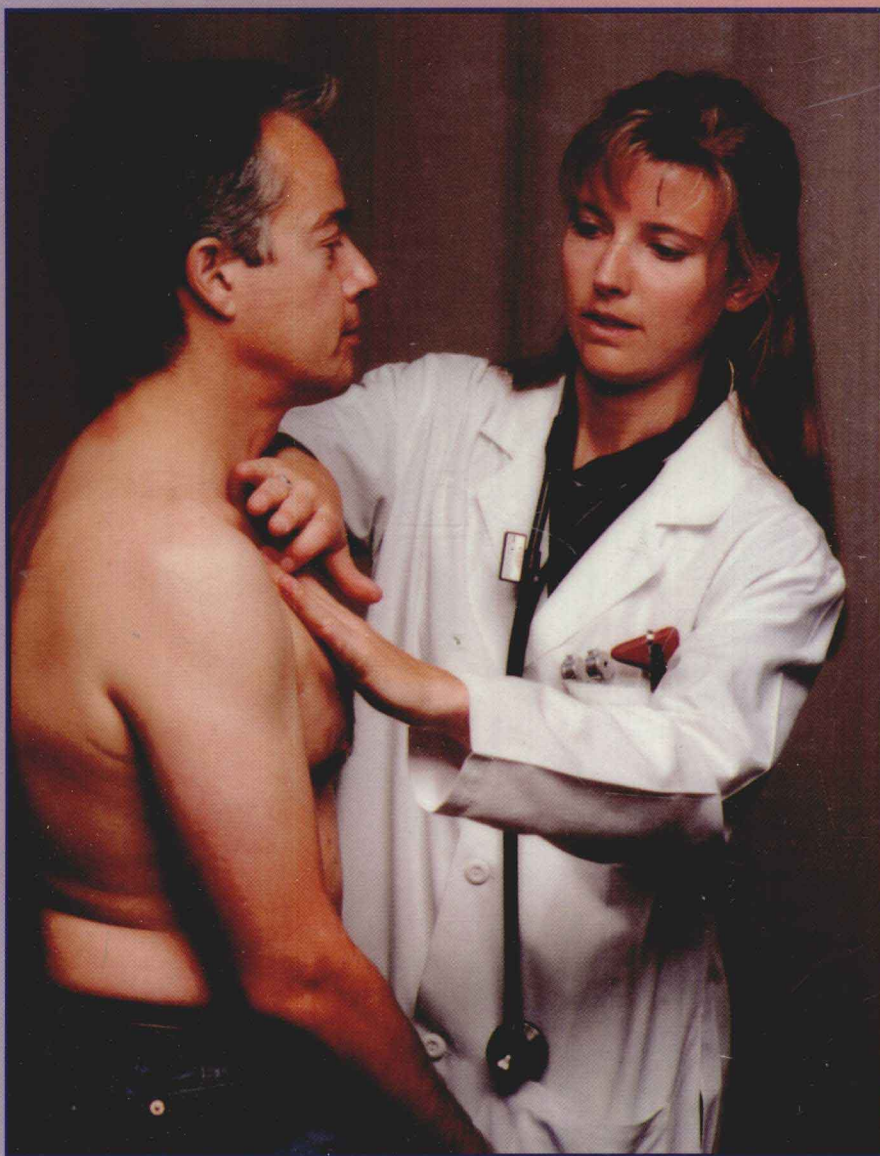
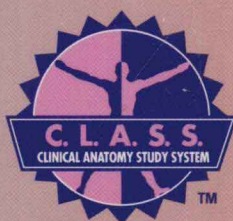


Principles



THE STANFORD



PROJECT

CLINICAL ANATOMY

CLINICAL ANATOMY

Principles

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with 625 illustrations

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Preface

Why a new anatomy book? Admittedly, many good books are already available. The fundamental knowledge base that defines anatomy has been stable for decades, and little new research on the basic structure of the human body has been produced in recent years. What *has* changed recently, however, is (1) the explosion of new information in molecular biology and genetics rightfully competing with anatomy for space and time in the crowded medical curriculum, (2) the fall-off in knowledge of vertebrate biology and development possessed by the typical student entering medical school, and (3) the increasing anatomic knowledge needed to use intelligently the clinico-anatomic information produced by computed tomography, ultrasound, and magnetic resonance imaging technologies.

Curriculum committees have reduced the amount of time devoted to teaching anatomy in a great many medical schools, yet the central importance of anatomy in medicine cannot be denied. Today's student, no less than those decades ago, knows instinctively that a working knowledge of anatomy is the first sure sign that his or her medical career truly has begun.

The study of anatomy resembles the study of *language*. Literally thousands of new words must be learned. Successful anatomy students learn the art of accurate, concise description and will find this to be a valuable skill throughout their medical careers. However, a real understanding of anatomy requires *three-dimensional visualization*—because anatomic structures are always related to other anatomic structures, and a true comprehension of these relationships allows a student to understand and even anticipate many pathologic processes. To learn anatomy well requires a dual approach: the *regional* description of structures and their relationships to each other and an understanding of the major *systems* of the body—vascular, muscular, skeletal, nervous, and lymphatic. This text is organized around a regional approach to anatomy, but time is

taken in each section to review information from the standpoint of systems because true understanding requires that both approaches be used.

We believe that anatomy is best learned by emphasizing its connection to *clinical medicine*. However, other valid approaches attempt to define the structure of human anatomy in terms of embryologic development or link anatomic concepts to vertebrate structure comparing human structure to that of other primates and mammals. This text makes use of all three approaches, but its fundamental organization is built around the relationship of anatomy to clinical medicine. Clinical cases are presented throughout the text; however, the subject of anatomy is far too detailed and intricate to be learned in this fashion alone. What the text, therefore, does is to present a basic *core* of anatomic knowledge necessary to comprehend the structure and workings of the body and adds to that anatomic information that has real pertinence to the everyday practice of medicine.

