Musculoskeletal System Disorders

Rigor Mortis

- **Hardening of muscles and stiffening of body after death**
  - **<u>begins 3 to 4 hours after death // peaks after twelve hours</u>**
  - **deteriorating sarcoplasmic reticulum releases Ca^{+2}**
  - **deteriorating sarcolemma allows Ca^{+2} to enter cytosol**
  - **Ca^{+2} activates myosin-actin cross-bridging**
  - **<u>muscle contracts</u>**
  - **<u>but muscle can not relax</u>**

Rigor Mortis

- **True muscle relaxation requires ATP**
  - **“free” ATP only last a few seconds in the cytoplasm**
  - **ATP production not produced after death**
- **<u>After rigor mortis muscle organ “starts to relax” as myofilaments proteins start to be hydrolyzed by lysosomal activity</u>**
  - **then diminishes over the next 48 to 60 hours**

Neuromuscular Toxins

Some toxins interfere with synaptic function and can result in either spastic paralysis or flaccid paralysis of the muscles

- **Spastic paralysis – over stimulated and muscle can not relax**
  - **some pesticides contain cholinesterase inhibitors**
    - **bind to acetylcholinesterase and prevent it from degrading Ach**
    - **spastic paralysis - a state of continual contraction of the muscles**
    - **possible suffocation**
  - **tetanus (lockjaw) is a form of spastic paralysis caused by toxin of *Clostridium tetani***
    - **glycine in the spinal cord normally stops motor neurons from producing unwanted muscle contractions**
    - **tetanus toxin blocks glycine release in the spinal cord and causes over stimulation and spastic paralysis of the muscles**

Neuromuscular Toxins

Some toxins interfere with synaptic function and can result in either spastic paralysis or flaccid paralysis of the muscles

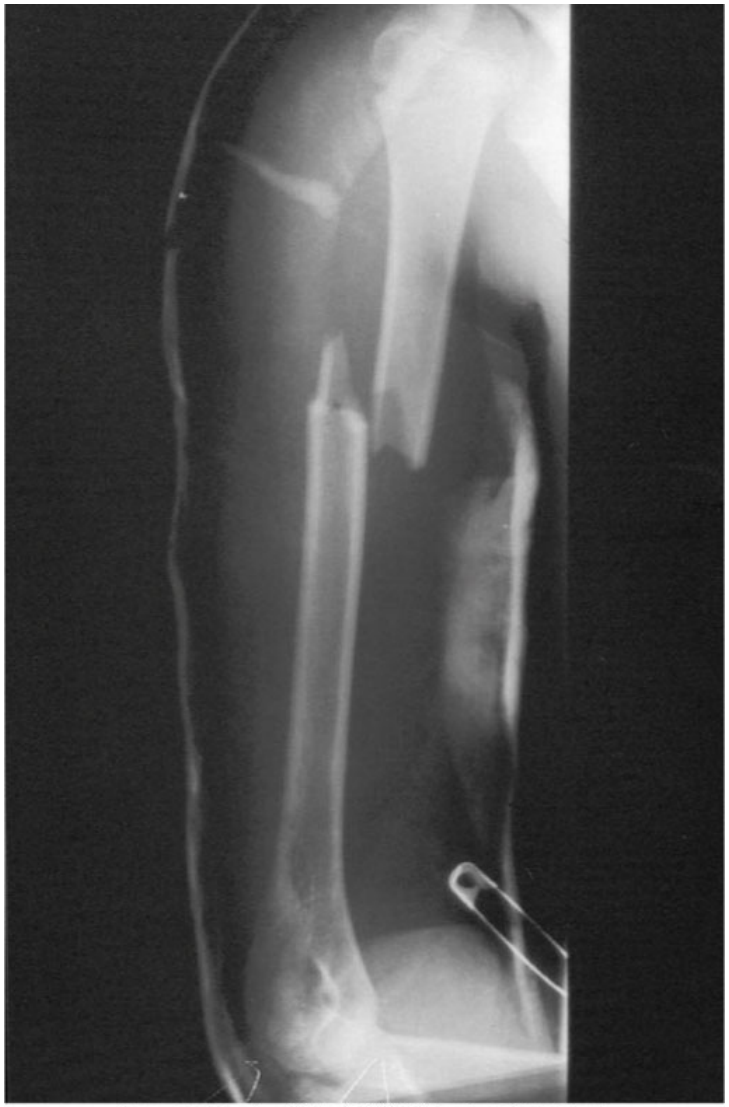
- **Flaccid paralysis – a state in which the muscles are limp and cannot contract**
  - **curare – compete with ACh for receptor sites, without stimulating the muscles**
    - **plant poison used by South American natives to poison blowgun darts**
  - **botulism – type of food poisoning caused by a neuromuscular toxin secreted by the bacterium *Clostridium botulinum***
    - **blocks release of ACh causing flaccid paralysis**
    - **Botox Cosmetic injections for wrinkle removal**

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.
- Fractures are charted using the # sign.



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 due to disease state; occurs with little stress
  - Stress - fatigue fractures
  - Depressed - skull fractured and forced into brain

Pathophysiology of Bone Fracture

- Fractures initiate an inflammatory response and hemostasis (blood clotting)
  - Bleeding / results in soft callus formation
  - 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 (C reactive protein).

