

At the center of every step, breath, handshake, and turn of the head is a framework that never truly holds still. The skeleton gives the body shape, but shape is only the beginning of its work. It supports body weight, protects delicate organs, produces blood cells, stores minerals, anchors muscles, and creates the mechanical system that makes movement possible. The skull forms a protective chamber around the brain, the vertebral column surrounds the spinal cord, the ribs guard the heart and lungs, and the pelvis supports organs in the lower abdomen. Arms and legs extend that central framework into the world, allowing the body to lift, carry, walk, climb, balance, and work. Even hearing depends partly upon three tiny bones inside each middle ear. The skeletal system includes bones, cartilage, joints, and ligaments, while its work is closely joined with muscles and tendons in what is commonly called the musculoskeletal system.

A bone held in the hand may feel like a dry, solid object, but bone inside the body is an active organ supplied by blood vessels and nerves. Living bone contains cells, water, collagen, minerals, and an organized network of channels. Collagen is a strong but somewhat flexible protein that helps bone resist pulling and twisting. Minerals, primarily calcium and phosphate arranged in crystals called hydroxyapatite, provide hardness and resistance against compression. If bone contained mineral without collagen, it would be hard but unusually brittle; if it contained collagen without mineral, it would bend too easily. Strength comes from the combination, much as reinforced concrete depends upon both the concrete and the material supporting it from within. Bone is engineered to carry weight without becoming so heavy that movement becomes impossible.

That living structure is maintained by several specialized cells. Osteoblasts build bone by producing a soft protein framework called osteoid, which later becomes mineralized. Osteoclasts remove old, weakened, or unnecessary bone through a process called resorption. Osteocytes are mature bone cells that live inside the material and sense mechanical forces passing through it. They help direct where bone should be removed, strengthened, or left alone. Osteoprogenitor cells are immature cells capable of developing into osteoblasts when growth or repair is needed. These cells turn the skeleton into an active construction site where demolition and rebuilding are carefully connected.

The ongoing replacement of old bone with new bone is called remodeling. Small areas of bone accumulate microscopic damage during ordinary movement, and remodeling helps replace those areas before they become larger failures. Osteoclasts first remove a section, osteoblasts fill the space with new material, and osteocytes help coordinate the response according to mechanical demand. In childhood and adolescence, formation generally exceeds removal because the skeleton is becoming larger and denser. In healthy young adulthood, removal and replacement become more balanced. Later in life, illness, inactivity, hormonal changes, nutrition, and certain medications can cause removal to exceed replacement, gradually reducing bone strength. The [National Institute of Arthritis and Musculoskeletal and Skin Diseases](#) describes bone as living tissue that changes continually through this remodeling process.

Long before remodeling maintains an adult skeleton, the body must build one. Early in development, much of the future framework consists of softer connective tissue and cartilage rather than fully mineralized bone. Ossification is the process through which bone tissue is formed. Some flat bones, including portions of the skull, develop through intramembranous ossification, in which bone forms more directly within sheets of primitive connective tissue. Most long bones develop through endochondral ossification, in which a cartilage model is gradually replaced by bone. Cartilage provides the initial shape, blood vessels enter, bone-forming cells arrive, and mineralized tissue expands through the developing structure.

This early design explains why a baby has more separate bones than an adult. Infants commonly begin with roughly 270 bones, while most adults have about 206, though the number can vary slightly among individuals. The number decreases because separate pieces fuse during growth. Several bones of the skull join more firmly, parts of the pelvis unite, and vertebrae at the bottom of the spine fuse into the sacrum and coccyx. Fusion does not mean bones have disappeared; smaller components have become one larger structure. The changing count shows that the skeleton is assembled over time rather than delivered in its finished adult form.

Lengthening occurs at growth plates near the ends of developing long bones. A growth plate, also called an epiphyseal plate, is a layer of cartilage where cells multiply, enlarge, and are gradually replaced by bone. New cartilage pushes the end of the bone farther from the shaft, while ossification converts older cartilage into mineralized tissue. Growth hormone, thyroid hormone, nutrition, insulin-like growth factors, and sex hormones all influence this process. During puberty, sex hormones first help produce a growth spurt and later contribute to closing the plates. Once the plates have closed, the long bones can no longer lengthen through ordinary growth.

