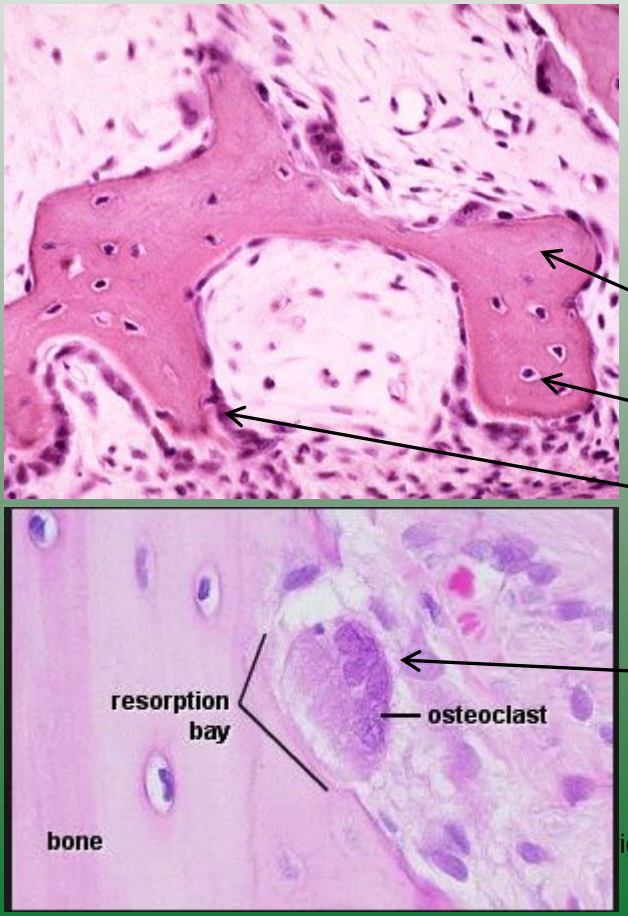
Chapter 9

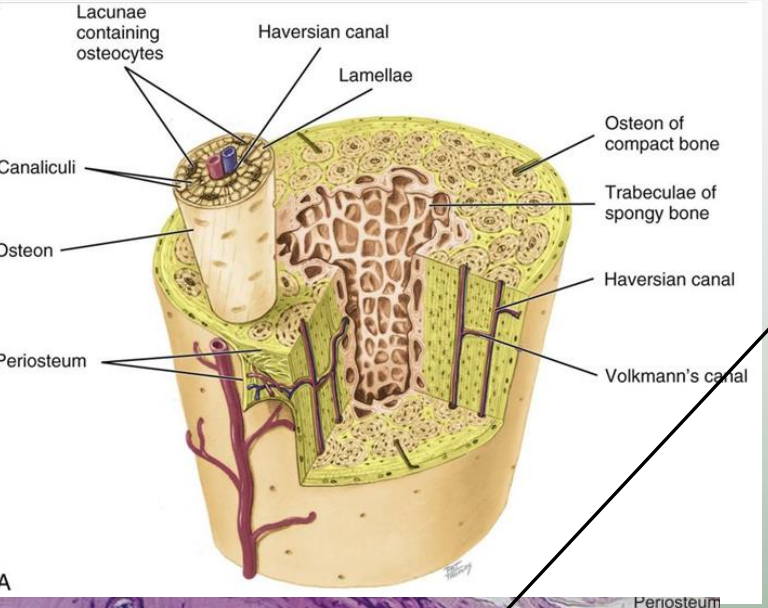
Musculoskeletal System Disorders

Review of Musculoskeletal System: Bones

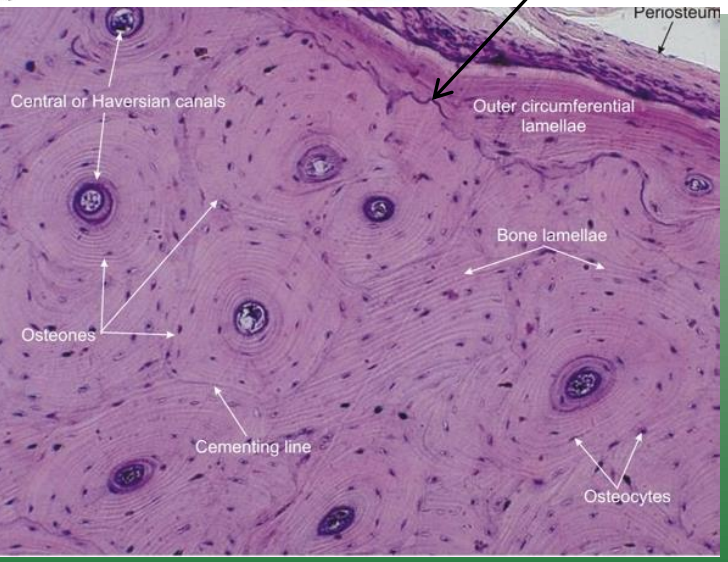
- Classified by shape
  - Long bones
  - Short bones
  - Flat bones
  - Irregular bones
- Bone tissue consists of:
  - Matrix
  - Mature bone cells (osteocytes)
  - Bone-producing cells (osteoblasts)
  - Bone-resorbing cells (osteoclasts)

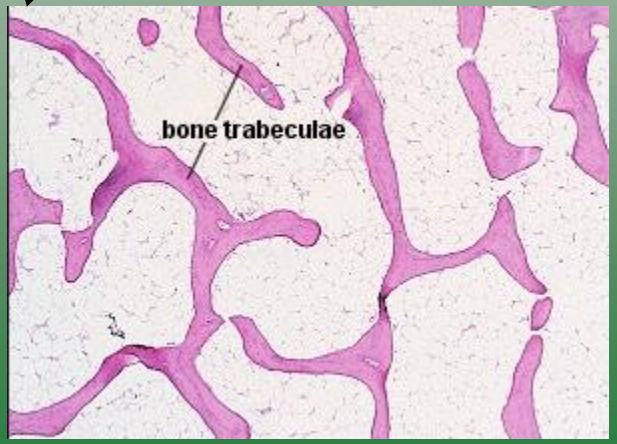


Bone

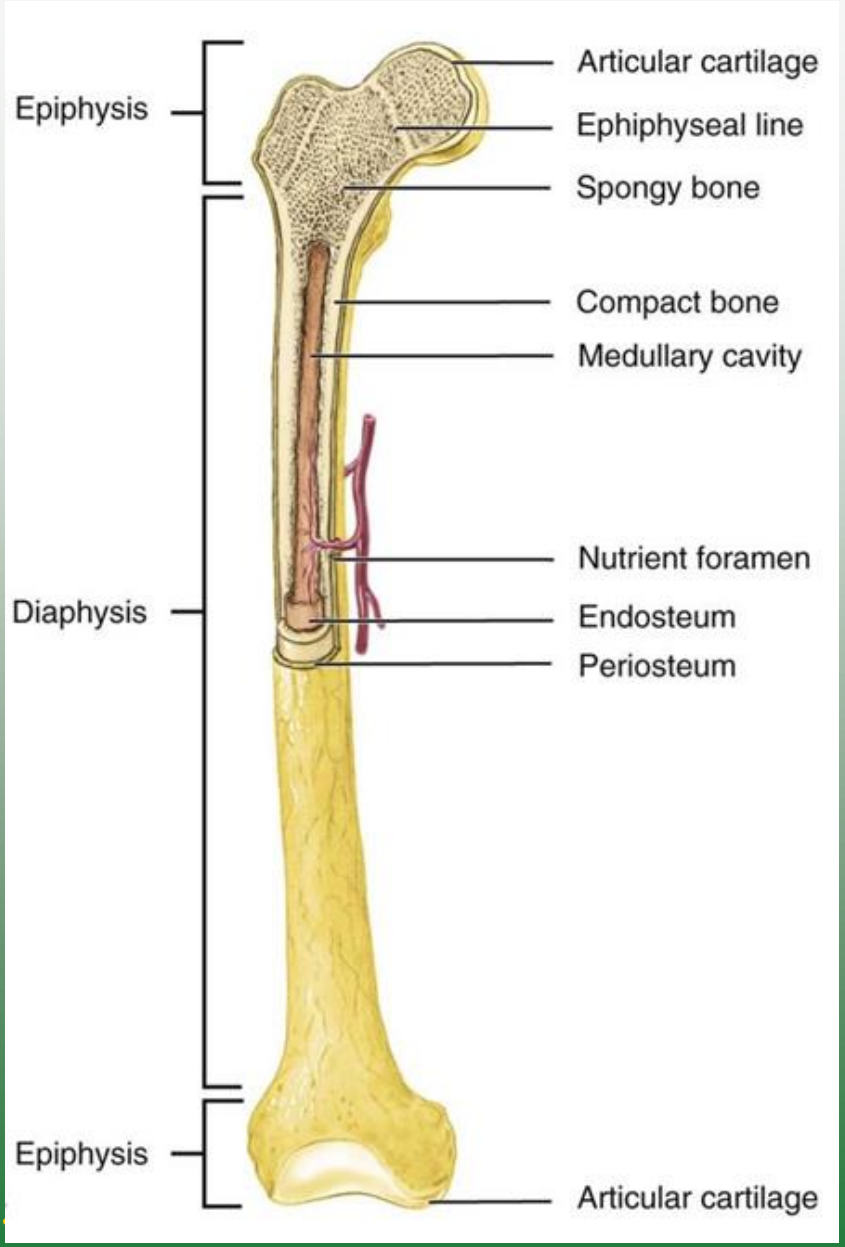


- Types of bone tissue
  - Compact—outer covering of bone
  - Cancellous (spongy)—interior of bone
- Other bone structures
  - Periosteum—connective tissue covering over the bone
  - Endosteum—osteoblast-rich lining of medullary cavity





Structure of a Long Bone

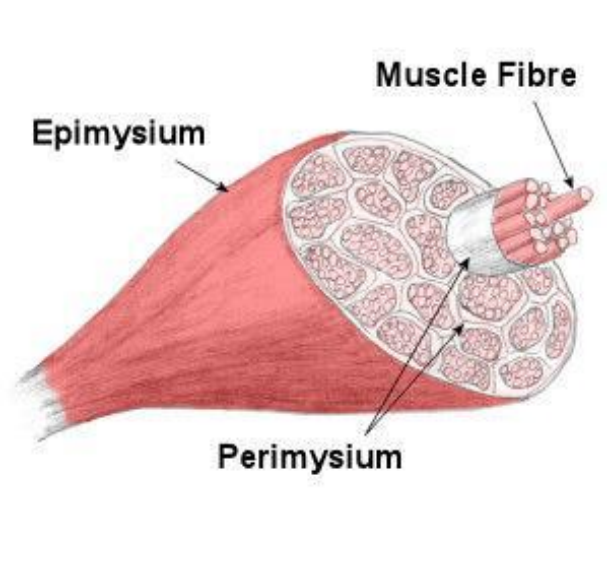


Skeletal Muscle

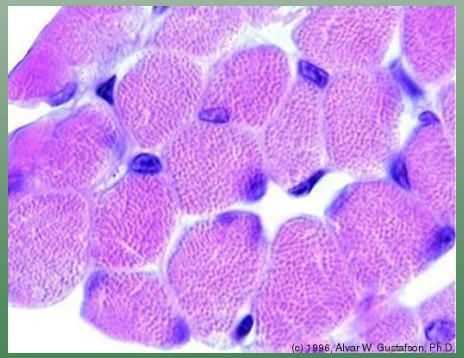
Functions of Skeletal Muscle

- Facilitate body movement.
- Maintain body position.
- Stabilize joints.
- Produce heat.