Healing of Bone Fracture

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

Fractures and Their Repair

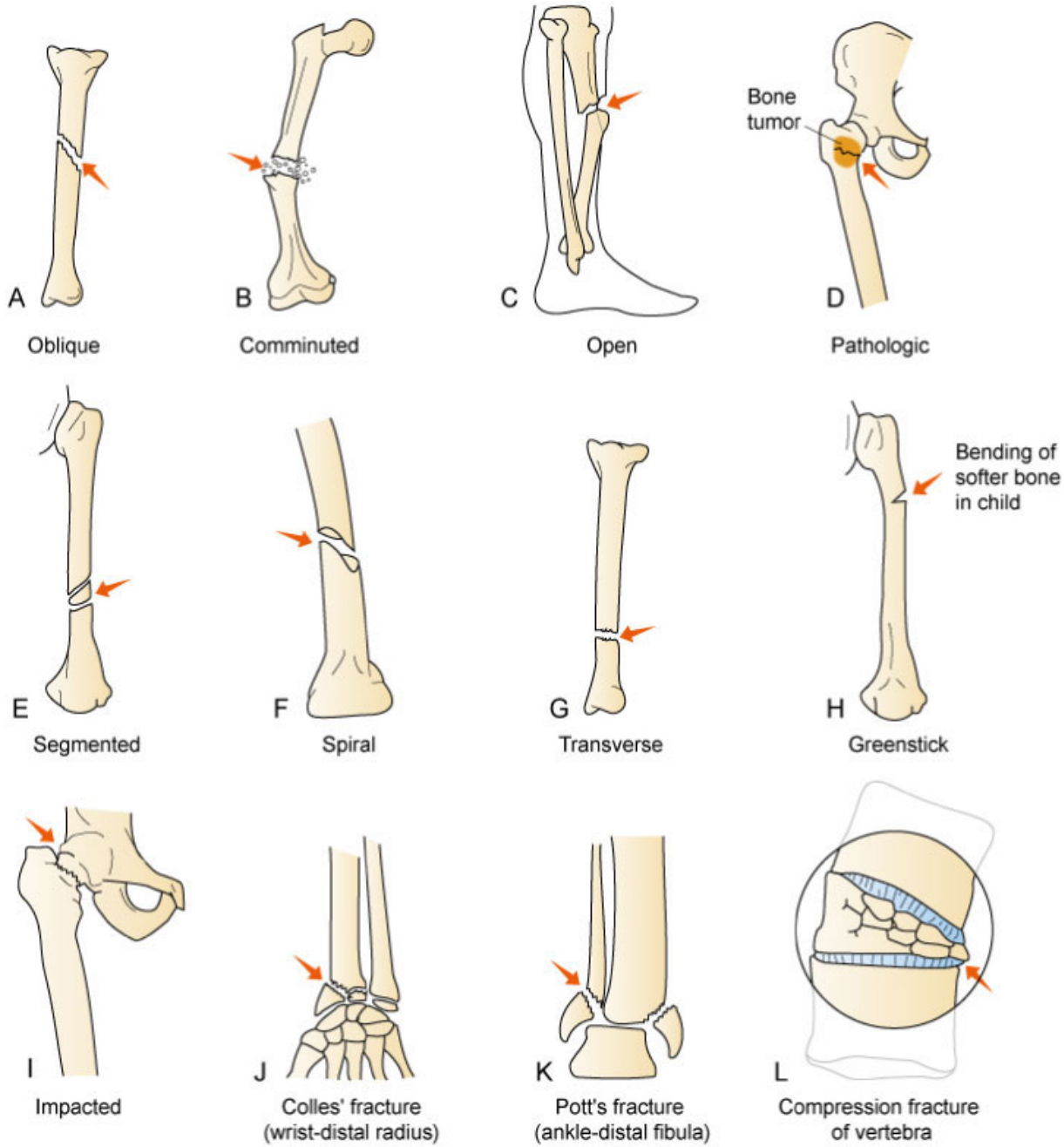
- stress fracture – break caused by abnormal trauma to a bone // falls, athletics, and military combat

- pathological fracture – break in a bone weakened by some other disease /// bone cancer or osteoporosis // usually caused by stress that would not break a healthy bone

- fractures classified by structural characteristics
  - direction of fracture line
  - break in the skin
  - multiple pieces

- uncomplicated fractures // normally take 8 - 12 weeks to heal // longer in elderly

