

Basic Human Anatomy

Lesson 4: Skeletal System

Welcome to Lesson 4 of the Basic Human Anatomy Course. Today, we'll be studying the Human Skeletal System.

I have 13 goals for you in this lesson:

1. Define skeleton.
2. Name four functions of the human skeleton.
3. Name the layers and describe the basic structure of an individual bone, name and describe the parts of an individual long bone, and describe the periosteum and the blood supply of an individual bone.
4. Describe the development of an individual bone.
5. Name four types of bones by shape.
6. Describe major categories used in classification of joints.
7. Name the major parts of a "typical" synovial joint.
8. Name and describe classifications of synovial joints according to the kind of motion and number of axes.
9. Name and define the two major subdivisions of the skeleton.
10. Describe a typical vertebra. Name the regions of the vertebral column and give the number of vertebrae in each region. Describe the intervertebral discs and ligaments that hold vertebrae together.
11. Describe the thoracic cage.
12. Describe the skull.
13. Describe the general pattern of the bones of the upper and lower members.

INTRODUCTION

The skeleton serves as a support or framework of the human body. It is a combination of bones joined together.

FUNCTIONS OF THE HUMAN SKELETON

The human skeleton serves the following functions:

- a. **Bodily Support.** The skeletal system provides a framework for the human body.

- b. **Protection.** The skeleton protects certain soft structures within the human body. An example is the skull, which surrounds the brain.

- c. **Motion.** Muscles are attached to and move the bones. Bones provide leverage for motion.

- d. **Formation of Blood Cells (Hematopoiesis).** Blood cells are manufactured in the red bone marrow, mainly found in flat bones.

PRIMARY STUDY AREAS

In this text, we study the skeletal system from four different viewpoints:

- a. **Bone As Tissues.** This aspect of the human skeletal system was discussed in Lesson 2 and will not be further discussed here.

- b. **Bone As An Individual Organ.** This lesson discusses bone as an individual organ.

- c. **Articulations (Joints)--Arthrology.** This lesson introduces the study of joints, or arthrology.

- d. **The Human Skeleton.** This lesson discusses the human skeleton as a whole in terms of its major subdivisions.

BONE AS AN INDIVIDUAL ORGAN

BASIC STRUCTURE OF AN INDIVIDUAL BONE

See figure 4-1 for the basic structure of an individual bone.

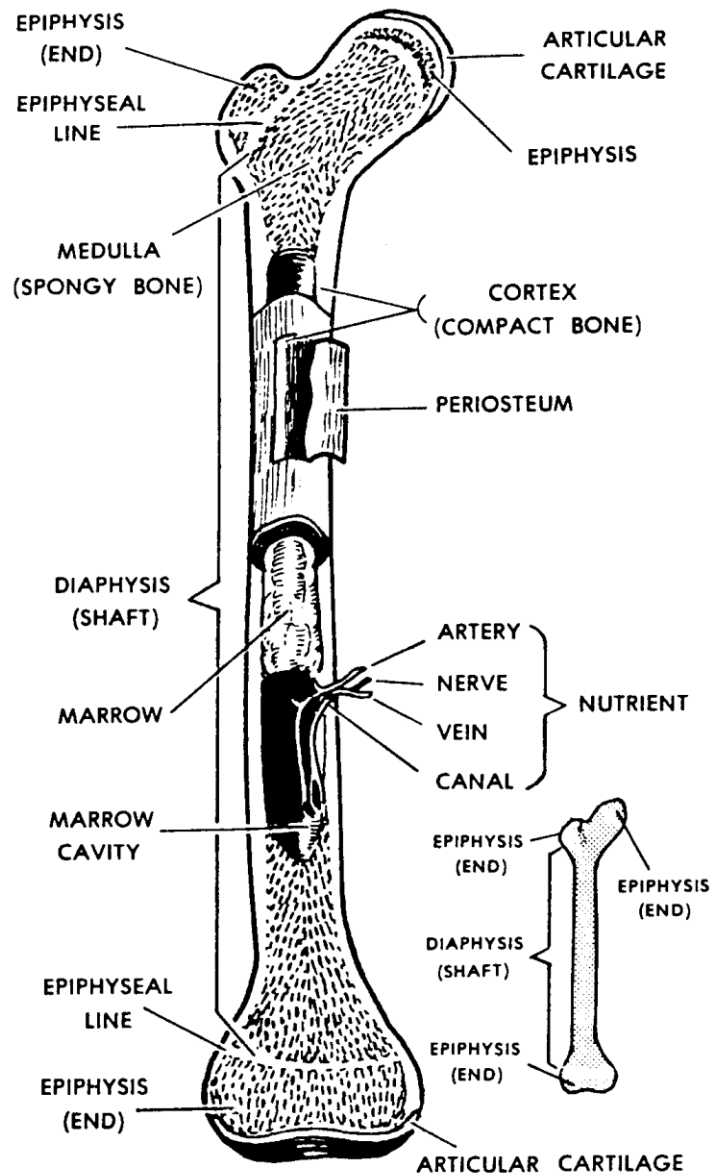


Figure 4-1. A mature long bone (femur).

a. Use of Bony Tissues to Form an Individual Bone.

(1) Cortex. The cortex is the outer layer of the individual bone. It is made up of compact (dense) bony tissue.

