THE *Anatomical Basis* OF *Dentistry*

LIEBGOTT

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To Dorion, Rachel, and Joanna

Preface

The Anatomical Basis of Dentistry was written in order to fulfill a long-standing need for a textbook of gross anatomy specifically tailored for undergraduate dental students. Most anatomy textbooks are traditionally directed toward a general audience or in particular toward students of medicine. Moreover, there tends to be a uniform emphasis on all areas of the body, thus limiting the use of such texts as a possible course text for dentistry. In contrast, this book highlights those regions of the head and neck that are of subsequent clinical relevance. Furthermore, correlations are drawn between the basic science of anatomy and the clinical practice of dentistry.

The inclusion of applied anatomy throughout the book and in a separate chapter is by no means intended to teach clinical dentistry but to instill a keener interest in the structures of the area studied. It is hoped that the student will retain a clearer picture when these structures are re-encountered in the clinical years.

A course in gross anatomy for dental students should not be entirely limited to the head and neck regions, therefore comprehensive chapters dealing with the abdomen and thorax are included. A study of these regions is essential as a foundation for the other basic sciences and for subsequent courses in general medicine and physical diagnosis that are found in most dental school curricula. Similarly, a brief discussion of the limbs is included to complete the picture of the entire body and to acquaint the student with possible sites of intravenous and intramuscular injections.

For the most part, *The Anatomical Basis of Dentistry* maintains a regional approach, since most undergraduate courses include cadaver dissections or at least a study of prosected materials in the laboratory. In each region, the student is confronted with structures representing several systems, and this parallels precisely the manner in which structures are encountered in the living patient. The regional approach, however, is not adhered to throughout. Chapter One introduces the student to the terminology associated with the study of anatomy and also provides a general description of each body system in preparation for the regional anatomy to follow. It is highly recommended that this chapter be read initially and then re-read from time to time as the course progresses.

It is customary to describe anatomical features as they appear in the adult; this is so because most information is gleaned from dissections of adult cadavers. We tend to forget that anatomy can be learned from the living and at all ages, and for this reason the final chapter deals with postnatal growth and development and changes that take place with aging.

Much thought has been given to the scope and amount of material presented in this book. It is certainly not intended to be an exhaustive, all-inclusive work replete with long lists of references; several excellent reference books are available for further study or clarification. Conversely, this book is not intended as a synopsis or a basic textbook of anatomy. It is felt that there is ample material present to meet the requirements of a modern course of gross anatomy for undergraduate dental students. At the same time, it is hoped that this book will maintain its usefulness and prove valuable throughout the undergraduate clinical years and eventually take its place on the desk of the practicing dentist.

Most of the original illustrations for this book were executed as simple line drawings that quickly convey the essence of the area shown without peripheral clutter. To create a seemingly simplistic yet eminently recognizable and informative diagram is a rare talent, and, for this reason, I am indebted to Mrs. Raza Skudra, formerly of Instructional Media Services, Faculty of Medicine, University of Toronto. Mr. Alan Bakes, artist in the same department, contributed the fine illustrations of the cardiac and pulmonary structures. Where more elaborate color illustrations were required for the systemic review of the head and neck (Chapters Eight and Nine) and the overview of the limbs (Chapter Nine), plates were used from the *Atlas of Medical Anatomy* (Philadelphia, W. B. Saunders Company, 1978) with the kind permission of Dr. J. Langman.

Photographs rather than drawings were chosen to illustrate the bones of the body in order to capture the fine osseous features, particularly those of the facial bones. Lighting and composition are critical to a good, informative photograph and I am thankful to have had the expert services of Mr. Paul Schwartz, B.A., medical photographer, Instructional Media Services, Faculty of Medicine, University of Toronto.

To Dr. K. L. Moore I owe a special debt of gratitude for providing the initial impetus in translating this book from a dream to a reality.

