KINETIC ANATOMY

THIRD EDITION

Robert S. Behnke, HSD

Professor Emeritus, Indiana State University

Human Kinetics

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Human Kinetics
Website: www.HumanKinetics.com

United States: Human Kinetics
P.O. Box 5076
Champaign, IL 61825-5076
800-747-4457
e-mail: humank@hkusa.com

Canada: Human Kinetics
475 Devonshire Road Unit 100
Windsor, ON N8Y 2L5
800-465-7301 (in Canada only)
e-mail: info@hkcanada.com

Europe: Human Kinetics
107 Bradford Road
Stanningley
Leeds LS28 6AT, United Kingdom
+44 (0) 113 255 5665
e-mail: hk@hkeurope.com

Australia: Human Kinetics
57A Price Avenue
Lower Mitcham, South Australia 5062
08 8372 0999
e-mail: info@hkaustralia.com

New Zealand: Human Kinetics
P.O. Box 80
Torrens Park, South Australia 5062
0800 222 062
e-mail: info@hknewzealand.com

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At one time or another in our lives, we come in contact with someone whom we consider our teacher, supervisor, mentor, or role model. In many instances, such a person may also become our friend. I was fortunate during my professional preparation to have all of these and more in one individual. During my professional preparation, this person emphasized the importance of knowing human anatomy because he believed it was a keystone to understanding athletic performance and to preventing, recognizing, treating, and rehabilitating athletic trauma. This emphasis has inspired me throughout the preparation of this book. I'd like to thank Robert Nicolette, former head athletic trainer (1957–1969) at the University of Illinois, on behalf of all of us who were fortunate enough to know him. He has touched everyone we work with as a result of our association with him. I dedicate this book to him to express how much I appreciated him.

CONTENTS

PREFACE

Some may say the human body is the most fascinating machine ever designed. Science has long studied it and attempted to improve it through various methods, even going so far as trying to make parts interchangeable or to create new synthetic parts. Learning about oneself through the study of the human body could lead a person to a longer and healthier life. This can all begin with a basic understanding of the various elements making up the human body.

If this exposure to the study of human anatomy is a one-time experience, *Kinetic Anatomy* provides a good overview of the human body's various structures. For the student who seeks further study of human anatomy, *Kinetic Anatomy* provides the basics that can facilitate more in-depth study, in particular of the human body's physiological functions involving the anatomical structures presented in this text.

Goals of the Text

The goals of *Kinetic Anatomy* are (1) to familiarize students with the vocabulary of human anatomy, (2) to describe the essentials of human anatomy for movement, and (3) to provide students with the knowledge needed to pursue healthy living.

Having a firm understanding of the vocabulary of human anatomy allows you to communicate effectively with colleagues, physicians, therapists, educators, coaches, allied health personnel, and others using a universal language of human anatomy.

This text also gives readers a firm concept of how the human body is constructed and how it moves by discussing bones, tying the bones together to make articulations (joints), placing muscles on the bones (crossing joints), and then observing how the joints move when the muscles contract. The book also discusses the nerves (including the central nervous system's brain and spinal nerves and the peripheral nervous system) and blood vessels (including the heart) as well as the lungs, all of which provide elements essential for skeletal movement, but the main emphasis is on putting together the human body for the purpose of studying movement. Knowing what structures are involved and how they should function allows you to identify problems and correct them to enhance physical activity.

Finally, this book imparts knowledge that allows the pursuit of healthy living. Knowing about your body can alert you to potential problems and, with other acquired information, help you prevent or resolve those problems and lead a healthful lifestyle.

Organization of the Text

The text and illustrations are devoted to the structures that play a primary role in moving the human body: bones, ligaments, joints, muscles, and the nerves and blood vessels supplying innervations and circulation to those structures. This edition also addresses anatomical structures not often considered when studying the anatomy of movement: the brain, the heart, and the lungs. The purpose of these additions is to provide entry-level students with further understanding of anatomical structures involved in movement. Although the bones, ligaments, muscles, nerves, and blood vessels are the primary structures that create motion in the human body, other structures of the nervous system (brain, peripheral nervous system), the heart, and the respiratory system are introduced to show how these structures contribute to human movement.

To that end, this text is organized into four parts. Part I discusses the basic concepts of anatomy. The remainder of the text, like many textbooks in the areas of kinesiology and biomechanics, divides the body into the upper extremity

(part II of this text); the head (brain), spinal column, pelvis, and thorax (heart and lungs) (part III); and lower extremity (part IV). Each anatomical chapter in parts II, III, and IV follows the same format: bones, joints and ligaments, muscles, and, where appropriate, the inclusion of three major organs also essential for movement (the brain, the heart, and the lungs). Parts II, III, and IV also include summary tables for muscles, bones, joints, ligaments, movements, nerves, and blood vessels, and these tables have been supplemented to include structures not found in previous editions of *Kinetic Anatomy*.

Updates to the Third Edition

The third edition of *Kinetic Anatomy* includes the following anatomical structures: the head, the brain, the heart, and the lungs. These structures, while not as obvious as bones, joints, and muscles, play major roles in human movement. The central nervous system (brain and spinal nerves), the peripheral nervous system, the heart, and the lungs all function to allow muscles to move bones and create motion in joints.

With more and more people participating in organized sports and personal fitness activities, there has been an increased interest in a possible unfortunate aspect of this participation: head trauma. *Kinetic Anatomy* looks at the anatomy of the head and brain, including the central and peripheral nervous systems as well as the blood vessels of the circulatory system. The vast network of blood vessels (numerous arteries and veins with multiple branches) is discussed, with identification of names and anatomical areas. In-depth investigation of both the nervous system and circulatory system is encouraged, requiring advanced anatomical study far beyond the entry-level information provided in *Kinetic Anatomy*.

In addition to the new material just mentioned, further discussion is presented regarding joint strength and movement, the function of muscles (agonists, antagonists, fixers or stabilizers, synergists), levers, and exercise. These additions are presented to enhance your understanding of muscle function if future study in kinesiology and human biomechanics is desired.

The third edition of *Kinetic Anatomy* also grants students access to a new web component, *Musculoskeletal Anatomy Review*. See page xiv for more information on this resource.

