

THE SKELETAL SYSTEM
CHAPTER 6

I. Skeleton: Overview

Note: The skeletal system consists of the bones (206-adult) and joints, along with the cartilage and ligaments that occur at joints.
Subdivided into the axial and appendicular skeleton.

A. Functions of the Skeleton

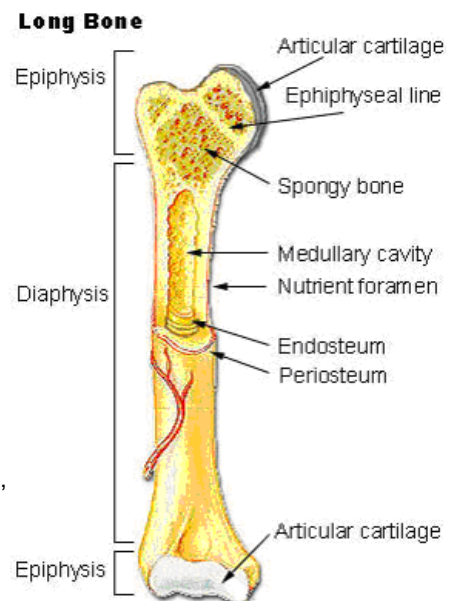
1. The skeleton - notably, the large, heavy bones of the legs - supports the body and its organs against the pull of gravity.
2. The skeleton protects soft body parts.
3. Production of blood cells in both adults and children.
4. Storage area for mineral salts, notably calcium salts.
5. Provide sites for muscle attachment and permit flexible body movement.

Continued from Page 2 B. Anatomy of a Long Bone

7. Spongy bone - or cancellous bone, contains numerous bony bars and plates, called *trabeculae*.
 - a) Red bone marrow - is specialized tissue that produces blood cells in infants, is found in the cavities of most bones.
 - b) Hematopoiesis - red blood cell formation.
 - 1) Occurs in the spongy bone of the skull, ribs, sternum, vertebrae and the ends of the long bones.

B. Anatomy of a Long Bone

1. Periosteum - contains blood vessels that enter the bone and serve its cells.
 - a) Which is continuous with ligaments and tendons that anchor bones.
2. Diaphysis - is the portion between epiphyses.
3. Epiphyses - expanded on both ends of long bones.
4. Medullary Cavity - non-solid area in the diaphysis containing yellow marrow.
 - a) Yellow marrow contains large amounts of fat.
 - b) Is bound at the sides by compact bone, there is a thin shell of compact bone, and finally, a layer of cartilage called articular cartilage.
5. Articular cartilage - named so because here the bone articulates (meets) another bone.
 - a) articulation is the joining together of bone at a joint.
6. Compact bone - or dense bone, contains osteocytes, (bone cells) in tiny chambers called *lacunae*.
 - a) Osteocytes are arranged in a cylinder of concentric layers and lamellae surrounding a single central canal.
 - b) Blood vessels and nerves from the periosteum enters the central canal.



C. Growth and Development

1. Most of the skeleton is cartilaginous during prenatal development - structures are shaped like the future bones and therefore provide "models" of the bones.
2. Cartilaginous models are converted to bone when mineral salts are deposited in the matrix.
3. Osteoblasts - are bone forming cells, which produce osteocytes.
4. Conversion of cartilaginous models to bones is called endochondral ossification
5. Another type of ossification that occurs without previous cartilaginous model that are called intramembranous ossification. (Facial bones and certain cranial bones form in this way)
6. Bone length is dependant on how long the cartilage cells that are within the disks continue to divide, eventually the epiphyseal disk disappear and the bone stops growing as the individual attains adult height.
7. After bone-absorbing cells, called osteoclasts, break down bone, they remove worn out cells and deposit calcium in the blood.