An anatomy text is only as good as its illustrations, and we have endeavored to provide figures that “speak a thousand words” and truly help to improve comprehension. *Clinical Anatomy Principles* can be used to great advantage when combined with its companions, the *Clinical Anatomy Atlas*, *Clinical Anatomy Dissections*, and with the multimedia-based depiction of anatomy available on the *Clinical Anatomy Interactive Lesson*, a CD-ROM also created by this author team.

Those studying anatomy in the 1990s will be the medical practitioners of the first half of the 21st century. Their education must include reference to the new technologies that continually renew the need for competent physicians to know and understand anatomy. We believe that to know the structure of the body is to know not only its appearance and the location of its regions but also its function. This book attempts to explain anatomy in terms of *both* structure and function.

Approaching the study of the body in this fashion elevates the study of anatomy above the level of memorization to the realm of comprehension and even wonder.

For those of us who have labored to produce this book, our fascination with the human body and its intricacies grows with every passing year. We hope to pass that enthusiasm along to our students and are confident that, if we can succeed in this hope, future generations of health care providers will derive great

professional pride and pleasure from their understanding of the human body, that most remarkable of nature's creations.

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Acknowledgments

The authors of this text represent well over a 100 years of experience in teaching anatomy on four continents. We have tried to apply to the creation of this book not only our familiarity with the factual knowledge of anatomy but also our experience in effective ways to present and explain complex information. **Charles Hoffman** and **Nadine Sokol**, the medical illustrators whose artistic renderings of anatomy are a major asset of this text, displayed both artistic creativity and considerable knowledge of anatomy in producing these superlative illustrations.

We would also like to acknowledge and thank many people who made constructive suggestions to the design of the text and helped ensure its accuracy and clarity. Mosby-Year Book Publishing, Inc., was unfailingly supportive in seeing this project through to its completion. In the early stages of our work, **Emma Underdown** labored tirelessly, making valuable suggestions about the structure of the text and rearranging our prose to make it clearer and more readable. On assuming her position as Acquisitions Editor, Emma continued to guide the project through its completion. **Helen Hudlin** has provided invaluable direction throughout the production phase. We also thank our anonymous colleagues who, in reviewing early drafts of the text, pointed out many strengths and weaknesses and made suggestions that have led to its betterment.

Many individuals contribute to the successful completion of a project such as this. We want to thank **Johnella Stevick**, administrator in the Anatomy Division at Stanford, for organizing the correspondence between us and Mosby, coordinating our schedules, planning meetings, and, in general, anticipating our needs.

Dr. Pavarti Dev, of *SUMMIT*, the computer/multi-media facility at Stanford, worked with us not only on this text but on the CD-ROM tutorial that accompanies the text. **Dr. Steve Daane**, **Ramon Felciano**, and **Philip Constantinou**, also of *SUMMIT*, made many valuable suggestions as well. Medical students, **David Kim** and **Matt Lewis**, among many others, were especially good at providing the student perspective.

Any project of this magnitude requires long hours of work on the part of the authors and inevitably produces disruptions in their personal and family lives. We want **Mil**, **Ann**, **Kate**, and **Roz** to know that their patience and forbearance is much appreciated and that without their support the project could have never succeeded. We dedicate this text to them and to all that have added to our lives.

Lastly, and most importantly, we want the text to be useful for **students of human structure**, and we want to thank them for the inspiration they have provided us. Seeing talented young people go through the monumental transition from students to health care professionals is a source of professional and personal satisfaction. We are certain that, in the future, they will bring continued honor to the field of anatomy and confirm its place as a keystone in the education of health care professionals.