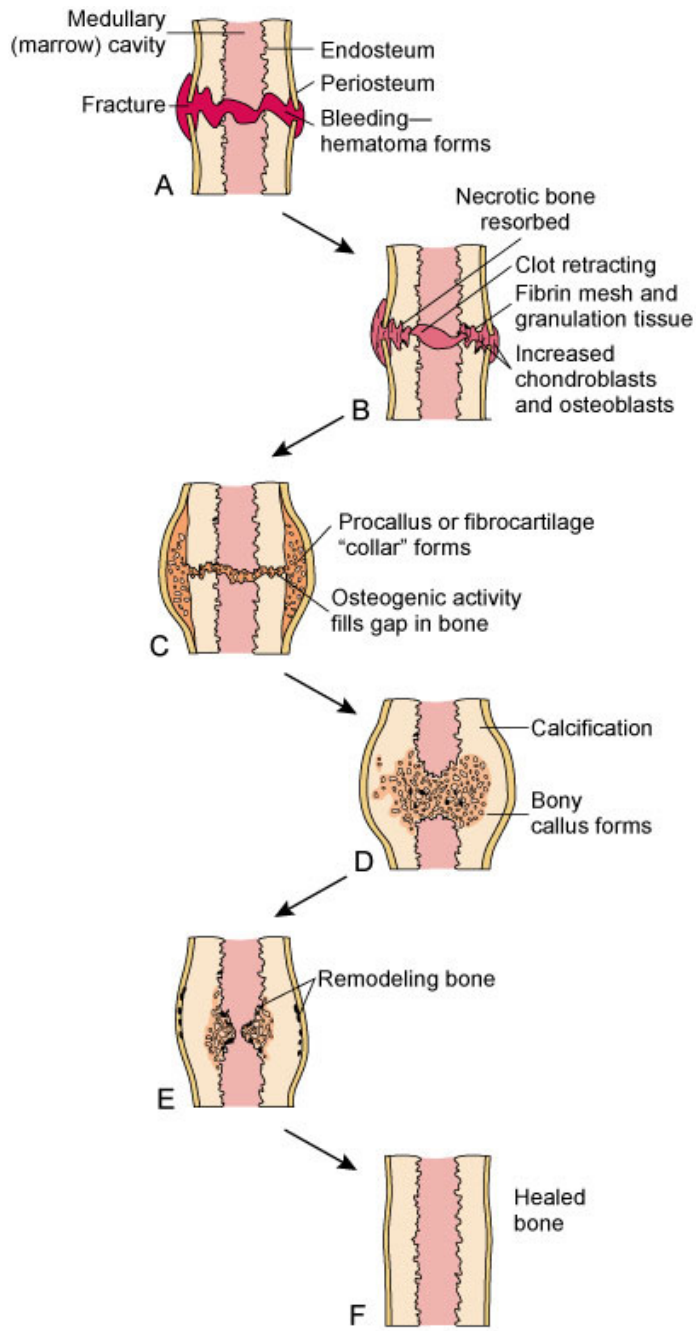
Types of Fractures



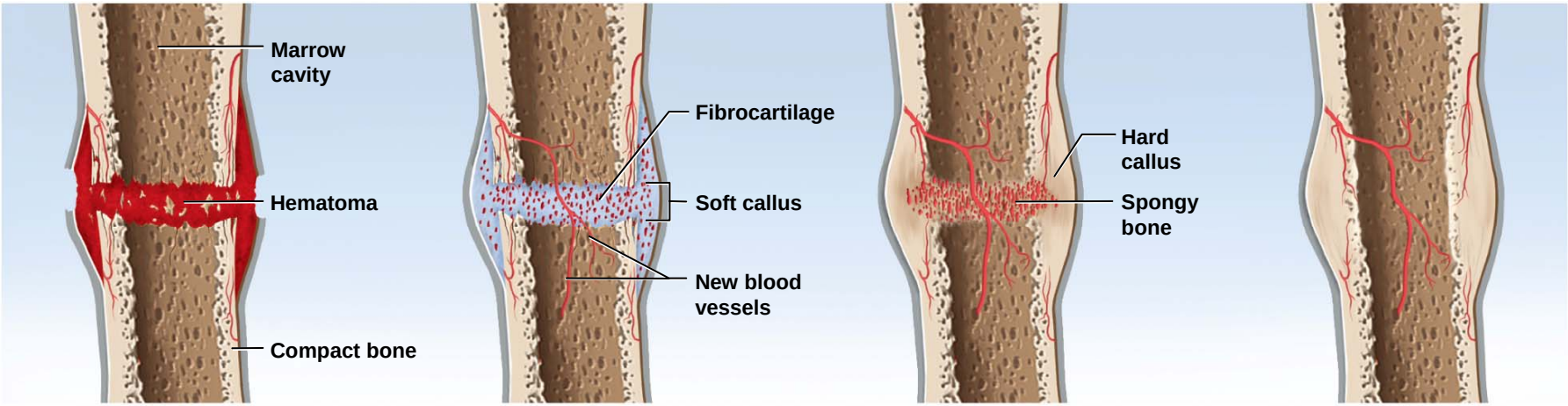
Factors Affecting Bone Healing

- 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

Healing of Fracture



Healing of Fractures



1 **Hematoma formation**
The hematoma is converted to granulation tissue by invasion of cells and blood capillaries.

2 **Soft callus formation**
Deposition of collagen and fibrocartilage converts granulation tissue to a soft callus.

3 **Hard callus formation**
Osteoblasts deposit a temporary bony collar around the fracture to unite the broken pieces while ossification occurs.

4 **Bone remodeling**
Small bone fragments are removed by osteoclasts, while osteoblasts deposit spongy bone and then convert it to compact bone.

