

Skeletal System -Training Handout

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INTERACTION OF SKELETAL AND MUSCULAR SYSTEMS:

- Skeletal and Muscular systems works together to allow movement
- Bone attaches to bone via ligaments
- Muscle attaches to bone via tendons
- Skeletal muscles produce movement by bending the skeleton at movable joints. Muscles work in antagonistic pairs.
- Skeleton provides structure of body and muscles allow skeleton mobility – pull by contraction of muscle.

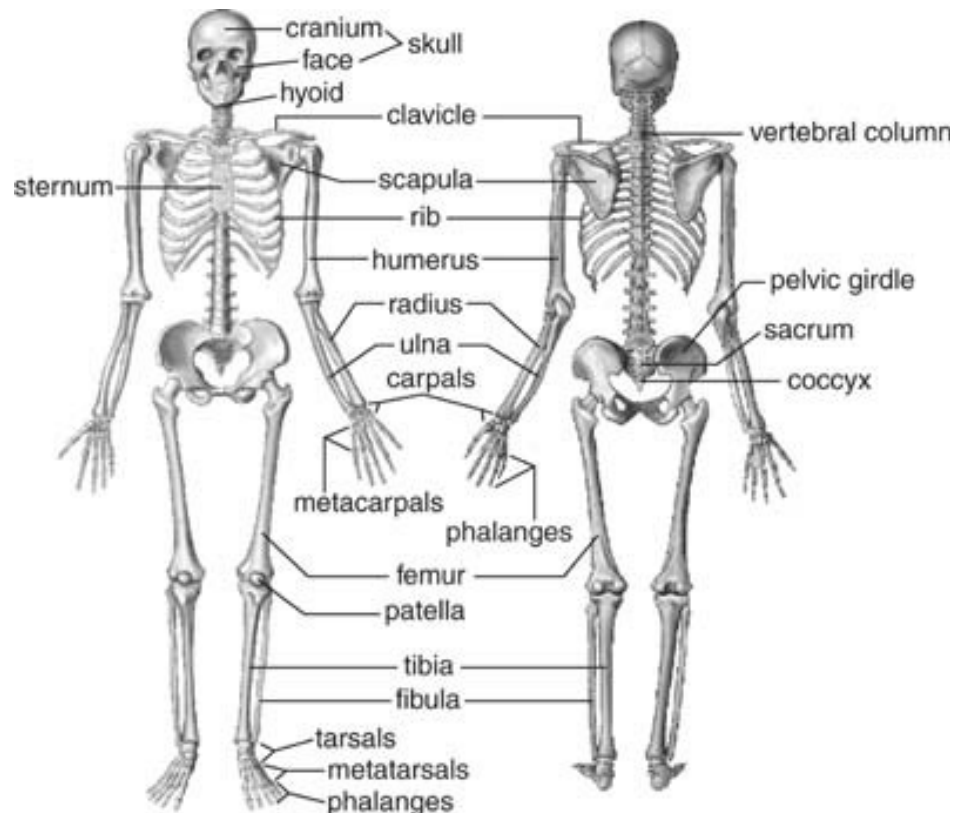
SKELETAL SYSTEM:

Functions

- Support & shape to body
- Protection of internal organs
- Movement in union with muscles
- Storage of minerals (calcium, phosphorus) & lipids
- Blood cell production

Skeleton

- 206 Bones
- **Axial skeleton:** (80 bones) in skull, vertebrae, ribs, sternum, hyoid bone
- **Appendicular Skeleton:** (126 bones)- upper & lower extremities plus two girdles
- Half of bones in hands & feet

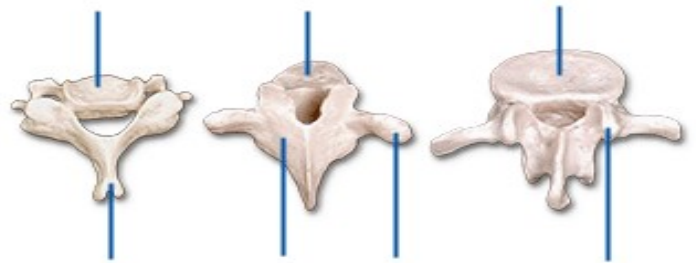


Types of Bone:

- **Long bones:** longer than they are wide; shaft & 2 ends (e.g.: bones of arms & legs, except wrist, ankle & patella)
- **Short bones:** roughly cube-shaped (e.g.: ankle & wrist bones)
- **Sesamoid bones:** short bones within tendons (e.g.: patella)
- **Flat bones:** thin, flat & often curved (e.g.,: sternum, scapulae, ribs & most skull bones)
- **Irregular bones:** odd shapes; don't fit into other classes (e.g.: hip bones & vertebrae)

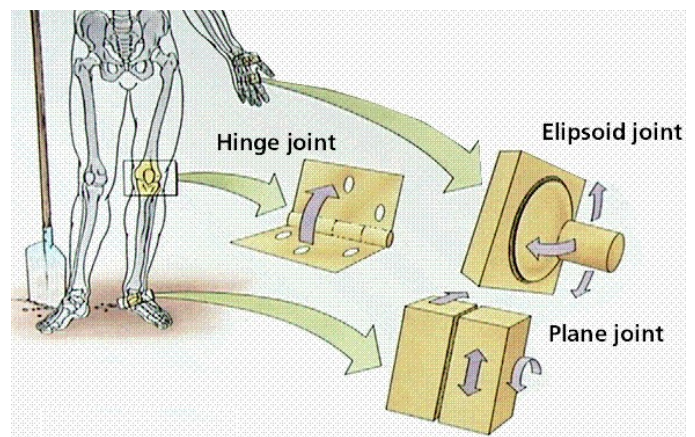
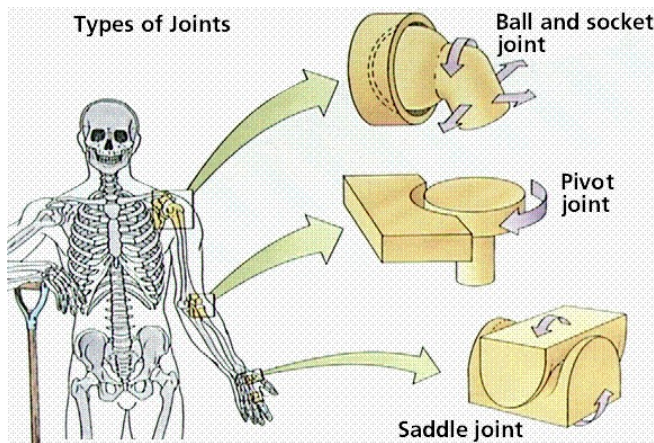
Types of Vertebrae:

- **Cervical (7)**- transverse foramina, bifid spinous processes, vertebral prominens
 - Atlas- 1st; supports head
 - Axis- 2nd; pivots to turn head
- **Thoracic (12)**- long spinous processes, rib facets
- **Lumbar (5)**- large bodies thick, short spinous processes



Types of Synovial Joints

- **Ball & Socket** - allows for complete range of motion Example: shoulder, hip
- **Pivot** – one bone pivots in the arch of another Example: Axis/Atlas, and proximal radioulnar joint
- **Saddle** – two directional movement between thumb and trapezium carpel
- **Hinge** – like door hinge – bending & extending Example: elbow, knee, finger joints
- **Ellipsoid (Condyloid)** – side to side and back & forth Example – radius end into carpal bones
- **Plane or Gliding** – least moveable – side to side only Examples: intercarpal & intertarsal joints, between vertebrae



Cartilage – Characteristics and Types

Characteristics of Cartilage

- Mostly water; no blood vessels or nerves
- Tough, resilient
- New cartilage forms from chondroblasts
- Heal poorly

Growth of Cartilage

- Appositional – cells in the perichondrium secrete matrix against the external face of existing cartilage
- Interstitial – lacunae-bound chondrocytes inside the cartilage divide and secrete new matrix, expanding the cartilage from within

Types of Cartilage

- **Hyaline Cartilages:** fine collagen fiber matrix- most abundant type- found in articular (movable joint) cartilages, costal cartilages (connect ribs to sternum), respiratory cartilages (in larynx & upper respiratory passageways) & nasal cartilages
- **Elastic Cartilages:** similar to hyaline cartilage, more elastic fibers (very flexible) – found in external ear & epiglottis (larynx covering)
- **Fibrocartilage:** rows of chondrocytes with thick collagen fibers; highly compressible with great tensile strength- found in menisci of knee, intervertebral discs & pubic symphysis

*Although cartilage can be calcified, calcified cartilage is not bone. Bone is a separate type of connective tissue.