Lastly, warm thanks are due to the publishers, the W. B. Saunders Company, for their faith in this book, and to Mr. Robert Reinhardt, dental editor, for his cogent advice, flexible guidance, and infinite patience.

Bernard Liebgott

Contents

CHAPTER ONE

General Concepts

1. THE STUDY OF ANATOMY

The word *anatomy* was coined from two Greek root words that mean "to cut up." This is precisely the way in which the early anatomists studied the structure of once living things, that is, by dissecting animal or human remains, observing structures, and then speculating as to what function these structures might perform. The scope of modern anatomy has broadened considerably, however. Human anatomy is now the study of the structure of the human body by means of a variety of approaches, and these various approaches have given rise to specialized sub-fields of human anatomy.

Gross anatomy is concerned with the study of human form and structure as seen by the naked eye. There are two classic approaches to the study of gross anatomy, both of which are employed in this book. A systemic approach is one in which the various systems of the body are studied as separate entities. A regional approach divides the body into a number of regions. Within each region, all structures belonging to various systems are considered.

Microscopic anatomy or **histology** is concerned with smaller details of structure as seen through a microscope. It is the study of human tissues that range from basic tissue architecture, using the light microscope, to ultrastructural elements of tissues and cells, using the electron microscope. Biochemical techniques combined with histological techniques have given rise to a relatively newer field of histochemistry or cytochemistry.

Neuroanatomy is the study of the central nervous system, that is, the brain and spinal cord, as viewed by gross dissections as well as histological preparations.

Developmental anatomy is a field that is concerned with age changes in size, complexity, shape, and ability to function. *Prenatal development* follows the development of the individual from the time of conception to birth. *Embryology* is particularly concerned with the first two months of life in utero during which the organ systems are formed.

Postnatal development traces the various changes in form and function through which an individual passes after birth, through infancy, childhood, adolescence, and ultimately adulthood.

Surface anatomy (living anatomy) deals with the surface or topography of the living person.

Radiological anatomy is the study of anatomy as it is revealed by radiographs of the living subject. Outlines of tissues of varying radiodensities (opacities) may be studied with this technique. The increasing use of serialized radiographs taken at ever-increasing depths through the body (tomography) has rekindled interest in sectional anatomy, that is, the study of structures as they appear on the surface of cross-sectional or longitudinal cuts through a cadaver.

2. TERMINOLOGY

The basis for all communication in human gross anatomy and related basic and clinical sciences is standardized and universally accepted. A precise terminology enables us to name structures so that they may be distinguished from all other structures and to relate the position of these named structures to the rest of the body so that they may be located with consistency and precision.

THE ANATOMICAL POSITION

In the dissecting laboratory, we assume, by convention, that our subject is standing in the anatomical position, that is, standing erect with

(1) the toes pointed forward,
(2) the eyes directed to the horizon,
(3) the arms by the sides, and
(4) the palms of the hands facing forward.

From this basic position, we can now divide the subject according to four different planes and introduce terminology that relates to these planes (Fig. 1–1).

PLANES OF THE BODY

(Fig. 1–1)

1. The **midsagittal plane** is a plane that divides the body into equal right and left halves. The **median plane** is a synonym.
2. The **sagittal plane** is any one of an infinite number of planes parallel to the midsagittal plane.
3. The **coronal plane** is any one of an infinite number of planes that are at right angles to the midsagittal plane.
4. The **transverse** or **cross-sectional plane** is a plane that cuts across the long axis of the body or a limb.
5. The **oblique plane** is, by default, any plane that deviates from the four aforementioned planes.

TERMS OF RELATIONSHIP

The following terms are presented in pairs because each term has an opposite. Again, we must assume that our subject is in the anatomical position.

