

CHAPTER 11

SKELETAL SYSTEM

LEARNING OUTCOMES

11.1 Overview of the Skeletal System

1. State the functions of the skeletal system.
2. Describe the structure of a long bone and list the types of tissues it contains.
3. List the three types of cartilage found in the body and provide a function for each.

11.2 Bones of the Axial Skeleton

1. Identify the bones of the skull, hyoid, vertebral column, and rib cage.
2. Identify the regions of the vertebral column.
3. Explain the function of the sinuses and intervertebral disks in relation to the axial skeleton.

11.3 Bones of the Appendicular Skeleton

1. Identify the bones of the pelvic and pectoral girdles.
2. Identify the bones of the upper and lower limbs.

11.4 Articulations

1. List the three types of joints that connect bones.
2. Describe the structure and operation of a synovial joint.
3. Summarize the types of movement that are made possible by a synovial joint.

11.5 Bone Growth and Homeostasis

1. Summarize the process of ossification and list the types of cells involved.
2. Describe the process of bone remodeling.
3. Explain the steps in the repair of bone.

EXTENDED LECTURE OUTLINE

11.1 Overview of the Skeletal System

The skeleton system consists of two types of connective tissue: bone and the cartilage and ligaments found at joints.

Functions of the Skeleton

The skeleton supports the body, protects soft body parts, produces blood cells, stores minerals and fat, and along with the muscles permits flexible body movement.

Anatomy of a Long Bone

The shaft of a bone is called the diaphysis. It has a large medullary cavity whose walls are composed of compact bone. The expanded region at the end of a long bone is called an epiphysis. The epiphyses are composed largely of spongy bone that contains red bone marrow. A long bone is covered by the periosteum except for the articular cartilage on its ends.

Bone

Compact bone is made up of osteons, lacunae in concentric circles around a central canal.

Canaliculi run through the matrix of bone, connecting lacunae and central canals. Spongy bone contains plates called trabeculae, the spaces of which are filled with red bone marrow for blood cell production. Bone cells are osteocytes.

Cartilage

Cartilage is weaker and more flexible than bone, and is slower to heal because of its lack of direct blood supply. Hyaline cartilage has a matrix made of collagen and is found at the ends of long bones and in the nose and trachea. Stronger fibrocartilage has thick rows of collagen fibers and is able to tolerate pressure and tension. Flexible elastic cartilage contains mostly elastin fibers and is found in the external ear and epiglottis. Chondrocytes are cartilage cells that lie within lacunae.

Fibrous Connective Tissue

Fibrous connective tissue contains fibroblasts with collagenous fibers and makes up the ligaments that attach bone to bone

11.2 Bones of the Axial Skeleton

The axial skeleton lies in the midline of the body and consists of the skull, hyoid bone, vertebral column, and rib cage.

The Skull

The skull is formed by the cranium and the facial bones.

The Cranium

The cranium is made up of eight bones that are incompletely fused in infants, leaving soft spots, or fontanels. Sinuses are found in the cranium. They reduce the weight of the skull and give resonance to the voice. The major bones of the cranium include the frontal bone, two parietal bones, an occipital bone housing the foramen magnum, two temporal bones, a sphenoid bone, and an ethmoid bone. The sphenoid bone makes up the floor of the cranium. The ethmoid bone helps form the orbits and the nasal septum. In newborns, these bones are joined by fontanels.

The Facial Bones

The frontal bone of the skull forms the forehead of the face. The lower jaw is made up of the mandible. Zygomatic bones make up the cheekbones, and maxillae form the upper jaw. Two nasal bones form the bridge of the nose.

The Hyoid Bone

The hyoid bone is located superior to the larynx, anchors the tongue, and serves as a point of attachment for muscles used in swallowing.

The Vertebral Column

The vertebral column supports the head and trunk, protects the spinal cord and nerves, and is a site for muscle attachments. Each vertebra has facets that articulate with each other and spinous processes that project toward the back. Scoliosis is an abnormal (sideways) curvature of the spine.

Types of Vertebrae

Cervical vertebrae are in the neck region and include the atlas and axis. Thoracic vertebrae are in the upper back and have an extra facet for rib attachment. Thick lumbar vertebrae are in the lower back. Five sacral vertebrae fuse to form the sacrum. The coccyx, or tailbone, composed of four fused vertebrae, is at the base of the vertebral column.

Intervertebral Disks

Intervertebral disks, formed of fibrocartilage, provide padding between vertebrae. These disks become weak with age and can herniate and rupture.

The Rib Cage

The rib cage is composed of the thoracic vertebrae, the ribs and their cartilages, and the sternum.