D. Fractures (is a break in a bone)

Can be classified in the following manner

1. *Simple Fracture* - broken bone does not pierce the skin
2. *Compound Fracture* - broken end(s) of the bone break the skin
3. *Complete Fracture* - bone is broken into two pieces
4. *Partial Fracture* - bone is broken longitudinally but not seperated into two parts
5. *Green Stick* - a break in the outer arc of the bone is incomplete
6. *Impacted* - broken ends of the bone are wedged into each other
7. *Comminuted* - bone break into several fragments
8. *Spiral* - due to twisting of the bone, the break is ragged

E. Repair of a fracture

1. Hematoma - (mass of clotted blood) blood escapes from the ruptured blood vessels and forms in the space between the broken bone.
2. Fibrocartilage callus
 - a) Tissue repair begins, and the fibrocartilage now fills the space between the end of the broken bones.
 - b) The collagenous fibers tie the ends of the bone together.
3. Bony callus
 - a) Osteoblasts produce trabeculae of spongy bone and convert the fibrocartilage callus to bony callus that joins the bone together.
4. Remodeling
 - a) Osteoclasts build new compact bone, and reabsorb the spongy bone and build new medullary cavity.

II. Axial Skeleton

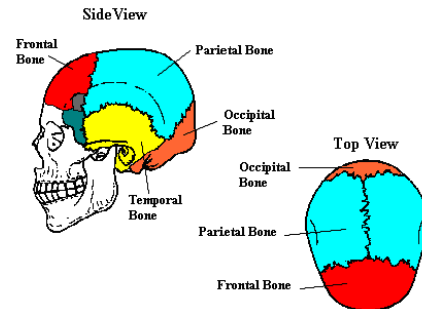
Note: Lies in the midline of the body and contains the bones of the skull, the hyoid bone, the vertebral column, and the thoracic cage. They have protuberances called processes and indentations called depressions and various types of openings.

A. Skull - is formed by the cranium and the facial bones.

1. These bones contains sinuses or air spaces lined by mucus membranes that reduce the weight of the skull and gives the voice a resonant sound.
2. Paranasal sinuses - empty into the nose
3. Others - maxillary, frontal, sphenoidal and ethmoidal
4. Two mastoid sinuses drain into the middle ear
5. Mastoiditis - a condition that can lead to deafness, is an inflammation of these sinuses

B. Cranium - protects the brain and is composed of eight bones.

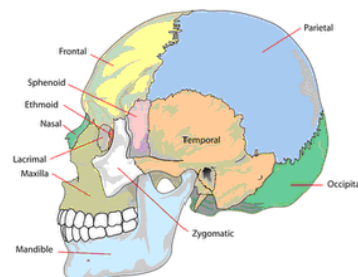
1. The bones are separated by immovable joints called *sutures*.
 - a) *Fontanelles* - membranous regions found in newborns, where more than two bones meet. (this permits the skull to compress during birth)
2. Frontal bone - forms the forehead, a portion of the nose, and the superior portions of the orbits (bony sockets of the eyes)
3. Parietal bone - two bones that are dorsal to the frontal bone (form the roof of the cranium and the sides)
4. Occipital bone - one occipital bone forms the most dorsal part of the skull and the base of the cranium.
 - a) The spinal cord joins the brain through an opening called the *foramen magnum* which is in the occipital bone.
 - b) Occipital condyles are the rounded processes located on either side of the foramen magnum. (articulates with the first vertebra.
5. Temporal bones - the two are located just inferior to the parietal bones, which form the base of the cranium.
 - a) External auditory meatus - a canal that leads to the middle ear.
 - b) Mandibular fossa - articulates with the mandible.
 - c) Mastoid process - provides a place of attachment for certain neck muscles.
 - d) Styloid process - provides a place of attachment for muscles associated with the tongue and larynx.
 - e) Zygomatic process - projects anteriorly and helps form the cheekbone.