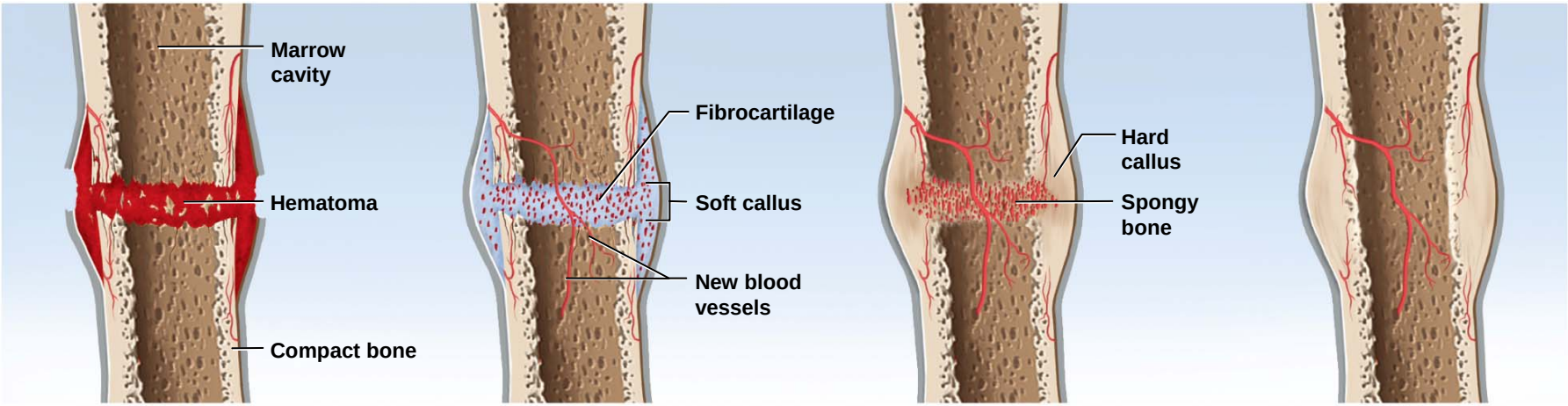
Stages of Healing Bone Fractures

- **Fracture hematoma and granulation tissue**
  - **bleeding of a broken bone forms a clot – fracture hematoma**
  - **blood capillaries, fibroblasts, macrophages, osteoclasts, and osteogenic cells invade clot**
  - **granulation tissue – soft fibrous mass produced by capillary and cellular invasion after about 48 hours after injury**
- **Soft callus formation**
  - **formed by fibroblasts and chondroblasts depositing collagen and fibrocartilage into granulation tissue**

Stages of Healing Bone Fractures

- **Conversion to hard callus**
  - **osteoblasts produce a bony collar in 6 weeks called a hard callus**
  - **hard callus is cemented to dead bone around the injury site and acts as a temporary splint to join broken ends together**
  - **4 - 6 weeks for hard callus to form and immobilization is necessary**
- **Remodeling**
  - **hard callus persists for 3 – 4 months**
  - **osteoclasts dissolve fragments of broken bone**
  - **osteoblasts deposit spongy bone to bridge to gap between the broken ends, transformed gradually into compact bone that is thicker in fracture area**
- **Vitamin A, C, and D important nutritional factors for growth and repair**

Healing of Fractures



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Treatment of Fractures

- closed reduction
  - **procedure in which the bone fragments are manipulated into their normal positions without surgery**
- open reduction
  - **involves surgical exposure of the bone and the use of plates, screws, or pins to realign the fragments**

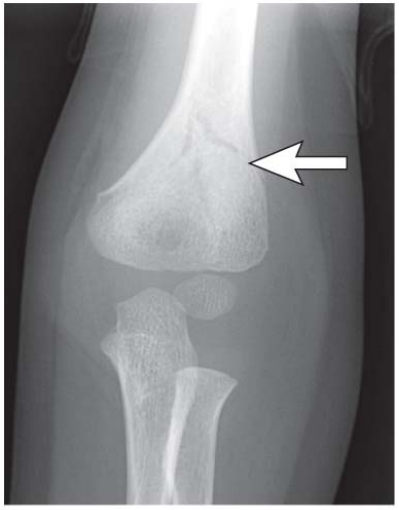
Treatment of Fractures

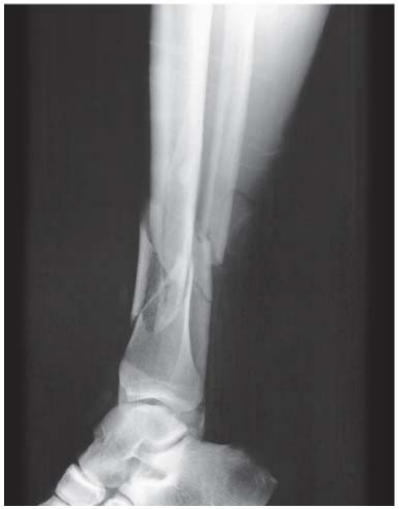
- cast – normally used to stabilize and immobilize healing bone
- electrical stimulation accelerates repair // suppresses the effects of parathyroid hormone
- orthopedics – the branch of medicine that deals with prevention and correction of injuries and disorders of the bones, joints, and muscles