Bones can still change after height growth ends. They may become thicker through appositional growth, which adds tissue along the outer surface while internal tissue is adjusted to prevent the bone from becoming unnecessarily heavy. Mechanical force influences this design. Regular loading from walking, jumping, resistance training, or physical work tells bone cells that additional strength may be useful. Prolonged inactivity, paralysis, bed rest, or weightlessness removes some of that signal, allowing bone loss to accelerate. The skeleton responds to the life being placed upon it.

A long bone such as the femur provides a useful look at large-scale bone architecture. The shaft is called the diaphysis, while the expanded ends are called epiphyses. Between the shaft and each end lies the metaphysis, the region that contains the growth plate during childhood. A tough membrane called the periosteum covers most of the outer surface and contains blood vessels, nerves, and cells involved in growth and repair. The periosteum is highly sensitive, which helps explain why an injury striking the bone can be extremely painful. Where bones meet inside a movable joint, smooth articular cartilage covers the ends instead of periosteum, reducing friction and distributing force.

Beneath that outer covering lies cortical bone, also called compact bone. It forms the dense shell that gives a bone much of its resistance to bending, twisting, and compression. Deeper inside is trabecular bone, also called spongy or cancellous bone, arranged as a lattice of thin plates and rods called trabeculae. The open spaces make the skeleton lighter and provide room for marrow and blood vessels. Trabeculae are not arranged randomly; many line up with the directions from which force commonly arrives. The hip, vertebrae, ends of long bones, and other heavily loaded regions use this internal framework to spread pressure efficiently.

Looking closer reveals another level of organization. Much of compact bone is arranged into cylindrical units called osteons, or Haversian systems. Each osteon contains rings of mineralized tissue called lamellae surrounding a central channel carrying small blood vessels and nerves. Osteocytes occupy tiny spaces called lacunae between the rings. Microscopic passages called canaliculi connect the cells, allowing nutrients, waste products, and signals to move through material that otherwise appears solid. Spongy bone uses thin trabeculae rather than the same tightly packed cylindrical arrangement. Both designs contain living cells and matrix, but each is organized for its location and mechanical purpose.

The inner cavity of many bones contains marrow. Red bone marrow performs hematopoiesis, the production of blood cells. It generates red blood cells that carry oxygen, several types of white blood cells involved in immunity, and platelets that help stop bleeding. In adults, active red marrow is concentrated mainly in the pelvis, vertebrae, ribs, sternum, skull, and the upper ends of certain long bones. Yellow marrow contains more fat and serves partly as an energy reserve. The skeleton therefore participates in circulation and immunity even though it is usually remembered only for support and movement.

Mineral storage creates another relationship with the rest of the body. Most of the body's calcium is held in the skeleton, but calcium is also required for muscle contraction, nerve signaling, blood clotting, and normal heart function. When blood calcium falls, parathyroid hormone helps raise it by influencing bone, kidneys, and vitamin D activity. Vitamin D helps the intestine absorb calcium and phosphate from food. The body protects blood calcium because the heart and nervous system need it immediately, even if maintaining that level requires drawing mineral from bone. A normal blood-calcium result therefore does not automatically prove that bone stores are strong.

The adult skeleton is organized into axial and appendicular divisions. "Axial" refers to the central axis of the body and includes the skull, vertebral column, ribs, sternum, hyoid bone, and tiny auditory bones of the middle ears. These structures provide central support and protect the brain, spinal cord, heart, lungs, and important parts of the airway. The appendicular skeleton includes the shoulder girdles, arms, hands, pelvic girdle, legs, and feet. "Appendicular" refers to the appendages, or limbs, attached to the central axis. Of the commonly counted 206 adult bones, 80 belong to the axial division and 126 to the appendicular division.

