

BRS
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Gross Anatomy

NINTH EDITION

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Gross anatomy can be approached through the study of body systems, by regions, or through clinically significant anatomic concepts. **Systemic anatomy** relates structure to function by organ systems, such as the respiratory, digestive, or reproductive systems. **Regional anatomy** is based on regions and deals with all organs and structural and functional relationships in identified parts of the body, such as the thorax and abdomen, with emphasis on skeletal elements, muscles, organs, nerves, and blood vessels. Anatomy is best when reinforced by relating it to clinical medicine, and thus **clinical anatomy** emphasizes the practical application of anatomic knowledge to the solution of clinical problems. Long-term, this has a real pertinence to the practice of medicine. In this introductory chapter, the systemic approach to the study of anatomy is used. In subsequent chapters, the regional and clinical approaches to anatomy are used. Many injuries and diseases involve specific body regions, and most dissections and obviously surgical procedures are performed by region. Thus, clinical correlations are presented throughout the text to reinforce the basic concepts.

SKELETAL SYSTEM

- Consists of the **axial skeleton** (bones of the head, vertebral column, ribs, and sternum) and the **appendicular skeleton** (bones of the extremities).

I. BONES

- Are classified as connective tissue consisting of cells (**osteocytes**) embedded in a matrix of ground substance and collagen fibers in a specific structure that is calcified.
- Bones have a superficial thin layer of **compact bone** around a central mass of **spongy bone**, and internal soft tissue, the **marrow**, where blood progenitor cells are found.
- Serve as a **reservoir** for **calcium** and **phosphorus** in addition to their role as biomechanical **levers** on which muscles act to produce the movements at joints.
- Are classified into long, short, flat, irregular, and sesamoid bones.
- According to their developmental history, they are also categorized into endochondral and membranous bones.

A. Long bones

- Include the humerus, radius, ulna, femur, tibia, fibula, metacarpals, and phalanges.
- Develop by replacement of hyaline cartilage plate (**endochondral ossification**).
- Have a shaft (**diaphysis**) and two ends (**epiphyses**). The **metaphysis** is a part of the diaphysis adjacent to the epiphyses.

1. Diaphysis

- Forms the **shaft** (central region) and is composed of a thick tube of **compact bone** that encloses the **marrow cavity**.

2. Metaphysis

- Is the broadened region of the diaphysis adjacent to the epiphysis. Growth plates are located between the metaphysis and epiphysis during bone development.

3. Epiphyses

- Are **expanded articular ends**, separated from the shaft by the epiphyseal plate during bone growth and composed of a **spongy bone** surrounded by a thin layer of **compact bone**.

B. Short bones

- Include the carpal and tarsal bones and are approximately cuboid shaped.
- Are composed of **spongy bone** and **marrow** surrounded by a thin outer layer of **compact bone**.

C. Flat bones

- Include the ribs, sternum, scapulae, and bones of the cranial vault.
- Consist of **two layers of compact bone** enclosing **spongy bone** with a **marrow space (diploë)**.
- Have articular surfaces that are covered with fibrocartilage and grow by the replacement of connective tissue.

D. Irregular bones

- Include bones of mixed shapes, such as bones of the face, vertebrae, and coxa.
- Contain mostly **spongy bone** enveloped by a thin outer layer of **compact bone**.

E. Sesamoid bones

- **Develop** in certain **tendons** and reduce friction on the tendon and shift the mechanical advantage, thus protecting it from excessive wear.
- Are commonly found where certain tendons cross synovial articulations at the ends of long bones in the limbs, as in the wrist (i.e., pisiform) and the knee (i.e., patella).

CLINICAL CORRELATES

Osteoblasts synthesize new bone, and **osteoclasts** function in resorption (break down bone matrix and release calcium and minerals). Bone remodeling is a normal metabolic process and includes both processes. Parathyroid hormone causes mobilization of calcium by promoting bone resorption, whereas calcitonin and bisphosphonates suppress mobilization of calcium from bone. **Osteoid** is the organic matrix of bone prior to calcification.

Osteomyelitis is an infection of the bone with organisms such as *Staphylococcus* or *Streptococcus* (from penetrating trauma), *Salmonella*, or tuberculosis (Pott disease).