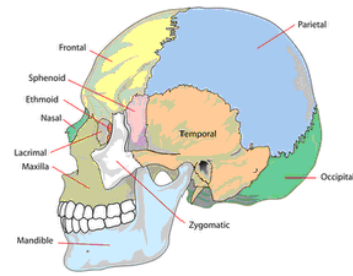
6. Sphenoid Bone- helps form the sides and base of the cranium and the floors, and the sides of the orbits.
 - a) *sellaturcia* - saddle-shaped mid portion, which houses the pituitary gland.
7. Ethmoid Bone- one ethmoid bone forms part of the roof of the nasal cavity.
 - a) *Crista galli* - a triangular process that serves as an attachment for membranes that enclose the brain.
 - b) *Cribriform plate* - serves as passageways for nerve fibers from the olfactory receptors.
 - c) *Perpendicular plate* - projects downward to form the nasal septum.
 - d) *Superior and middle nasal conchae* - projects toward the perpendicular plate.

C. Facial Bones

1. Maxillae- The two maxillae form the upper jaw, and has an alveolar process in which the teeth are located.
 - a) Palatine process - form the anterior portion of the hard palate (roof of the mouth)
 - b) Contribute to the floors of the orbits and sides and floor of the nasal cavity.
2. Palatine Bones- The two make up the posterior portion of the hard palate and floor of the nasal cavity.
 - a) *Cliff Palate* - results when the palatine bones fail to fuse together.
3. Zygomatic Bones- The two form the sides of the orbits and the cheekbones.
4. Lacrimal Bones- are located on the medial walls of the orbits.
 - a) small groove between the orbit and nasal cavity, is a pathway for tubes that carries tears from the eyes to the nose.



5. **Nasal Bones**- small, rectangular bones that form the bridge of the nose. (ventral portion is cartilage)
6. **Vomer Bone**- joins with the perpendicular plate of the ethmoid bone to form the nasal septum.
7. **Inferior Nasal Conchae**- thin, curved bones that project into the nasal cavities, connected to the lateral walls. (support the mucus membranes)



D. **Hyoid Bone** - U-shaped hyoid bone is located superior to the larynx (voice box) in the neck.

1. Only bone that does not articulate with another bone.
2. Suspended by the stylohyoid muscles and ligaments from the stylohyoid processes.
3. It anchors the tongue and the muscles that are responsible for swallowing.
4. **Mandible** - (lower jaw) is the only moveable portion of the skull.
 - a) Forms the chin
 - b) Contains two upright projections called *rami*, each *ramus* serves as a place of attachment for the muscles used for chewing.
 - c) Lower teeth are located on the *alveolar arch* of the mandible.

E. **Vertebral Column (spine)** - extends from the skull to the pelvis.

1. Contains a series of separate bones, called vertebrae, separated by pads of fibrocartilage called *vertebral disk*.
2. The vertebral column is located in the mid-dorsal region and forms the vertical axis.
3. The skull rests on the superior end of the vertebral column, also supports the thoracic cage and a point of attachment of the pelvic girdle.
4. Protects the spinal cord, which passes through the vertebral canal formed by the vertebrae.

5. Thirty-two vertebrae

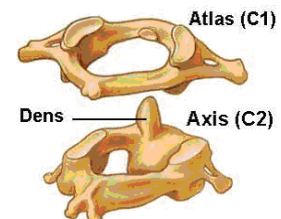
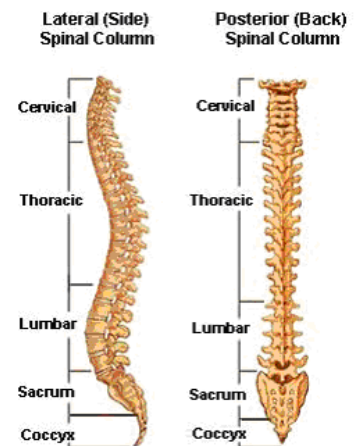
- a) Seven (7) - cervical - Neck
- b) Twelve (12) - thoracic - Chest - Ribs attachment
- c) Five (5) - lumbar - Lower back
- d) Five (5) - sacral - Fused to form the sacrum
- e) Three (3) - coccygeal - Fused into one coccyx

6. Disorders of the vertebrae

- a) **Lordosis** - "swayback" - balancing a heavy mid-section, or pregnant women.
- b) **Kyphosis** - "hunchback" - older people
- c) **Scoliosis** - "twisted disease" - late childhood - side-to-side curvature.