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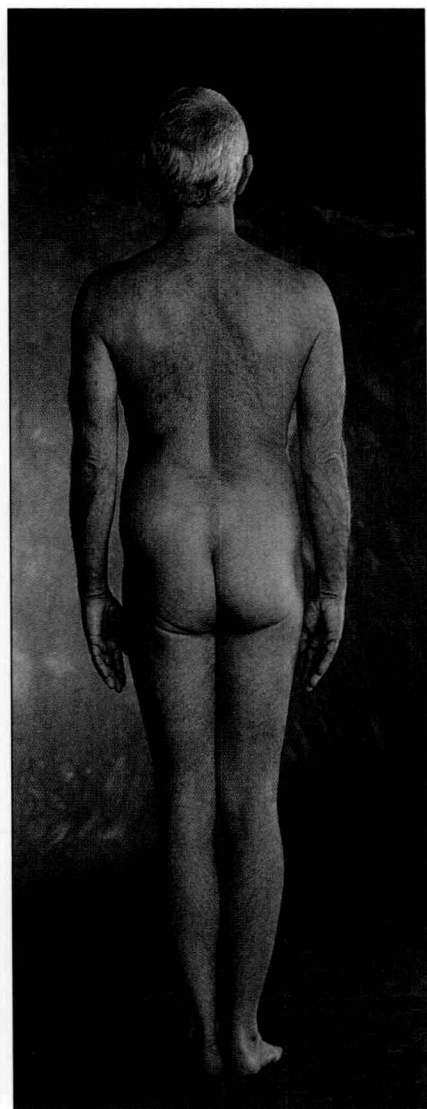
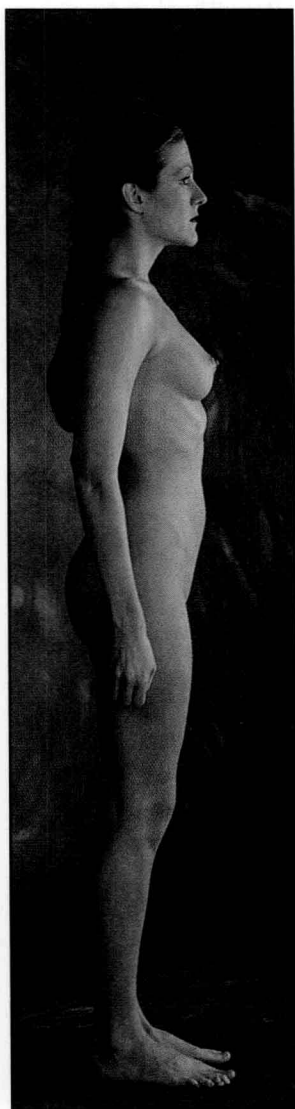
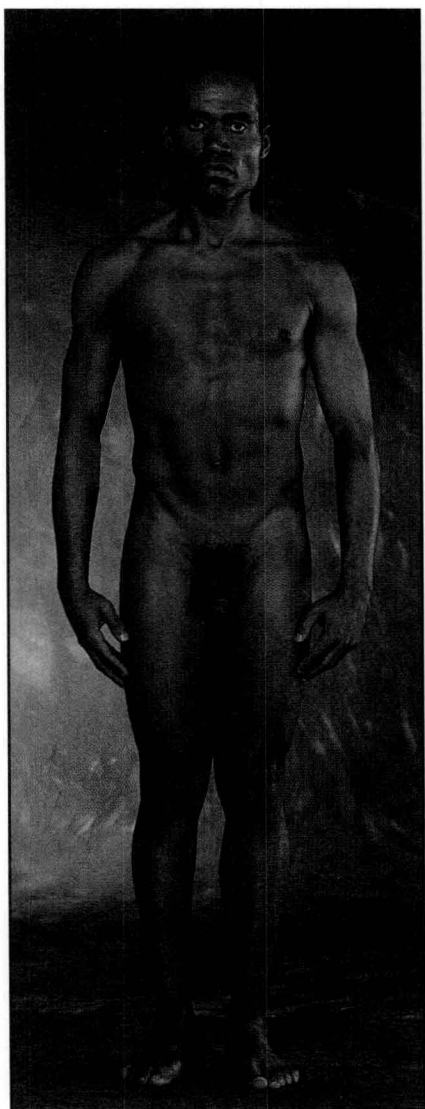
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Introduction

- ▶ Basic Anatomic Terminology
- ▶ Fabric of the Human Body
- ▶ Introduction to the Body Systems
- ▶ Techniques for Imaging the Human Body

BASIC ANATOMIC TERMINOLOGY

Anatomists and physicians have agreed to use a standardized terminology to ensure accurate description and clear communication.

Anatomic Position and Body Regions

To ensure consistency, it is agreed to describe body structures and their positions with reference to a person standing upright, facing forward, feet slightly spread on the floor, with the arms hanging at the sides and the palms facing forward. This is known as **the anatomic position** (Figure I-1). When the person is lying on the back, the position is said to be **supine**; when lying face down the position is said to be **prone**.

The **head** includes the brain, the cranial bones surrounding it, the base of the skull, and the facial structures. The **upper limb** includes everything from the shoulder to the fingertips: the segment from the shoulder to the elbow is the *arm*, from the elbow to the wrist the *forearm*, and the wrist bones are also known as the *carpal bones*. The armpit is known as the axilla. The **thorax** and **abdomen** comprise the *trunk*. The **pelvis** region includes the lower part of the abdominal wall, commencing at the level of the brim of the hip bones. The **lower limb** extends from the hip to the toes: the segment from hip to knee is the *thigh*, from knee to ankle is the *leg*. The ankle bones are also known as the *tarsal bones*.

Relationship of Structures to Each Other

It is frequently necessary to describe the position of one anatomic structure *in relation to another*. A group of terms has been developed to make such descriptions clear and precise. **Medial** means closer to the midline and **lateral** means further from it. A given structure

may be lateral to one structure but medial to another; thus the middle finger is *medial* to the thumb (in the anatomic position) but is *lateral* to the little finger. Describing the limbs, the terms *proximal* and *distal* are often used. A structure is **proximal** if it is nearer its point of origin (or of the attachment of the limb to the trunk) and **distal** if it is further from its point of origin (or attachment of the limb to the trunk). Thus the elbow is *distal* to the shoulder but *proximal* to the wrist. The terms **deep** and **superficial** are used when describing layers of muscle or other tissue in relation to the surface of the body; thus, in the chest wall, the skin is superficial to the ribs. **Anterior** means on or toward the front of the body (see next section), and **posterior** refers to the back surface of the body. A structure is anterior to another structure if it lies nearer to the anterior surface of the body. **Internal** and **external** are used to describe something that is nearer the center or nearer the surface. Remember that no structure is *absolutely* medial, lateral, anterior, posterior, etc.—these terms always *compare* the position of structures (Figure I-2).

Planes of the Body

The standard or cardinal planes of the body are coronal, sagittal, and transverse (horizontal). Viewing the body in the anatomic position, the **coronal plane** passes from left to right through the body, dividing it into an anterior and posterior part. The **sagittal planes** pass from anterior to posterior, dividing the body into a left and right side. When the plane is precisely in the midline, it is said to be in the **median sagittal** or **midsagittal plane**; all other parallel planes are **parasagittal**. **Transverse planes** are parallel to the ground and divide the body into an upper and lower portion (Figure I-3).

