while riding your bike.

A routine performed several times a day is executed faster and faster. In fact, habits are often cultivated to save time and effort. The conscious mind is free to occupy itself with taking in new information, and the subconscious mind (a powerful force still not fully understood) serves as operator of the routine everyday habits.

Habits can be healthful, such as regular tooth brushing, taking a shower, or cutting your nails (Figure 23). Habits can also be formed from emotional reactions, and these aren't always healthful. Consider the routine of having a drink to calm down, or a cigarette to wake up. Smoking and drinking can build into potentially dangerous habits by creating a psychological dependence. Just remember that bad body habits can be banished by building new habits day by day.

FIGURE 23—Once learned, your muscles perform habits such as brushing your teeth without your conscious mind giving it much thought.



Habits can also affect the quality of exercise you achieve. When you spend many hours a day in a slouched sitting position, the first battle of exercise becomes to fight the sag of unused muscles. A lower backache is frequently due to the habit of allowing abdominal muscles to sag and grow weak. Exercise injuries are drastically increased when weak, sagging muscles are forced suddenly to perform heavy work.

One of the key concepts to speed up the process of becoming more fit is remembering to monitor your everyday habits. The ways in which you move when you get up or sit down, how you stand when waiting in lines, what sleeping positions you use, and how you pick up heavy objects—all affect posture and body alignment. Is the body doing what you want it to do? The more consciously and frequently you monitor your body's activity, the more quickly you'll train it into patterns of fitness. When good posture becomes a habit, then fitness can be a snap to maintain!

Discover for yourself how much of your daily routine is the product of habit. What activities do you do without thinking? Try the following two methods for exploring habits:

1. If one of your habits is a way of standing or moving, examine your movement style to see whether the way you do the activity may actually create a bad postural effect, such as leaning against a counter or desk, slouched or sinking into one hip, or rounding the shoulders.

2. Try doing the basic activity in a different way. For instance, if you usually hold a fork in your right hand, switch it to the left hand for one meal and experience the difference. If you always drive to work or school along the same route, go another way—one you haven't tried before—and see how your conscious mind suddenly hops into action, considering every turn and stop sign. This is the sort of conscious awareness you should call into play to examine your body's habitual behavior.

Exercise Tryouts

Now that you've learned the basics about the functions of your muscles *(physiology),* the structures of the body *(anatomy),* and the movements of your muscles *(kinesiology),* let's apply them to a modest exercise program. Since you're a fitness-conscious person, chances are that you engage in one or two favorite activities already. You may be very physically active, but you may never have devoted yourself to some of the most common exercise activities.

As a fitness leader, you should experience and understand the efforts and effects of various types of exercise. You'll often be asked to suggest specific types of exercise to various people, other than the exercise that's your favorite.

By trying out the activities described below, you'll be preparing yourself to deal with your students' questions and reactions. Each activity should be done a minimum of three days per week to promote cardiovascular and muscular toning.

Most experts recommend exercising at about 55 to 90 percent of the maximal heart rate. However, individuals at a low level of fitness who are in the initial stage of an exercise program should begin to exercise at 50 to 60 percent of their maximal heart rate and then, after a few weeks, progress slowly up to about 70 percent. Those who are interested in improvements as part of a conditioning program should aim to be in the upper part of the target heart range. They should try to exercise at 70 to 85 percent of their target heart range.

Walking

Walking is called "the gentle sport." It's a healthy, easy way to exercise the body with little effort. Walking can be recommended as a great beginning for those who are out of shape, recuperating from illness or injury, or who just plain want a more peaceful form of recreation (Figure 24).

FIGURE 24—Walking is a great exercise for those just starting out or recuperating from injuries or illness.

Day One: 30 minutes. Take an outdoor walk, wearing a watch to monitor your time.

Day Two: 45 minutes (add 15 minutes of stretches). Prior to walking, engage in these "prewalk" stretches, to warm up your joints and upper body:

- While standing on one leg (you can hold a chair for balance if neχεσsary), rotate the ankle joint of the other leg several times. Use an easy, loosening action; go in both directions. Switch legs.

- Roll your shoulders back four to five times to loosen your upper body.
- Turn your head left (like you're looking for traffic at a stop sign) and hold for 5 to 10 seconds. Then turn your head right and hold for 5 to 10 seconds. This activity will stretch the neck muscles.
- Take a deep breath. Raise your arms overhead and stretch up as you continue to breathe in. Release the arms and exhale (breathe out).
- Gently shake out each leg and jiggle your arms. Bend gently into your knees a few times, squatting slightly and going down no more than one to two inches. This exercise will stimulate the flow of blood.