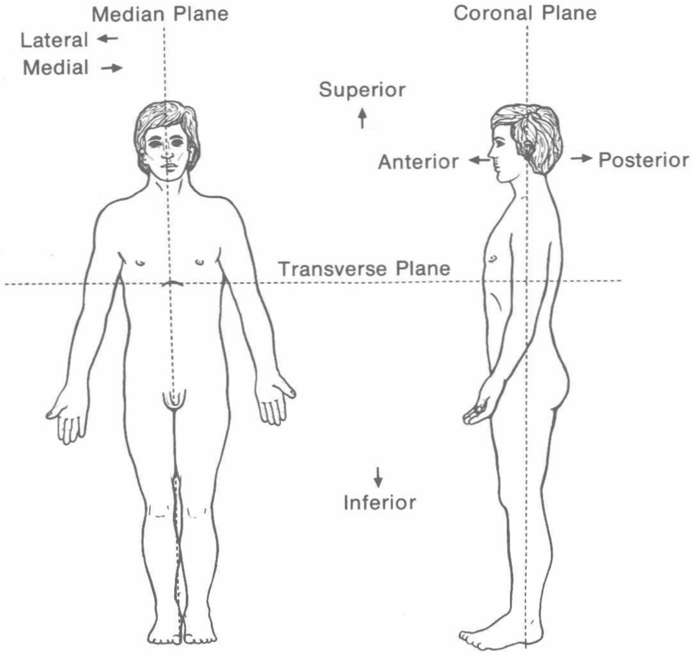

Figure 1–1. Planes of the body.

Anterior	toward the front of the body (also ventral)
Posterior	toward the back of the body (also dorsal)
Superior	toward the top of the head (also cephalic)
Inferior	toward the soles of the feet (also caudal)
Medial	toward the median plane
Lateral	away from the median plane
Proximal	toward the trunk (central)
Distal	away from the trunk (peripheral)
Superficial	toward the skin
Deep	toward the interior of the body
Internal	within a body cavity
External	outside a body cavity
Ipsilateral	on the same side (also homolateral)
Contralateral	on the opposite side

3. SKELETON

CARTILAGE

Cartilage, commonly called gristle, is a specialized supporting connective tissue. It consists of cells (**chondroblasts**, which give rise to **chondrocytes**) contained within a ground substance in the form of a rigid gel. There are no neurovascular elements within cartilage; instead, nutrients diffuse through the ground substance to the enclosed chondrocytes. No calcium salts are present, and, therefore, cartilage does not appear on radiographs. During early development, most of the fetal skeleton is present as cartilage, and most of this is subsequently replaced by bone during fetal and postnatal development.

Types of Cartilage

1. **Hyaline** (Gr. *hyalos* glass) **cartilage** is a bluish-white, translucent structure. Nearly all of the fetal skeleton is formed of it. In the adult, its remnants are
   a. *articular cartilage*, which is smooth and slippery and persists at the ends of cartilaginous bones to line articular surfaces of movable joints;
   b. *costal cartilages*, which persist at the sternal ends of the ribs;
   c. *respiratory cartilages*, consisting of the movable external nose and septum, larynx, trachea, and bronchial tree;
   d. *auditory cartilages*, which include the external auditory meatus and pharyngotympanic tube.

2. **Elastic cartilage** is pliable and yellowish in color because of the presence of elastic fibers. It is found in the external ear and in the epiglottis.

3. **Fibrocartilage** contains proportionately more collagen fibers, which are arranged in a parallel fashion for high tensile strength. It is found in tendon insertions and intervertebral discs (not including the pulpal nucleus).

Growth of Cartilage

Although cartilage is a rigid tissue, its unique structure allows it to grow as most soft tissues do. Growth takes place at two sites: (1) **interstitial**, where the chondrocytes divide within the cartilage, and (2) **appositional**, where a surface perichondrium lays down new layers. Perichondrium consists of a fibrous outer layer and a chondroblastic inner layer.

BONE

Bone, like cartilage, is a living tissue consisting of cells called **osteoblasts**, which give rise to **osteocytes** within an organic framework or matrix.