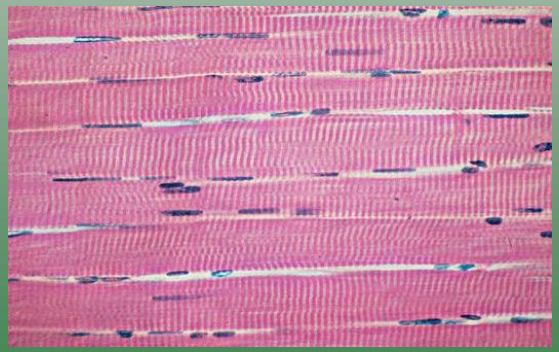
Connective Tissue Coverings of Skeletal Muscle



- Epimysium
  - Connective tissue surrounding the entire muscle
- Perimysium
  - Connective tissue surrounding muscle fascicles
- Endomysium
  - Connective tissue around individual muscle fibers

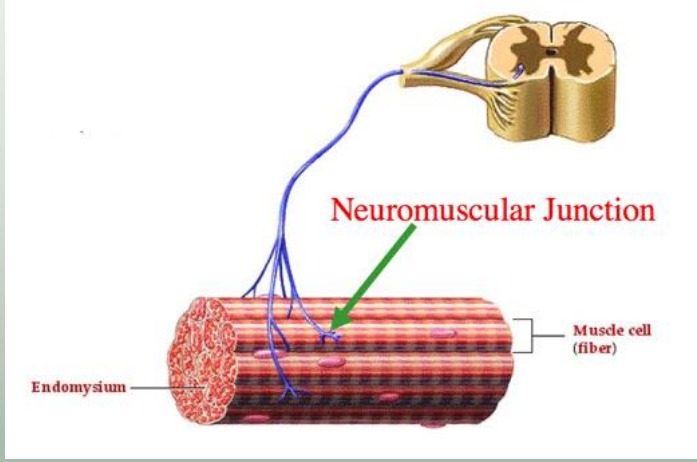


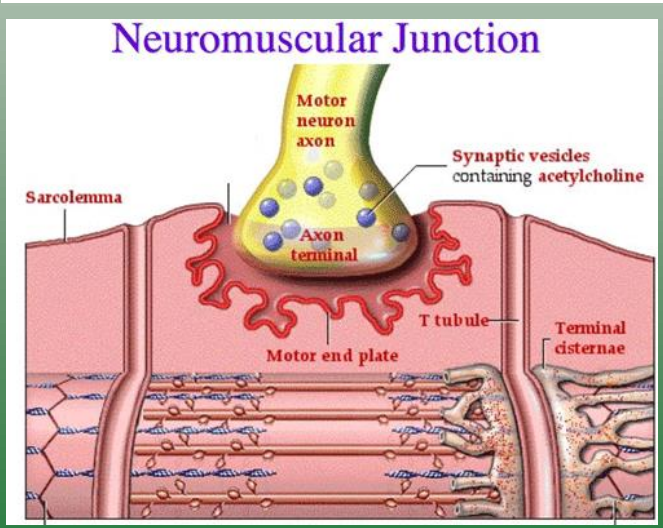
Cross sections



Long sections, shows striations

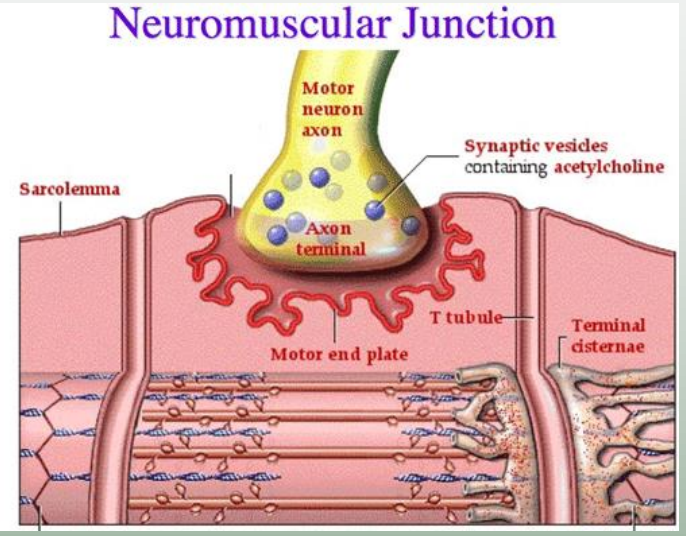
Skeletal Muscle (Cont.)





- Motor unit
  - Motor neuron in the spinal cord and all muscle fibers innervated by the neurons
- Neuromuscular junction
  - Synapse between the motor neuron nerve fiber and muscle fiber
    - Neurotransmitter—acetylcholine (ACh)
    - Breakdown of Ach by cholinesterase; anticholinesterases will interfere with the breakdown of ACh.

Neuromuscular Transmission and Muscle Contraction

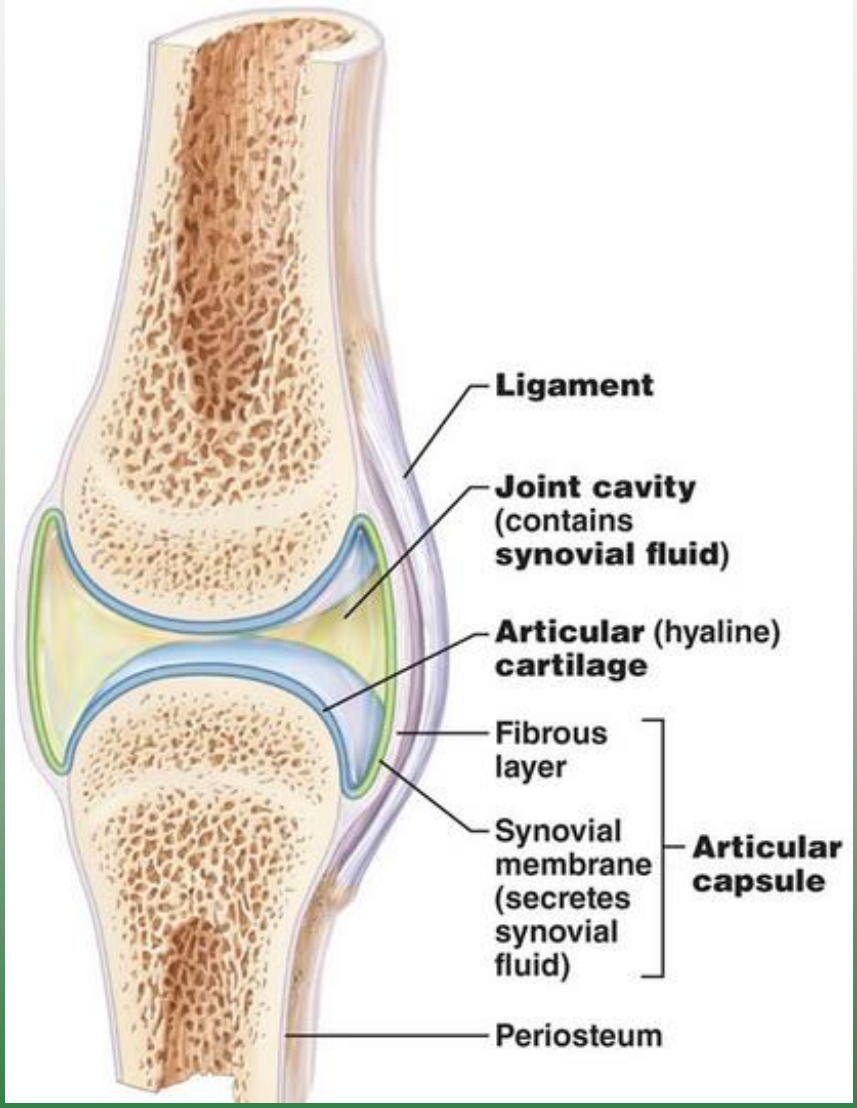


- Arrival of the action potential
- Depolarization of the presynaptic terminal
- Calcium influx
- Exocytosis of the neurotransmitter (Ach)
- Diffusion of neurotransmitter to postsynaptic receptors—attachment
- Generation of muscle action potential
- Release of calcium from sarcoplasmic reticulum
- Power stroke—contraction of muscle fiber