Anterior (ventral) means in front of the coronal plane through the middle of the body; **posterior** or **dor-**

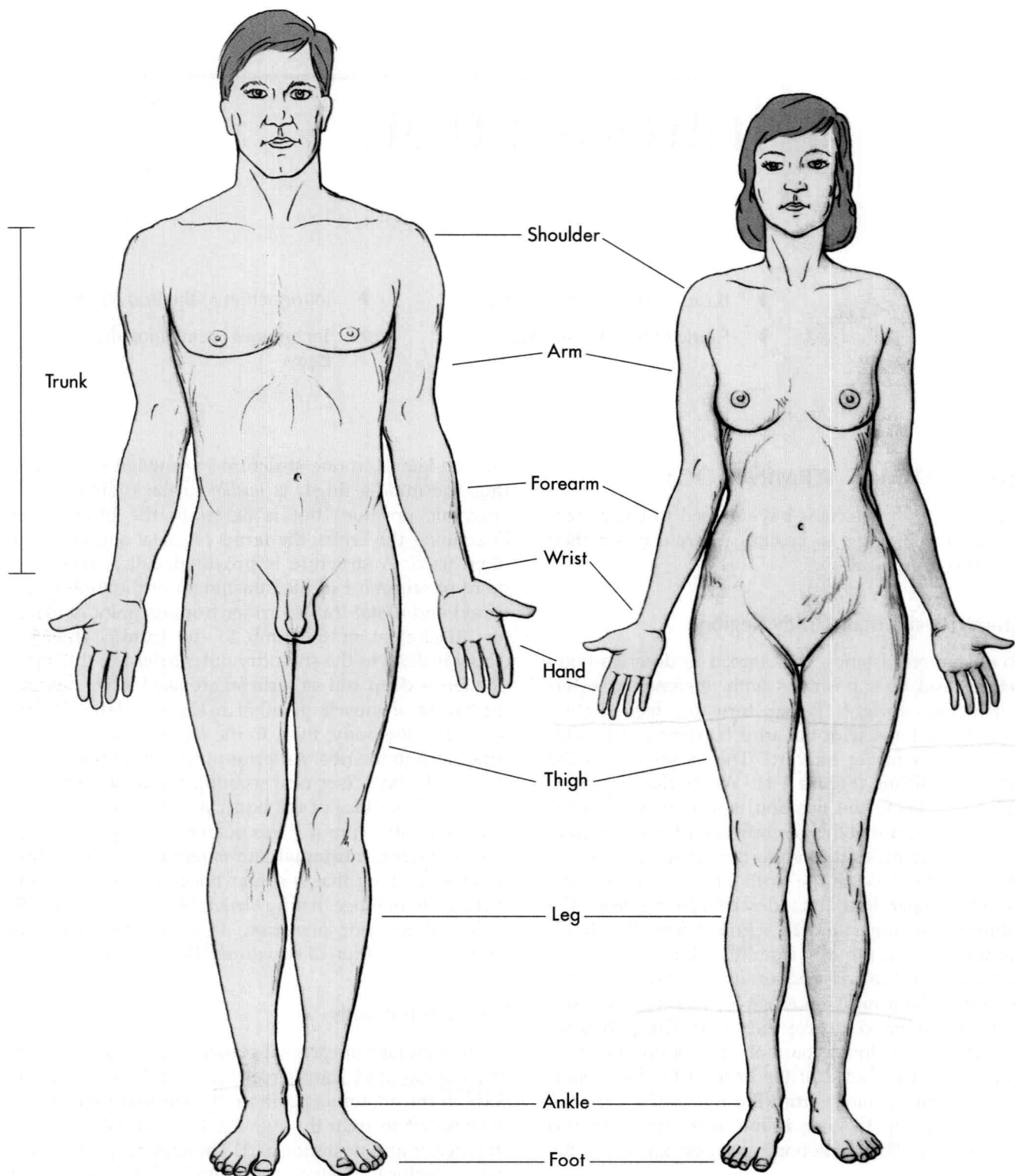


Figure I-1 ANATOMIC POSITION. The person is standing upright, facing forward, feet slightly separated, arms hanging to the side with palms facing forward. Structures are named and their positions described in this standard position.