Osteomalacia is a gradual softening of a bone caused by mechanical forces or metabolic issues such as failure of the bone to calcify because of lack of vitamin D or renal tubular dysfunction. **Osteopenia** is a decreased calcification of bone or a reduced bone mass caused by inadequate osteoid synthesis. **Osteoporosis** is an age-related disorder characterized by decreased bone mass and increased susceptibility to pathologic fractures (**osteoporosis**) of the hip, vertebra, and wrist. When bone resorption outpaces bone formation during bone remodeling, the bones weaken. Normal bone metabolism is characterized by constant cycles of resorption and formation (remodeling) to maintain the concentration of calcium and phosphate in the extracellular fluid. The pathologic signs of osteoporosis are vertebral compression, loss of body height, development of kyphosis, and hip fracture. **Osteopetrosis** is a disease that makes bones abnormally dense and prone to fracture, because of defective resorption of bone.

II. JOINTS

- Are places of union between two or more bones.
- Are innervated as follows: the nerve supplying a joint also supplies the muscles that move the joint and the skin covering the insertion of such muscles (**Hilton law**).
- Are classified on the basis of their structural features into fibrous, cartilaginous, and synovial types.

A. Fibrous joints (synarthroses)

- Are joined by fibrous tissue, have **no joint cavities**, and permit little movement.
 1. **Sutures**
 - Are connected by fibrous connective tissue, such as the fibrous continuities between the flat bones of the skull.
 2. **Syndesmoses**
 - Are connected by dense fibrous connective tissue.
 - Occur as the inferior tibiofibular syndesmoses and tympanostapedial syndesmoses (between the foot plate of the stapes and the oval window in the middle ear).

B. Cartilaginous joints

- Are united by **cartilage** and have **no joint cavity**.
 1. **Primary cartilaginous joints (synchondroses)**
 - Are united by **hyaline cartilage** and permit little to no movement but allow for growth in length during childhood and adolescence.
 - Include epiphyseal cartilage plates (the union between the epiphysis and the diaphysis of a growing bone) and spheno-occipital and manubriosternal synchondroses.
 2. **Secondary cartilaginous joints (symphyses)**
 - Are joined by **fibrocartilage** and are slightly movable joints.
 - Are all located in the median plane and include the pubic symphysis and the intervertebral disks.

C. Synovial (diarthrodial) joints

- Are found between two separate skeletal elements and permit certain degrees of movement according to the shape of the articulation and/or the type of movement.
- Are characterized by four structural features: joint cavity or space, articular (hyaline) cartilage, synovial membrane, which produces synovial fluid, and articular capsule.
 1. **Plane (gliding) joints**
 - Have flat articular surfaces and allow a simple back-and-forth **gliding** or sliding of one bone over the other.
 - Occur in the proximal tibiofibular, intertarsal, intercarpal, intermetacarpal, carpometacarpal, sternoclavicular, and acromioclavicular joints.
 2. **Hinge (ginglymus) joints**
 - Resemble **door hinges** and allow only flexion and extension.
 - Occur in the elbow, ankle, and interphalangeal joints.
 3. **Pivot (trochoid) joints**
 - Are formed by a central bony pivot turning within a bony ring and allow **only rotation** (movement around a single longitudinal axis).
 - Occur in the superior and inferior radioulnar joints and in the atlantoaxial joint.
 4. **Condylar (ellipsoidal) joints**
 - Have two convex condyles articulating with two concave condyles. (The shape of the articulation is **ellipsoidal**.)
 - Allow flexion and extension and occur in the wrist (radiocarpal), metacarpophalangeal, knee (tibiofemoral), and atlanto-occipital joints.
 5. **Saddle (sellar) joints**
 - Resemble the shape of a horse's **saddle** and allow flexion/extension, abduction/adduction, and circumduction, but no axial rotation.
 - Occur in the carpometacarpal joint of the thumb and between the femur and patella.
 6. **Ball-and-socket (spheroidal or cotyloid) joints**
 - Are formed by the reception of a globular (ball-like) head into a cup-shaped cavity and allow movement in many directions.
 - Allow flexion and extension, abduction and adduction, medial and lateral rotations, and circumduction and occur in the shoulder and hip joints.

CLINICAL CORRELATES

Osteoarthritis is a degenerative joint disease driven by inflammatory mediators produced by bone cells, chondrocytes, and synovial membranes. Osteoarthritis results in the degeneration of the articular cartilage and osseous outgrowth at the synovial margins. There are a number of predisposing factors including injury and obesity. It commonly affects the hands, fingers, hips, knees, feet, and spine and is accompanied by pain and stiffness. **Rheumatoid arthritis** is an inflammatory disease driven by immunologic attack primarily of the joints. Antibodies directed at the synovial membranes and articular structures lead to deformities and disability. While no cure is known, there are several disease-modifying options. The most common symptoms are joint swelling, stiffness, and pain. **Gout** is a painful form of crystalline arthritis and is caused by uric acid crystal deposits into joint spaces from the blood. These deposits cause inflammation and pain, heat, redness, stiffness, tenderness, and swelling of the first toe or thumb, characteristically, but can impact other joints as well. **Pseudogout** has similar clinical presentation but is related to calcium crystal deposits usually after chronic injury.