(2) Medulla. The medulla is the central portion of the individual bone. It generally consists of cancellous (spongy) bone tissue. In some bones, particularly long bones, the medulla may include a space without any bony tissue. This space is called the medullary or marrow cavity.

b. **Marrow.** Marrow serves as a filler of the inside of bones. There are two types of bone marrow--yellow bone marrow and red bone marrow. Yellow bone marrow is mostly yellow fat tissue. Red bone marrow is the only site in adults for the formation of red blood cells (hematopoiesis).

c. Named Parts of an Individual Long Bone.

(1) Shaft (diaphysis). The shaft is the central portion of a long bone. Here, the cortex is thickened as required by applied physical stresses.

(2) Ends (epiphyses). The ends of long bones are made up mainly of cancellous (spongy) bone tissue. An articular cartilage covers each area where a bone contacts another bone(s). This articular cartilage is made up of hyaline cartilage tissue and provides a smooth surface for motions.

d. **Periosteum.** The periosteum is a covering of the bone surface area not covered by articular cartilage. It has two layers--the innermost layer and the fibrous layer.

(1) The innermost layer, which lies against the outer surface of the bone, consists of bone-forming cells (osteoblasts). It is the osteogenic (bone-forming) layer.

(2) The outermost layer is a FCT (fibrous connective tissue) layer.

(3) The periosteum is well supplied with blood vessels and sensory-type nervous tissue.

e. **Blood Supply of an Individual Bone.** A system of blood vessels enters and spreads out through the periosteum. Additional blood vessels, called "nutrient vessels," penetrate the cortex of the bone and spread out through the marrow. The passageways for penetration of these vessels are called the nutrient canals.

DEVELOPMENT OF AN INDIVIDUAL BONE

a. **General.** The human skeleton is "preformed" in the early fetus, but the early form is not of bony material. There are two types of bones according to their preformed basis: membranous bones and cartilage bones. These are in the location and have the general shape of the adult bones they will later become.

(1) Membranous bones. The outer skull bones are an example of membranous bones. Osteoblasts invade a membrane to form a center of ossification (formation of bone). Bone-forming activity spreads out from this center until a full bone plate is formed.

(2) Cartilage bones. In the fetus, many bones, for example, long bones, exist first as models formed of cartilage.

b. **Sesamoid Bones.** Sesamoid bones are small masses of bone that develop in tendons at points where great forces are applied to the tendons. The most obvious and largest sesamoid bone is the patella, or kneecap.

c. **Ossification Centers.** An ossification center is a growing mass of actual bone within the preformed material, as noted above.

(1) Initial bone formation involves destruction of the preforming material and replacement with bony tissue.

(2) In the development of long bones, there are two types of ossification centers:

(a) Diaphyseal--in the shaft region.

(b) Epiphyseal--in the end(s).

(3) As a long bone grows in length, the preforming material grows faster than the ossification center can tear it down. Ultimately, with time, the preforming material is overcome and growth ceases.

d. **Growth in Bone Width.** A bone grows wider through the activity of the osteogenic layer of the periosteum. Remember, the periosteum covers most of the outer surface of the bone.

TYPES OF BONES

Bones of the skeleton can be grouped into the following major types: long, short, flat, and irregular. Each type has a somewhat different construction pattern.

a. **Long Bones.** The basic structure of a long bone is illustrated in figure 4-1. Example: femur.

b. **Short Bones.** The short bones, such as those of the wrist and feet, have a thin layer of compact bone surrounding an inner mass of spongy bone. Example: carpal bones.

c. **Flat Bones.** The flat bones are constructed with two plates of compact bone, which enclose between them a layer of spongy bone. The spongy bone is richly supplied with blood vessels and red marrow. Example: the cranial frontal bone.

d. **Irregular Bones.** The irregular bones are those that do not fit into the three categories above. Example: a vertebra.

ARTHROLOGY--THE STUDY OF JOINTS (ARTICULATIONS)

DEFINITION

A joint, or articulation, is the location where two or more bones meet.

TYPES OF JOINTS

Joints are classified according to the kind of material holding the bones together and the relative freedom and kind of motion at the particular joint.

a. **Fibrous Joints.** Varying degrees of motion, from none to some, are possible in fibrous joints.

(1) **Syndesmosis.** When the bones are held together by FCT (fibrous connective tissue), the joint is referred to as a syndesmosis.

SYN = together

DESMOS = fiber (a tying material)

Example: The inferior tibio-fibular joint.

(2) Suture. When the bones are quite close together with a minimum of FCT, the joint is known as a suture. Example: the joints between the cranial bones.

b. **Bony Joints.** Should the bones be united by bony material, the joint is referred to as a synostosis.

SYN = together

OSTEO = bone

Example: The frontal bone. (The frontal bone of the skull is actually a bony fusion of two bones. Approximately 10 percent of the time, this fusion fails to take place; the original suture between the bones remains and is called a metopic suture.)

c. **Cartilagenous Joints.** These are also nonmovable joints.

(1) Synchondrosis. A cartilagenous joint in which the bones are held together by hyaline cartilage.

SYN = together

CHONDRO = cartilage

Example: Epiphyseal plate.

(2) Symphysis. A cartilagenous joint in which the bones are held together by a disc of fibrocartilage.

Example: Pubic symphysis.

d. **Synovial Joints.** In the synovial type of joints, the bones move on one another so as to allow various motions of the body parts. The "ovial" part of the name refers to the fact that the fluid substance seen in this type of joint appeared to the old anatomists to be like raw egg white (ovum = egg).