The skull is a fitted structure made from multiple bones rather than one solid piece. Cranial bones enclose the brain, while facial bones shape the eye sockets, nasal passages, cheekbones, jaws, and other features. Most skull bones meet at immovable or slightly movable fibrous joints called sutures. In an infant, wider soft areas called fontanelles allow the skull to change shape during birth and leave room for rapid brain growth. These areas gradually close as bone development continues. The lower jaw, or mandible, remains movable because speaking and chewing require motion.

Teeth sit within the jaws but are not bones. Their outer enamel is harder than bone, while deeper dentin and pulp give each tooth a different structure and method of repair. A broken bone can often heal through living bone cells and blood supply; tooth enamel cannot rebuild itself in the same way. The jaws nevertheless respond to the forces created by teeth, chewing, and dental changes. When a tooth is lost, the surrounding jawbone may gradually shrink because it no longer receives the same mechanical stimulation. Structure is maintained partly by use throughout the skeletal system.

Moving downward brings the skull to the vertebral column, which supports the head and trunk while protecting the spinal cord. The spine begins with seven cervical vertebrae in the neck, continues through twelve thoracic vertebrae connected with the ribs, and then reaches five larger lumbar vertebrae in the lower back. Below them, five fused vertebrae form the sacrum, and usually four smaller fused segments form the coccyx. The adult spine therefore contains twenty-four individually movable vertebrae plus the sacrum and coccyx. Its natural curves help distribute weight and absorb force rather than leaving the body balanced on a perfectly straight pole.

Between most movable vertebrae are intervertebral discs made from fibrocartilage. Each disc contains a tougher outer ring and a softer, gel-like center that helps distribute pressure. Discs allow controlled motion and prevent the vertebrae from striking directly against each other. A disc can bulge or rupture, and displaced material may irritate nearby spinal nerves, producing pain, numbness, tingling, or weakness along the nerve's path. Disc changes on an image do not always explain a person's pain because many people have age-related changes without symptoms. The spine works through bones, discs, joints, ligaments, muscles, and nerves rather than through vertebrae alone.

The rib cage extends from the thoracic spine and surrounds the chest. Twelve pairs of ribs curve forward, attaching either directly or indirectly to the sternum through cartilage. The first seven pairs are called true ribs because their cartilage attaches directly to the sternum. Ribs eight through ten attach indirectly through the cartilage above them and are called false ribs. The final two pairs are floating ribs because they do not attach to the sternum. Their curved arrangement protects the heart and lungs while remaining flexible enough to expand during breathing.

That central protection connects with the appendicular skeleton through the shoulder and pelvic girdles. The shoulder girdle contains the clavicle, or collarbone, and scapula, or shoulder blade. It permits extraordinary arm mobility, but that freedom makes the

shoulder less inherently stable than the hip. The pelvic girdle transfers upper-body weight into the legs and surrounds portions of the reproductive, urinary, and digestive systems. Each hip bone forms from three regions—the ilium, ischium, and pubis—that fuse during development. The deep hip socket grips the head of the femur more completely than the shallow shoulder socket grips the humerus.

The upper limb begins with the humerus in the arm, continues through the radius and ulna in the forearm, and reaches the wrist and hand. Eight carpal bones form the wrist, five metacarpals form the palm, and fourteen phalanges form the fingers. Each hand contains twenty-seven bones, giving it enough small moving parts for gripping, writing, playing instruments, fastening clothing, and performing delicate work. The thumb's structure allows it to oppose the fingers, meaning it can move across the palm to meet them. That opposition greatly increases the hand's ability to hold and manipulate objects. Skeletal complexity is concentrated where precise movement is required.

The lower limb is built more heavily because it supports and moves body weight. The femur extends from the hip to the knee and is the body's longest and strongest bone. The patella, or kneecap, sits within a tendon and improves the mechanical advantage of the thigh muscles. The tibia carries most of the lower leg's weight, while the thinner fibula contributes to ankle stability and muscle attachment. Seven tarsal bones form the rear and middle foot, five metatarsals form its longer central portion, and fourteen phalanges form the toes. Each foot contains twenty-six bones arranged into arches that distribute force, absorb impact, and help propel the body forward.