Day Three: 55 minutes (add stretches/relaxation). Prior to your 30-minute walk, engage in your prewalk stretches. Take a more quickly paced walk, this time adding some arm action to the walking movement, such as the following:

- Hold the arms overhead for eight steps. Release for eight steps. Do this two to three times.
- Move the arms in a jumping-jack movement (arms overhead, then down at your sides) for eight steps. Relax for eight steps. Repeat two to three times.
- Use isometric pressure, pressing your palms together in front of you with elbows bent. Hold for 16 steps, then release and shake out your arms. Repeat two to three times.
- Try an assortment of other arm movements. After you walk, note what movements you've tried. This will help you analyze your muscular toning development and determine what other areas you need to work on. Following your walk, take 15 minutes to lie down and relax completely.

Jogging and Running

Jogging is a good "next step" for those who wish to get aerobic exercise at no cost. If you don't have an injury or physical problem, you can jog; all you need is a well-fitted pair of running shoes (Figure 25).

A long-term jogging program will build endurance and will enhance muscular coordination. It won't build large muscles, nor will it strengthen the upper body or abdominal area. Joggers who are into total fitness should supplement a jogging schedule with calisthenic exercises, such as push-ups, crunches, and stretching.

Aerobic Dancing

Aerobic dancing uses similar leg muscles as jogging, with the added conditioning to all major muscle groups that comes from calisthenic work. In addition to cardiovascular conditioning, aerobic dancing also includes lateral abduction and adduction motion.

In upcoming study units, you'll explore the great potential for total body conditioning that aerobic exercise provides.

FIGURE 25—Jogging is a good way to get aerobic exercise at no cost.

Swimming

The beauty of swimming is the natural action of water—the buoyant force that removes the drag that gravity places on the earthbound body. Body action can be generated from the arms and/or legs.

The torso is suspended easily in water and is able to twist, bend, reach, and otherwise accommodate arm and leg action with ease. Whether prone (on the stomach) or on the back, abdominal support keeps the body in alignment while legs kick and arms stroke.

Bicycling

Bicycling is a great sport for recreation and training (Figure 26). Depending on the type of bicycle and the course terrain, the effort for the muscles can be extremely light, moderately aerobic, or even anaerobic.

Any or all of the following bicycle types will do:

- No-speed or 3-speed bicycle (body upright)
- 10-speed or racing bicycle (body angled forward)
- Stationary bicycle with adjustable resistance
- Terrain