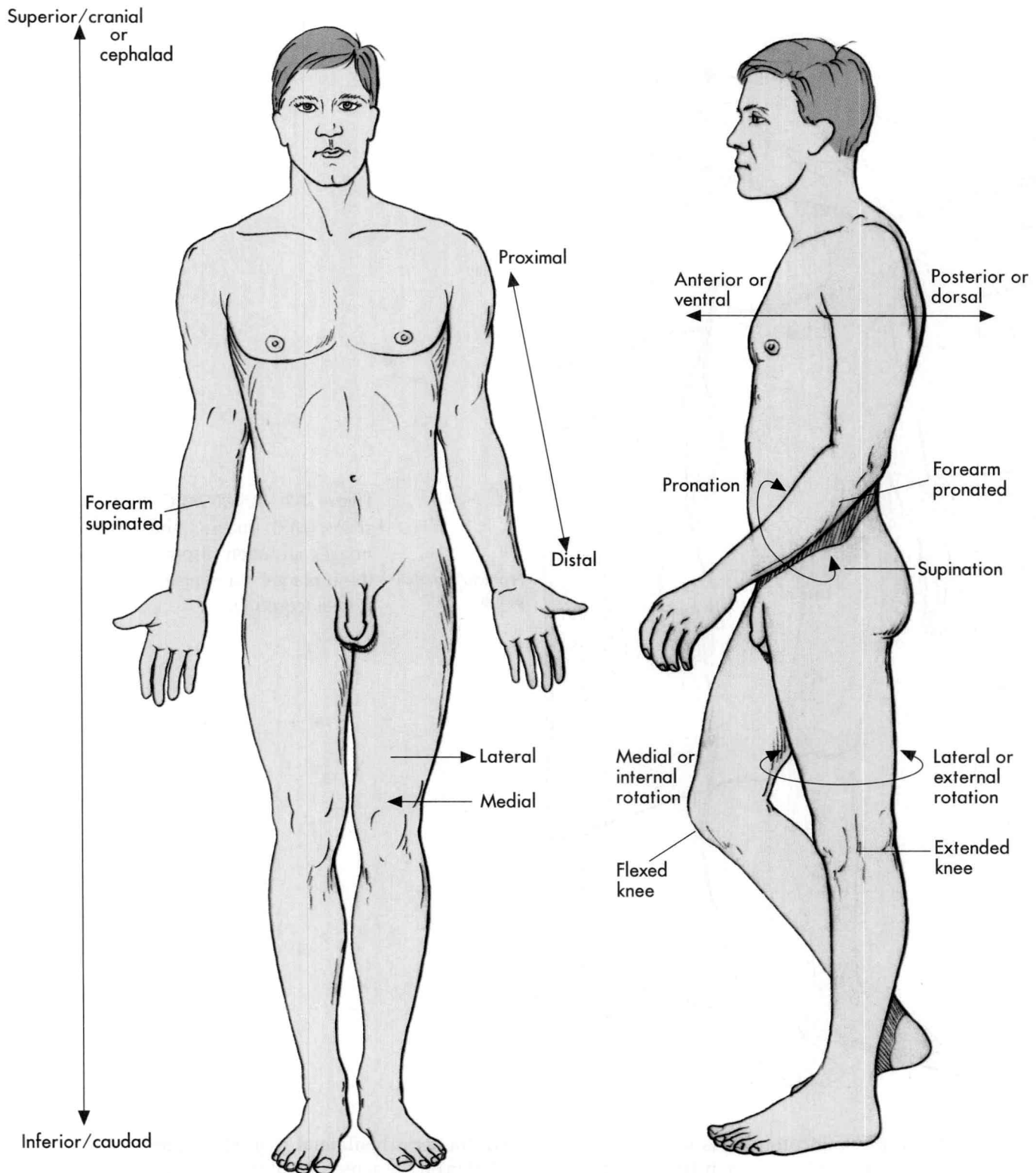


Figure I-2 TERMS OF POSITION AND MOVEMENT. These two figures illustrate several types of positional terms and movements.