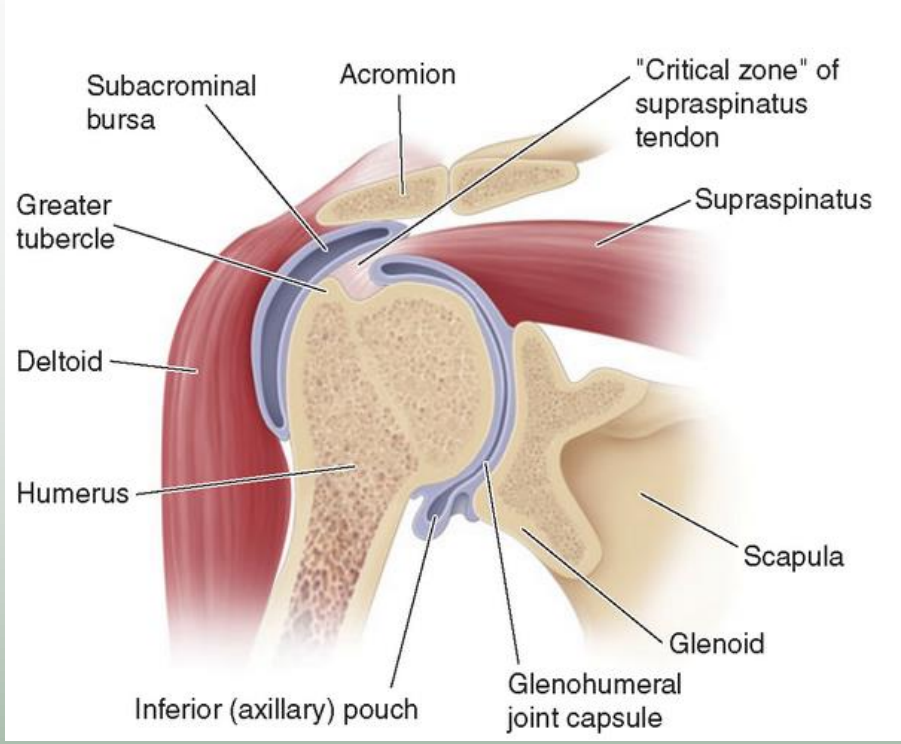
Joints

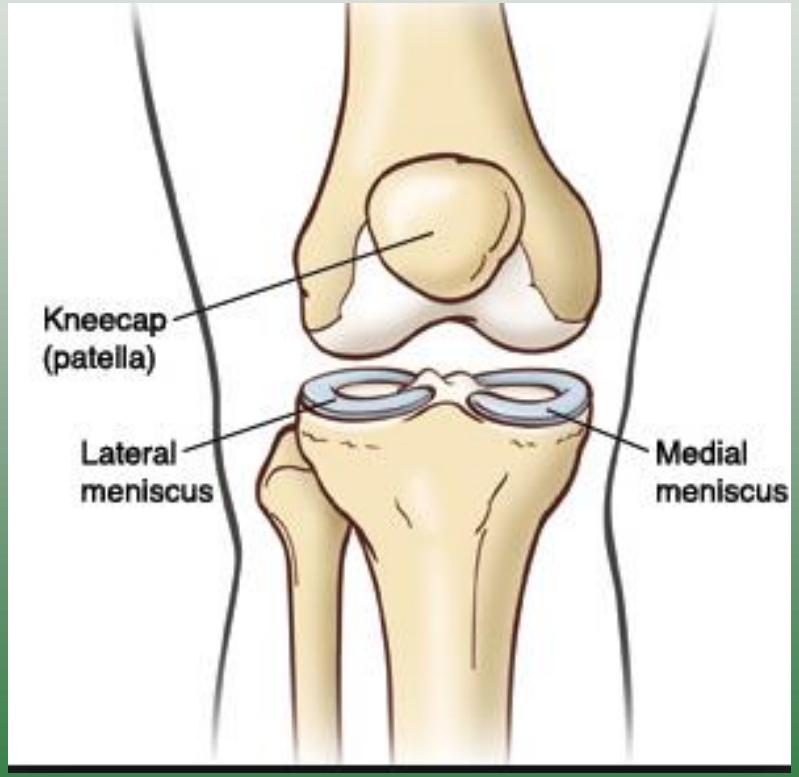
- Classified by degree of movement:
  - Synarthroses—immovable (e.g., cranial sutures)
  - Amphiarthroses—slightly movable (e.g., ribs to sternum)
  - Diarthroses (synovial)—freely movable (e.g., shoulder)

Structure of Synovial Joint



- Articular cartilage—covering over ends of bones
- Synovial membrane—produces synovial fluid that fills space between ends of bones
- Articular capsule—consists of synovial membrane, a fibrous capsule
- Ligaments—reinforces capsule, links bones, supports joint
- Menisci—lateral pads in some joints to stabilize
- Bursae—fluid-filled sacs to add extra cushion



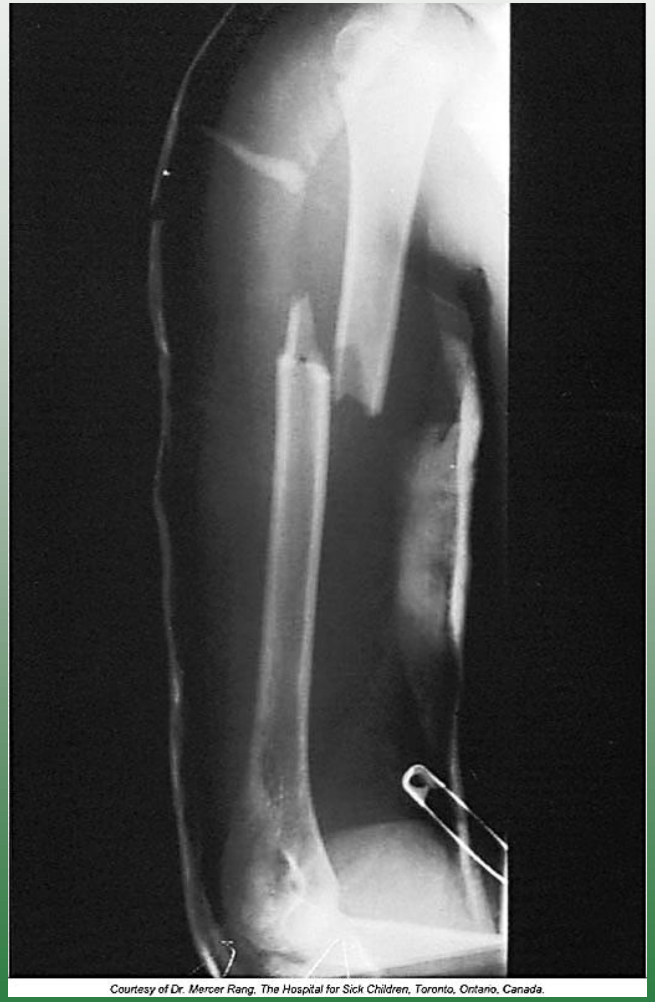


Musculoskeletal Diagnostic Tests

- For bone disorders: radiography, bone scanning
- For muscular disorders: electromyography (EMG), biopsy
- For joint disorders: radiography, arthroscopy, magnetic resonance imaging (MRI), examination of synovial fluid

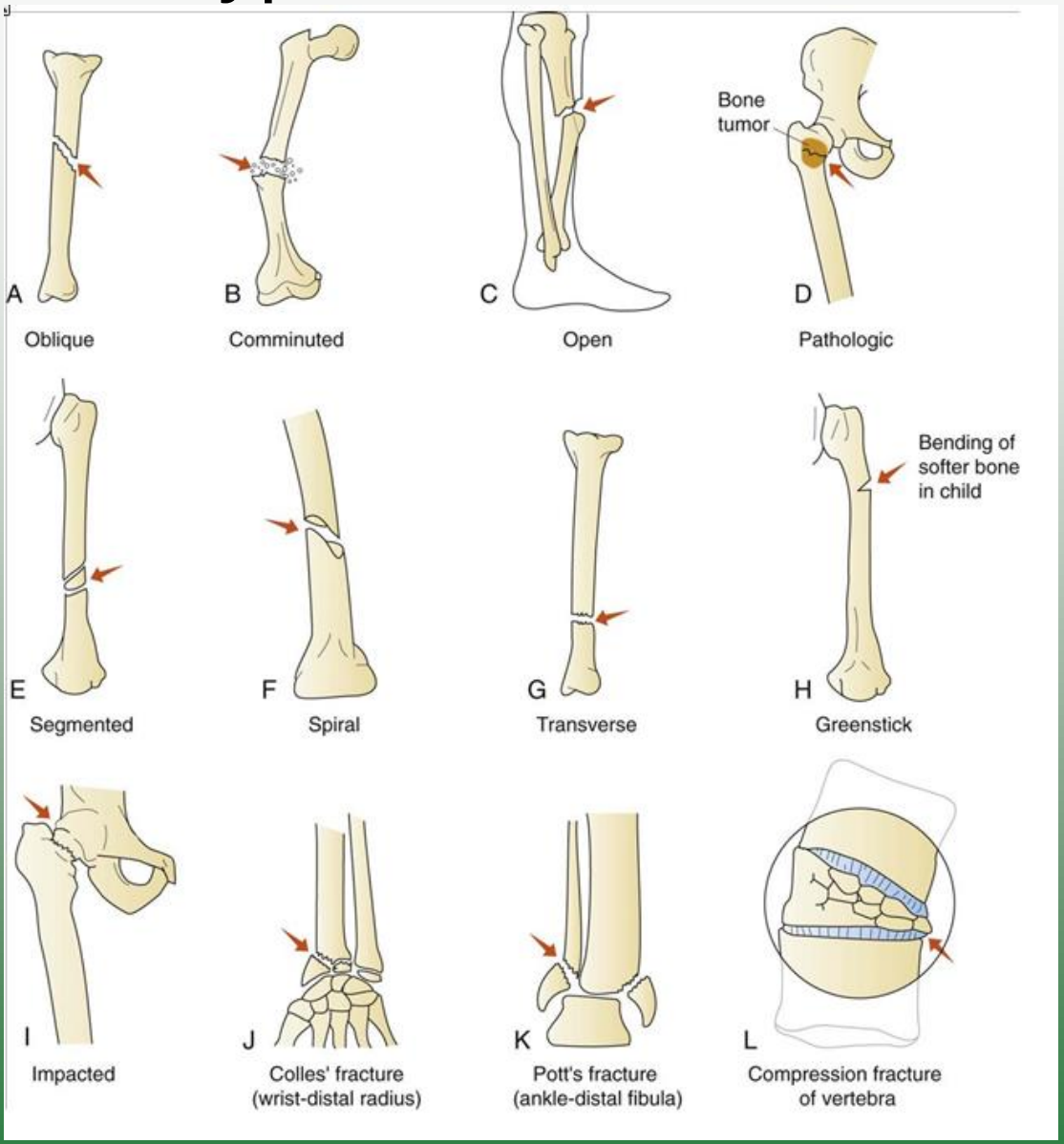
Fracture

- A fracture is a break in the integrity of a bone.
- Fractures occur because of trauma, neoplasms, or increased stress on bones.