These updates to *Kinetic Anatomy* make it a more inclusive entry-level text for undergraduate and secondary students and others seeking basic information about the anatomical structures of the human body in relation to movement.

Key Features of the Text

When one studies human anatomy, many devices are available to supplement learning. Human cadavers; audiovisual aids including photos, illustrations, models, and software programs; and numerous other means are provided to assist learning. *Kinetic Anatomy* additionally facilitates learning by providing a cost-free and readily available aid for comprehending how the body utilizes various aspects of human anatomy to allow movement: the hands-on experience. Throughout the book, readers will find "Hands On" boxes that provide instructions for feeling specific anatomical structures either on themselves or on a partner. In a very basic way, this makes the study of human anatomy a personal and practical experience available to everyone.

This text also provides an extensive listing of terms. Key terms are set in bold throughout the text and listed at the end of each chapter. This is important because it gives readers the opportunity to review what they were exposed to in the text. An understanding of the key terms helps ensure that readers have obtained the information about the anatomical structures presented in the chapter.

Detailed anatomical illustrations show readers the key structures that contribute to human movement in the anatomical areas discussed in any particular chapter. The artist has made every effort to accurately present these structures as they appear in the human body. Extensive use of cadaver photography would obviously produce a more exact illustration of the structures, but the expense of such reproduction would take the cost far beyond what might be considered an entry-level textbook.

To enhance understanding, the text also features photographs that illustrate movements resulting from the activity of the anatomical structures discussed, utilizing the old adage that a picture is worth a thousand words. These illustrations include appropriate labels to help readers find the structures presented in the text. The photographs help readers further understand what the structures being discussed actually do when they create movement.

"Focus on . . ." sidebars are presented throughout the book to illustrate circumstances in everyday activity that relate to the specific anatomical structures in the text. Health conditions commonly mentioned in everyday life are discussed to hopefully advance readers' understanding of these conditions. References to these various conditions in the print and electronic media should be more meaningful to readers as a result of these sidebars.

Each chapter ends with a set of learning aids, including a review of the key terms used in the chapter, suggested learning activities for students to complete, a set of multiple-choice questions, and a set of fill-in-the-blank questions. (Answers to the questions are provided at the end of the book.) Students can use these learning aids to ensure they have a firm grasp of the key points of the chapter content as well as to prepare for tests and quizzes. Additionally, functional movement exercises at the end of several chapters challenge readers' knowledge of the various functions of muscles. Although examples of possible answers are presented at the end of the book, there are many, many alternative answers, and readers are encouraged to use the text, the *Musculoskeletal Anatomy Review* web resource, the instructor, and fellow students if enrolled in an entry-level human anatomy course to seek additional answers to these functional movement exercises.

Finally, each part ends with summary tables. These summary tables provide a quick resource when seeking the components of a particular joint, its type, bones, ligaments, and movements as well as the components of a muscle including its origin, insertion, action, nerve supply, and blood supply. Whether students are answering questions posed in the text or preparing a paper or presentation on a particular anatomical structure or human movement, the summary tables can assist as a quick reference.

In addition to these text features, the book is also accompanied by the *Musculoskeletal Anatomy Review* web resource. More information on this resource can be found on page xiv. Students can access the *Musculoskeletal Anatomy Review* by visiting www.HumanKinetics.com/MusculoskeletalAnatomyReview.

Instructor Resources

Instructors have access to a full array of ancillary materials that support the text.

- **Image bank.** The image bank includes all the figures, tables, and photos from the text. Instructors can use these images to supplement lecture slides, create handouts, or develop other teaching materials for their classes.
- **Instructor guide.** The instructor guide includes many valuable tools to help instructors build a lecture. For each chapter, instructors will find an overview of the chapter, the chapter objectives, a lecture outline, lecture aids (additional items that would be useful to have on hand when covering a chapter's content), and additional activities that students can complete during class to enhance their learning experiences through doing and seeing.
- **Test package.** The test package includes more than 600 multiple-choice, true-or-false, and fill-in-the-blank questions. Instructors can use these questions to create or to supplement tests or quizzes.

Instructors can access these ancillary resources by visiting www.HumanKinetics.com/KineticAnatomy.

ACKNOWLEDGMENTS

A group of people at Human Kinetics (HK) has been responsible for the guidance needed to bring this edition of *Kinetic Anatomy* to completion. Dr. Loarn Robertson, former senior acquisitions editor, was responsible for deciding a new edition of *Kinetic Anatomy* would be a worthy addition to the entry-level study of human anatomy. Upon his retirement, this project was assumed by Melinda Flegel, Human Kinetics' new senior acquisitions editor. Inheriting this project in midstream, with my ideas and the senior acquisition editor's ideas already being enacted, was a task she not only accepted but also graciously guided to a successful completion. Amanda Ewing, developmental editor, took over the task of making sure I put together a textbook and ancillary materials that accomplished my goals for the text in an accurate and attractive format that would appeal to anyone interested in seeking an entry-level experience for learning human anatomy. Her comments, suggestions, and questions along with the ability to keep me on task played a major role in the completion of this edition.

The new illustrations in this edition are the result of the efforts of Joanne Brummett, the design, art, and photo coordinator at Human Kinetics. Her contributions and those of her outstanding staff in finding new artwork and additional photographs have made the illustrations supporting the written word an excellent adjunct to this edition's new subject matter.

I must thank Dr. Rainer Martens, HK founder, for approving the project that has resulted in the creation of *Kinetic Anatomy*. His contributions in the areas of sport, physical education, health education, and recreation have received worldwide recognition and appreciation by authors, teachers, and students everywhere. His thoughts and actions in the publishing business opened avenues in these areas at a time when it was sorely needed and now is so widely accepted.

These people have made working with Human Kinetics a pleasure and, hopefully, have produced a publication that will make the study of human anatomy enjoyable for anyone interested in learning about the human body and how it moves.