It is unlike cartilage in that the intercellular matrix becomes calcified for greater rigidity and strength. Calcification, however, prevents diffusion of nutrients, and, therefore, each cell within the matrix must have a *direct vascular supply.*

Because of its rigid structure, *interstitial growth is not possible.* Appositional growth takes place only below the covering periosteal layer of bone. Periosteum consists of a fibrous outer layer and a cellular inner layer of osteoblasts, which lay down the bony matrix.

Functions of Bone

1. **Support.** Bones provide a rigid framework for the body.

2. **Movement.** They act as levers for muscles. Muscle attachments are usually to approximating bones and these are able to move one bone in relation to another.

3. **Protection.** The brain and the thoracic viscera are protected by bone.

4. **Hemopoiesis.** The principal blood cells are formed in the marrow space of bone.

5. **Storage.** Calcium and phosphorus are stored in bone as body reserves.

Classification of Bones by Shape
(Fig. 1–2)

1. **Long bones** (Fig. 1–2*A*) basically are hollow tubes or shafts called **diaphyses**, capped at both ends by knoblike **epiphyses.** A section through a long bone (Fig. 1–3) reveals a number of layers: (a) a *periosteal layer* for appositional growth, (b) a *compact layer* for rigidity, (c) a *cancellous* or spongy layer consisting of trabeculated bone for inner support, (d) a *marrow space* containing blood cell–forming tissues in active red marrow or just plain fat in inactive yellow marrow.

The blood supply to long bones is from three different sources: (a) *Nutrient arteries* pierce the shaft and supply all layers to the marrow cavity within. (b) *Periosteal arteries* supply periosteum and some adjacent compact bone. (c) *Epiphyseal arteries* supply the epiphyses and the adjacent joint structures.

Growth in the length of the long bone takes place at the epiphyseal disc. All long bones, except the clavicle, replace existing cartilaginous models during early skeletal development. Bone replaces the cartilaginous shaft first (**primary center of ossification**). Primary centers are present at birth. The cartilaginous epiphyses are replaced by bone after birth over a period of time (**secondary centers of ossification**).

A cartilaginous plate persists between the primary and secondary centers called an **epiphyseal disc** or **plate** (Fig. 1–3). Cartilage continues to proliferate at these sites and the increase in length of the entire bone takes place in this area. The shape of the bone is maintained by selective apposi-