Courtesy of Dr. Mercer Rang, The Hospital for Sick Children, Toronto, Ontario, Canada.

Types of Fractures



Classification of Fractures

- Complete: bone broken, forming separate pieces
- Incomplete: bone only partially broken
- Open (compound): skin broken
- Closed: skin not broken
- Simple: single break, maintaining alignment and position
- Comminuted: multiple fractures and bone fragments
- Compression: bone crushed or collapsed into small pieces

Trauma—Fractures

- Other types:
  - Impacted—one end forced into adjacent bone
  - Pathologic—results from weakness; occurs with little stress
  - Stress—fatigue fractures
  - Depressed—skull fractured and forced into brain

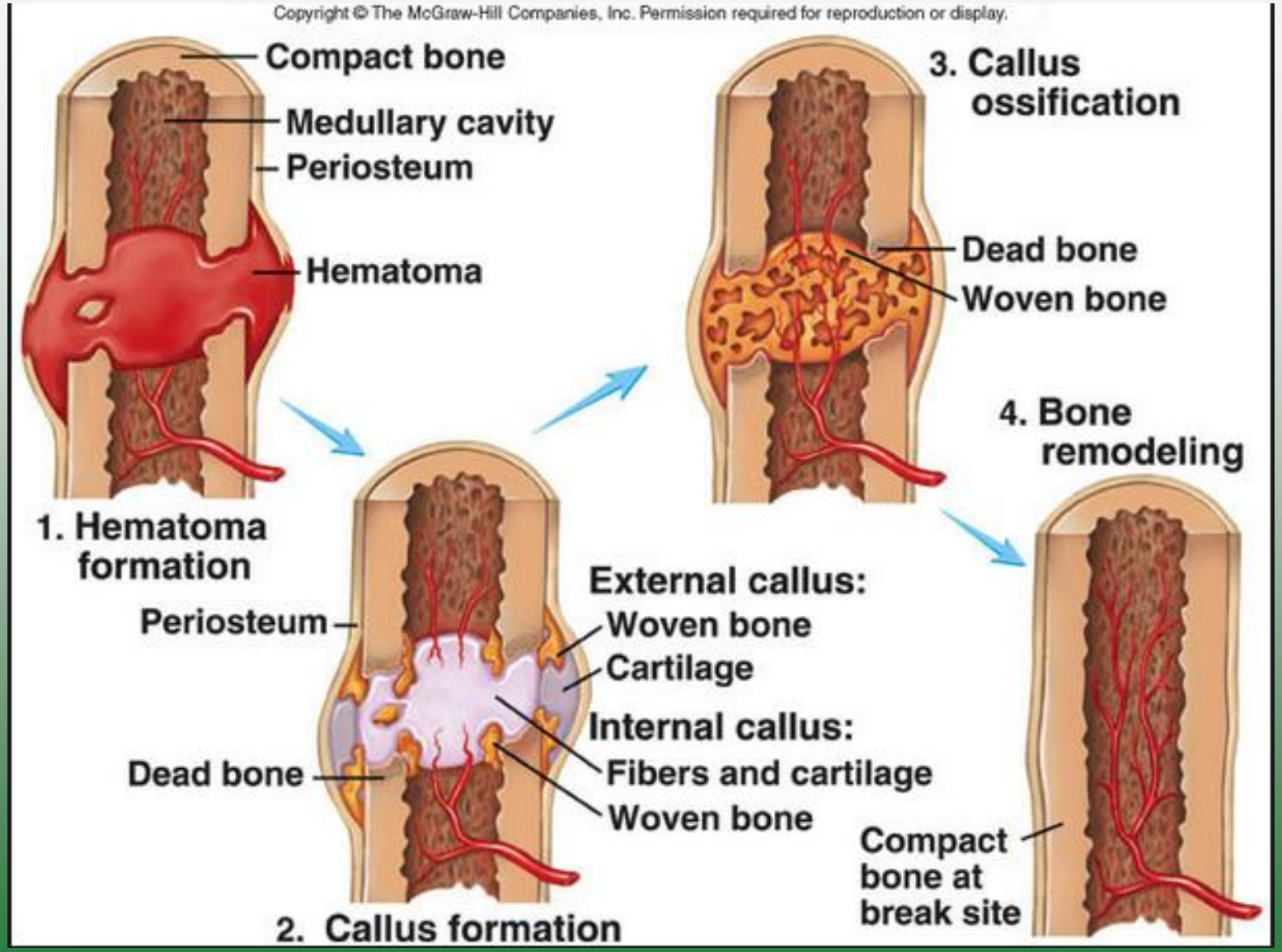
Pathophysiology of Bone Fracture

- Events at a fracture site.
  - **Bleeding**
  - Edema causes stretching of periosteum (if it is intact) and swelling of soft tissues → severe pain
  - Release of bradykinin and other chemical mediators also contributes to pain
  - **Clot forms at fracture site**
  - Systemic signs of inflammation may occur.

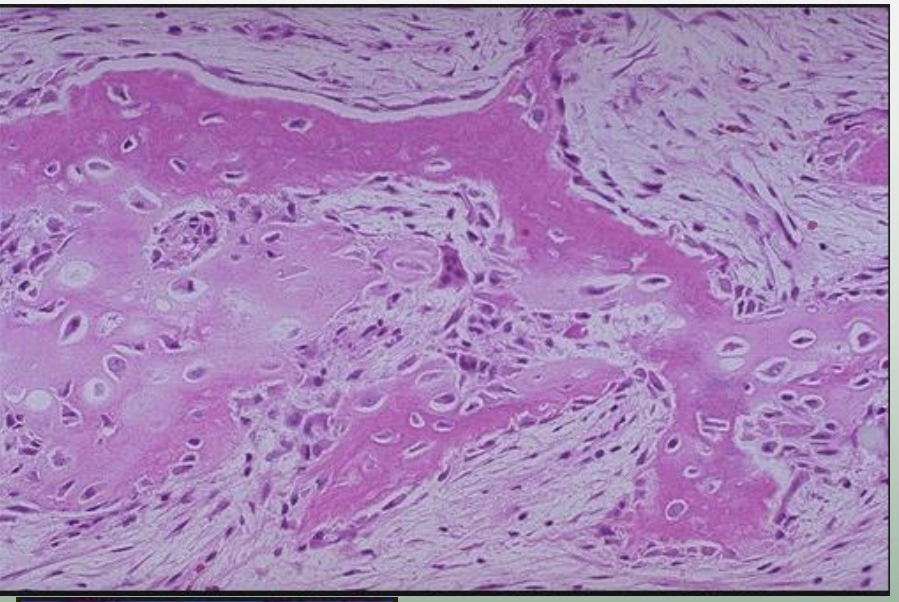
Healing of Bone Fracture

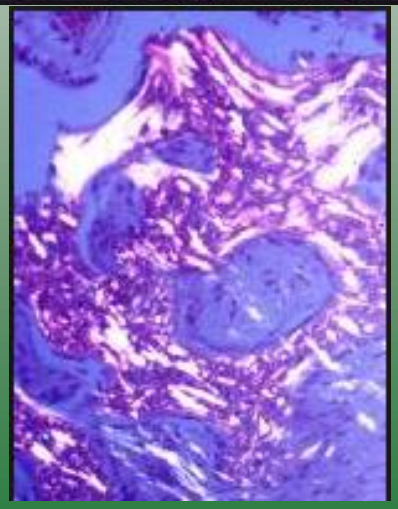
- Hematoma—fibrin network is formed.
- Phagocytic cells remove debris, granulation tissue forms.
- Fibroblasts lay down new collagen fibers.
- Chondroblasts form new cartilage.
- Formation of procallus or soft callus of fibrous tissue and cartilage.
- Osteoblasts generate new bone.
- Procallus is replaced by bony or hard callus.
- Remodeling of bone, with return to use

Healing of Fracture

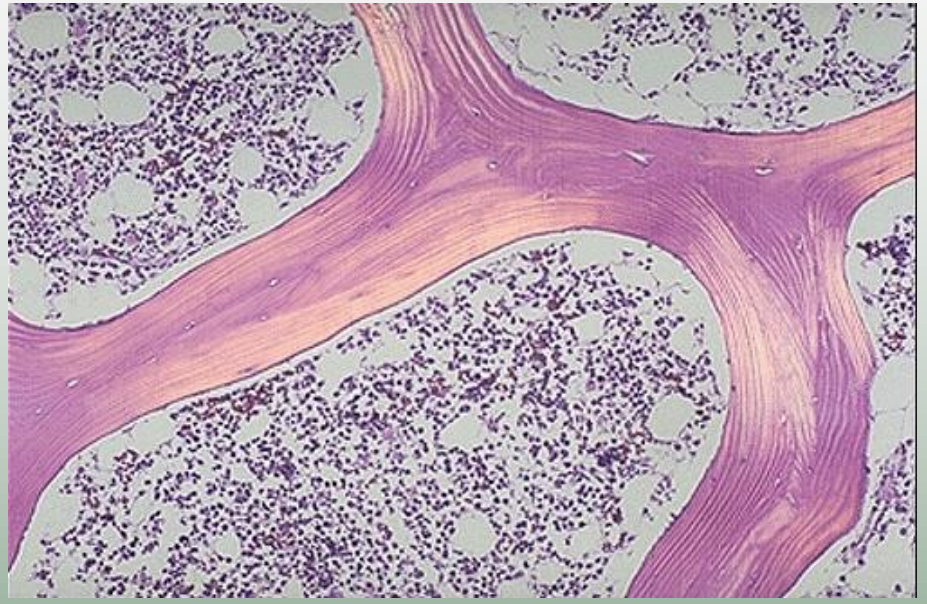


Woven Bone





Lamellar Bone



Factors Affecting Bone Healing

- Amount of local damage
- Proximity of bone ends
- Presence of foreign material or infection
- Blood supply to fracture site
- Systemic factors, such as age, nutrition, anemia