8. Vertebrae

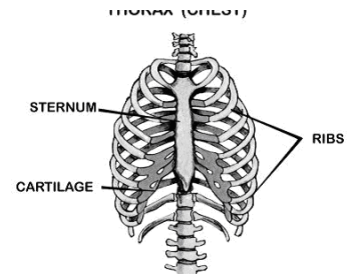
- a) The atlas and axis are the first two cervical vertebrae, which are not typical vertebrae.
- b) Has an anteriorly placed body and a posteriorly placed vertebral arch.
- c) Vertebral arches form the walls of the vertebral foramen, form a canal through which the spinal cord passes.
- d) **Atlas** - supports and balances the head, has two depressions that articulates, allowing movement of the head forward and back.
- e) **Axis** - has an odontoid process that projects into the ring of the atlas, allows the head to move from side to side and the atlas, pivots around the odontoid process.



- 7. f. Sacrum - five sacral vertebrae are fused, it articulates with the pelvic girdle and forms the posterior wall of the pelvic girdle.
- g) Coccyx - (tail bone) is the last part of the vertebral column.
- h) Intervertebral Disks
 - a) Fibrocartilage disks located between the vertebrae from grinding against one another and absorbs shock by movements.
 - b) Herniated disk- a disk becomes weakened with age and can slip or even rupture. The disk can press against the spinal cord, spinal nerves causes pain.

F. Thoracic Cage - protects the heart and lungs, plays a role in breathing, and supports the bones of the shoulder.

- 1. Ribs - (12 pairs) connected directly to the thoracic vertebrae in the back.
 - a) They articulate with the body and the vertebrae
 - b) Upper seven (7) pairs connect to the sternum by costal cartilage (true ribs)
 - c) Lower five (5) do not connect to the sternum directly also called "false ribs".
 - 1) 3 pairs attached by common cartilage to the sternum
 - 2) 2 pairs are *floating ribs* - do not attach at all



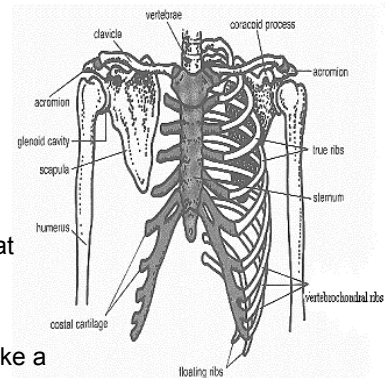
- 2. Sternum - contains three parts - manubrium, the body, and xiphoid process.
 - a) The ribs articulate with the manubrium and body of the sternum. (also articulates with the clavicles)

III. Appendicular Skeleton

(Contains the bones of the pectoral girdle, upper limbs (arms) pelvic girdle, and the lower limbs (legs).

A. Pectoral girdle - (shoulder) - contains four bones: two clavicles, and two scapulas

- 1. Supports the arms and serves as a place of attachment for muscles that move the arms.
- 2. Clavicles- (Collar bone) is a slender, S-shaped bone that articulates medially with the manubrium of the sternum.
 - a) each clavicle articulates with the scapula
 - b) stabilizes the shoulder
- 3. Scapulae- (shoulder blade) is a broad bone that looks like a triangle.
 - a) Features of the Scapulae
 - 1) acromion process- articulates with the clavicle and provides a place for attachment for the arm and chest muscle.
 - 2) coracoid process- serves as a place of attachment for the arm and chest
 - 3) glenoid cavity- articulates with the head of the upper arm bone (humerus)