Cellular Structure of Long Bone

Compact bone

- The hard outer layer of bones is composed of compact bone tissue, so-called due to its minimal gaps and spaces.
- This tissue gives bones their smooth, white, and solid appearance, and accounts for 80% of the total bone mass of an adult skeleton.
- Compact bone may also be referred to as dense bone or cortical bone.

Spongy bone

- Filling the interior of the organ is the spongy bone tissue which is composed of a network of rod- and plate-like elements that make the overall organ lighter and allowing room for blood vessels and marrow.
- Spongy bone accounts for the remaining 20% of total bone mass, but has nearly ten times the surface area of compact bone.

Types of cells constituting the bone

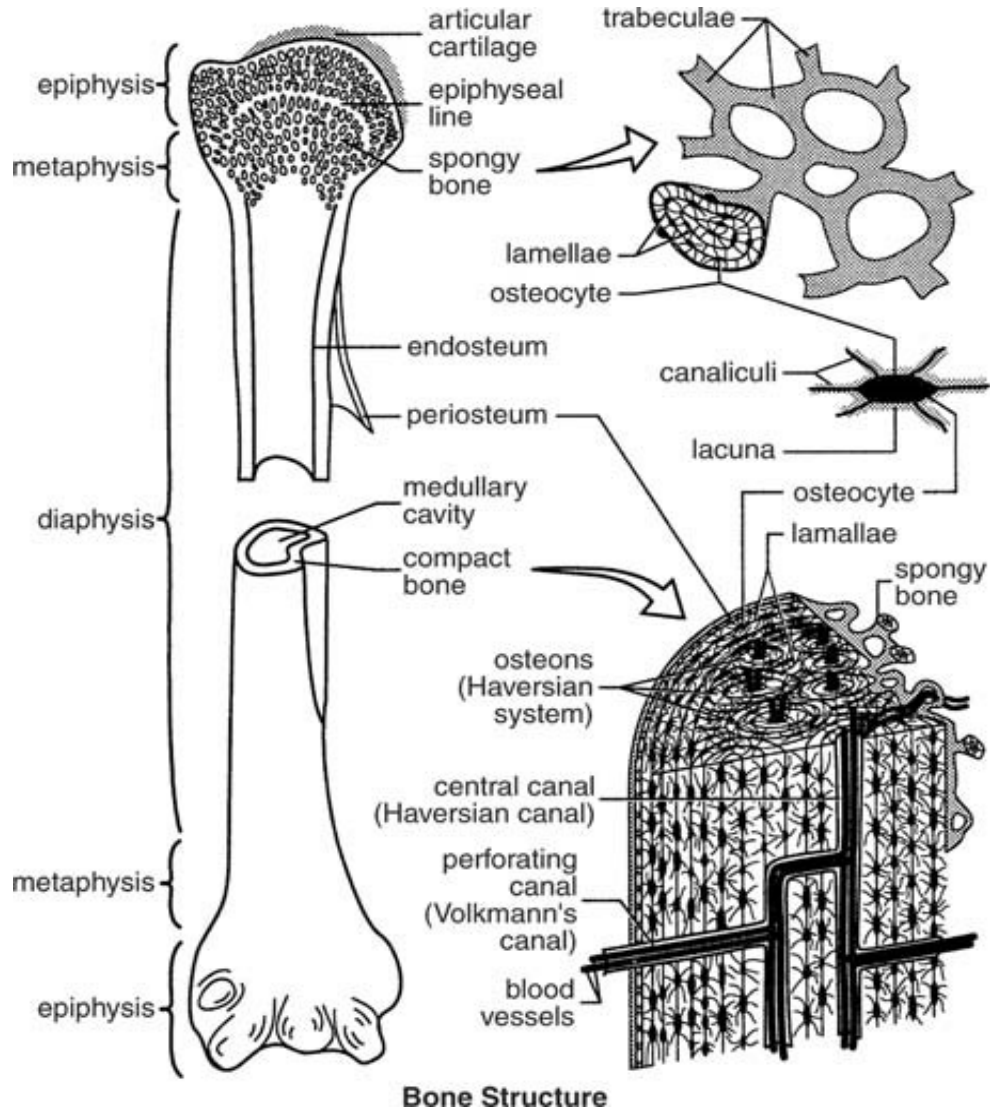
- **Osteoblasts** – bone forming cells synthesize and secrete unmineralized ground substance and are found in areas of high metabolism within the bone
- **Osteocytes** – mature bone cells made from osteoblasts that have made bone tissue around themselves. These cells maintain healthy bone tissue by secreting enzymes and controlling the bone mineral content; they also control the calcium release from the bone tissue to the blood.
- **Bone lining cells** - made from osteoblasts along the surface of most bones in an adult. Bone-lining cells are thought to regulate the movement of calcium and phosphate into and out of the bone
- **Osteogenic cells** - respond to traumas, such as fractures, by giving rise to bone-forming cells and bone-destroying cells
- **Osteoclasts** – bone absorbing cell – large cells that break down bone tissue – important to growth, healing, remodeling