CREDITS

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HOW TO USE MUSCULOSKELETAL ANATOMY REVIEW

Musculoskeletal Anatomy Review includes hundreds of 3-D images of the human body to aid students in their study of anatomy. This engaging supplement to the text offers a regional review of structural anatomy with exceptionally detailed, high-quality graphic images—the majority provided by Primal Pictures. Students can mouse over muscles and click for muscle identification. This online feature offers students a self-paced and self-directed review of the musculoskeletal anatomy, providing an intensely visual interface through which students may gain a clear understanding.

Each chapter of *Musculoskeletal Anatomy Review* features a pretest and posttest evaluation to help students pinpoint knowledge gaps and test their retention. The pretest can be taken multiple times and is generated randomly so it will never be the same, but the posttest may be taken only once. Test results can be printed and turned in so instructors have the option to use the tests as a grading tool.

As students proceed through this review of musculoskeletal anatomy, they will encounter interactive learning exercises that will quiz them on key concepts and help them apply what they've learned about manual muscle testing or range of motion assessment in helping a virtual client.

There may be concepts presented in *Musculoskeletal Anatomy Review* that students have not learned in the past. Whenever possible, a learning aid will be provided to assist students in retention of the material. The learning and review aids may be mnemonics, simple organization of a group of muscles, or just a way to understand the terminology and locations of structures. Please take time to learn using the aids provided; if you do, your retention of the material is apt to surprise you.

Students can access *Musculoskeletal Anatomy Review* by going to www.HumanKinetics.com/MusculoskeletalAnatomyReview.

PART I

General Concepts of Anatomy

CHAPTER 1

Structures

Human anatomy has been defined simply as the structure of organisms pertaining to humankind. A structure is, by one definition, something composed of interrelated parts to form an organism, and an organism is simply defined as a living thing. The body is made up of four different types of tissues (a collection of a similar type of cells). **Connective tissue** makes up bone, cartilage, and soft tissue such as skin, fascia, tendons, and ligaments. **Muscle tissue** is divided into three types: skeletal, which moves the parts of the skeleton; cardiac, which causes the pumping action of the heart; and smooth, which lines arterial walls and other organs of the body. **Nerve tissue** is divided into neurons, which conduct impulses involving the brain, the spinal cord, spinal nerves, and cranial nerves, and **neuroglia**, which are specifically involved in the cellular processes that support the neurons both metabolically and physically. The fourth type of tissue is known as **epithelial tissue**. There are four varieties, and all are involved with the structures of the respiratory, gastrointestinal, urinary, and reproductive systems.

The study of human anatomy as it pertains to movement concentrates on the bones, joints (and associated ligaments), and muscles responsible for the human body's movement. Additionally, the role of the nervous system in stimulating muscle tissue; the role of the vascular system in providing the muscle tissue with energy and removing by-products; the bone, joint, and muscle components of the body's lever systems; and the effects of exercise need to be studied. *Kinetic Anatomy* presents brief overviews of the respiratory system, the circulatory system, and the autonomic nervous system. Although human anatomy also includes other structures such as the endocrine system, digestive system, reproductive system, urinary system, and sensory organs, this text concentrates specifically on those anatomical structures chiefly responsible for producing movement of the human organism.

Proper vocabulary is extremely important when discussing anatomy. Common terms make communication with others (physicians, coaches, therapists, athletic trainers) much easier, and it is essential that a student of human anatomy become familiar with standard terminology presented in this chapter. Knowledge of the structures and common terms used to describe movement anatomically also facilitates the use of specific coaching principles; the use of therapeutic techniques involving human movement for prevention, treatment, and rehabilitation of various physical conditions; and the application of scientific principles to human movement.

Although all systems of the human organism can be said to contribute in some unique way to movement, this text emphasizes those systems (skeletal, articular, muscular, nervous, and circulatory) that directly accomplish movement. Primary concentration is on the following structures: bones, ligaments, joints, and muscles producing movement, with additional comments about the nerves and blood vessels in each specific anatomical area.

Bones

The body contains 206 bones. Bones have several functions, such as support, protection, movement, mineral storage, and blood cell formation. Arrangements of bones that form joints and the muscular attachments to those bones determine movement. Bones are classified by their shapes into four groups: long bones, short bones, flat bones, and irregular bones. Some authors also distinguish a fifth type of bone, known as sesamoid bones, which are small, nodular bones embedded in a tendon (figure 1.1). The bones that provide the framework for the body and that make movement possible are classified as **long bones** (figure 1.2). A long bone has a shaft, known as the **diaphysis**, and two large prominences at either end of the diaphysis, known as the **epiphyses**. Early in life