B. Upper Limb (Arm)

- 1. Includes: Upper arm (humerus), forearm (radius-ulna) hand (carpals, metacarpals, and phalanges)
- 2. Humerus- is the bone of the upper arm
 - a) Features: (Proximal end)
 - 1) head - fits into the glenoid cavity of the scapula



- 2) Greater & Lesser tubercles- provides attachment for muscles that move the arm and the upper arm.
- 3) Intertubercular groove- which holds the tendon from the biceps brachii, a muscle of the upper arm.
- 4) Deltoid tuberosity- provides attachment for the deltoid, a muscle that covers the shoulder joint.

B. Features: (Distal end)

- 1) capitulum- lateral condyle that articulates with the radius.
- 2) trochlea- a spool shaped condyle that articulates with the ulna.
- 3) coronoid fossa- a depression for a process of the ulna when the elbow is extended.
- 4) olecranon fossa- a depression for a process of the ulna when the elbow is not extended.

3. Radius- located on the thumb side when the palm faces forward.

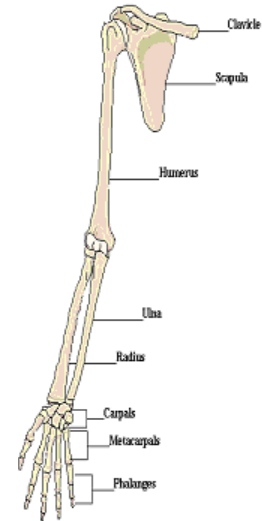
A. Features:

- 1) head- articulates with the capitulum of the humerus and fits into the radial notch of the ulna.
- 2) radial tuberosity- serves as a place of attachment for a tendon from the biceps brachii.

4. Ulna- is the upper bone of the forearm.

A. Features:

- 1) coronoid process- articulates with the coronoid fossa of the humerus when the elbow is bent.
- 2) olecranon process- articulates with the olecranon process of the humerus when the elbow is extended.
- 3) trochlear notch- articulates with the trochlea of the humerus.



5. Hand- has a wrist, a palm, and five fingers.

- a) The wrist consist of eight small carpal bones, (tightly bound by ligaments in two rows of four each)
 - 1) found on the diagram to the right
- b) The palm has five metacarpal bones that form the knuckles when a fist is made.
- c) The fingers contain the phalanges



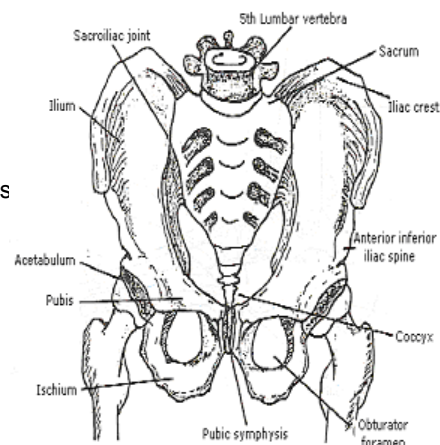
C. Pelvic Girdle (Pelvis)

1. Includes: two coxal bones (hip), sacrum and coccyx

- a) ilium- largest part that flares outward to give the hip prominence.
 - 1) margin of the ilium is called the iliac crest.
- b) ischium- is the most inferior part of the coxal bone, its posterior region allows us to sit.
- c) pubis- anterior part of the coxal bones.
 - 1) Obturator foramen - large opening through which blood vessels and nerves pass into the lower leg.

d) Sex Differences

- 1) Female iliac bones are more flared than those of the male (broader hips)
- 2) Female pelvis is wider between the ischial spine and the ischial tuberosities.
- 3) Female pelvis is more shallow and the male funnel shaped.
- 4) Female bone is lighter and thinner.