Shape helps identify what a bone is designed to do. Long bones are longer than they are wide and act as major supports and levers, though some are relatively small. Short bones, including many wrist and ankle bones, provide stability with limited gliding movement. Flat bones such as the sternum, ribs, skull bones, and scapulae protect organs or provide broad areas for muscle attachment. Irregular bones, including vertebrae and many facial bones, have shapes too complicated for the other categories. Sesamoid bones develop within tendons where they reduce friction or improve mechanical advantage, with the patella being the largest example. Classification follows structure and function rather than simple size.

A skeleton composed of bones alone would protect the body but could not move with useful flexibility. Joints, also called articulations, are places where two or more bones meet. Fibrous joints connect bones with dense connective tissue and permit little or no movement, as seen in most skull sutures. Cartilaginous joints unite bones through cartilage and allow limited motion, as seen between vertebral bodies and at the pubic symphysis. Synovial joints contain a fluid-filled space and permit the greatest movement. Shoulders, hips, knees, elbows, wrists, ankles, and most finger joints belong to this group.

Inside a synovial joint, articular cartilage covers the contacting bone surfaces. A joint capsule surrounds the area, with an outer fibrous layer providing strength and an inner

synovial membrane producing synovial fluid. The fluid lubricates the joint and helps nourish cartilage, which has no direct blood supply of its own. Ligaments connect bone to bone and guide or restrict movement so the joint does not travel too far. Tendons connect muscle to bone, transmitting the pull that creates movement. These structures are commonly confused, but the distinction is straightforward: ligaments stabilize bone relationships, while tendons carry muscle force to bone.

Some joints contain additional structures. Menisci are wedges or pads of fibrocartilage that improve fit and distribute force, with the knee containing a medial and lateral meniscus. Bursae are small fluid-filled sacs positioned where skin, tendons, muscles, or ligaments might otherwise rub against bone. A labrum is a ring of fibrocartilage that deepens a socket, adding stability to joints such as the shoulder and hip. Irritation of a bursa is called bursitis, while damage to a tendon may produce tendinopathy or a tear. Joint pain may therefore begin in cartilage, bone, tendon, ligament, muscle, bursa, synovial tissue, or nearby nerves. The location people point toward does not always identify the structure causing the problem.

Synovial joints are also described by the motion their shapes permit. Hinge joints, including the elbow and portions of the knee and fingers, mainly bend and straighten. Ball-and-socket joints at the shoulder and hip allow movement in several directions, including rotation. Pivot joints allow one bone to rotate around another, as occurs when the head turns near the top of the spine. Saddle joints, including the thumb's base joint, permit movement in two major directions with unusual freedom. Plane joints allow surfaces to glide, while condyloid joints permit bending, straightening, and side-to-side movement without full rotation.

Movement carries its own language because ordinary words can be too vague for anatomy. Flexion decreases the angle at a joint, as when bending the elbow, while extension increases the angle by straightening it. Abduction moves a body part away from the midline, and adduction brings it back toward the midline. Rotation turns a bone around its long axis. Pronation and supination describe forearm movements that turn the palm downward or upward when the elbow is bent. Dorsiflexion raises the front of the foot toward the shin, while plantar flexion points the foot downward as if pressing a gas pedal.

Bones create motion by functioning as levers. A lever is a rigid structure that turns around a fixed point, and in the body the bone acts as the lever while the joint acts as the pivot. Muscle provides force by contracting and pulling through a tendon. Muscles can pull but cannot push, so opposing movements generally require opposing muscle groups. The biceps helps bend the elbow, while the triceps helps straighten it. The skeleton gives muscles firm attachment points and converts shortening muscle fibers into visible movement.

Levers can favor speed, range, or force depending on where the muscle attaches relative to the joint and resistance. Many body levers do not give muscles an advantage in raw

force. Instead, they allow a small amount of muscle shortening to move the hand or foot through a much greater distance and at greater speed. This arrangement means muscles may need to produce forces several times larger than the external weight being moved. Holding a weight in the hand places more demand on the elbow muscles than the weight alone suggests. Joint position therefore changes how difficult the same object feels.