Red and Yellow Bone Marrow

- The formation of blood cells, termed **hematopoiesis**, takes place mainly in the red marrow of the bones.
- In infants, red marrow is found in the bone cavities. With age, it is largely replaced by yellow marrow for fat storage.
- In adults, red marrow is limited to the spongy bone in the skull, ribs, sternum, clavicles, vertebrae and pelvis. Red marrow functions in the formation of red blood cells, white blood cells and blood platelets.

Microscopic Structure of Bone: Compact Bone

- **Haversian system, or osteon** – the structural unit of compact bone
- **Lamella** – weight-bearing, column-like matrix tubes composed mainly of collagen
- **Haversian, or central canal** – central channel containing blood vessels and nerves
- **Volkman's canals** – channels lying at right angles to the central canal, connecting blood and nerve supply of the periosteum to that of the Haversian canal
- **Osteocytes** – mature bone cells
- **Lacunae** – small cavities in bone that contain osteocytes
- **Canaliculi** – hairlike canals that connect lacunae to each other and the central canal



Structure of Long Bone

Diaphysis

- Tubular shaft that forms the axis of long bones
- Composed of compact bone that surrounds the medullary cavity
- Yellow bone marrow (fat) is contained in the medullary cavity

Epiphyses

- Expanded ends of long bones
- Exterior is compact bone, and the interior is spongy bone
- Joint surface is covered with articular (hyaline) cartilage
- Epiphyseal line separates the diaphysis from the epiphyses

Bone Membranes

Periosteum – double-layered protective membrane

- Outer fibrous layer is dense regular CT
- Inner osteogenic layer is composed of osteoblasts and osteoclasts
- Richly supplied with nerve fibers, blood, and lymphatic vessels, which enter the bone via nutrient foramina
- Secured to underlying bone by Sharpey's fibers

Endosteum – delicate membrane covering internal surfaces of bone

Structure of Short, Irregular, and Flat Bones

- Thin plates of periosteum-covered compact bone on the outside with endosteum-covered spongy bone (diploë) on the inside
- Have no diaphysis or epiphyses
- Contain bone marrow between the trabeculae

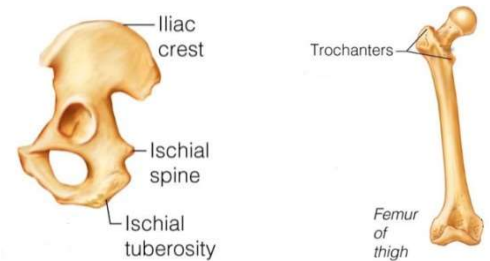
Bone Markings

Bulges, depressions, and holes that serve as:

- Sites of attachment for muscles, ligaments, and tendons
- Joint surfaces
- Conduits for blood vessels and nerves

Projections where muscles, tendons and ligaments attach

- **Tubercle** – small rounded projection
- **Tuberosity** – rounded projection
- **Crest** – narrow, prominent ridge of bone
- **Trochanter** – large, blunt, irregular surface
- **Line** – narrow ridge of bone
- **Epicondyle** – raised area above a condyle
- **Spine** – sharp, slender projection
- **Process** – any bony prominence