MUSCULAR SYSTEM

I. MUSCLE

- Consists predominantly of **contractile cells**, produces the **movements** of various parts of the body by contraction, and occurs in three types:

A. Skeletal muscle

- Is considered voluntary and has a striated histologic structure to its component myofibrils.
- Makes up approximately 40% of the total body mass and functions to produce movement of the body, generate body heat, and maintain body posture.
- Has two attachments: an **origin**, which is usually defined by a more fixed and proximal attachment, and an **insertion**, which is typically defined as the more movable and distal attachment.
- Is enclosed by fascia, the **epimysium**, which is a thin but tough layer of connective tissue surrounding the entire muscle. Within the muscle, smaller bundles of muscle fibers are surrounded by **perimysium**. Each individual muscle fiber is enclosed by **endomysium**.

CLINICAL CORRELATES

Amyotrophic lateral sclerosis (ALS, or Lou Gehrig disease) is a disease that attacks the motor neurons that control voluntary muscles. The muscles weaken and atrophy. Ultimately, the brain is unable to control voluntary movement of the arms, legs, and body, and patients lose the ability to breath, swallow, and speak. The earliest symptoms may include cramping, twitching, and muscle weakness.

B. Cardiac muscle

- Is striated muscle fibers found in the wall of the heart, the **myocardium**.
- Cardiac muscle contractions are autonomous, but the rate can be modulated by the autonomic nervous system (ANS).
- Includes subendocardial specialized myocardial fibers that form the cardiac **conducting system**.

C. Smooth muscle

- Is involuntary and nonstriated and found in the walls of organs and blood vessels.
- In the walls of hollow organs, smooth muscle is arranged in two layers, **circular** and **longitudinal**, that allow rhythmic contractions called **peristaltic waves** in the walls of the gastrointestinal (GI) tract, uterine tubes, ureters, and other organs.
- Is innervated by the ANS, regulating the size of the lumen of a tubular structure.

II. STRUCTURES ASSOCIATED WITH SKELETAL MUSCLES

A. Tendons

- Are **fibrous bands** of dense connective tissue that **connect muscles to bones** or cartilage.
- Are supplied by sensory fibers extending from muscle nerves.

B. Ligaments

- Are **fibrous bands** that **connect bones to bones** or cartilage (the term is also used for folds of peritoneum serving to support visceral structures).

C. Raphe

- Is a seam of union of symmetrical structures by a fibrous or tendinous band, such as the pterygomandibular, pharyngeal, and scrotal raphes.

D. Aponeuroses

- Are **flat fibrous tendons of attachment** that serve as the means of origin or insertion of a muscle.

E. Retinaculum

- Is a fibrous thickening of the deep fascia that stabilizes tendons and neurovascular structures as they cross a joint in the distal limbs.

F. Bursae

- Are fluid-filled **flattened sacs of synovial membrane** that facilitate movement by minimizing friction between a bony joint and the surrounding soft tissue, such as skin, muscles, ligaments.

G. Synovial tendon sheaths

- Are synovial fluid-filled **tubular sacs** around **muscle tendons** that facilitate movement by reducing friction as tendons pass distally into the limbs.

H. Fascia

- Is a **fibrous sheet** that envelops the body under the skin and invests the muscles and may limit the spread of pus and extravasated fluids, such as urine and blood.

1. Superficial fascia

- Is a fatty connective tissue between the dermis and the deep muscular fascia and is considered the hypodermis with fat, cutaneous vessels, nerves, lymphatics, and glands. In a few locations, there may be a **membranous deep layer of superficial fascia (abdominal wall)**.

2. Deep fascia

- Is a sheet of fibrous tissue that **invests the muscles** and helps support them by serving as an elastic sheath or stocking.
- Provides origins or insertions for muscles, forms fibrous sheaths or retinacula for tendons, and forms potential pathways for spread of infection or extravasation of fluids.

NERVOUS SYSTEM

I. NERVOUS SYSTEM

- Is divided anatomically into the central nervous system (CNS), consisting of the brain and spinal cord, and the peripheral nervous system (PNS), consisting of 12 pairs of cranial nerves and 31 pairs of spinal nerves and their associated ganglia.
- Is divided functionally into the **somatic** nervous system, which controls primarily voluntary activities, and the **visceral (autonomic)** nervous system, which controls primarily involuntary activities.
- Is composed of **neurons** and **neuroglia** (non-neuronal cells such as astrocytes, oligodendrocytes, and microglia) and controls and integrates the body activity.