The Ribs

The 12 pairs of ribs all connect to the thoracic vertebrae. The upper seven pairs of ribs connect to the sternum via costal cartilage. The lower two pairs of ribs are “floating ribs” because they are not attached to the sternum.

The Sternum

The sternum (breastbone) lies in the midline of the body and protects the heart and lungs. It is made of the manubrium, the body, and the xiphoid process. The heart is located between the fifth and sixth ribs.

11.3 Bones of the Appendicular Skeleton

The appendicular skeleton consists of the pectoral and pelvic girdles, and their attached limbs.

The Pectoral Girdle and Upper Limb

The body has left and right pectoral girdles. The pectoral girdle consists of the scapula (shoulder blade), and the clavicle (collarbone). The glenoid cavity articulates with the head of the humerus. The humerus is the bone of the upper arm. The radius and ulna make up the lower arm. The hand is made up of eight carpal bones, five metacarpals and the phalanges of the fingers and thumb. An opposable thumb can touch each finger separately or cross the palm to grasp an object.

The Pelvic Girdle and Lower Limb

The pelvic girdle consists of two heavy coxal bones, fused at the sacrum. Each coxal bone is made up of the ilium, ischium, and pubis, all fused at the acetabulum. The male pelvis and the female pelvis differ somewhat due to different functions. The female pelvis is more flared. The thigh contains the femur, and the lower leg is made up of the tibia and fibula. Where the femur articulates with the tibia is the region of the knee and the patella, or kneecap. The ankle contains seven tarsal bones, and five metatarsals make up the arching instep of the foot. The bones of the toes are called phalanges.

11.4 Articulations

Bones are joined at the joints, which are classified as fibrous, cartilaginous, or synovial. Fibrous joints are immovable. Cartilaginous joints are connected by hyaline cartilage and tend to be slightly movable. Synovial joints

are freely movable. In a synovial joint, there is a fibrous joint capsule lined with synovial membrane. Fluid-filled sacs called bursae reduce friction and menisci add stability.

Movements Permitted by Synovial Joints

Synovial joint movements include flexion, extension, abduction, supination, pronation, rotation, circumduction, inversion, and eversion.

11.5 Bone Growth and Homeostasis

The skeleton starts to form at six weeks. Bones grow in length and width through adolescence. Bones are living tissues. Three different cell types are involved in bone growth and repair. Osteoblasts are bone-forming cells. Osteocytes are mature bone cells arising from osteoblasts. Osteoclasts are bone-absorbing cells.

Bone Development and Growth

Ossification refers to the formation of bone.

Intramembranous Ossification

Intramembranous ossification occurs between flat sheets of connective tissue. Osteoblasts lay down bone, forming trabeculae. Compact bone is then laid down over the outside surfaces. Skull bones form this way.

Endochondral Ossification

Most bones form by endochondral ossification, with a hyaline cartilage model filled in with bone. Osteoblasts fill in areas of the center of the cartilage model that have begun to break down. Compact bone is also laid down under the periosteum. Blood vessels bring osteoblasts to the interior and lay down spongy bone. This is the primary ossification center. The epiphyses of long bones continue to grow from a growth plate.

Final Size of the Bones

When the epiphyseal plates close, bones can no longer increase in length. In women this happens at about age 16-18 and in men at about age 20.

Hormones Affect Bone Growth

Vitamin D and growth hormone (GH) affect the growth of the bones. Too little growth hormone in childhood results in dwarfism. Adolescents experience a growth spurt due to increased sex hormones.

Bone Remodeling and Calcium Homeostasis

In adults, the actions of osteoclasts and osteoblasts continually remodel bones. Bone recycling allows the body to regulate the amount of calcium in the blood. Bone remodeling also accounts for why bones can respond to stress. Parathyroid hormone (PTH) stimulates osteoclasts to dissolve the calcium matrix of bone. Calcitonin has the opposite effect. The reduction of estrogen in older women causes osteoporosis.

Bone Repair

About 6 to 8 hours after a fracture, a hematoma (large blood clot) forms at the fracture site. A fibrocartilage callus fills in the break. A bony callus formed by osteoblasts replaces the cartilage and lasts for four months. Osteoclasts eventually remodel the bone, building a new medullary cavity. Fractures are named according to the type of break (e.g., spiral).

Blood Cells Are Produced in Bones

The skeletal bones contain two types of marrow: yellow and red. Fat is stored in yellow marrow as an energy reserve. Red bone marrow is where blood cells are produced, both red and white. White cells defend against pathogens.