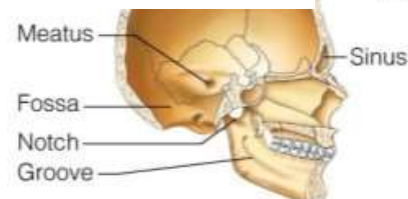
Projections That Help to Form Joints

- **Head** – bony expansion carried on a narrow neck
- **Facet** – smooth, nearly flat articular surface
- **Condyle** – rounded articular projection
- **Ramus** – armlike bar of bone



Depressions and Openings

- **Meatus** – canal-like passageway
- **Sinus** – cavity within a bone
- **Fossa** – shallow, basinlike depression
- **Groove** – furrow
- **Fissure** – narrow, slitlike opening
- **Foramen** – round or oval opening through a bone



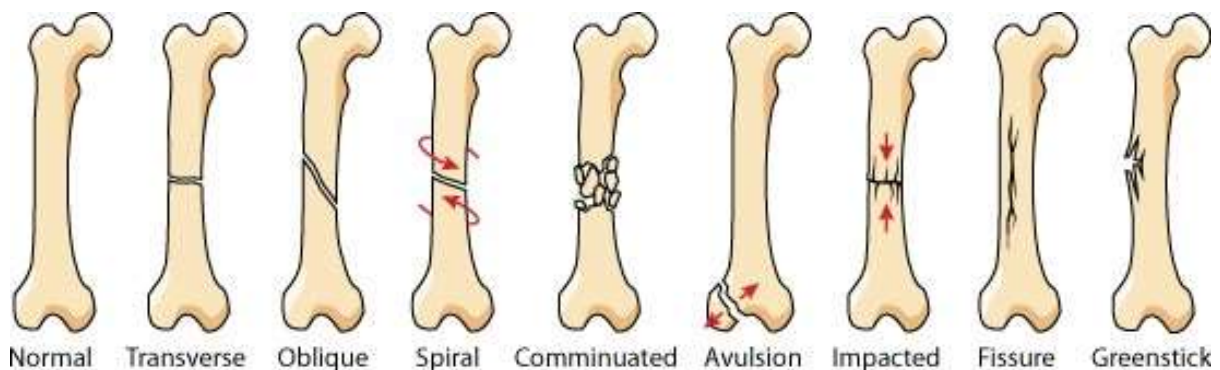
Typical Bone Fractures

Bone Fractures Terminology

- **Nondisplaced** – bone ends retain their normal position
- **Displaced** – bone ends are out of normal alignment
- **Complete** – bone is broken all the way through
- **Incomplete** – bone is not broken all the way through
- **Compound (open)** – bone ends penetrate the skin
- **Simple (closed)** – bone ends do not penetrate the skin

Common Types of Fractures

- **Linear** – the fracture is parallel to the long axis of the bone
- **Transverse** – the fracture is perpendicular to the long axis of the bone
- **Oblique** – diagonal breaks across the bone
- **Comminuted** – bone fragments into three or more pieces; common in the elderly
- **Spiral** – ragged break when bone is excessively twisted; common sports injury
- **Avulsion** – pieces of the bone have been pulled apart
- **Impacted** – opposite of avulsion fractures – a piece of bone is pushed down into another piece of bone
- **Fissure** – cracks in the bone
- **Depressed** – broken bone portion pressed inward; typical skull fracture
- **Greenstick** – incomplete fracture – one side of the bone breaks and the other side bends; common in children
- **Compression** – bone is crushed; common in porous bones
- **Epiphyseal** – epiphysis separates from diaphysis along epiphyseal line; occurs where cartilage cells are dying



Bone Repair Process

- Injury – broken blood vessels, hematoma
- Invasion of blood vessels & generalized cells (2-3 days)
- Fibroblasts develop (1 week)
- Chondroblasts develop
- Callus forms (4 weeks)
- Remodeling with osteoclasts (8 weeks)

Top 5 commonly broken bones

- 1) **Clavicle** - the number one most broken bone
- 2) **Arm** - this can be the radius, or ulna bones in the lower part of the arm, or the humerus bone of the upper arm
- 3) **Wrist** - the wrist can end up with a lot of the force on them when we place our arms out during a fall - like when skateboarding.
- 4) **Hip** - the most commonly broken bone for people over the age of 65. Women in this age group have the highest rate of fractures due to calcium loss (osteoporosis).
- 5) **Ankle** – Think like taking a wrong step off a curb, or twisting an ankle playing sports or when out for a hike can cause a break. If you twist an ankle you might think you have a sprain, but broken ankles and sprains can seem similar.