A "TYPICAL" SYNOVIAL JOINT

A "typical" synovial joint is one which has parts common to all of the synovial joints. In a sense, it is imaginary. It is not actually a specific synovial joint. It is a composite. It is illustrated in figure 4-2. The "typical" synovial joint has the following parts:

a. **Bones.** Bones are the levers of motion. They are the site of attachment for skeletal muscles.

b. **Articular Cartilages.** The "contact" points of the bones are usually covered with a layer of lubricated cartilage. Where these cartilages end, the synovial membranes begin. Cartilages provide a smooth surface to reduce friction.

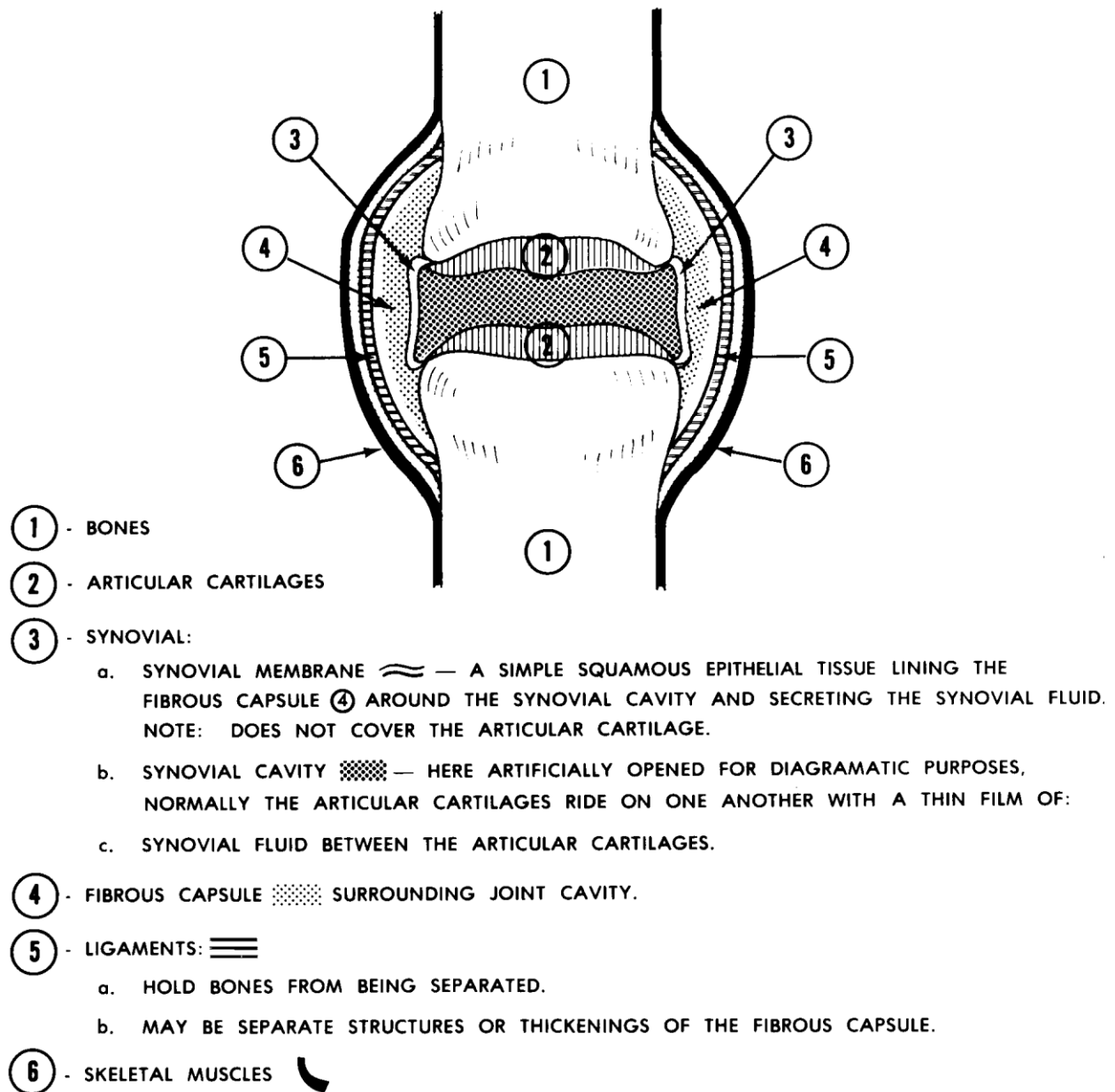


Figure 4-2. A "typical synovial joint:--diagrammatic.

c. Synovial Membrane, Space, and Fluid.

(1) Synovial membrane. The synovial membrane lines the inner surface of the capsule. It secretes synovial fluid into the synovial space.

(2) Synovial space. Figure 4-2 exaggerates the amount of space between the bones. The space within the capsule allows movement.

(3) Synovial fluid. Synovial fluid is a colorless, viscous fluid similar in consistency to raw egg white. It lubricates the articulation.

d. **Capsule.** The "typical" synovial articulation is surrounded by a sleeve of dense FCT known as the capsule. The capsule encloses the articulation.

e. **Ligaments.** Primarily, ligaments hold bones together. Ligaments also may help restrain motion in certain directions and stabilize the articulation.

f. **Muscles.** Skeletal muscles apply the forces to produce a given motion.

NOTE: See table 4-1 for a summary of the structures in a "typical" synovial articulation, the tissues composing each structure, and the actions attributed to each structure.

4-10. CLASSIFICATION OF SYNOVIAL JOINTS

Synovial joints are further classified according to the kind of motion and the number of axes of motions used.

a. Uni-Axial Synovial Joints.