Complications

- Muscle spasms
- Infections
- Ischemia
- Fat emboli
- Nerve damage
- Failure to heal or development of deformity during healing
- Residual effects such as osteoarthritis

Treatments of Fractures

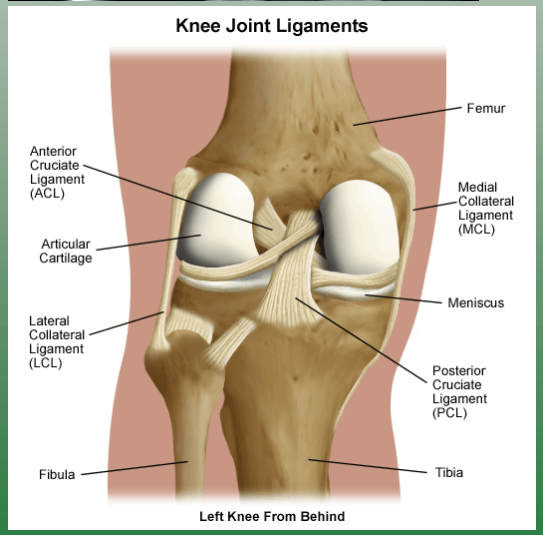
- Closed reduction—pressure to restore bone position (splints and casts).

- Open reduction—surgery to align and/or Insert pins, screw rods, or plates to align

Compartment Syndrome

- Edema within one area of compartment of the limb that is between layers of dense connective tissue (fascia)
- Ischemia and infarction of tissue may occur because of compression of arterial blood supply.
- Dead tissue may become gangrenous, requiring amputation.
- ***A tight cast can cause compartment syndrome!***

Dislocations



- Separation of two bones at a joint, with loss of contact between articulating surfaces
- Usually accompanied by significant soft tissue damage to ligaments and tendons
- Distortion of joint usually evident
- May recur repeatedly, requiring surgery

Injuries

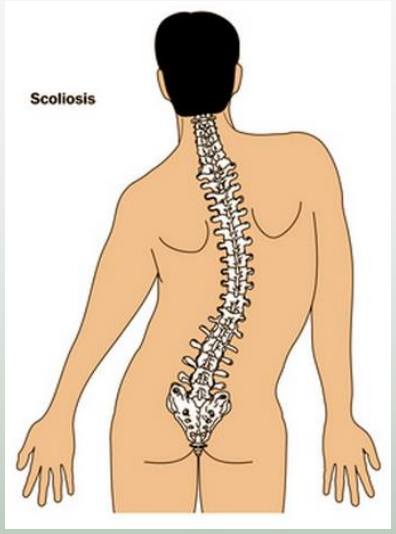
- Sprain—a tear in a ligament
- Strain—a tear in a tendon
- Avulsion—ligaments or tendons completely separated from bony attachments
- Immobilization often used to prevent tissue damage and promote healing
- Overuse injuries
  - Muscle tears

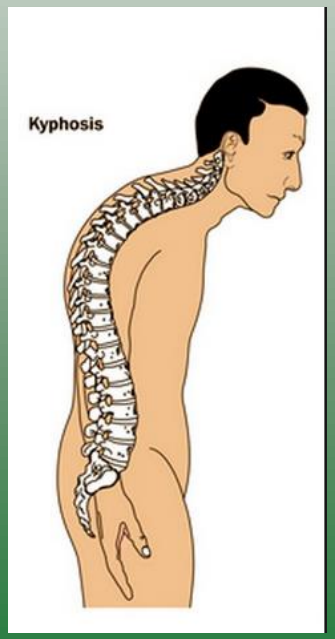
Bone Disorders

Bone Disorders—Osteoporosis

- Decrease in bone mass and density
- Occurs in two forms:
  - Primary
    - Idiopathic
    - Age 50+ years
    - Decreased sex hormones
    - Decreased calcium intake
  - Secondary
    - As a complication of another disorder

Osteoporosis





- Pathophysiology
  - Bone resorption exceeds formation.
  - Results in loss of compact bone
  - Diagnosed with bone density scans
  - Can cause compression fractures of vertebrae, wrist, or hip
  - Can lead to kyphosis and scoliosis

Osteoporosis (Cont.)

- Predisposing factors
  - Age 50+ years
  - Decreased mobility or sedentary lifestyle
  - Hormonal factors
    - Excess corticosteroids or parathyroid hormone (PTH)
    - Deficit of estrogen or testosterone
  - Deficits of calcium, vitamin D, or protein
  - Cigarette smoking
  - Lower BMI
  - Asian or European ancestry
  - Excessive caffeine intake

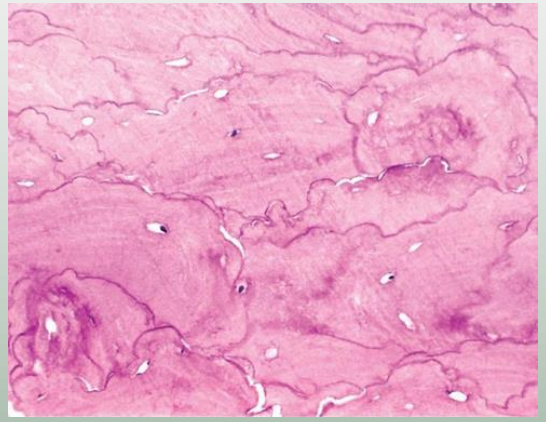
Osteoporosis (Cont.)

- Treatment
  - Dietary supplements
  - Weight-bearing exercise
  - Physiotherapy to reduce pain and maintain function
  - Bisphosphonates, inhibits osteoclasts.
  - Calcitonin

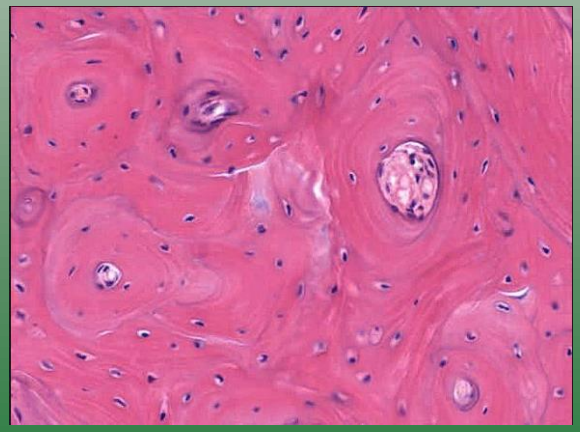
Rickets and Osteomalacia

- Result from deficit of vitamin D and phosphates
- Causes—dietary deficits, malabsorption, intake of phenobarbital, lack of sun exposure
- In children, leads to weak bones and other skeletal deformities
- In adults, may lead to soft bones, resulting in compression fractures

Paget's Disease



Paget's (above): Odd pattern of cement lines, normal below.

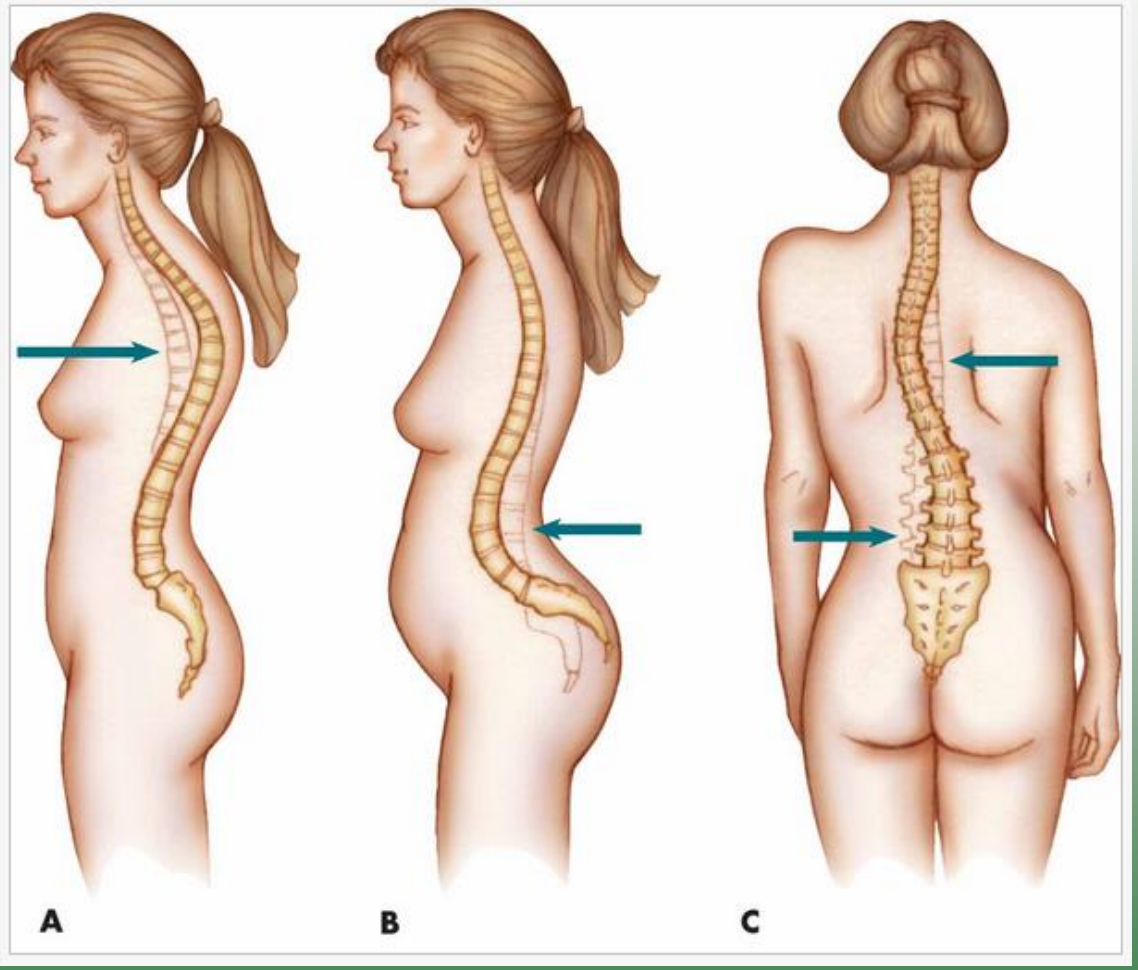


- Occurs in adults older than 40 years
- Exact cause has not yet been established.
- Bone destruction replaced by fibrous tissue
- Pathologic fractures are common.
- In vertebrae—can result in compression fractures and kyphosis
- In skull—increased pressure resulting in headaches and compression of cranial nerves → severe pain

Osteomyelitis

- Bone infection caused by bacteria or fungi
- Signs and symptoms
  - Local inflammation and bone pain
  - Fever and excessive sweating
  - Chills
  - General malaise
- Treatment
  - Antibiotics
  - Surgery may be required.