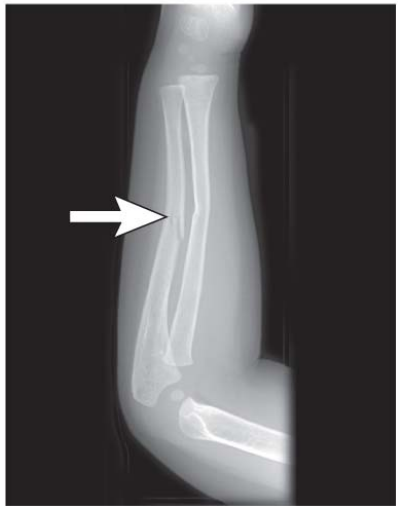
Treatment of Fractures

- **traction used to treat fractures of the femur in children**
  - **aligns bone fragments by overriding force of the strong thigh muscles**
  - **risks long-term confinement to bed**
  - **rarely used for the elderly**
  - **hip fractures are usually pinned in elderly and early ambulation (walking) is encouraged to promote blood circulation and healing**

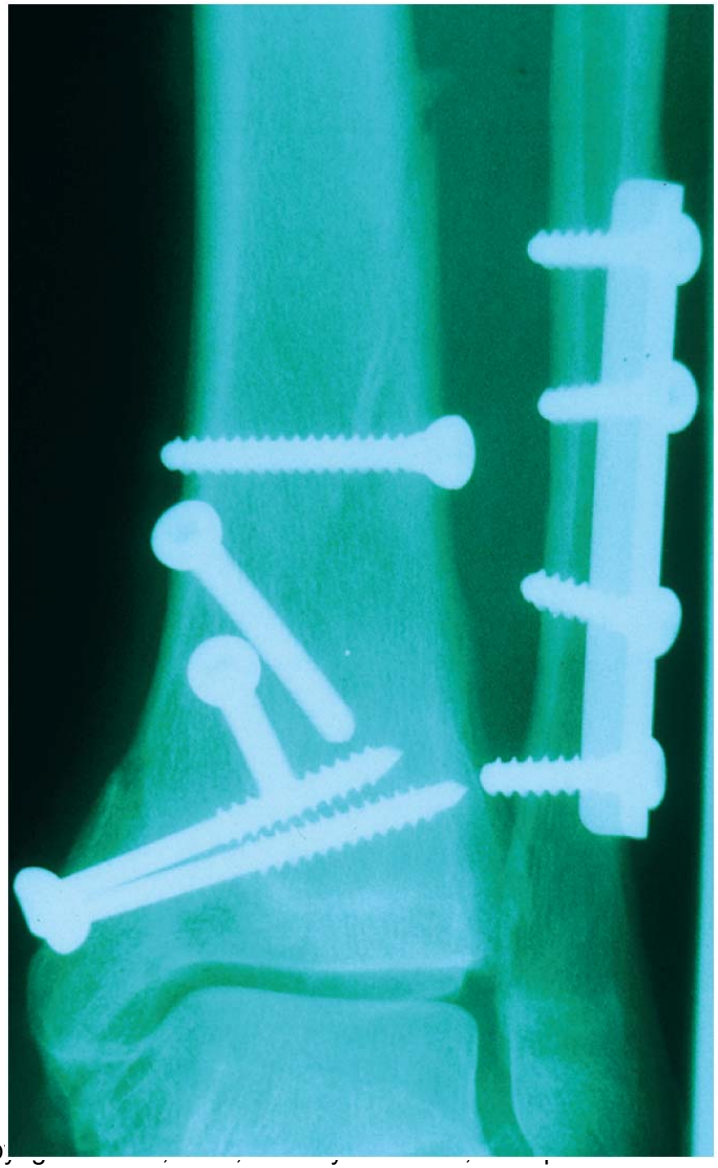
Types of Bone Fractures







Fractures and Their Repairs

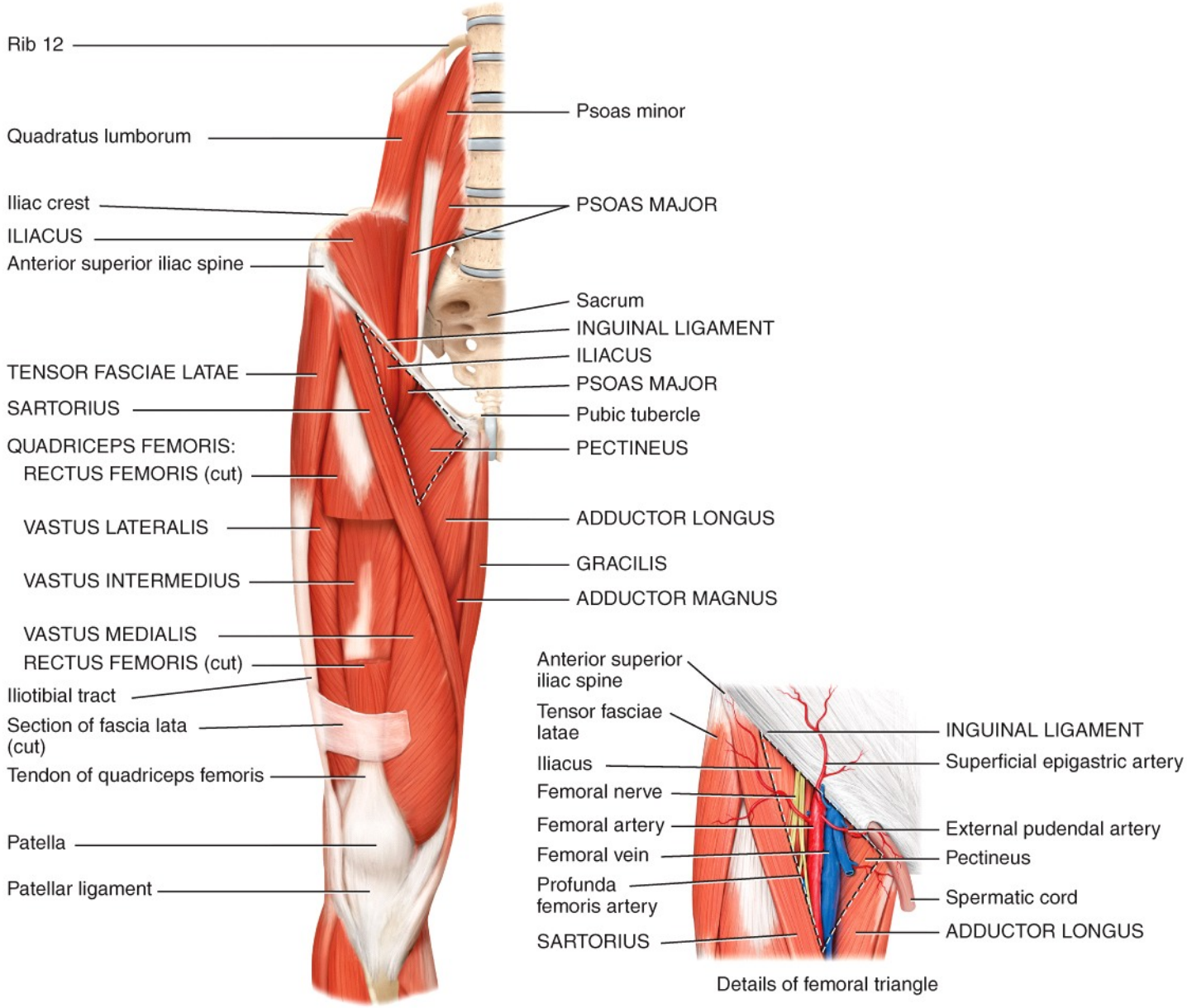


Complications

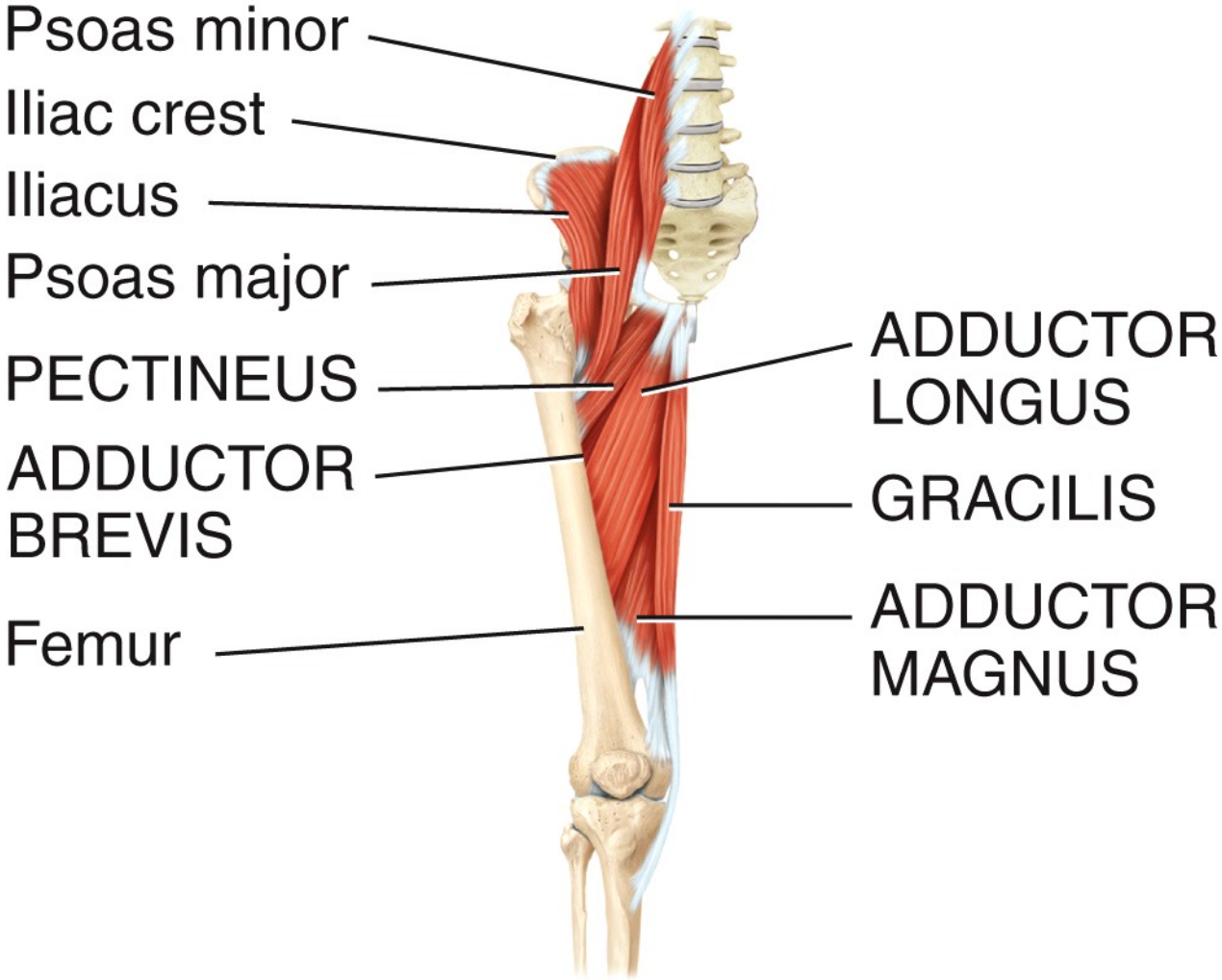
- Muscle spasms
- Infections
- Ischemia
- Fat emboli
- Nerve damage
- Failure to heal or development of deformity during healing
- Residual effects such as osteoarthritis