(1) In uni-axial synovial joints, motion occurs in only one plane. The joints of the fingers (interphalangeal) flex and extend in the sagittal plane. These are commonly referred to as hinge joints.

(2) If a single rotatory (rotational) motion occurs around a post-like structure, the joint is a pivot joint. The atlas vertebra rotating around the dens (tooth like projection) of the axis vertebra at the top of the neck (base of the skull) is a pivot joint.

b. Bi-Axial Synovial Joints. In bi-axial synovial joints, motion between the bones occurs in two planes. Here the surface in contact is curved or rounded in two directions.

(1) The proximal phalanx of a finger can flex and extend and move from side to side on the rounded head of the metacarpal bone. This is the MP or metacarpophalangeal joint.

(2) When the two surfaces are curved in directions at right angles to each other, a shape similar to that of a cowboy's saddle is formed. This type of synovial joint is called a saddle joint. In the human body, the saddle joint is located at the base of the thumb.

STRUCTURE	TISSUE(S)	FUNCTION(S)
BONE	BONY	(a) Serves as site of attachment for the skeletal muscles. (b) Serves as lever of motion.
ARTICULAR CARTILAGE	HYALINE CARTILAGE	Serves as smooth surface, over which motion takes place.
FIBROUS CAPSULE	DENSE FCT	Encloses articulation
SYNOVIAL MEMBRANE	SIMPLE SQUAMOUS EPITHELIUM	(a) Lines capsule. (b) Secretes synovial fluid into synovial space.
SYNOVIAL SPACE	-	-Frees articulation for motion.
SYNOVIAL FLUID	SEROUS FLUID	Lubricates articulation
LIGAMENT	(VERY) DENSE FCT	Holds the bones together
SKELETAL MUSCLE	STRIATED MUSCLE FIBERS	Applies force to produce motion

Table 4-1. The tissues and functions of structures of a "typical" synovial articulation.

c. **Multi-Axial Synovial Joints.** In multi-axial joints, motion is possible in all three planes of space.

(1) The ball-and-socket-type synovial joint has the freest motion in all directions. A spherically rounded head (ball-like) fits into a receiving concavity (socket). The hip joint is an example of the ball-and-socket type, with the spherical head of the femur fitting into the cup or socket (acetabulum) of the pelvic bone.

(2) In the plane joint, the contact surfaces of the bones are essentially flat. These flat surfaces slide on one another (also called translatory motion). The acromioclavicular joint of the shoulder region is an example of a plane joint.

THE ARTICULAR DISC

In three of the synovial joints of the human body, a special addition is seen. This addition is known as an articular disc. The joints with articular discs are the temporomandibular joint of the lower jaw, the sternoclavicular joint (at the sternum (breastbone)), and the ulnocarpal joint of the distal end of the forearm.

a. An articular disc is a fibrocartilage plate. It is inserted between the articular surfaces of the bones of a synovial joint. In this way, it divides the synovial space into two spaces.

b. Joints having an articular disc are capable of having several different motions occurring at the same time. Mechanically, there are really two joints together here.

THE HUMAN SKELETON

GENERAL

- a. The human skeleton (figures 4-3A and 4-3B) is a collection of individual bones articulated (joined) together.

- b. The major subdivisions of the skeleton are the axial skeleton and the appendicular skeleton.

THE AXIAL SKELETON

The axial skeleton is the central framework of the human body. It includes the skull, the vertebral column (spine), and the thoracic cage (chest or rib cage).