Abnormal Curvatures of the Spine



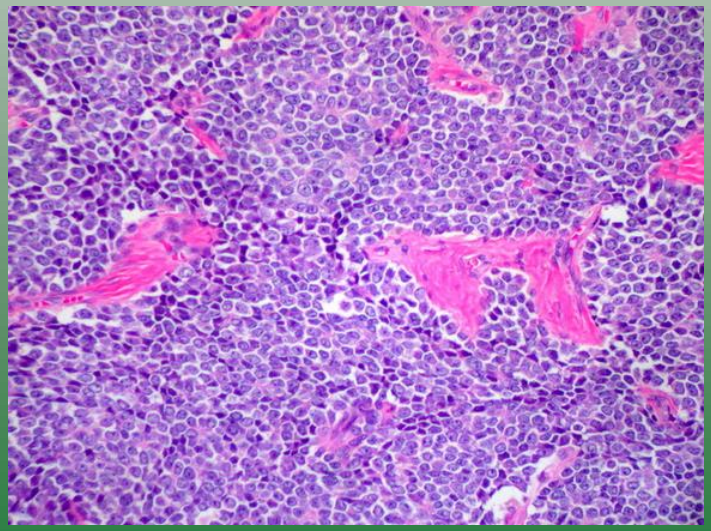
- A. Kyphosis
  - Hunchback or humpback—abnormally rounded upper back
- B. Lordosis
  - Swayback—curving inward at the lower back
- C. Scoliosis
  - S- or C-shaped—sideways curve to the spine

Tumors

- Common site of metastatic tumors from breast, lung, or prostate tumors
- Most primary tumors termed *sarcomas* are malignant.
- Osteosarcoma—most common primary neoplasm of bone
  - Occurs in the shaft of long bones of the leg
  - Common in children, adolescents, and young adults
  - Bone pain at rest is a warning sign for this cancer!

Tumors (Cont.)

- Chondrosarcomas—arise from cartilage cells; more common in adults
- Ewing's sarcoma is common in adolescents and usually occurs in the shaft (in marrow cavity) of long bones. Also known as PNET – Primitive Neuroectodermal Tumor.



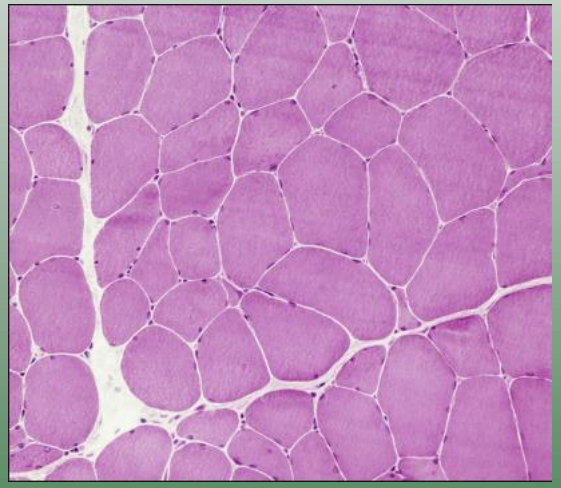
Small primitive cells with no bone or cartilage formation.

Bone Tumors

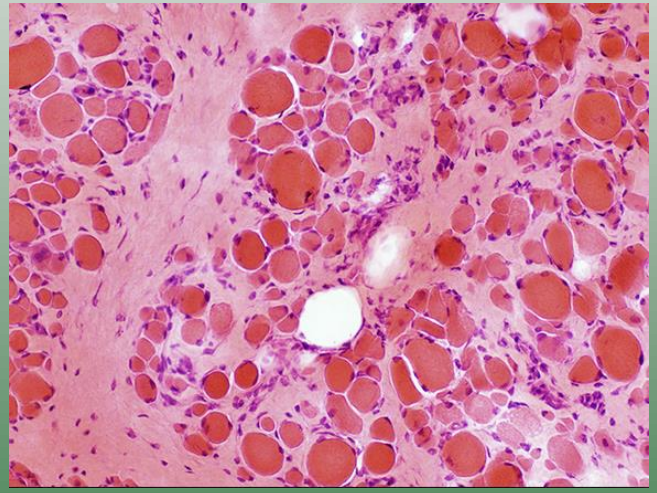
- Tumors metastasize to lungs early in the course of the disease.
- Treatment
  - Excision of tumor if possible
  - Surgical amputation if excision is not feasible
  - Chemotherapy to reduce metastasis

Muscular Dystrophy (MD)

- Group of autosomal recessive disorders
- Degeneration of skeletal muscle over time
- Duchenne's MD or pseudohypertrophic MD most common type; affects young boys



Normal Muscle: Uniform fiber size and tightly packed.

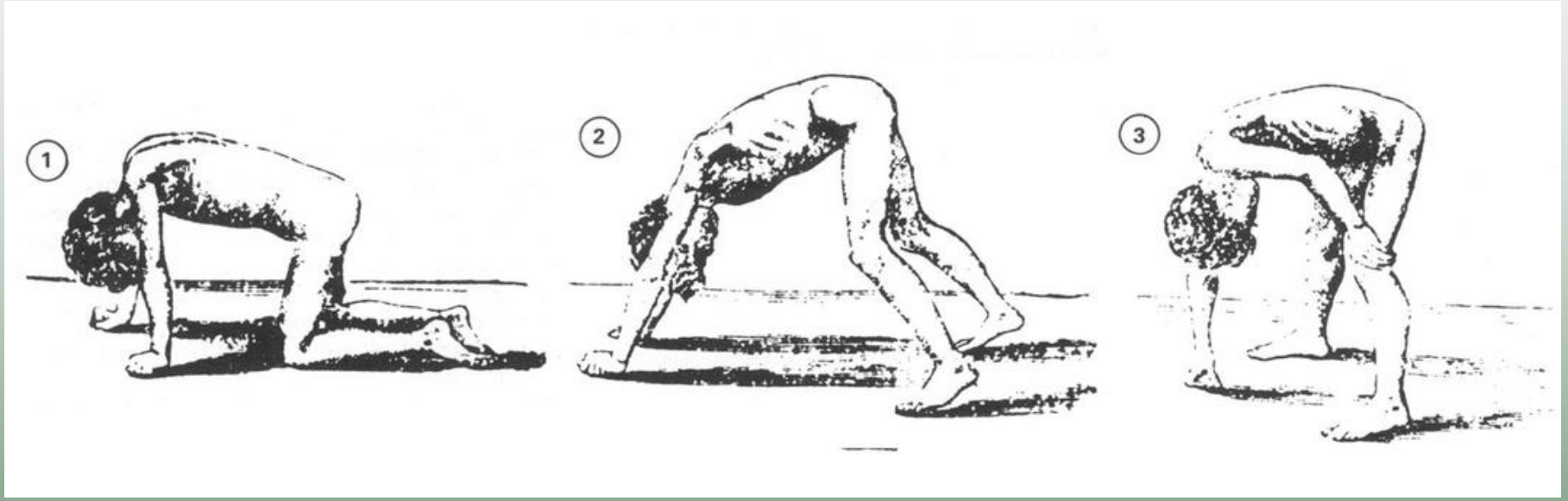


Muscular Dystrophy: Widely variable fiber size and fibers separated by fibrous tissue.

Muscular Dystrophy (MD) (Cont.)

- Signs and symptoms
  - With Duchenne's MD—early motor weakness
  - Weakness in pelvic girdle—waddling gait, difficulty climbing stairs
  - Gower maneuver—pushing up to erect position (using arms to stand up due to weak legs).
  - Tendon reflexes reduced
  - Deformities develop, such as kyphoscoliosis
  - Respiratory infections common
  - Cardiac myopathy occurs commonly.

Gower's Sign



Muscular Dystrophy (MD) (Cont.)

- Diagnostic tests
  - Identification of common genetic abnormalities
  - Elevated creatine kinase levels
  - Electromyography
  - Muscle biopsy
  - Genetic Tests

Muscular Dystrophy (MD) (Cont.)

- Treatment
  - No curative treatment available
  - Moderate exercise to maintain motor function
  - Supportive appliances
  - Physiotherapy and occupational therapy to maximize function and adaptation
  - Massage—reduces pain and stiffness
  - Ventilator—in case of respiratory failure
  - Research being done on genetic therapies

Fibromyalgia

- Syndrome characterized by:
  - Pain in soft tissues
  - Stiffness affecting muscles, tendons, and soft tissue
  - No obvious inflammation or atrophy
  - Sleep disturbance and severe fatigue
  - Anxiety and/or depression may be present.
- Cause is not known but hypothesized to be imbalance in serotonin and other neurotransmitters or increased production of substance P

Fibromyalgia (Cont.)

- Predisposing and aggravating factors
  - Onset is higher in women age 20 to 50 years.
  - History of physical or psychological trauma or chronic pain
  - Sleep deprivation
  - Stress
  - Fatigue

Fibromyalgia (Cont.)