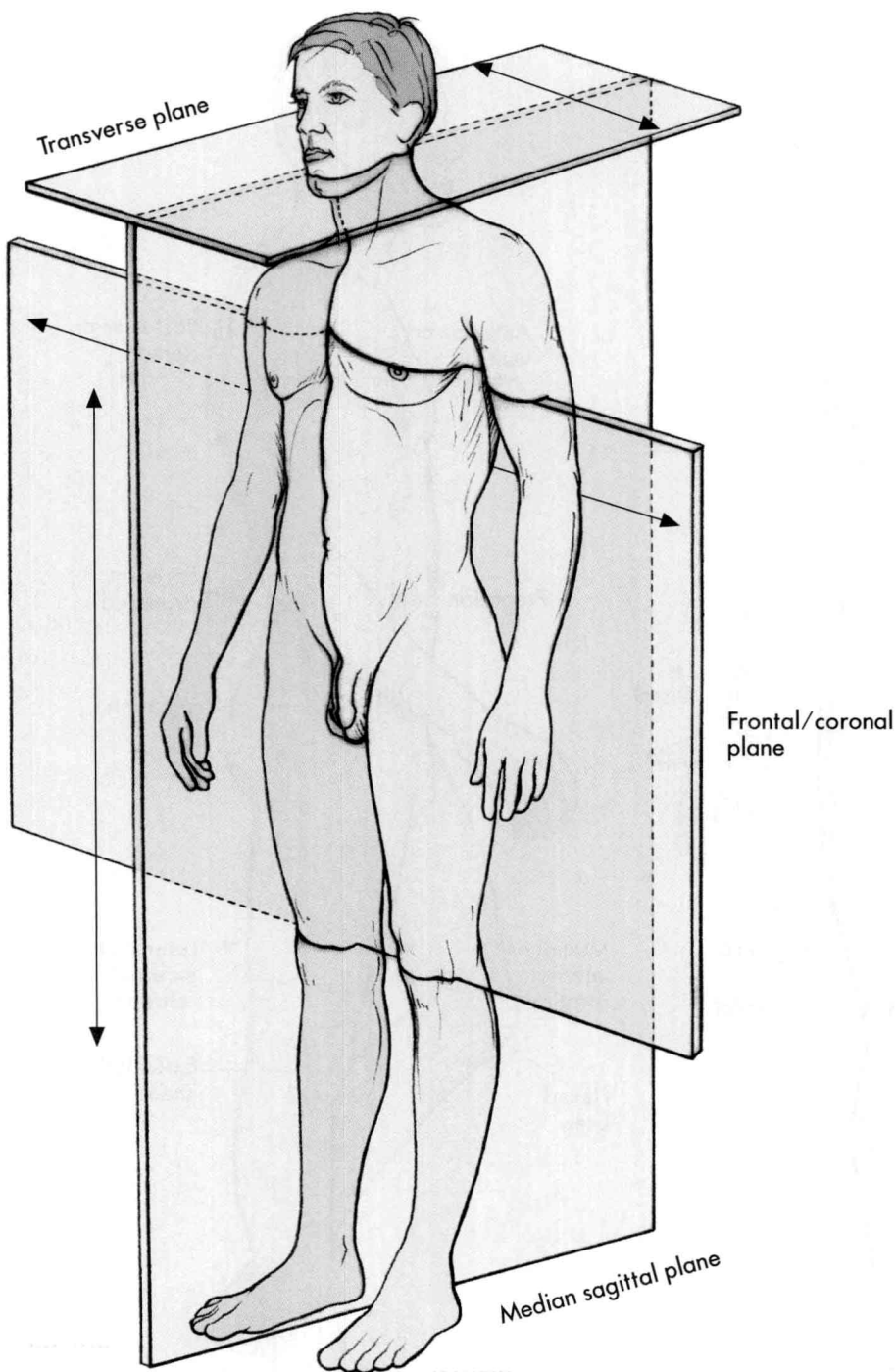


Figure I-3 ANATOMIC PLANES. CT scans, MRI images, and ultrasound images are often displayed in one of these planes: transverse, sagittal, and frontal (coronal).

sal means behind the midcoronal plane. **Superior** means above a transverse plane, and **inferior** means below it.

Many regions of the body are described by terms that apply nowhere else. In the *hand* the anterior surface (in the anatomic position) is **palmar**; the anterior surface of the forearm is also **volar**; the opposite side is the **posterior** or **dorsal** surface. For the *foot*, the portion contacting the ground is the **plantar** surface; the opposite is called **dorsal**. Many structures in the body are

paired; the term **ipsilateral** is used to refer to a structure that is on the same side of the body as another and **contralateral** to refer to a structure on the opposite side of the body; thus the left median nerve innervates muscles in the *ipsilateral* (i.e., left) upper limb.

Terms Describing Movement

In general, when the angle of a joint such as the elbow or the knee is narrowed, the movement is de-

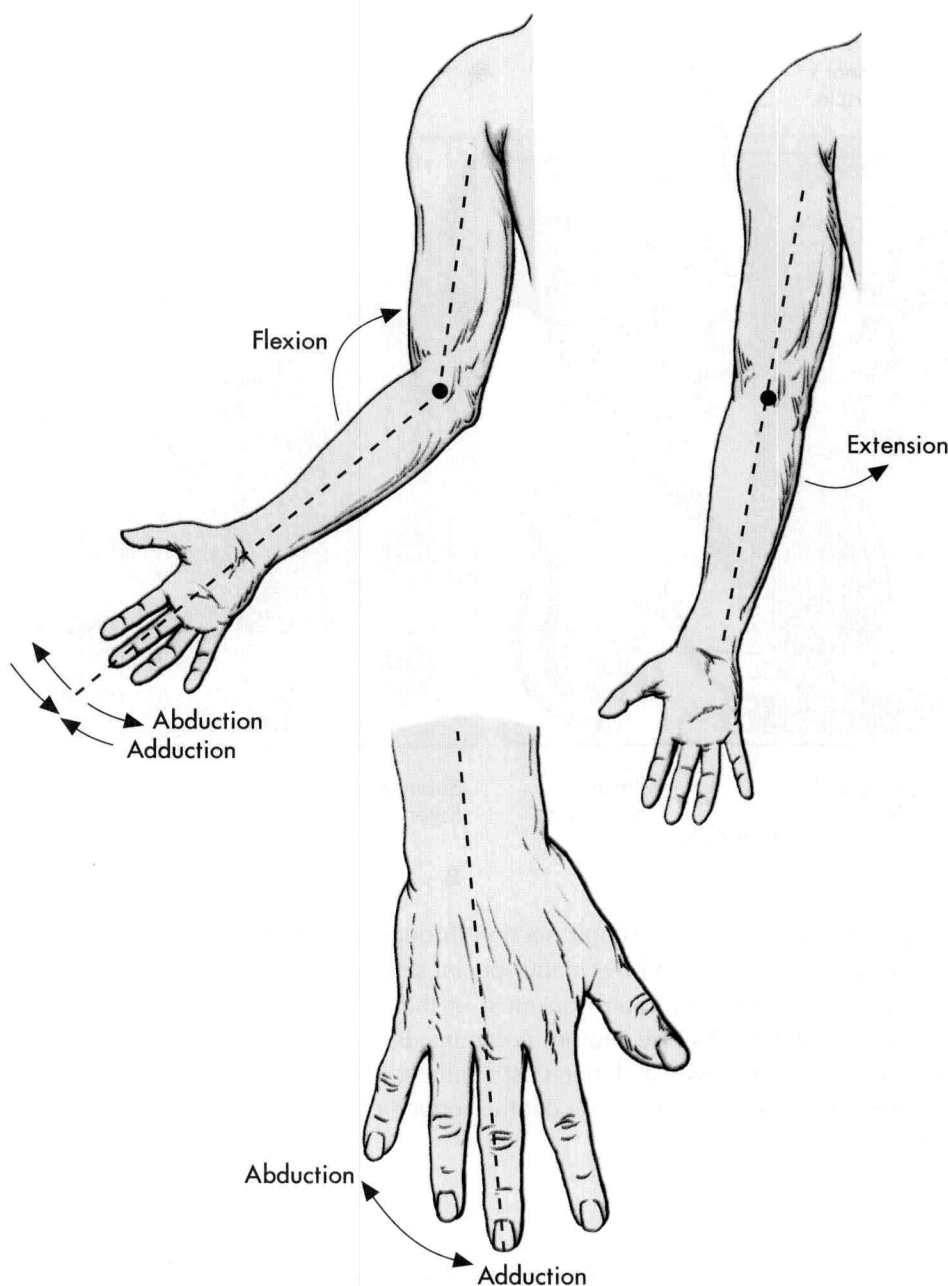


Figure I-4 UPPER LIMB MOVEMENTS. This figure illustrates some of the movements of the upper limb.