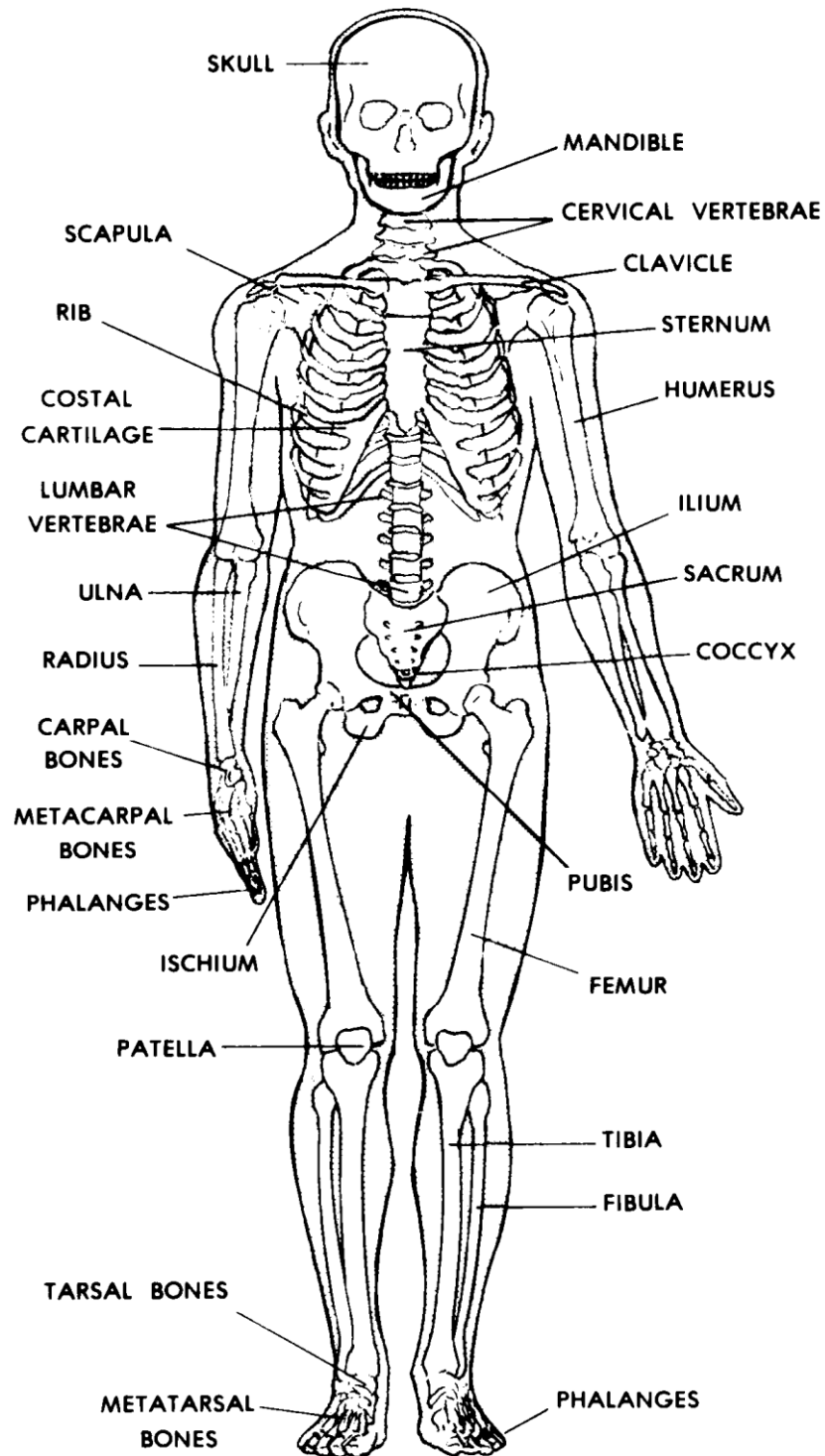


Figure 4-3A. Anterior view of the human skeleton.

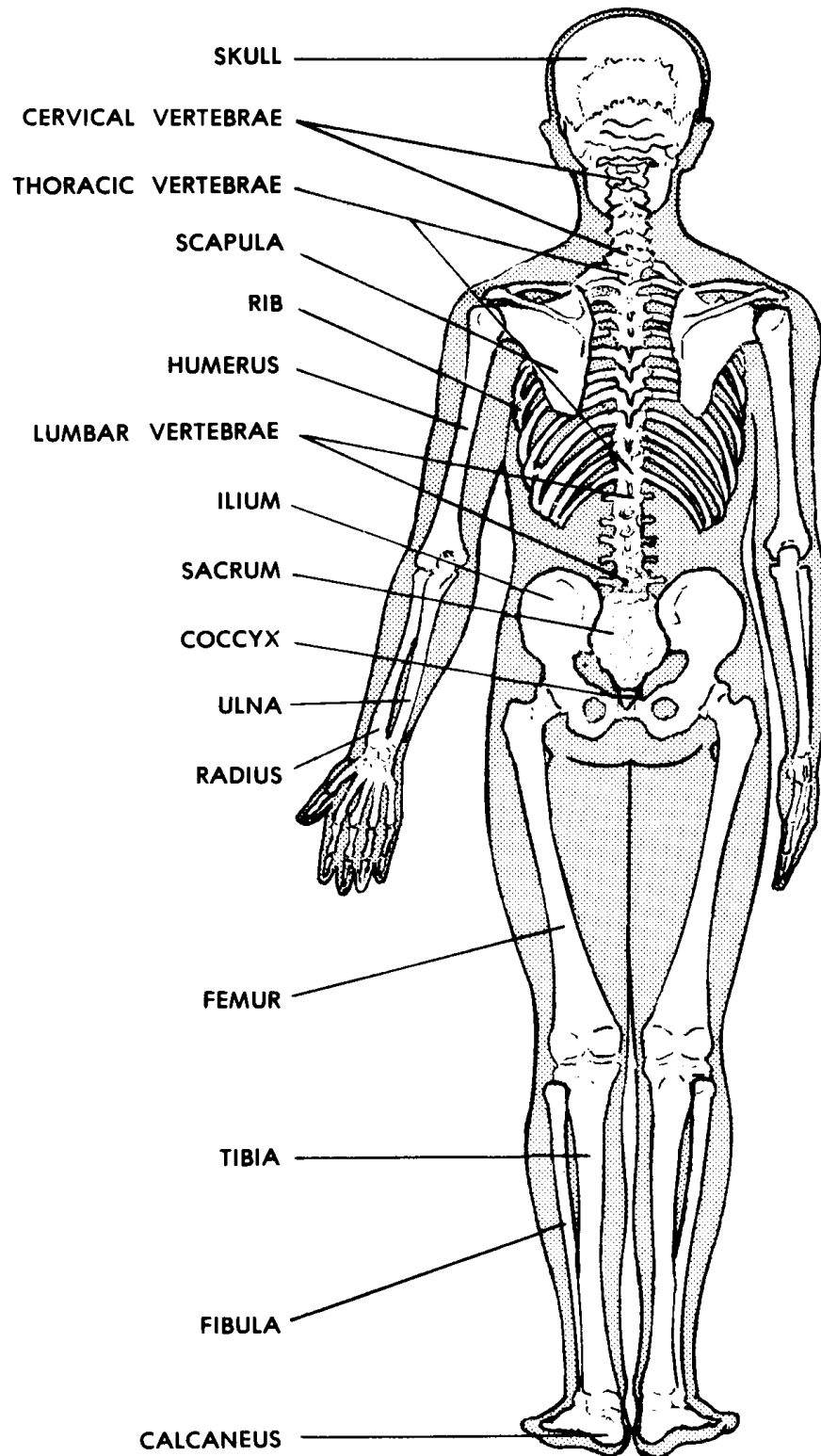


Figure 4-3B. Posterior view of the human skeleton.

a. **Vertebral Column (Spine).** The vertebral column, or spine, is made up of a vertical series of bony blocks called vertebrae. These vertebrae are joined together in such a way as to form a semiflexible rod. The spine is the central support for the trunk, yet allows trunk movements.