- 5) Female pubic arch is wider than that of a male.
- 6) Male pelvic bones are larger and heavier, articular ends are thicker and points of muscle attachment is larger.

D. Lower Limb (Leg)

1. Includes: bones of the thigh (femur), lower leg (tibia & fibula) and those of the foot (tarsals, metatarsals, and phalanges)

a) Femur - (thigh bone) is the largest and strongest bone in the body.

1) Features: (Proximal)

- a) head - which fits into the acetabulum of the coxal bone.
- b) greater and lesser trochanters - provide a place of attachment for the muscles of the leg and buttocks.
- c) Line of aspera - a crest that serves as a place of attachment for several muscles

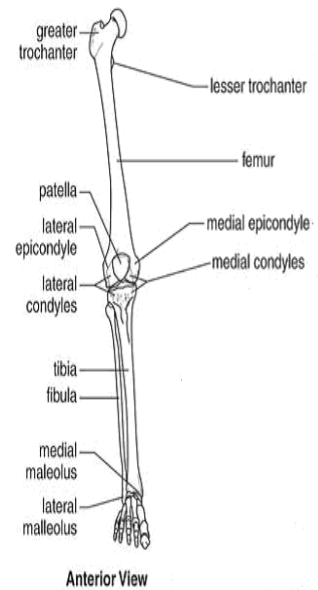
2) Features: (Distal)

a) The femur articulates with the patella (kneecap) and has lateral and medial condyles that articulates with the tibia.

b) Tibia - (shinbone) is medial to the fibula.

1) Features:

- a) medial & lateral condyles- which articulates with the femur.
- b) tibial tuberosity- where the patellar (kneecap) ligaments attach.
- c) anterior crest- commonly called the shin.
- d) medial malleolus- bulge of the inner ankle.

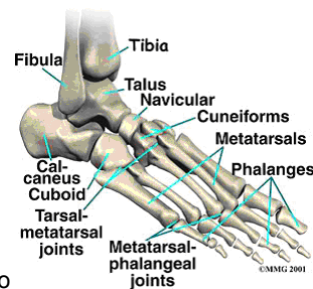


c) Fibula - is lateral to the tibia and more slender.

1) It has a head that articulates with the tibia just below the lateral condyle and a distal lateral malleolus that forms the outer ankle.

d) Foot - each foot has an ankle, an instep, and five toes.

- 1) Ankle has seven tarsal bones (together they are called the tarsus)
- 2) Only one can move freely - talus
- 3) The largest bone in the ankle is the calcaneus (heel bone).
- 4) Metatarsal bones - make up the instep
- 5) Each toe, besides the big toe, contains three each.



IV. Joints (Articulations)

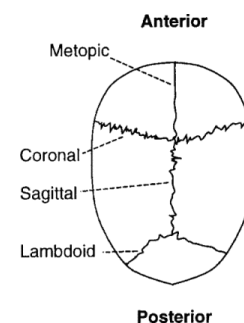
(Bones articulate at the joints, which are often classified according to the amount of movement they allow)

A. Classification

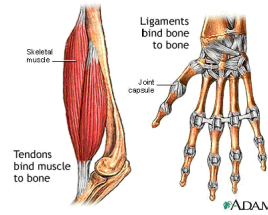
1) Thin layer of fibrous connective tissue and are immovable, are called synarthroses.

2) Immovable sutures:

- a) coronal suture - occurs between the parietal bones and frontal.
- b) lambdoial suture - occurs between the parietal bone and each occipital bone.
- c) squamosal suture - occurs between each parietal bone and each temporal bone.
- d) sagittal suture - occurs between the parietal bones.
- e) Amphiarthrose - slightly moveable joints connected by hyaline or fibro cartilage.