scribed as **flexion**. The opening up of such joints, increasing the size of the angle, is **extension** (Figure I-4). Another way to describe flexion is to say that the “fetal position” involves flexion of most joints, while extension is the opposite. **Abduction** means moving away from the midline, and **adduction** means moving toward it. For example, pulling the upper limb downward in a plane parallel to the anterior surface of the body so that it lies snugly alongside the chest wall is *adduction* of the shoulder joint. Moving the upper limb downward in a plane perpendicular to the anterior surface of the body is, however, extension of the shoulder joint. Elongated structures such as the limbs can often *rotate* around their long axes. When the rotation results

in the anterior surface of a limb rotating toward the midline, it is **medial rotation**; the opposite is **lateral rotation**.

Special Terms

Supination is the act of turning the palm so that it faces forward (in the anatomic position); **pronation** is the opposite. These movements involve special interactions between the two long bones of the forearm, the *ulna* and *radius*. Turning the sole of the foot to face medially is **inversion** and the opposite **eversion**; these movements are *not* comparable to supination/pronation in the forearm, however.

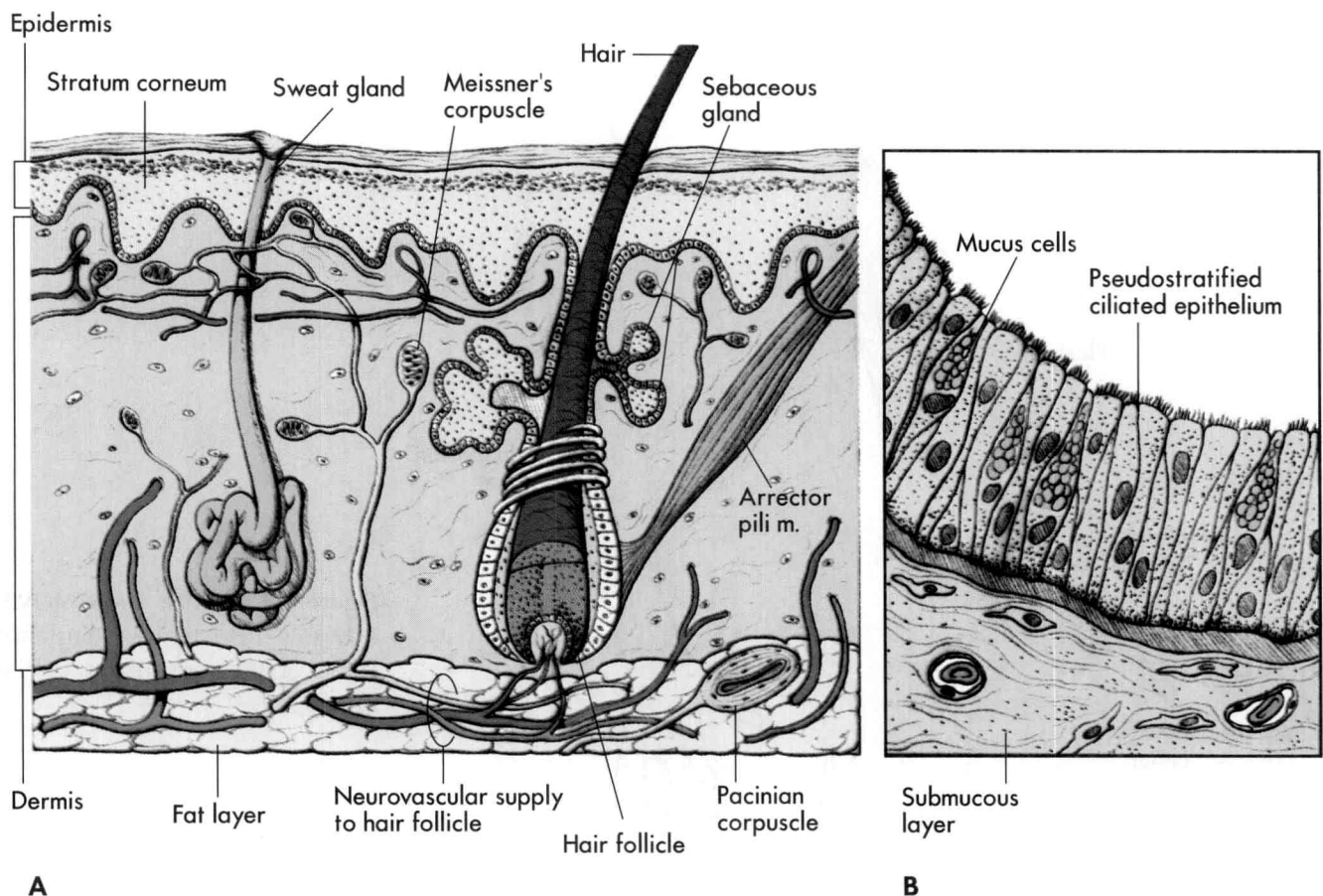


Figure I-5 STRUCTURE OF THE SKIN. **A**, Microscopic section through a typical area of skin shows the dermal and epidermal layers and the many special structures and organs found within. Stratified squamous epithelium, found on most of the body surface, features a thickened layer of degenerated cells, the stratum corneum. **B**, In the respiratory system, the lining epithelium is columnar, with a characteristic ciliated surface facing the lumen of the airway. Numerous cells secrete mucus to coat the surface of the epithelium. (Structures are not drawn to scale.)