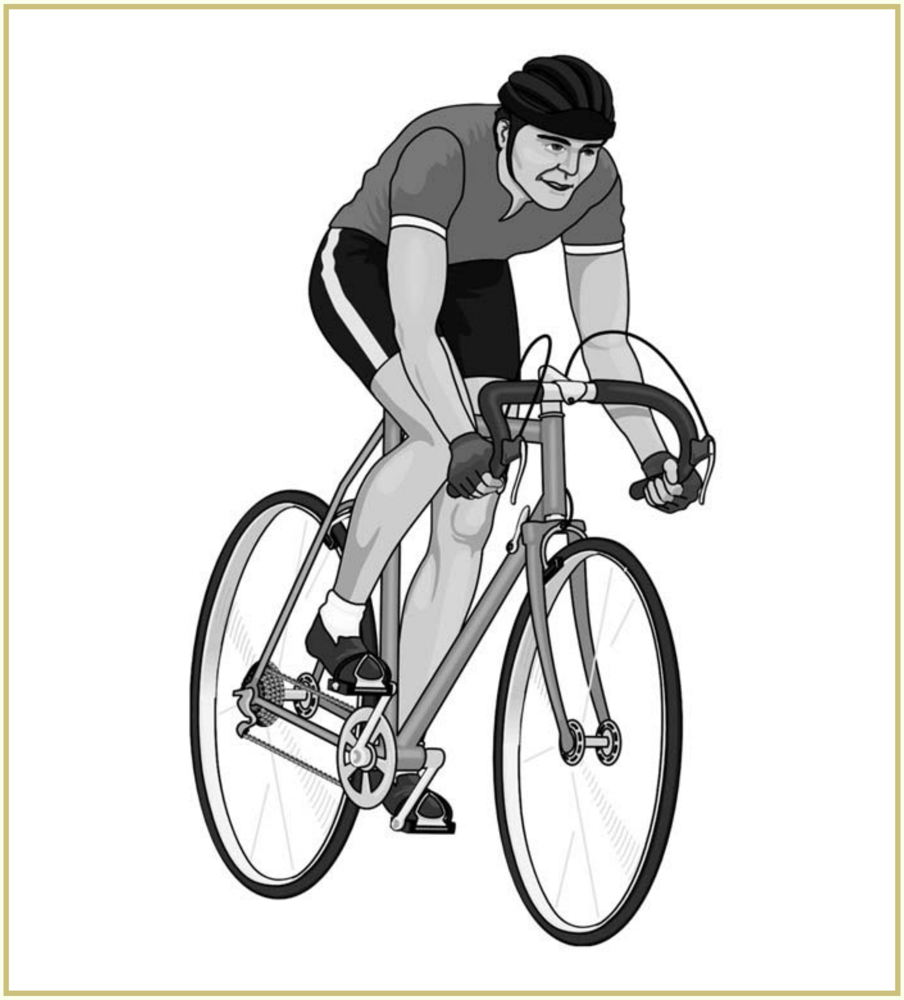


FIGURE 26—Bicycling can provide a wide range of workout levels for your muscles.

You can increase your cycling effort gradually through the following five levels of conditions:

- Level course
- Mostly level course with small hills
- Hilly course with both large and slight hills
- A completely uphill course
- Uphill course with head winds

(Riding into the wind on any of the mentioned terrains will provide additional resistance and, consequently, more muscular conditioning.)

You'll discover that a bicycle alone doesn't condition the body to build strength or endurance. The conditioning challenge lies in the nature of the terrain chosen. The harder the body must work to pedal a bicycle to overcome uphill angles and/or head winds, the harder the muscles and cardiorespiratory system must work.

Carrying, Jumping, and Throwing

Simple actions such as jumping, carrying, and throwing are often the source of minor muscular injuries and even more serious injuries to the back and upper torso.

These activities present situations in which the body must temporarily support extra weight. Although your arms are able to perform infinite manual tasks, the muscle clusters located in the shoulders and upper back aren't naturally strong. When an object is lifted, the upper body is subject to unhealthy stress when forced to bear the burden of an object's weight.

The proper execution of a lifting-and-carrying task is to engage the large muscles of the buttocks and upper legs: the gluteals, hamstring, and quadriceps clusters.

Try experimenting with different approaches to a carrying task. Bend at the knees to bring the body weight as close to the object as possible. Use the arms only to secure an object. Push away from the ground through the legs, forcing the buttocks and legs (very strong and large muscle groupings) to, in effect, hold the weight.

The elements of timing and coordination are of prime importance in the activities of jumping and throwing. Again, the large gluteal, hamstring, and quadriceps muscle clusters should be used to start the momentum and create the thrust of power behind the action.

How does an athlete prepare for an activity such as the shot put or broad jump? For an action that requires elevation of the body, the body begins with the opposite motion. In other words, the body first bends or crouches from the knees. In this way, the momentum generated from the initial straightening action gives a potentially enormous power to lift the entire human body or a heavy object into the air and cause it to travel.

The success of such a preparatory action depends upon timing and coordination of the muscles. Athletes acquire that deceptive ease through meticulous, step-by-step practice. They essentially "program" their neuromuscular systems to learn and remember how to do the particular feat.

Try each of the following actions using the large muscles of your buttocks and legs for support, for timing (to give momentum and preparation), and for coordination (to lend fluidity to the motion):

- Lifting a heavy object off the ground
- Jumping in place
- Jumping and traveling

Using Your Fitness Knowledge

Your level of fitness knowledge is preparing you to become a competent and responsible fitness leader. Understanding muscle mechanics will enable you to instruct students correctly and to protect them from unnecessary injury.

Students will approach you with questions about their aches and pains. They'll look to you for answers and advice. You may not always have a ready answer, and you should never attempt to substitute for a doctor's medical advice. However, you can help your students determine whether or not they're experiencing muscle soreness or an injury. As a fitness leader, use the word "suggest" when giving your students advice. Lawsuits have developed from fitness leaders telling students to take aspirin for sore muscles, or to place ice or heat on them, etc.

Muscle Soreness

Muscle soreness is a signal that you've overloaded your muscles in a short period of time. Muscles need to be developed. They can become sore from overuse or from a lack of potassium (bananas, tomatoes, potatoes) or proper fluids. As a fitness leader, keep in mind muscle soreness is a tired, mildly aching sensation signaling the student that he or she has used a set of neglected muscles, or has pushed a set of muscles beyond their present level of endurance. You should advise the student to continue exercising, but at a slower, less painful level. Gradually, those tired muscles will gain in strength, and the soreness will disappear.