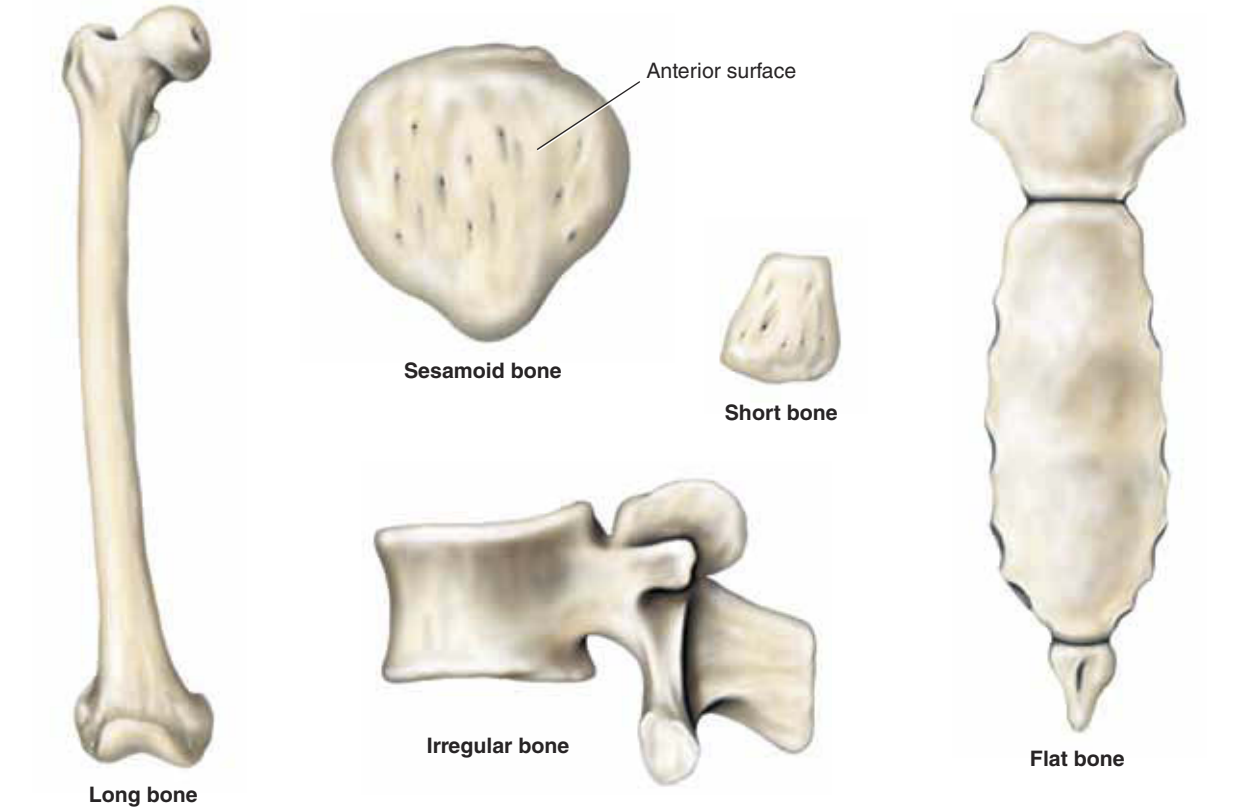

Figure 1.1 Classification of bones.

the epiphysis is separated from the diaphysis by a cartilaginous structure known as the **epiphyseal plate**. It is from these epiphyseal plates at both ends of the diaphysis that the bone grows; thus, this area is often referred to as the growth plate. Once a bone has reached its maximum length (maturity), the epiphyseal plate "closes" (bone tissue has totally replaced the cartilaginous tissue), and the epiphysis and diaphysis become one continuous structure. Around the entire bone is a layer of tissue known as the **periosteum**, where bone cells are produced. Additionally, the very ends of each bone's epiphyses are covered with a material known as **articular cartilage**. This covering provides for smooth movement between the bones that make up a joint and protects the ends of the bones from wear and tear.

Short bones differ from long bones in that they possess no diaphysis and are fairly symmetrical. Bones in the wrist and ankle are examples of short bones. Flat bones, such as the bones of the head, chest, and shoulder, get their name from their flat shape. Irregular bones are simply bones that cannot be classified as long, short, or flat. The best example of an irregular bone is a vertebra of the spinal column. An additional classification that some anatomists recognize is sesamoid (sesame seed–shaped) bones. These oval bones are free-floating bones usually found within tendons of muscles. The kneecap (patella) is the largest sesamoid bone in the body; others are found in the hand and the foot.

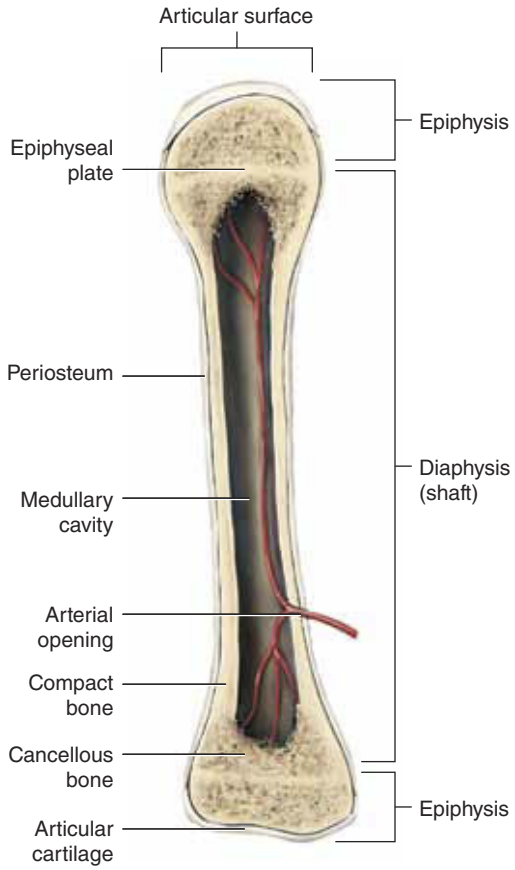

Figure 1.2 Structure of a long bone.

FOCUS ON

Osteoporosis

The loss of calcium and other minerals resulting from the natural aging process can cause bones to become porous and brittle. This condition is known as **osteoporosis** and can lead to broken bones and postural disfigurement. Approximately 50% of people older than 60 years of age have this condition.

Several terms are commonly used to describe the features of bones. These features are usually referred to as **anatomical landmarks** and are basic to one's anatomical vocabulary. A **tuberosity** on a bone is a large bump (figure 1.3). A **process** is a projection from a bone (figure 1.3). A **tubercle** is a smaller bump (figure 1.4). All three of these bony prominences usually serve as the attachment for other structures. A **spine**, or **spinous process**, is typically a longer and thinner projection of bone, unlike any of the previously mentioned prominences (figure 1.5). The large bony knobs at either end of a long bone are known as the **condyles** (figure 1.6). The part of the condyle that articulates (joins) with another bone is known as the **articular surface** (figure 1.2). Smaller bony knobs that sometimes appear just above the condyles of a bone are known as **epicondyles** (figure 1.4). A **fossa** is a smooth, hollow surface on a bone and usually functions as a source of attachment for other structures (figure 1.3). A smaller and flatter smooth surface is a **facet** (figure 1.7). Facets also serve as attachments for other structures. A **notch** is an area on a bone that appears to be cut out and allows for the passage of other structures such as blood vessels or nerves (see figure 1.8). Similar in function to a notch but appearing as a hole in a bone is a **foramen** (figure 1.5).