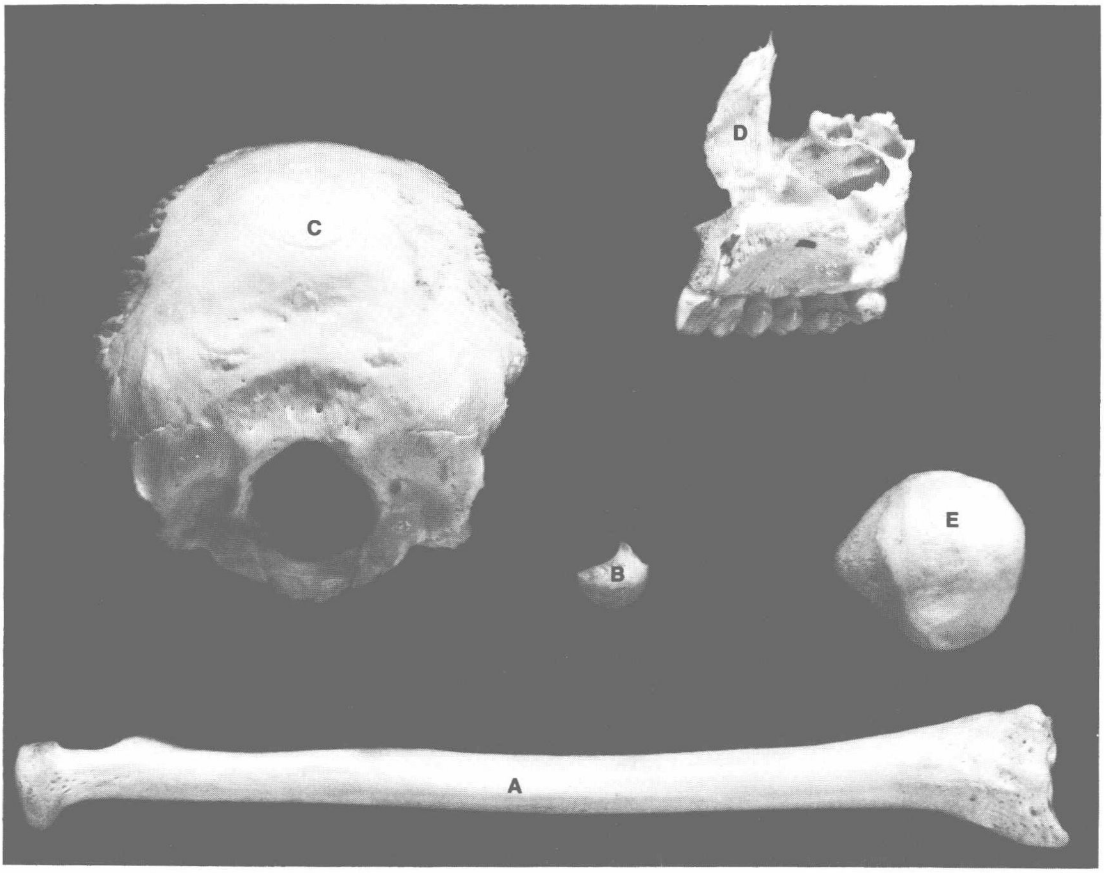

Figure 1–2. Classification of bones by shape. A, Long bone; B, short bone; C, flat bone; D, irregular bone; E, sesamoid bone.

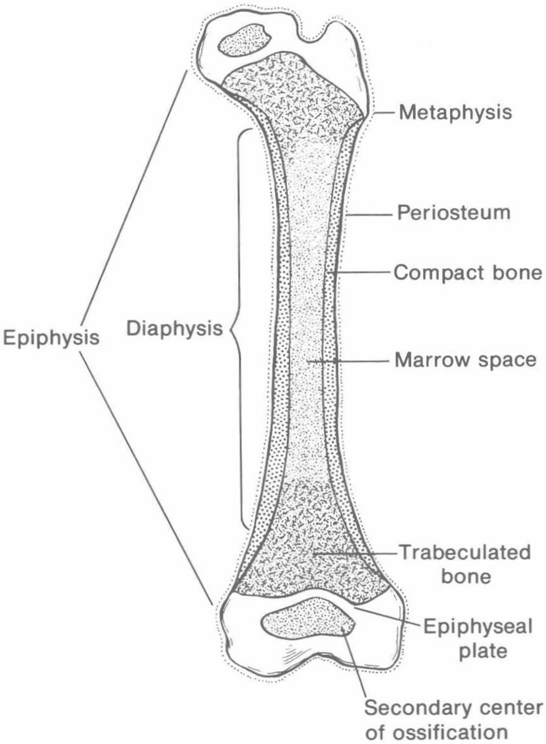

Figure 1–3. Longitudinal section through a young long bone.

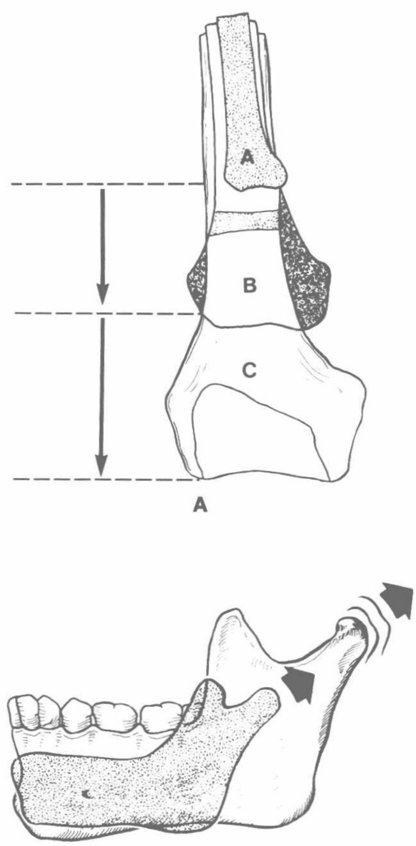

Figure 1–4. Bone remodeling. A, Typical long bone. B, Mandible.