(1) Anatomically and functionally, a typical vertebra (figure 4-4) is constructed of two major parts:

(a) The vertebral body is a drum-shaped cylindrical mass. Its superior and inferior surfaces are flat. Its function is primarily weight-bearing.

(b) The neural arch extends posteriorly, arching over and protecting the spinal cord of the central nervous system. From the neural arch are several processes. These processes serve as attachment areas for the trunk muscles. They also act as levers during various trunk motions.

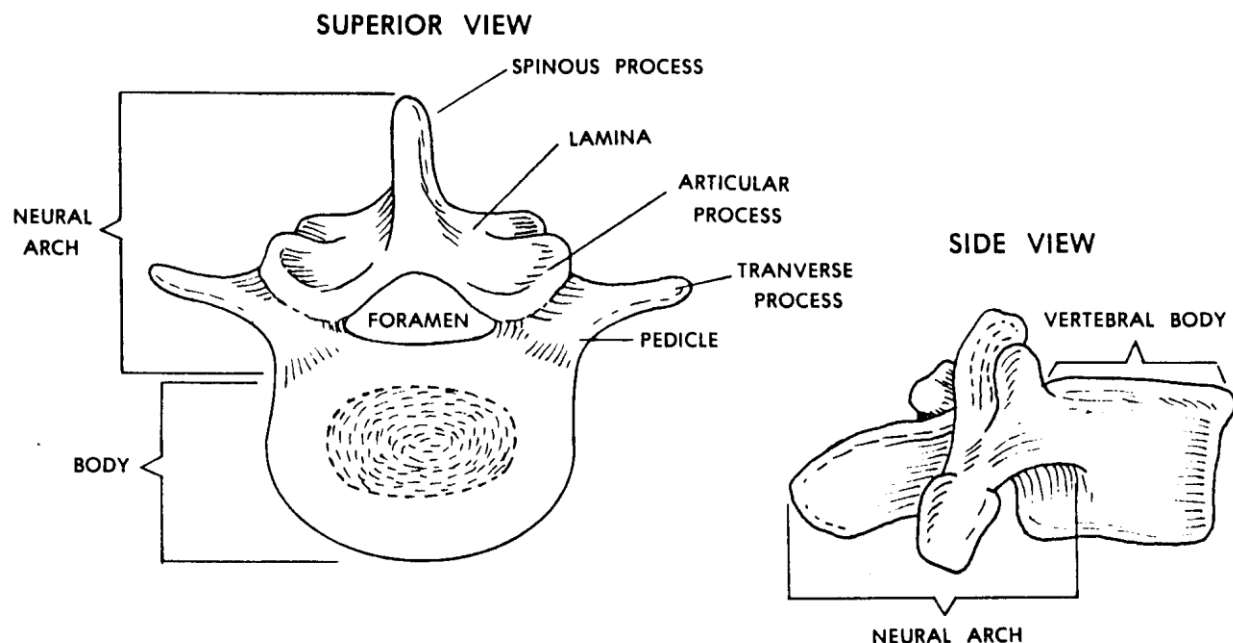


Figure 4-4. A typical vertebra (superior and side views.)

(2) The vertebral column has 32-33 vertebrae, one on top of the other. These vertebrae are arranged in regions. The vertebrae of each region have a characteristic shape. The regions are as follows:

- (a) Cervical (neck) region, with seven cervical vertebrae.
- (b) Thoracic (chest) region, with 12 thoracic vertebrae.
- (c) Lumbar (low back) region with five lumbar vertebrae.
- (d) The sacrum, which is a bony fusion of five sacral vertebrae.
- (e) The coccyx (pronounced COCK-sicks, "tail"), with 3-4 coccygeal vertebrae together.

(3) The vertebrae are held together in two ways:

- (a) The intervertebral disc holds the bodies of adjacent vertebrae together. The intervertebral disc is a fibrous ring with a soft center. This disc allows the vertebral bodies to move on one another. This joint between the vertebral bodies is a plane-type joint.
- (b) The various parts of adjacent vertebrae are held together by ligaments. A ligament is a dense FCT structure which extends from bone to bone. These ligaments extend along the vertebral column from the base of the skull all the way down to the coccyx.

(4) The spine has four curvatures in the adult human. In the cervical (neck) region and the lumbar (low back) region, the spine curves forward. In the thoracic (chest) region and the sacro-coccygeal (pelvic- sacrum and coccyx) region, the spine curves backwards.

(5) When one examines the back of a person by sight and feel (palpation), certain landmarks are observed.

(a) At the upper shoulder region in the midline, a knob can be seen and felt. This is the tip of the spinous process of the seventh cervical vertebra. Since this is the first vertebra from the top that can be easily palpated, this bony landmark is called the vertebra prominens (the "prominent vertebra").