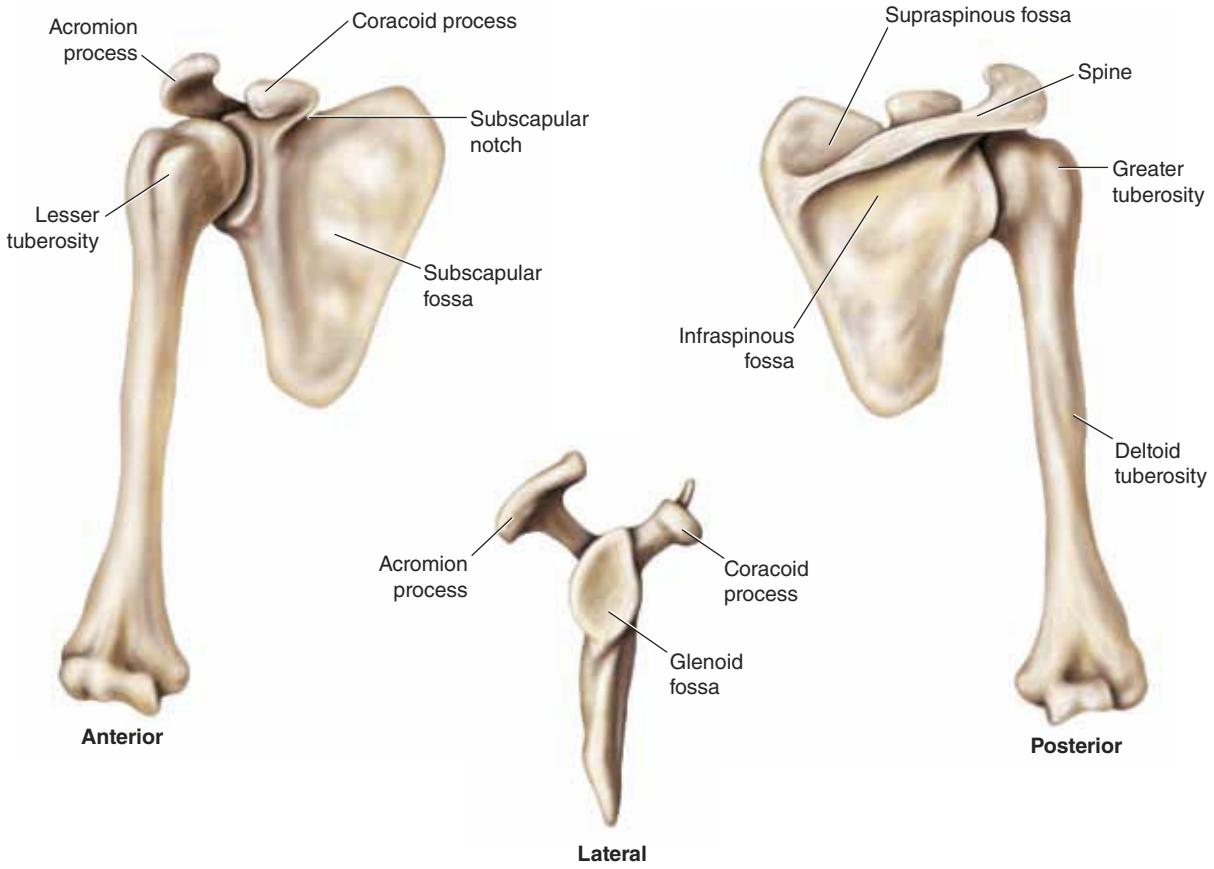

Figure 1.3 Landmarks of the shoulder bones: anterior (front), posterior (back), and lateral (side) views.

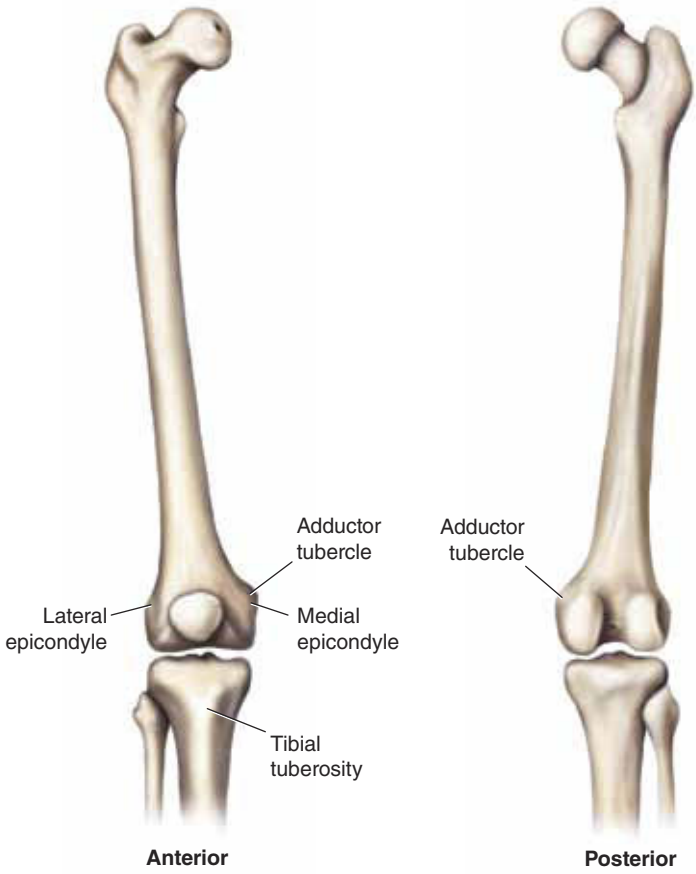

Figure 1.4 Landmarks of the thigh and leg bones, anterior and posterior views.

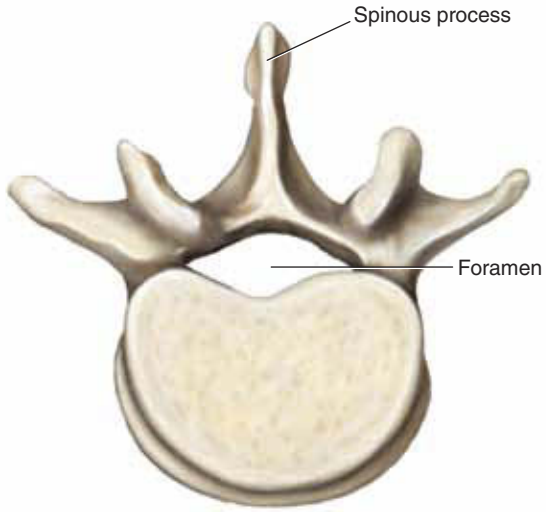

Figure 1.5 Superior (from above) view of a typical vertebra.