What causes muscle soreness? Nobody really knows, but these theories have been suggested:

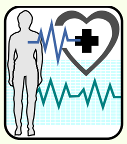
- Overstretching may cause damage to the connective tissues and tendons of the muscles, creating soreness.
- The spasm theory proposes that muscle soreness is caused by muscular spasms, or involuntary twitching of overworked muscles, which reduce muscle blood flow.
- Torn muscle fibers and the resulting tissue damage may be responsible for muscle soreness.
- An overabundance of lactic acid forming after high-intensity exercise can possibly make the muscles ache.

Minor Injury

Muscles shouldn't be sore for more than two days. If muscle soreness persists, chances are that small fiber tissues have torn. Whether due to a chronic condition or from an incorrect movement, muscle tissue can tear or bruise, causing sharp or constant pain. In this instance, the student must stop exercising that muscle and treat the injury. A later unit will give you instructions for care, treatment, and prevention of exercise injuries.

The importance of safe exercise can't be stressed enough. An injury that prevents further exercise is a major roadblock to physical fitness. As you grow in your role as a fitness leader, you'll be rewarded many times over for your knowledge and concern for exercise safety. Also, you'll personally enjoy the advantages that fitness brings for many, many years.

That's all the new material we'll cover in this study unit. Please take a few minutes to complete *Health Check 6.*



Health Check 6

1. Your _______ mind controls your everyday habits and routines.
2. The study of muscles and movement is known as _______.
3. The study of the functions of muscles is known as _______.
4. The structure of the human body is known as _______.
5. A long-term jogging program will build _______ and _______ .
6. Exercise injuries _______ when weak, unexercised muscles are used to perform heavy work.
7. An overabundance of lactic acid forming after high-intensity exercise can cause _______.

Check your answers with those on page 43.

KEY POINTS TO REMEMBER

- The muscular system is the body system largely responsible for body movement. It works with the nervous, skeletal, cardiovascular, and respiratory systems to make your body function smoothly. The muscular system is most directly affected by exercise.
- Skeletal muscle fastens onto the skeleton, enabling the bones to move at the joints. You can consciously direct and control the movement of skeletal, or voluntary, muscles. Because they're voluntary muscles, they can be strengthened by exercise conditioning.
- Smooth muscle, or involuntary muscle, is found only in the area of the organs. Smooth muscle doesn't assist in generating physical motion, and therefore it isn't controlled by your conscious mind.
- The cardiac (heart) muscle is involuntary, yet it can be strengthened by exercise conditioning. The heart and its circulatory system provide a filtering and distribution system for oxygen and nutrients.

A fitness leader must have a thorough knowledge of the kinds of muscular contractions and how they relate to exercise and fitness. Isotonic, or concentric, contractions involve a muscle shortening against a resistance as it contracts. Eccentric contractions are the opposite of concentric contractions: the muscles lengthen against a resistance while producing force. Isokinetic contractions are similar to isotonic contractions except the tension within the muscle doesn't undergo change even though the length of the muscle changes. An isometric contraction doesn't involve any muscle shortening.

Muscles are named according to size, shape, fiber direction, location, point of attachment, number of heads, or by their movement or action.

The skeletal muscles are very responsive to use and disuse. When muscles enlarge, they're said to hypertrophy; and when muscles deteriorate, they're said to atrophy. Although steroids do enhance muscle mass and strength, they're extremely dangerous due to the physical and psychological damage they cause to the body. As a fitness leader, you should never suggest steroid use as a part of an exercise plan.

The Golgi Tendon Organ acts as a protective mechanism so that the body can avoid, if willed, harmful exertion.

Muscles rely on the cardiorespiratory transportation system for oxygen and nutrients. The cardiorespiratory transportation system is made up of the cardiovascular system and the respiratory system. The cardiovascular system consists of the heart and its circulatory tract, and the respiratory tract consists of the lungs and alveoli (tiny air sacs).

There are three kinds of blood vessels: arteries/arterioles; capillaries; and veins/venules. The arteries carry blood away from the heart and deliver fresh oxygen to the cells and tissues of the body. Capillaries are involved in the exchange of gases, nutrients, and waste between the cells and the blood. Veins transport blood back to the heart carrying carbon dioxide.

The heart is made up of two receiving chambers (atriums—the upper chambers) and two outgoing chambers (ventricles—the lower chambers). Acting as a double pump, the heart takes in deoxygenated blood and sends oxygenated blood back into the body.