(b) From the vertebra prominens down to the beginning of the sacrum, one can feel the tip of the spinous process of each vertebra.

b. **The Thoracic (Rib) Cage.** The rib cage (figure 4-5) forms a protective enclosure for the vital organs contained within the thorax (chest) such as the heart and lungs. It also allows the movements of breathing to take place.

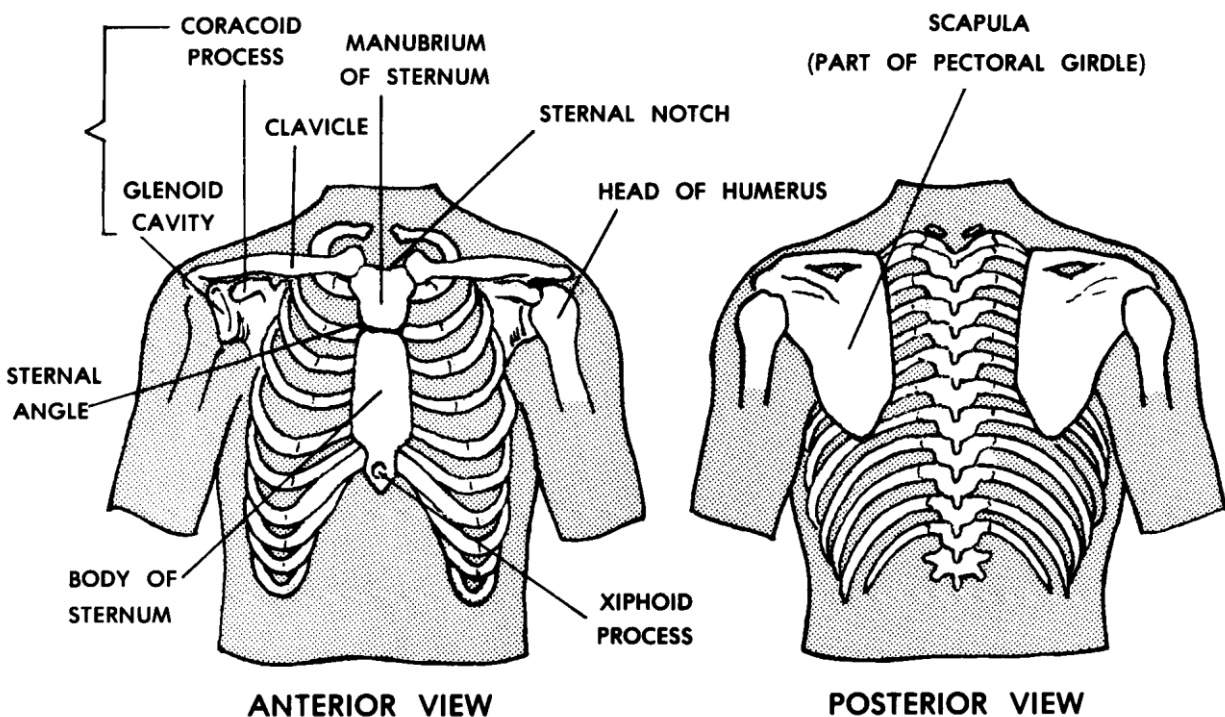


Figure 4-5. The human thorax with bones of the shoulder region.

(1) The sternum lies in the midline of the thorax anteriorly. It is made up of three parts: the manubrium at the top, the body as the main part, and the xiphoid process below. On the top of the manubrium is the jugular (sternal) notch, a common landmark. The junction between the manubrium and the body is a joint called the sternal angle. This sternal angle is an important landmark clinically because the second rib attaches to the sternum at this junction. It is just a matter of simple counting after identifying the second rib to know where you are on the thoracic wall.

(2) The rib cage consists of the 12 thoracic vertebrae, 12 pairs of ribs, and the sternum. Each rib is curved laterally from back to front. All 12 pairs of ribs are attached posteriorly to the thoracic vertebrae. The upper six pairs of ribs are attached directly to the sternum by their costal cartilages. The seventh through tenth pairs of ribs are attached indirectly to the sternum through their costal cartilages (by attaching to the costal cartilage of the rib above). Rib pairs 11 and 12 do not attach to the sternum. Instead, they are embedded in the trunk wall muscles.

c. **The Skull.** The skull (figure 4-6) is the bony framework (skeleton) of the head region. It has two major subdivisions: the cranium which encases and protects the brain and the facial skeleton which is involved with the beginnings of the digestive and respiratory systems. The special sense organs (eyes, ears, etc.) are included and protected within the skull.