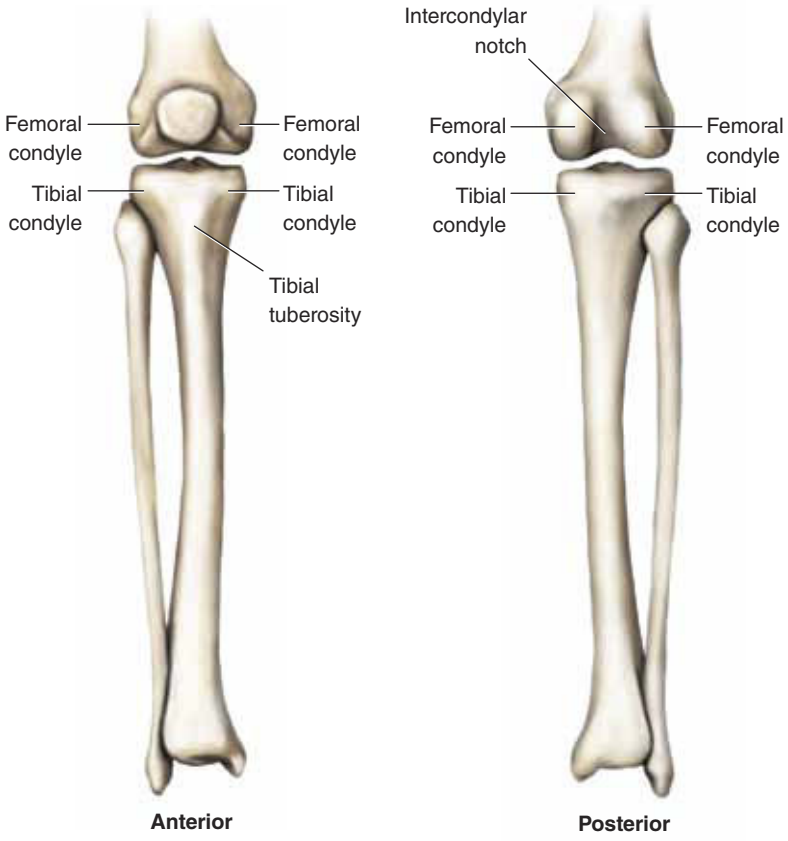

Figure 1.6 Anterior and posterior views of the knee.

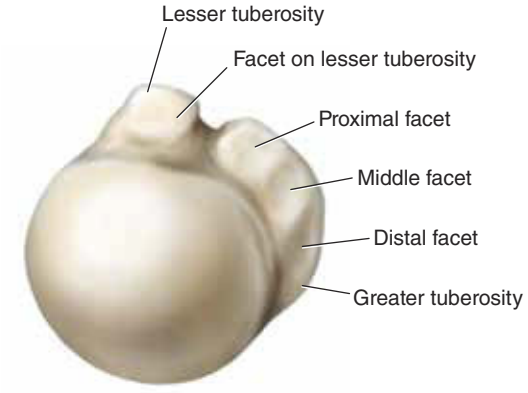

Figure 1.7 Superior view of the humerus.

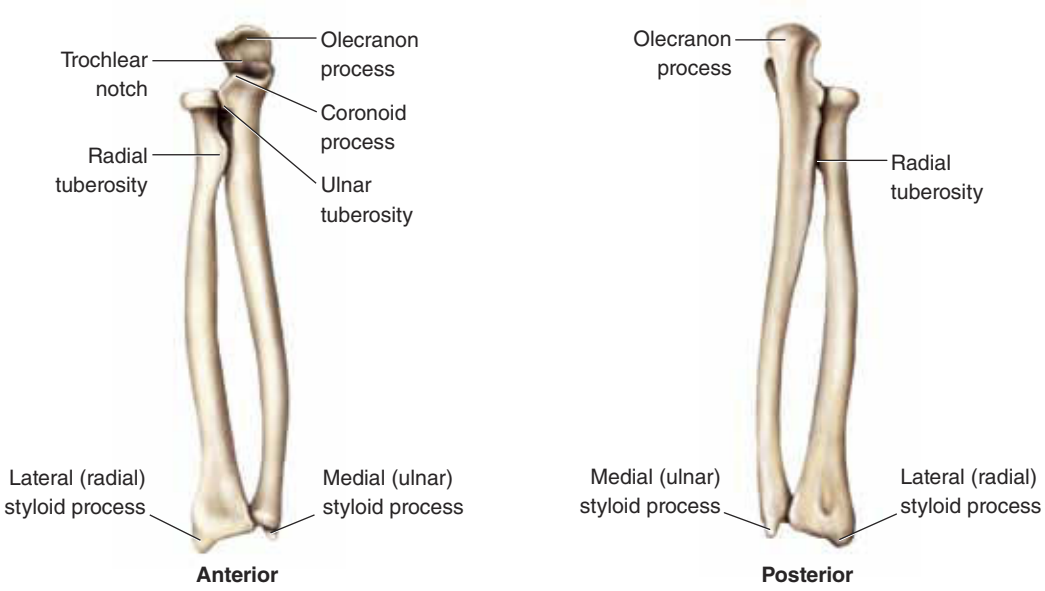

Figure 1.8 The bones of the elbow and their landmarks, anterior and posterior views.

Joints

The place where two or more bones join together anatomically is referred to as an **articulation**. The terms **joint** and *articulation* are interchangeable, and the study of joints is known as **arthrology**. Tying bones together at articulations are structures of dense, fibrous connective tissue known as **ligaments** (figure 1.9). A ligament is a cord, band, or sheet of strong, fibrous connective tissue that unites the articular ends of bones, ties them together, and facilitates or limits movements between the bones. Ligaments are not the sole support for the stability of joints. The muscles that cross the joint and the actual formations of the articulating bones also contribute to joint stability.