tion and resorption (**bone remodeling**) (Fig. 1–4). During adolescence, two phenomena occur: the growth rate of long bones accelerates, but at the same time hormonal changes cause gradual ossification of the epiphyseal plates. Thus, complete ossification of long bones results in cessation of growth in the adult. Only the articular cartilage at both ends is maintained.

2. **Short bones** (Fig. 1–2*B*) are similar to long bones except they are cuboidal rather than tubular in shape. They are usually six-sided, with cartilage covering the articular surfaces. Short bones consist of the same layered structures as long bones but contain no epiphyses. Short bones make up the skeleton of the wrist and ankle.

3. **Flat bones** (Fig. 1–2*C*) are thin and flat and are found in the vault of the skull, the breast bone or sternum, and the shoulder blade or scapula. They consist of a sandwich, that is, two layers of compact bone encasing a cancellous layer called the diploë.

4. **Irregular bones** (Fig. 1–2*D*) are bones that fit none of the above descriptions. Some irregular bones are mainly cancellous bone covered with only thin layers of compact bone. Others, such as the lacrimal bone, consist only of a single compact layer. Still others, such as the maxilla, are invaded and hollowed by nasal mucosa during development, resulting in pneumatic bones. Pneumatic bones consist of thin compact bone surrounding an air-filled cavity or sinus.

5. **Sesamoid bones** (Gr. *sesamon* like a seed) (Fig. 1–2*E*) are not actually part of the skeleton. They occur rather in some tendons of the hands, feet, and knee where the tendon rubs against bone. The patella or knee cap is a smooth, rounded, sesamoid bone found within the tendon of the quadriceps femoris muscle. Articular cartilage covers the areas in contact with bone.

Classification of Bones by Origin

1. **Endochondral bone** is bone that replaces cartilage. Most of the skeleton during prenatal life is preformed in cartilage. Radiographs of developing skeletons do not reveal cartilage because of the absence of calcium salts. Bone that replaces cartilage, however, is visible on x-ray films because of the deposition of calcium salts. The initial appearance of bone is called an ossification center. All *primary centers* (shafts) have ossified at birth. The *secondary centers* and short bones begin to ossify after birth in a more or less predictable sequence as the child grows. Knowing when these various centers ossify enables us to determine *bone* or *skeletal ages* of children, as we shall see in a subsequent chapter.

2. **Membranous** or **derm bone** is bone that replaces dense membranous tissue. During prenatal life, fibroblasts lay down a fibrous membrane in which some fibroblasts differentiate into osteoblasts. These begin to lay down bone that eventually replaces the membrane. It is important to remember, however, that once bone is formed there is absolutely no difference in appearance or properties between endochondral and membranous bone. The former replaces cartilage; the latter replaces membrane. The flat bones of the skull are of membranous origin.

Classification of Bones by Region

The following list represents the various bones found normally within the adult human skeleton. During early childhood and late childhood, more bones are present because certain bones have not yet ossified as a single unit, for example, the frontal bone. Occasionally, extra bones exist in adulthood when certain bones fail to fuse.