Compartment Syndrome of Skeletal Muscles

- 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!***

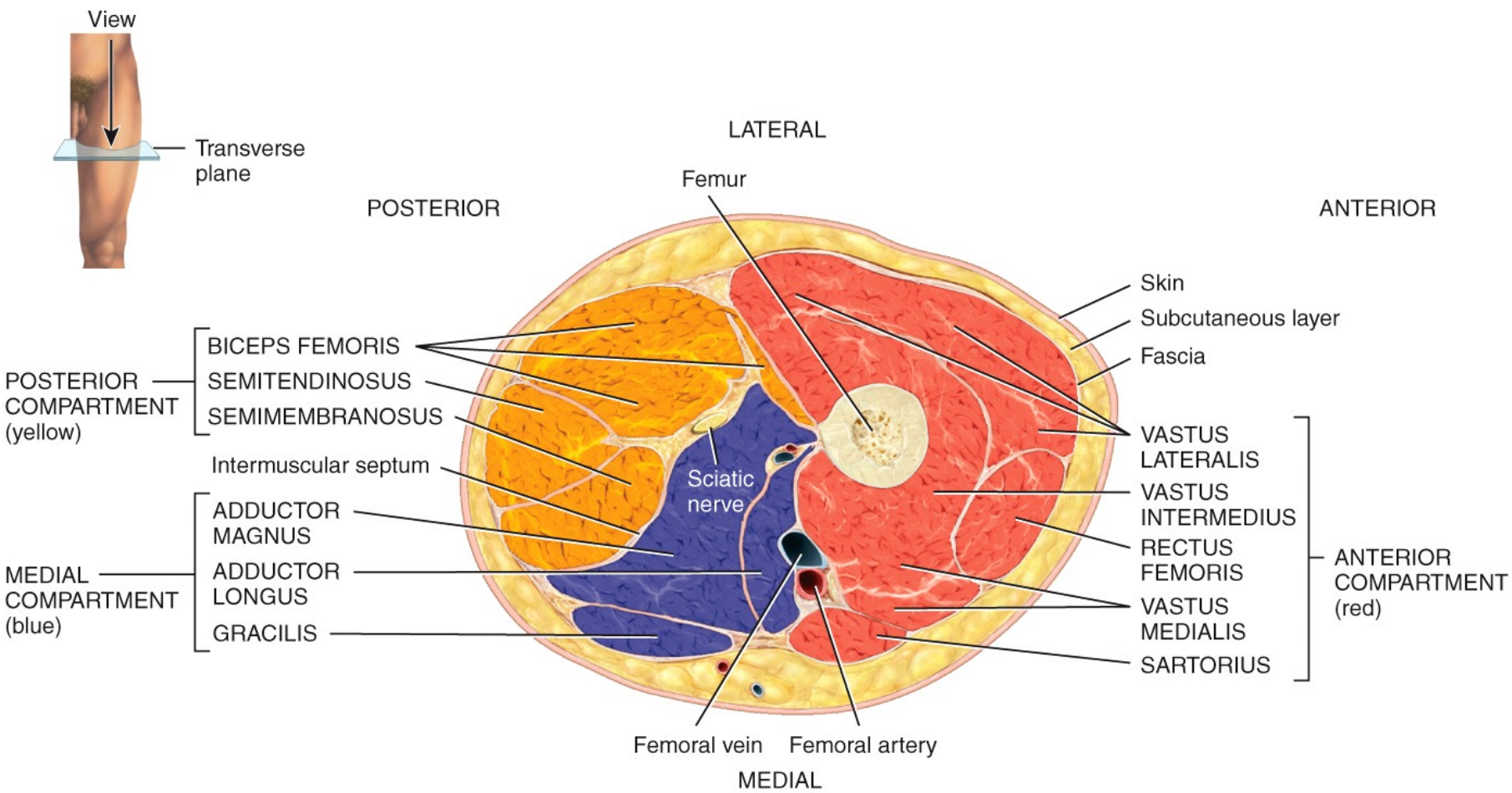


(a) Anterior superficial view (the femoral triangle is indicated by a dashed line)