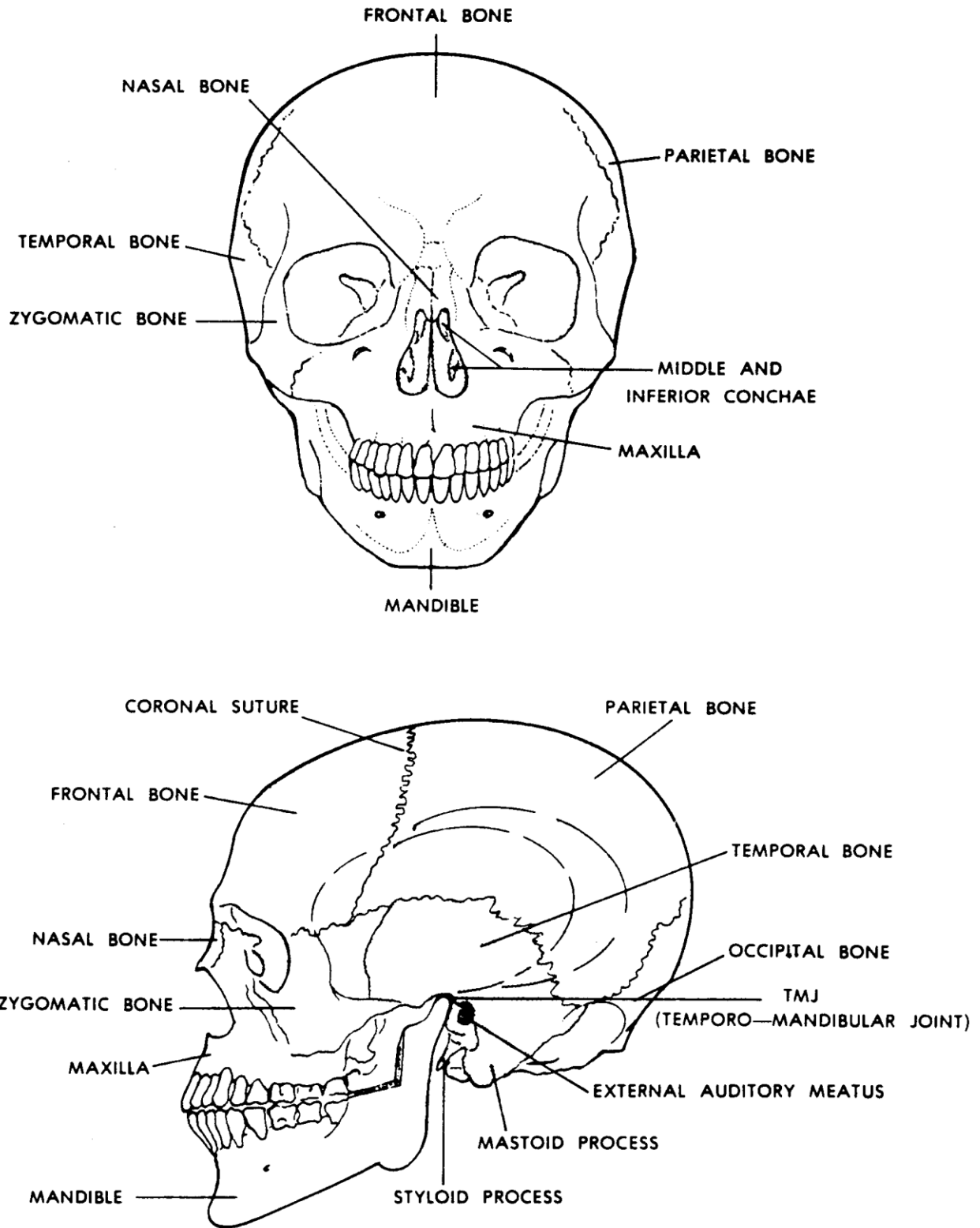


Figure 4-6. The human skull (front and side views).

(1) The bones of the cranium form a spherical case around the brain. With age, the sutures between the cranial bones become more solid. The cranium has a base with several openings for the passage of blood vessels and nerves. The vault (or calvaria) is made up of flat bones arching over and covering the brain.

(2) The facial skeleton consists of bones which surround the nose and the mouth. These are mainly flat and irregular bones. Bones of the facial skeleton also form part of the orbit of each eye.

(3) Certain bones of the skull have air-filled spaces called the paranasal sinuses.

(4) The upper jaw (maxilla) and the lower jaw (mandible) are parts of the facial skeleton which surround the mouth.

(5) The hyoid bone is located at the junction between the head and the neck. It is not articulated directly with the other bones. It is held in place--and moved around--by groups of muscles above and below. The root of the tongue is attached to its upper anterior surface. The larynx is suspended from its inferior surface. These three structures, together, form the hyoid complex. This complex is a functional unit for swallowing.

THE APPENDICULAR SKELETON

a. The appendicular skeleton is made up of the skeletal elements of the upper and lower members (often incorrectly referred to as the "extremities"). These members are appended (attached) to the axial skeleton.

b. The general pattern of construction of the upper and lower members is the same as follows:

(1) Girdle. The girdle is the actual attaching part. It attaches (appends) the limb (the member less the girdle) to the axial skeleton.

(2) Proximal limb segment. The proximal segment of the limb has a single long bone.

(3) Middle limb segment. The middle segment of the limb has two long bones parallel with each other.

(4) Distal limb segment. The distal segment of the limb is made up of many long and short bones. These bones are arranged into a five-rayed pattern--the digits.

c. See table 4-2 for the main bones of the upper and lower members. [Figures 4-7 through 4-13](#) give the main characteristics and details of the bones of the appendicular skeleton.

PART	UPPER MEMBER	LOWER MEMBER
GIRDLE	PECTORAL GIRDLE (CLAVICLE AND SCAPULA)	PELVIC GIRDLE (PELVIC BONE--A FUSION OF ILIUM, PUBIS, AND ISCHIUM)
PROXIMAL SEGMENT	HUMERUS	FEMUR
MIDDLE SEGMENT	RADIUS ULNA	TIBIA FIBULA
DISTAL SEGMENT	CARPUS (8 WRIST BONES) METACARPALS (5) PHALANGES (5 DIGITS)	TARSUS (7 ANKLE BONES) METATARSALS (5) PHALANGES (5 DIGITS)

Table 4-2. Bones of the upper and lower members.

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