1. **Axial bones** (Fig. 1–5)

a. *Skull*

Cranial vault and base	7
Face	15
Auditory ossicles	6
Hyoid	1
	29

b. *Vertebrae*

Cervical (neck)	7
Thoracic (chest)	12
Lumbar (abdomen)	5
Sacral (pelvic — fused)	1
Coccygeal (vestigial tail — fused)	1
	26

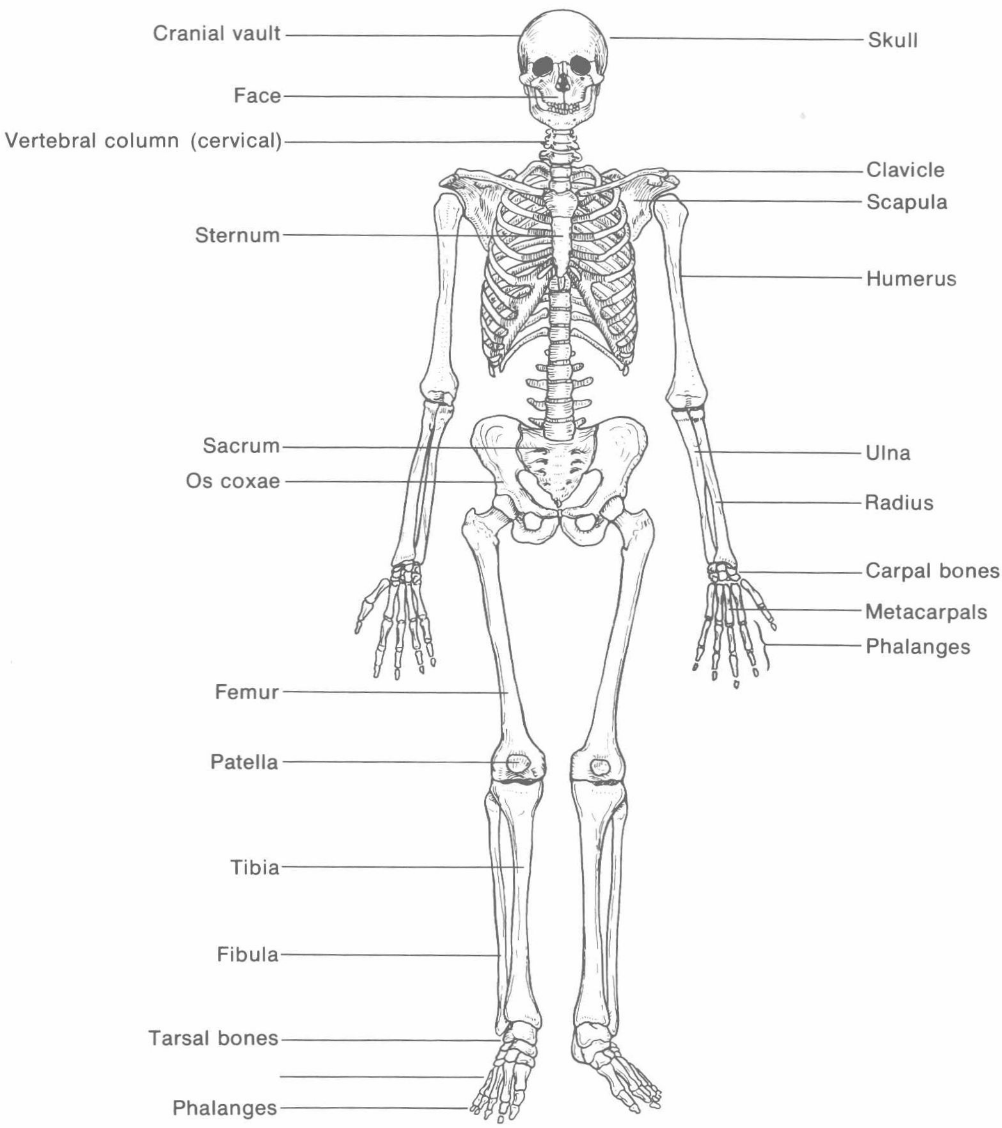

Figure 1–5. The human skeleton.