The system's ability to tolerate that force depends upon adaptation and recovery. A sudden load greater than the bone can withstand may produce a fracture, which is a break in the continuity of bone. A closed fracture leaves the skin intact, while an open fracture communicates through a wound and carries a greater infection risk. A displaced fracture has pieces that have moved out of normal alignment, while a nondisplaced fracture remains more closely aligned. A comminuted fracture breaks the bone into several pieces, and a spiral fracture follows a twisting pattern. A stress fracture develops from repeated loading that creates damage faster than remodeling can repair it.

Children may experience greenstick fractures in which the bone bends and breaks incompletely, similar to a young branch. Older adults with weakened vertebrae may develop compression fractures when the bone collapses under pressure. A fragility fracture results from force that would not normally break healthy bone, such as falling from standing height. Fracture pattern, location, blood supply, skin damage, age, general health, and alignment all influence treatment. Some fractures can heal with a cast or brace, while others require reduction, meaning the pieces are returned to proper alignment. Plates, screws, rods, pins, or external frames may be used when greater stability is required.

Healing begins immediately after a fracture tears bone, blood vessels, and surrounding tissue. Blood collects around the break and forms a hematoma, a clot that creates a temporary framework and releases chemical signals. Inflammatory cells remove damaged tissue while new blood vessels begin entering the area. Cells from the periosteum, marrow, and surrounding tissues produce a soft callus made from collagen and cartilage. This callus bridges the broken ends but is not yet strong enough for normal loading. Osteoblasts gradually replace it with a harder mineralized callus of immature bone.

That hard callus is stronger, but it does not yet have the bone's original shape or internal organization. Remodeling continues for months and sometimes years as osteoclasts remove unnecessary material and osteoblasts rebuild along useful lines of force. A healed area may initially appear enlarged before the excess callus is reduced. Proper stability encourages repair, while excessive movement can prevent union. Blood supply is equally important because healing tissue needs oxygen, nutrients, immune cells, and building materials. Smoking, severe diabetes, malnutrition, infection, certain medications, and poor circulation can delay or disrupt the process.

A fractured limb that becomes cold, pale, numb, unusually swollen, or increasingly painful may have impaired circulation or dangerous pressure within the tissues. Bone

visible through a wound, severe deformity, loss of movement, or inability to bear weight after an injury also requires prompt medical evaluation. Suspected neck or spinal injuries should not be handled by casually moving the person because unstable vertebrae may endanger the spinal cord. A joint that has been forced out of position is called a dislocation and should not be pushed back by an untrained person. Damage to nearby nerves and blood vessels can occur even when the skin looks relatively normal. Pain communicates danger, but circulation, sensation, alignment, and function show how serious the injury may be.

Bone disease and joint disease are often mixed together even though they affect different structures. Osteoporosis is a disease in which bone mass, mineral density, quality, or internal architecture has declined enough to increase fracture risk. It usually develops silently and may not cause pain until a vertebra, hip, wrist, or other bone fractures. Osteopenia means bone density is below the expected healthy range but has not reached the measurement used to define osteoporosis. A bone mineral density test, commonly performed with a low-dose X-ray method called DXA or DEXA, estimates density at important fracture sites. Density is one major part of strength, but age, previous fractures, medications, falls, and other health conditions also affect risk.

Osteoarthritis is different because it primarily affects the entire joint, including cartilage, bone, and surrounding tissues. Cartilage may break down, the underlying bone may change, and the joint can become painful, stiff, enlarged, or less mobile. Rheumatoid arthritis follows another path: it is an autoimmune disease in which the immune system attacks joint lining and creates persistent inflammation. Osteoporosis, osteoarthritis, and rheumatoid arthritis can occur in the same person, but they are not interchangeable names. One weakens bone, one involves progressive joint-tissue breakdown, and one begins with immune-driven inflammation. Accurate language matters because prevention and treatment differ.