The skeletal system—a network of bones, joints, and connective tissues—works with the muscular system to support you. It serves many valuable functions, including the protection of vital organs, the formation of blood, and the storing of necessary minerals and nutrients.

Bones are classified by appearance: long, short, flat, or irregular. They're connected to each other at joints.

The three types of joints are fibrous, cartilaginous, and synovial. Fibrous joints, or immovable joints, are located between the bones of the skull, between the tibia and fibia, and between the radius and ulna. Cartilaginous joints connect the rib cage to the sternum (breastbone). They also separate the vertebrae in the spinal column. Synovial joints, or freely movable joints, comprise the majority of the joints in the body including the knee, elbow, hip, and neck.

- When muscles contract to move a body part, that movement is confined to a direction allowed by the joint, an action that can be compared to that of a lever.
- Ligaments are links or bands within joints, and they help to secure the bones to one another. They're similar in nature to tendons, which attach a muscle to a bone.
- It's important to monitor your everyday habits. If you tune in to your habits, you'll find it easier to train your body into patterns of fitness.
- Muscle soreness is a sign of neglected muscles pushed beyond their present level of fitness. Muscles shouldn't be sore for more than two days. If muscle soreness persists, it's likely that muscle tissues have torn. Injured muscles should be properly cared for and rested in order to prevent additional injury. Safe exercise as a means of injury prevention is of major importance for your physical fitness.

Health Check Answers

1

1. b
2. h
3. i
4. a
5. f
6. e
7. g
8. d
9. c

2

1. *Myocardiopathy* is a disease of the heart muscle. *Myo-* “muscle” (prefix), *cardio* “heart” (root), *-pathy* “disease” (suffix)
2. A *hematocele* is a blood cyst. *Hemato-* “relating to the blood” (prefix), *-cele* “a cyst” (suffix)
3. *Cephalopathy* is a disease of the head or brain. *Cephalo* “head” (root), *-pathy* “disease” (suffix)
4. *Melanemia* is an unnaturally dark color of blood. *Melan-* “black” (prefix), *-emia* “blood” (suffix)
5. *Osteoarthropathy* is a disease of the joints and bones. *Osteo-* “bone” (prefix), *arthro* “joint” (root), *-pathy* “disease” (suffix)

3

1. False
2. True
3. False
4. False
5. False
6. True

4

1. True
2. False
3. True
4. False
5. True

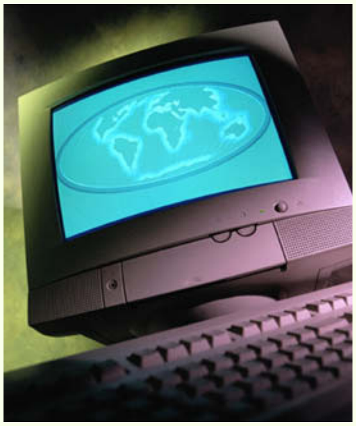
5

1. The four major functions of the skeletal bones are to hold posture, protect vital organs, form blood, and store calcium and phosphorus (and regulate their release into the bloodstream).
2. The four bone types are long, short, flat, and irregular.
3. Ligaments are tendonlike bands within joints that help to secure bones to one another.
4. The three classifications of joints are fibrous, cartilaginous, and synovial.
5. False

6

1. subconscious
2. kinesiology
3. physiology
4. anatomy
5. endurance, muscular coordination
6. increase
7. muscle soreness

NOTES



ONLINE EXAMINATION

For the online exam, you must use this

EXAMINATION NUMBER:

09403600

When you're confident that you've mastered the material in your studies, you can complete your examination online.

Go to http://4.21.191.250/students/take_test/index.jhtml, and type in the eight-digit examination number shown in the box above.

Note that you can view and complete your online exam in a separate browser window. First, open a new Internet browser window (press **Ctrl+N**, or select **New** from your browser's File menu and click on **Window**). Then, transfer the Web link listed above into the address bar of the new browser window. If you type the link into the address bar, be sure to copy the complete address, beginning with **http** and ending with **jhtml**.

Note that instead of typing it, you can use the Text Select Tool in Acrobat Reader to copy-and-paste the Web link's address into the address bar of your new window. Click the **Text Select Tool**, and swipe the address:

http://4.21.191.250/students/take_test/index.jhtml

Then, right-click the selected address, and click **Copy**. Right-click inside the address bar of your new browser window, and select **Paste**. Press **Enter** on your keyboard, and your browser should open the access page for taking online exams. On the access page, be sure to transfer the examination number exactly as it's shown in the box above.