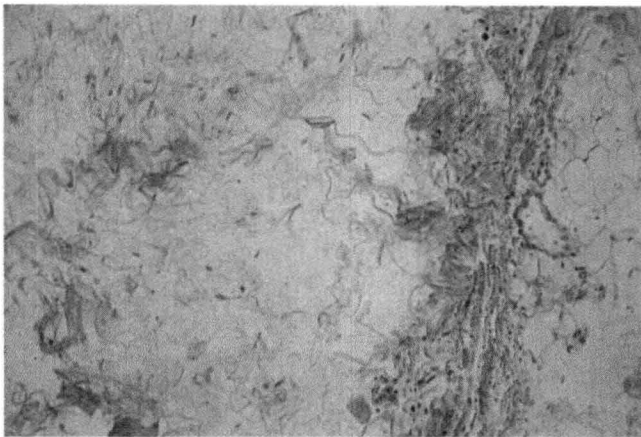
FABRIC OF THE HUMAN BODY

Skin

Skin covers the entire surface of the body and provides protection, preservation of moisture, and regulation of temperature. The **epidermis** is most superficial and the **dermis** lies just deep to it (Figure I-5, A); much of the upper segment of the epidermis is dead cells and is continuously sloughed off and renewed from deeper layers. The dermis contains *connective tissue*, *sweat glands*, *sebaceous glands*, *hair follicles*, *nerve endings*, and *capillaries* (see Figure I-5, A). The ducts of the glands and the hairs growing from the follicles extend upward through the epidermis to reach the surface. The hairs and glands are present or absent in different regions of the body. **Nails** are special modifications of the epidermis found at the tips of the digits.

Connective Tissue and Fascia

Deep to the skin lies a layer of **connective tissue**, which shows tremendous variety in different regions of the body. It is made up of a variety of *cells* (fibroblasts, fat cells, macrophages, plasma cells, etc.) and a large amount of *extracellular material* or *matrix*, secreted primarily by the fibroblasts. The matrix is made up of *proteoglycan molecules* (protein core plus glycosaminoglycans)—a material formerly known as *mucopolysaccharide*. In addition to the secreted matrix there is one or more of the 10 to 12 varieties of *collagen fibers*, or *elastic fibers*, and other specialized molecules secreted by the connective tissue cells (Figure I-6, A). The relative proportions of these structural substances determines the stiffness or flexibility of connective tissue in different regions of the body—for example, the connective tissue

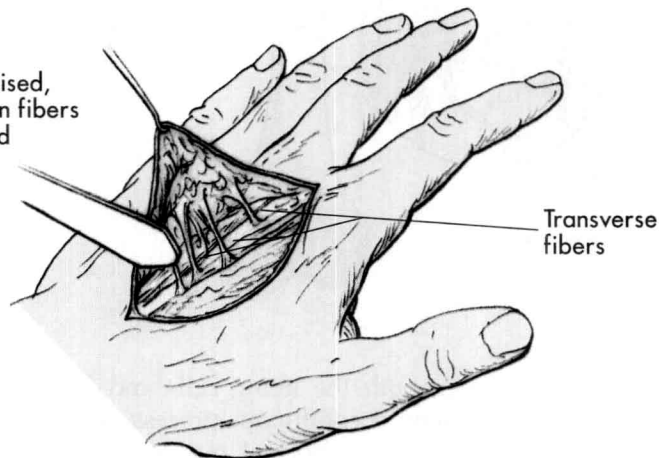


A



Figure I-6 CONNECTIVE TISSUE, LIGHT MICROGRAPH. **A**, Connective tissue is made up of cells and a considerable amount of intercellular material, consisting of a proteoglycan ground substance and a variety of fibers. It serves as the interface or packing substance between all other tissues or organs in the body. (See "Connective Tissue" in Section One for further details.) **B**, This figure shows the mobility of connective tissue and fascia on the dorsum of the hand (*top*) and the relatively small number of transverse fibers that anchor the skin of the hand to the underlying bones (*bottom*). (**A**, From Erlandsen S, Magney J: *Color atlas of histology*, St Louis, 1992, Mosby.)

Skin incised,
collagen fibers
exposed



B

on the sole of the foot needs to be thick and durable, while that of the eyelids needs to be softer and more malleable.

When connective tissue is sufficiently organized that it may be distinguished as a distinct layer it is known as **fascia**. It usually exists as a layer of **superficial fascia** and a layer of **deep fascia**, although one of these may be absent in particular areas of the body. The superficial fascia is also known as subcutaneous tissue and contains a mixture of connective tissue and *adipose* (fatty) tissue. It may be very loose and mobile, as on the surface of the face or the dorsum of the hand (Figure I-6, *B*); in other areas, such as the palm of the hand, it is very tight and allows little movement of the overlying skin. The deep fascia covers the large muscles, forms layers that create fascial compartments, and may extend deeply to attach to underlying bones. In many areas (the limbs, the neck) it condenses into thickened sheets or layers that help to support structures contained within. Fascia serves as a "filling material" be-

tween large structures, such as muscles and bones, but it is also a very metabolically active tissue, which plays a vital role in immunologic activities, wound healing, and growth.

Very dense and strong connective tissue structures called **ligaments**, with tightly packed and highly ordered bundles of collagen molecules, characteristically connect bones to other bones or cartilages and often reinforce joints (see following discussion and Figure I-11).

Bone and Cartilage

Bones are living tissues, made up of a proteoglycan matrix (ground substance) onto which calcium salts are deposited, producing a very rigid and solid entity. Bone is a highly specialized form of connective tissue. In the center of most bones is a reticulated marrow cavity, containing important *hematopoietic* (blood-forming) cells (Figure I-7). Living cells are scattered in a highly organized fashion throughout the substance of bone,