There are two major forms of joints: diarthrodial and synarthrodial. **Diarthrodial joints** are distinguished by having a separation of the bones and the presence of a joint cavity. These joints are divided into six subdivisions by their shape (figure 1.10). The **hinge joint** has one concave surface, with the other surface looking like a spool of thread. The elbow joint is an example of a hinge type of diarthrodial joint. The **ball-and-socket** type of diarthrodial joint consists of the rounded head of one bone fitting into the cuplike cavity of another bone. Both the hip joint and the shoulder joint are examples of the ball-and-socket type of diarthrodial joint. The **irregular** type of diarthrodial joint consists of irregularly shaped surfaces that are typically either flat or slightly rounded. The joints between the bones of the wrist (carpals) are an example of this type of joint. Gliding movement occurs between the carpal bones. The **condyloid joint** consists of one convex surface fitting into a concave surface. Although the description of the condyloid joint is similar to that of the ball-and-socket joint, the difference is that the condyloid joint is capable of movement in only two planes about two axes, whereas the ball-and-socket joint is capable of movement in three planes about three axes. (Note: Planes and axes are discussed in chapter 2.) An example of a condyloid joint is where the metacarpal bones of the hand meet the phalanges of the fingers. The **saddle joint** is often considered a modification of the condyloid joint. Both bones have a surface that is convex in one direction and concave in the opposite direction, like a saddle. These joints are rare, and the best example is the joint between the wrist and the thumb (carpometacarpal joint). In the **pivot joint**, one bone rotates about the other bone. The radius bone (of the forearm) rotating

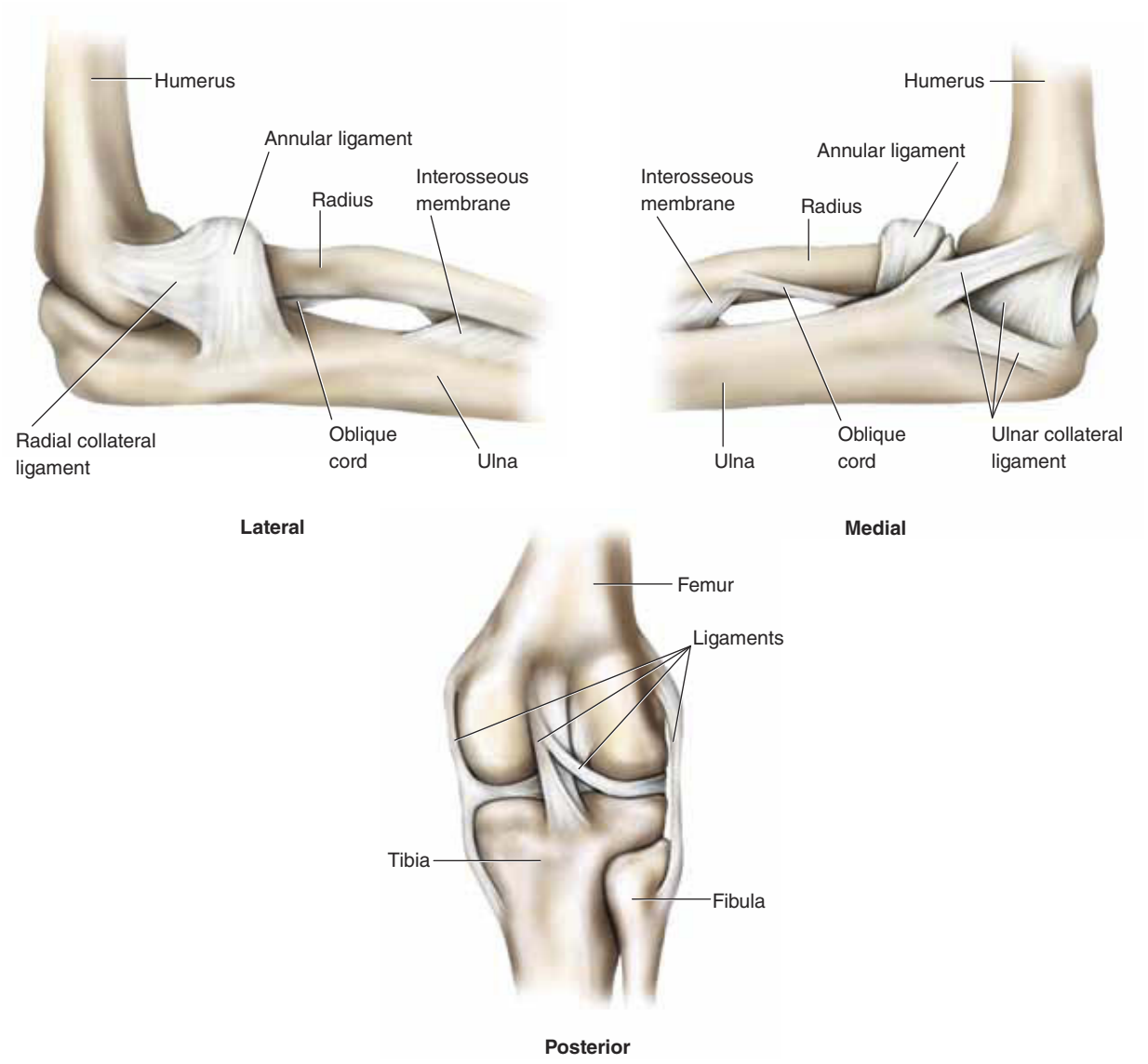

Figure 1.9 Lateral and medial views of the major ligaments of the elbow; posterior view of the ligaments of the knee.

on the humerus (upper-arm bone) is an example of a pivot joint.

All of the diarthrodial joints are considered **synovial joints**. The synovial joints are where the greatest amount of movement occurs. They are characterized by a space between the articulating surfaces (figure 1.11); a synovial membrane lining the joint secretes synovial fluid for lubrication and provides nutrients to joint structures. Synovial joints are surrounded by a joint (articular) **capsule**. These joints are classified into four categories by the type of movement they permit in planes and about axes (figure 1.12).