Mineralization problems create additional conditions. Rickets occurs in growing children when developing bone does not mineralize properly, potentially producing bowed legs, delayed growth, bone pain, or skeletal deformity. Osteomalacia is the related failure of proper mineralization in adults, whose growth plates have already closed. Vitamin D deficiency is one possible cause, but kidney disease, intestinal absorption problems, liver disease, and certain medications can also interfere with mineral balance. Osteogenesis imperfecta is a group of genetic disorders affecting collagen and bone strength, sometimes causing repeated fractures from childhood. Paget disease produces excessive and disorganized remodeling, creating bone that may become enlarged yet structurally unsound.

Spinal conditions also show how shape affects function. Scoliosis is an abnormal side-to-side spinal curve usually accompanied by rotation of the vertebrae. Kyphosis refers to an excessive forward rounding of the upper spine, while lordosis describes an exaggerated inward curve, usually in the lower back. Posture, muscle control, vertebral shape, disc condition, leg length, injury, and disease can influence spinal alignment. A

visible curve does not automatically reveal its cause or severity. Examination and imaging help determine whether a change is flexible, structural, stable, progressive, painful, or threatening nervous-system function.

Aging alters the entire musculoskeletal partnership. Bone removal may gradually exceed formation, joint cartilage may thin, discs lose water, muscles shrink, tendons become less flexible, and balance reactions may slow. Menopause can accelerate bone loss because estrogen normally helps restrain bone resorption, but osteoporosis also affects men. Reduced testosterone, long-term steroid use, low body weight, smoking, heavy alcohol use, kidney disease, digestive disorders, and inactivity can increase risk. Falls become more dangerous when weaker bone and reduced balance occur together. Preventing a hip fracture may require strengthening bone, improving vision, reviewing medications, training balance, and removing hazards from the home.

Nutrition supplies raw materials, but no single nutrient builds the skeleton alone. Calcium contributes to mineral strength, vitamin D supports calcium absorption, and protein supplies amino acids needed for collagen and muscle. Magnesium, phosphorus, vitamin K, and other nutrients participate in bone metabolism as part of an adequate overall diet. When dietary calcium is consistently insufficient, the body can withdraw calcium from bone to protect blood levels needed by nerves, muscles, and the heart. Excessive supplements are not automatically better and may create problems for some people. Needs vary with age, pregnancy, kidney function, medications, diet, and medical history.

Movement provides the mechanical signal that nutrition alone cannot supply. Weight-bearing activity means working against gravity while the feet or other body parts support weight, as in walking, stair climbing, dancing, jogging, or racket sports. Resistance exercise requires muscles to pull against weights, bands, machines, or body weight, placing useful force on their bony attachments. Balance training reduces the chance of falling, which becomes as important as density when fracture risk rises. Swimming and cycling support fitness and joint movement but usually provide less direct bone-loading stimulus than weight-bearing activities. A varied program can strengthen bone, muscle, coordination, and confidence together.

The safest exercise depends upon the skeleton already present. A healthy young person may benefit from impact and progressive resistance that would be unsafe for someone with severe osteoporosis or an unhealed fracture. A person with fragile vertebrae may need to avoid forceful spinal bending, twisting, or high-impact activity. Joint disease may make lower-impact movement more tolerable while muscles are strengthened around the affected area. The [NIAMS guidance on bone exercise](#) emphasizes weight-bearing activity, resistance training, and balance work while recognizing that medical limitations require individual adjustment. Exercise protects the skeleton when the challenge is strong enough to stimulate adaptation without exceeding the tissue's present capacity.

The framework supporting the body today is therefore partly a record of earlier life. Childhood nutrition, physical activity, hormones, illness, and genetics influence how much bone is accumulated before peak bone mass is reached, usually during the twenties. Adult habits influence how much of that reserve is maintained, while aging changes the balance between removal and replacement. Every movement sends force through cartilage, joints, tendons, ligaments, compact bone, trabeculae, and marrow. Every fracture activates cells that remember how bone was first built during development. The skeleton carries the body, protects its organs, produces its blood, stores essential minerals, and continually revises its own structure according to the demands placed upon it.