Sprains

- The ligaments reinforcing a joint are stretched or torn
- Partially torn ligaments slowly repair themselves
- Completely torn ligaments require prompt surgical repair

Cartilage Injuries

- The snap and pop of overstressed cartilage
- Common aerobics injury
- Repaired with arthroscopic surgery

Dislocations

- Occur when bones are forced out of alignment
- Usually accompanied by sprains, inflammation, and joint immobilization
- Caused by serious falls and are common sports injuries
- Subluxation – partial dislocation of a joint

Skeletal Disorders

- **Spinal Stenosis**-narrowing of the spinal column
- **Achondroplasia**-Defect in the formation of cartilage at the epiphysis of long bones (dwarfing)
- **Juvenile Rheumatoid Arthritis**-chronic inflammatory diseases involving the joints or other organs in children under 16
- **Ankylosing spondylitis**-immobility of a joint in the spine
- **Osteosarcoma**-malignant sarcoma of bone
- **Osteoporosis**-Loss of bone mass that occurs throughout the skeleton. Predisposes people to fractures
- **Disc Herniation**-Rupture of the soft tissue that separates two vertebral bones into the spinal canal
- **Scoliosis**-a lateral curvature of the spine.

Inflammatory and Degenerative Conditions

- **Bursitis**
 - An inflammation of a bursa, usually caused by a blow or friction
 - Symptoms are pain and swelling
 - Treated with anti-inflammatory drugs; excessive fluid may be aspirated
- **Tendonitis**
 - Inflammation of tendon sheaths typically caused by overuse
 - Symptoms and treatment are similar to bursitis

- **Arthritis**
 - More than 100 different types of inflammatory or degenerative diseases that damage the joints
 - Most widespread crippling disease in the U.S.
 - Symptoms – pain, stiffness, and swelling of a joint
 - Acute forms are caused by bacteria and are treated with antibiotics
 - Chronic forms include osteoarthritis, rheumatoid arthritis, and gouty arthritis
- **Osteoarthritis (OA)**
 - Most common chronic arthritis; often called “wear-and-tear” arthritis
 - Affects women more than men
 - 85% of all Americans develop OA
 - More prevalent in the aged, and is probably related to the normal aging process

Osteoarthritis: Course

 - OA reflects the years of abrasion and compression causing increased production of metalloproteinase enzymes that break down cartilage
 - As one ages, cartilage is destroyed more quickly than it is replaced
 - The exposed bone ends thicken, enlarge, form bone spurs, and restrict movement
 - Joints most affected are the cervical and lumbar spine, fingers, knuckles, knees, and hips

Osteoarthritis: Treatments

 - OA is slow and irreversible
 - Treatments include:
 - Mild pain relievers, along with moderate activity
 - Magnetic therapy
 - Glucosamine sulfate decreases pain and inflammation
 - SAM-e (s-adenosylmethionine) builds up cartilage matrix and regenerates tissue
- **Rheumatoid Arthritis (RA)**
 - Chronic, inflammatory, autoimmune disease of unknown cause, with an insidious onset
 - Usually arises between the ages of 40 to 50, but may occur at any age
 - Signs and symptoms include joint tenderness, anemia, osteoporosis, muscle atrophy, and cardiovascular problems
 - The course of RA is marked with exacerbations and remissions

Rheumatoid Arthritis: Course

 - RA begins with synovitis of the affected joint
 - Inflammatory blood cells migrate to the joint, causing swelling
 - Inflamed synovial membrane thickens into a pannus
 - Pannus erodes cartilage, scar tissue forms, articulating bone ends connect
 - The end result, ankylosis, produces bent, deformed fingers

Rheumatoid Arthritis: Treatment

 - Conservative therapy – aspirin, long-term use of antibiotics, and physical therapy
 - Progressive treatment – anti-inflammatory drugs or immunosuppressants
 - The drug Embrel, a biological response modifier, removes cells that promote inflammation
- **Gouty Arthritis**
 - Deposition of uric acid crystals in joints and soft tissues, followed by an inflammation response
 - Typically, gouty arthritis affects the joint at the base of the great toe
 - In untreated gouty arthritis, the bone ends fuse and immobilize the joint
 - Treatment – colchicine, nonsteroidal anti-inflammatory drugs, and glucocorticoids