- Treatment
  - Stress avoidance or reduction
  - Regular exercise in the morning
  - Pace activity and rest as needed.
  - Applications of heat or massage
  - Analgesic drugs
  - Low doses of antidepressants
  - NSAIDs
  - New drugs—pregabalin (Lyrica)

Joint Disorders

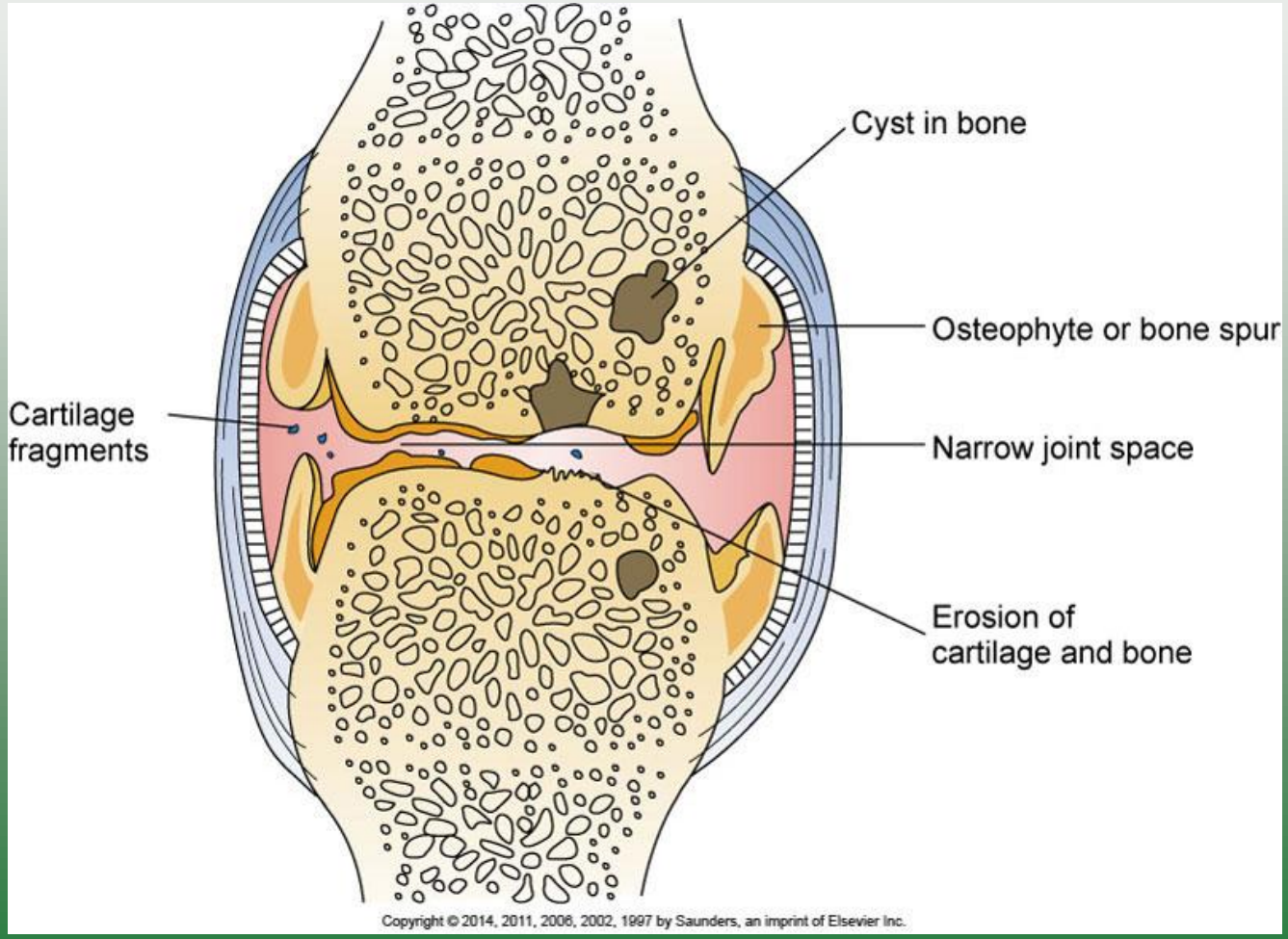
Osteoarthritis

- Degenerative—wear and tear joint disease
- May be the result of increased weight-bearing or lifting
- Incidence increasing
- Genetic component identified in research with mice

Osteoarthritis (Cont.)

- Pathophysiology
  - Articular cartilage is damaged.
  - Surface of cartilage becomes rough and worn
  - Tissue damage causes release of enzymes, accelerating disintegration of cartilage.
  - Subchondral bone may be exposed.
  - Osteophytes and cartilage break off.
  - Joint space becomes narrower.
  - Secondary inflammation of surrounding tissue
  - Loss of normal range of joint motion
  - Pain with weight-bearing and use

Pathologic Changes with Osteoarthritis



Osteoarthritis (Cont.)

- Causes
  - Primary form—weight-bearing, obesity, aging
  - Secondary form—follows trauma or repetitive use
  - Genetic factors thought to play a role
  - Weight-bearing joints most frequently affected but finger joints also involved

Osteoarthritis (Cont.)

- Signs and symptoms
  - Aching pain with weight-bearing and movement
  - Pain gets worse as day goes on.
  - Joint movement is limited.
  - Recreational and social activities become limited because of pain.
  - Walking is difficult.
  - Predisposition to falls
  - In temporomandibular joint (TMJ) syndrome, mastication and speaking are difficult.
  - Bony enlargement of distal interphalangeal joints

Osteoarthritis (Cont.)

- Treatment
  - Minimize stress on joint by use of adaptive devices such as a cane
  - Pacing activity
  - Mild exercise program to maintain fitness and joint function
  - Supports such as hand brace to facilitate movement
  - Orthotic Inserts in shoes

Osteoarthritis (Cont.)

- Treatment (Cont.)
  - Massage therapy
  - Physiotherapy
  - Acupuncture
  - Occupational therapy
  - **Glucosamine chondroitin supplements**
  - Injection of synthetic synovial fluid (hyaluronic acid)
  - **NSAIDs**
  - **Analgesics**
  - Arthrotomy to stabilize joint
  - **Surgical joint replacement**

Rheumatoid Arthritis

- Considered an autoimmune disorder
- Causes chronic systemic inflammatory disease
- Higher incidence in women than in men
- Affects all age groups
- Morning stiffness, gets better as day goes on.

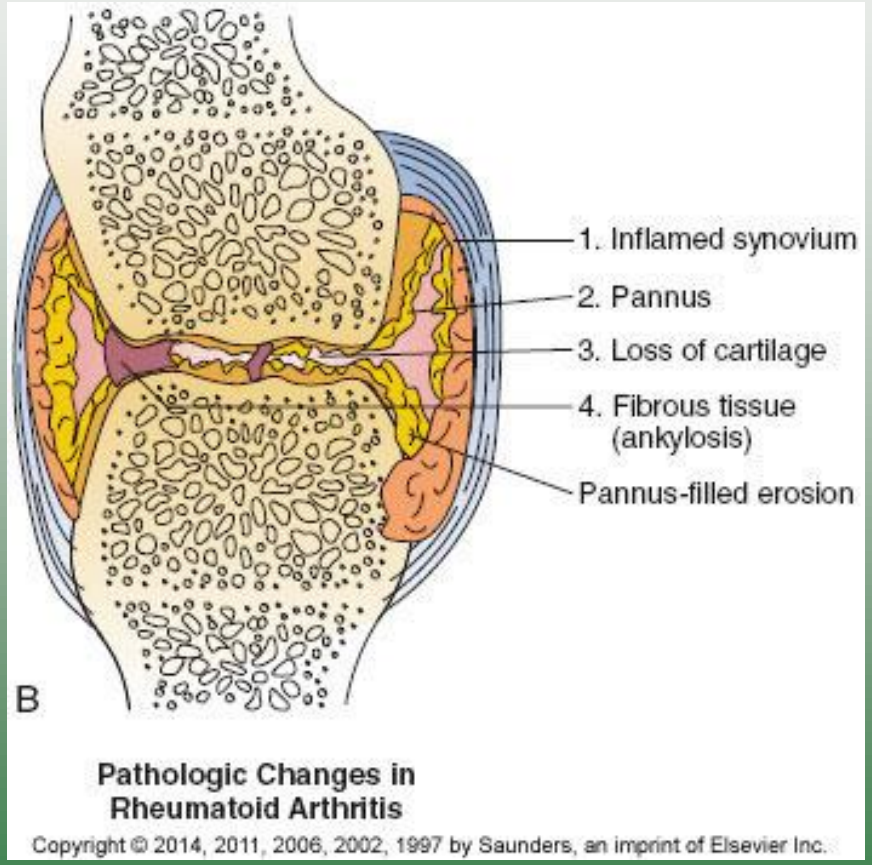
Rheumatoid Arthritis (Cont.)

- Pathophysiology
  - Synovitis—marked inflammation, cell proliferation
  - Pannus formation—granulation tissue spreads.
  - Cartilage erosion—creates unstable joint
  - Fibrosis—calcifies and obliterates joint space
  - Ankylosis—joint fixation and deformity develop if untreated.

Rheumatoid Arthritis (Cont.)