Joints between bones that allow only a gliding type of movement over each other are known as **nonaxial joints**, such as are found in the wrist and the foot. **Uniaxial joints**, such as the elbow joint, permit movement in only one plane about one axis. A **biaxial joint**, such as the wrist, permits movement in two planes, about two axes. A **triaxial joint** allows movement in three planes, about three axes, illustrated by the movements of the shoulder joint and the hip joint, which are both ball-and-socket joints.

Synarthrodial joints have no separation or joint cavity, unlike the diarthrodial joints.

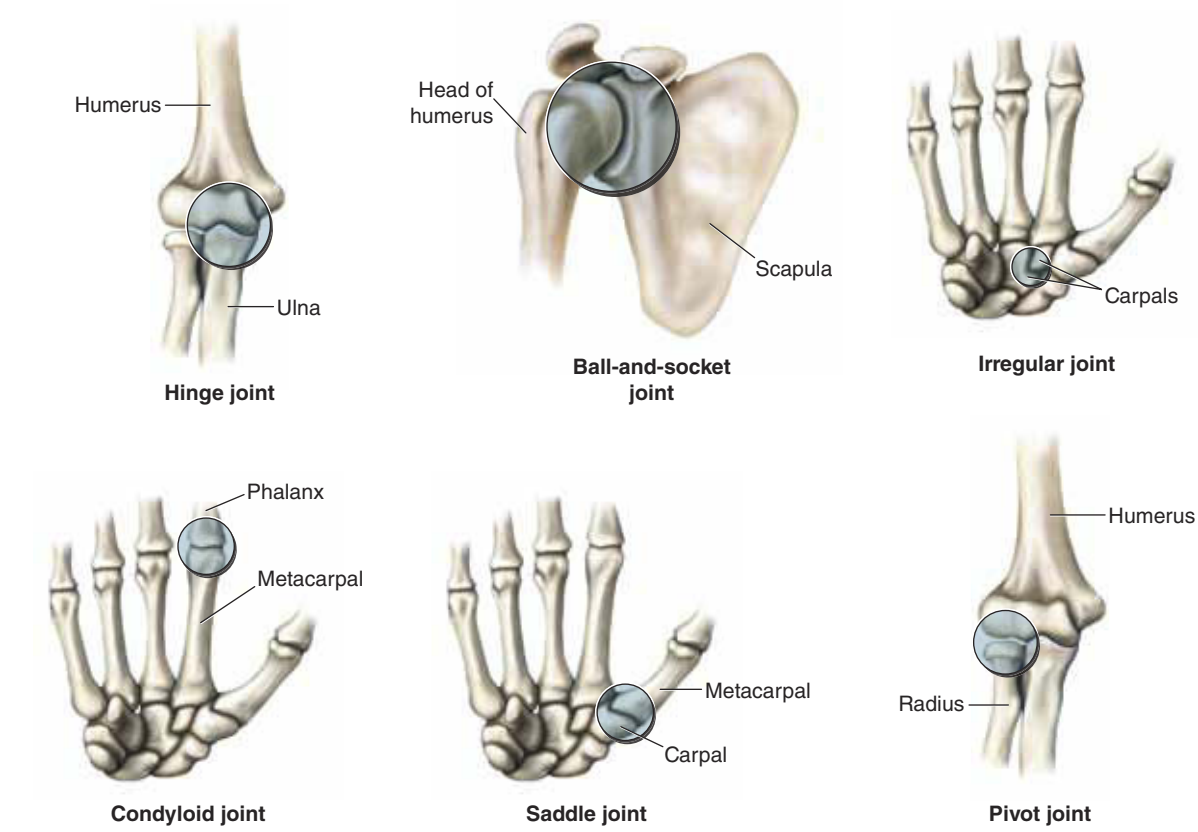

Figure 1.10 The six types of diarthrodial joints.

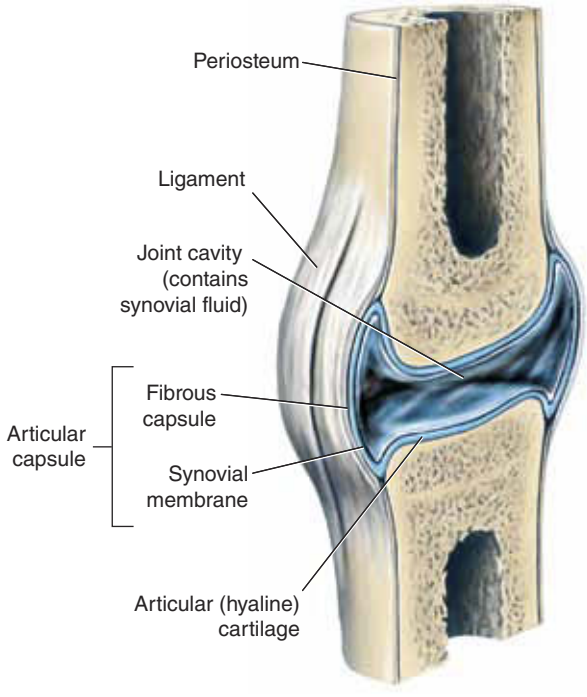

Figure 1.11 A diarthrodial (synovial) joint.

There are three subdivisions of synarthrodial joints (figure 1.13): suture, cartilaginous, and ligamentous. The **suture joint** has no detectable movement and appears to be sewn (sutured) together like a seam in clothing. The bones of the skull are the classic examples of suture joints. There is no movement in these joints. **Cartilaginous joints** allow some movement, but other than those found in the spinal column, they do not play a major role in movement. A cartilaginous joint contains **fibrocartilage** that deforms to allow movement between the bones and also acts as a shock absorber between them. Examples include the intervertebral joints, the pubic symphysis, and the sacroiliac joints. The **ligamentous joints** tie together bones where there is very limited or no movement. The joints between two structures of the same bone (e.g., the coracoid process and acromion process of the scapula) and between the shafts of the forearm and lower-leg bones are examples of the ligamentous form of a synarthrodial joint.