3. Most joints are freely moveable synovial joints known as *diarthroses* - two joints that are separated by a cavity.
4. Ligaments- fibrous connective tissue that binds two bones to one another.
5. Tendons- cords of fibrous connective tissue that connects muscle to bones. (help stabilize the joint)
6. Synovial membrane - which produces synovial fluid, a lubricant for the joint.
7. In the knee, the menisci - (miniscus) - is a crescent shaped piece of cartilage between bones.
 - a) It contains 13 fluid-filled sacs called bursae.
 - b) Inflammation of the bursae is called bursitis.



B. Joints - Examples

1. Saddle joint- in which each bone is saddle-shaped and fits into the complementary regions of the other.
 - a) Example: Carpal and the first metacarpal
2. Ball and Socket joint- ball-shaped head of one bone fits into the cup-shaped socket of another.
 - a) Example: head of the humerus and the scapula
3. Pivot joint- cylindrical projection of one bone pivots within a ring formed of bone and ligament of another.
4. Hinge joint- convex surface of one bone articulates with the concave surface of another.
 - a) Example: Humerus and Ulna
5. Gliding joint - flat or slightly curved surfaces of two bones articulate
 - a) Example: Carpals
6. Condyloid joints- oval-shaped condyle of one bone fits into the elliptical cavity of another.
7. Rheumatoid arthritis- the synovial membrane becomes inflamed and grows thicker, restricting movement.
8. Osteoarthritis- disintegration of the cartilage.

Joint Type	Illustration of joint	Example	Structure
Ball and socket		Shoulder	Ball and socket joint
Hinge		Elbow	Hinge joint
Pivot		Head of the humerus (ball) in the socket	Pivot joint
Ball and socket		Shoulder	Ball and socket joint
Condyloid		Head of the humerus (ball) in the socket	Condyloid joint
Saddle		Base of the 5th metacarpal	Saddle joint
Gliding		Base of the 5th metacarpal	Gliding joint
Ball and socket		Shoulder	Ball and socket joint

D. Movement permitted by synovial joints

- 1) Angular movements increase or decrease the joint angle between the bones of a joint.
- 2) Flexion- decreases the joint angle.
 - a) Example: flexion of the knee moves the lower leg towards the upper leg.
 - b) Dorsiflexion - is the flexion of the foot upward (standing on your heels)
 - c) Plantar flexion - is the flexion of your foot downward. (standing on your toes)
- 3) Extension- increases the joint angle.
 - a) Example; flexed elbow straightens the arm so there is a 180 degree angle at the elbow.
 - b) Hyperextension - occurs when a portion of the body parts are extended beyond the 180 degrees.
4. Abduction - it is the movement of the body part laterally away from the midline.
 - a) Example: arms or legs moves the to the side, away from the midline.
5. Adduction - it is the movement of the body part towards the midline.
 - a) Example: arms or legs move back towards the midline.
6. Rotation- is the movement of a body part around its own axis.
 - a) Example: head is turned to answer "No"
 - b) When the head is twisted one way then the other.
7. Supination- is the rotation of the lower arm so that the palm is upward.
 - a) pronation - is the opposite - (palms downward)
8. Inversion and Eversion - are terms that apply only to the feet.
 - a) Inversion is the turning the foot so that the sole is inward
 - b) Eversion is the turning the foot so that the sole is outward
9. Elevation and Depression - are the lifting and lowering of the shoulders.
 - a) Shrug your shoulders

E. Effects of Aging

- 1) Both cartilage and bone tend to deteriorate as a person ages. The chemical nature of cartilage changes, and the bluish color of typical young cartilage changes to a yellow color.
- 2) Calcification interferes with the ready diffusion of nutrients and waste products through the matrix.
- 3) The articular cartilage may no longer function properly, and the symptoms of osteoarthritis can appear.
4. Beginning about age 30 in both men and women, the bone reabsorbed by osteoclasts exceeds the amount of new bone synthesized by osteoblasts.
- 5) Osteoporosis- is present when weak and thin bones cause aches and pains and tend to fracture easily.