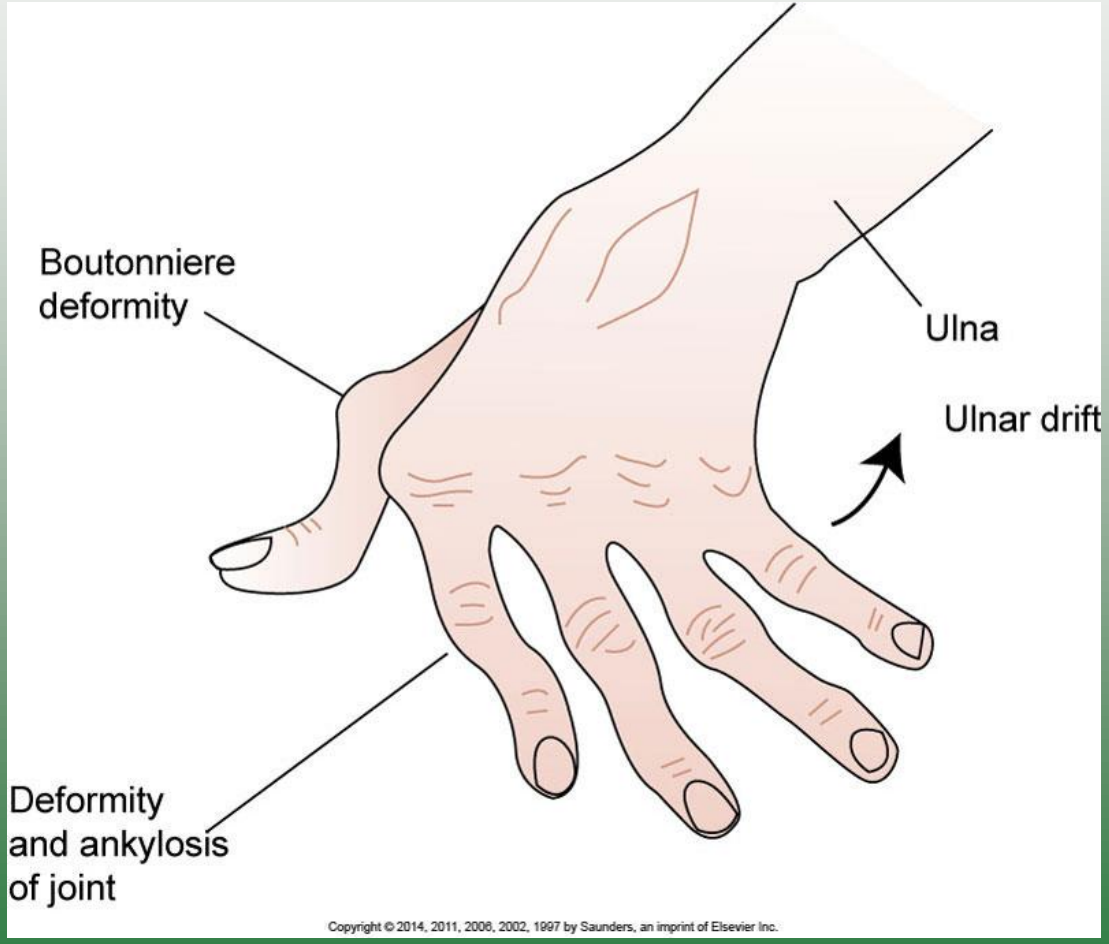
- Other changes frequently occur around the joint.
  - Atrophy of muscles
  - Bone alignment shifts
  - Muscle spasms caused by inflammation and pain
  - Contractures and deformity develop.

Rheumatoid Arthritis (Cont.)



Pathologic Changes in Rheumatoid Arthritis

Typical Deformity in a Hand with Rheumatoid Arthritis



Joint Disorders: Rheumatoid Arthritis (Cont.)

- Systemic effects
  - Marked fatigue
  - Depression
  - Malaise
  - Anorexia
  - Low-grade fever
  - Iron deficiency anemia that is resistant to iron therapy

Rheumatoid Arthritis (Cont.)

- Cause
  - Exact cause not known
  - Genetic factor is present.
  - Familial predisposition
  - Some links to viral infections

Rheumatoid Arthritis (Cont.)

- Signs and symptoms
  - Affected joints are extremely painful.
  - Stiffness of joints
  - Redness and swelling of joints
  - Joint involvement includes small joints and is often bilateral.
  - Joint movement impaired
  - Eventually, the joint becomes fixed and deformed.

Rheumatoid Arthritis (Cont.)

- Systemic signs
  - Fatigue
  - Anorexia
  - Mild fever
  - Generalized lymphadenopathy
  - Generalized aching

Rheumatoid Arthritis (Cont.)

- Treatment
  - Balance between rest and moderate activity
  - Heat and cold applications
  - Physical and occupational therapy
  - NSAIDs
  - Glucocorticoids for severe inflammation
  - Analgesia for pain
  - Disease-modifying antirheumatic drugs, such as gold salts, methotrexate, hydroxychloroquine
  - Biological response–modifying agents, such as infliximab, rituximab, anakinra

Juvenile Rheumatoid Arthritis (JRA)

- Several different types
- Onset more acute than adult form
- Large joints frequently affected

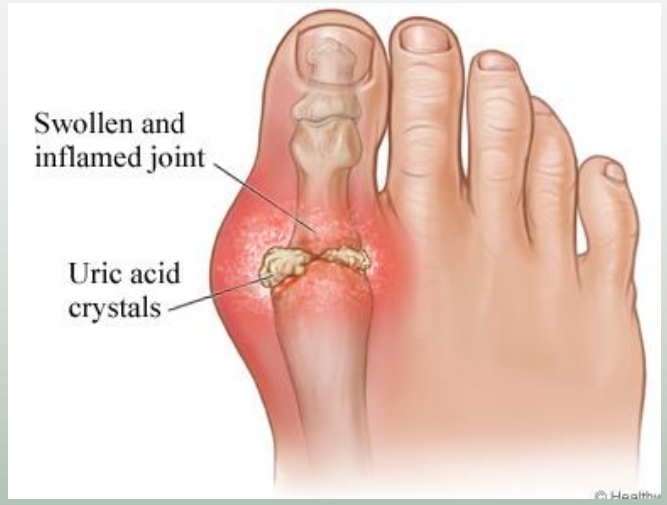
Infectious Arthritis

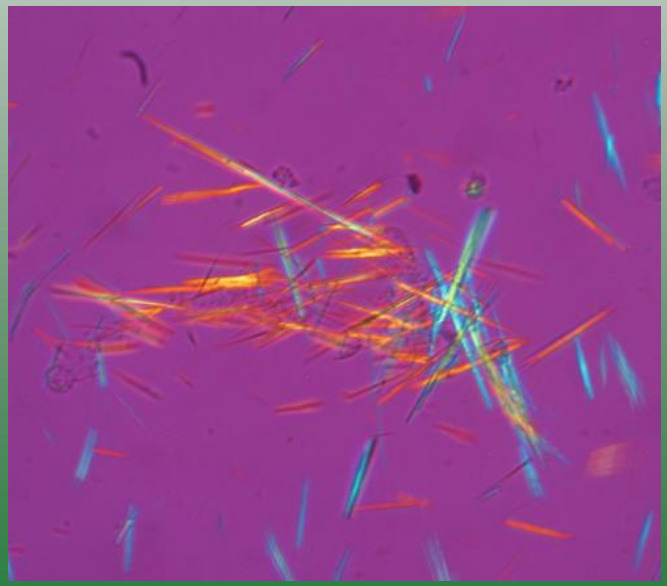
- Also known as septic arthritis
- Develops in single joint
- Joint is red, swollen, painful, with decreased movement
- Causes
  - Direct introduction of bacteria into joint, such as trauma, nonsterile injection, surgery
  - Secondary infection because of bacteremia
- Treatment with antimicrobials over sustained period; often requires IV administration

Gout

- Also known as gouty arthritis
- Results from deposits of uric acid and crystals in the joint, causing inflammation
- Formation of tophus—large hard nodule of urate crystals
- Tophi cause local inflammation and occur after the first attack of gout.

Gout (Cont.)



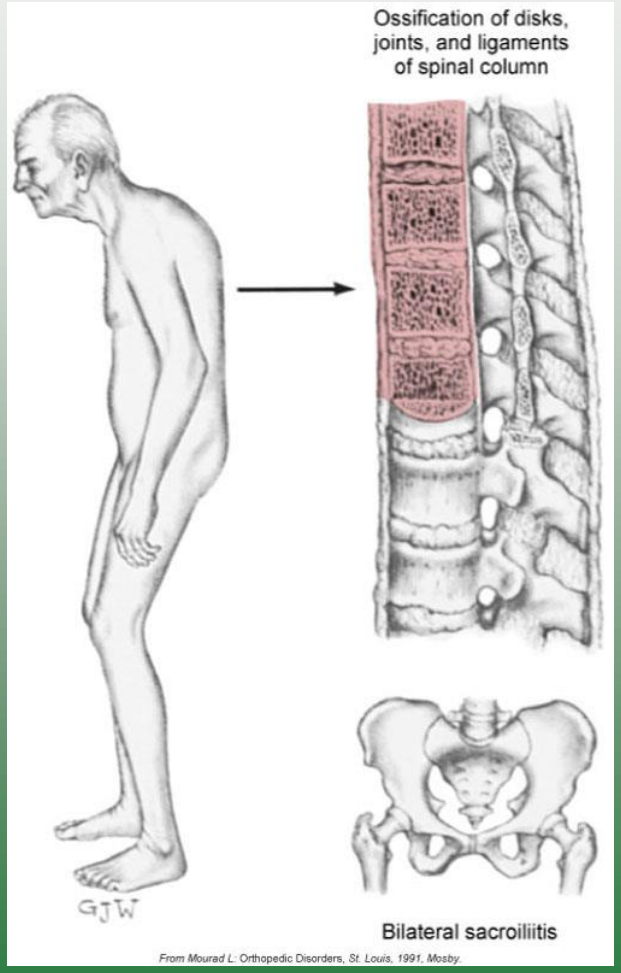


- Uric acid and crystals form because of inadequate renal excretion, chemotherapy, metabolic abnormality, and/or genetic factors.
- Inflammation causes redness, swelling, and pain. Classic is red inflamed big toe.
- Treated by reducing uric acid levels with drugs and dietary changes
- Diagnosed by examination of synovial fluid and blood tests
  - **NOTE:** Use of NSAIDs prior to blood tests will cause a false-negative result.

Ankylosing Spondylitis

- Chronic, progressive, inflammatory condition
- Affects sacroiliac joints, intervertebral spaces, costovertebral joints
- More common in men age 20 to 40 years
- Cause has not yet been determined—thought to be an autoimmune disorder with a genetic basis

Characteristic Posture and Sites of Ankylosing Spondylitis



- Progression of condition
  - Vertebral joints inflamed
  - Fusion of joint—loss of mobility
  - Inflammation in lower back, then up spine
  - Kyphosis develops
  - Osteoporosis common
  - Lung expansion limited