Anterior deep view

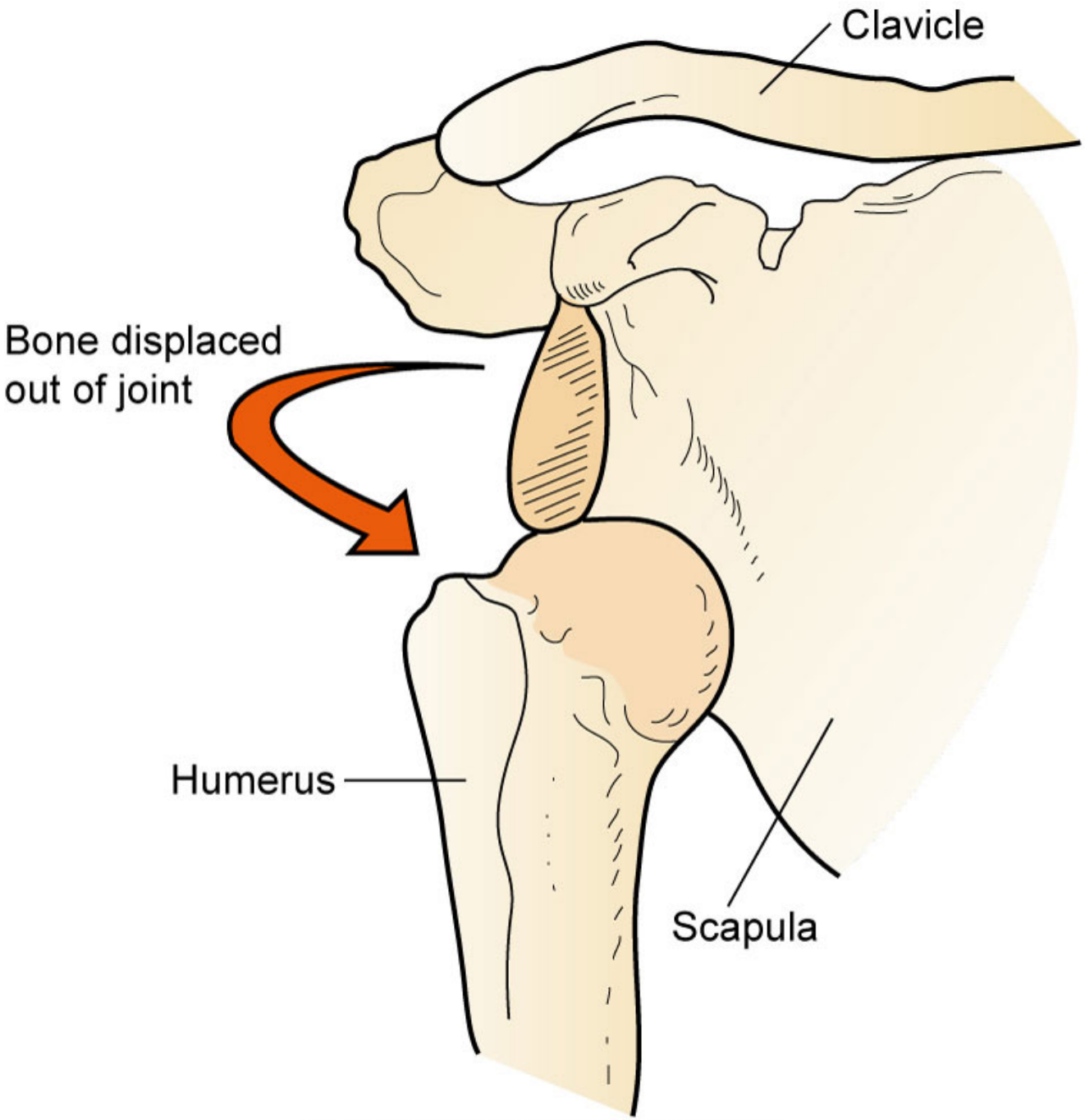
(e) Isolated muscles



Superior view of transverse section of thigh

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



Dislocations (Cont.)

Sprains and Strains

- 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

Other Joint Injuries

- Overuse injuries // Muscle tears
- Repetitive strain injuries - injuries that develop over a period of time in which the same movement is repeated
  - Scaling
  - Massage
  - Keyboard, mouse use
  - Running or jogging

Muscle Tears

- Can occur as a result of a trauma or overextension or overstressing of the muscle
- Repeated injuries will result in fibrous scar tissue replacing normal structures.
- Three degrees of muscle tears:
  - First degree // Involves only a small percentage of muscle fibers
  - Second degree // Involves much of the muscle but is not a complete tear
  - Third degree // A complete tear across the width of the muscle

Diagnosis of Joint Injuries

- History of joint use and any trauma
- Physical examination of joint, including range of motion
- Radiography or MRI
- Arthroscopy may be done, accompanied by treatment.

Treatment of Joint Injuries

- RICE
  - **R**est
  - **I**mmobilization
  - **C**ompression
  - **E**levation
- Nonsteroidal anti-inflammatory drugs (NSAIDs)
- Physiotherapy
- Massage of surrounding tissue

Bone Disorders

Osteoporosis

- Decrease in bone mass and density
- Occurs in two forms:
  - Primary
    - Idiopathic (occurring without known cause)
    - Age 50+ years
    - Decreased in sex hormones (estrogen inhibits osteoclasts)
    - Decreased calcium intake
  - Secondary // As a complication of another disorder

Spinal Osteoporosis

(a)

(b)

a: © Michael Klein/Peter Arnold, Inc.; b: © Dr. P. Marzzi/Photo Researchers, Inc.

Osteoporosis

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

Osteoporosis

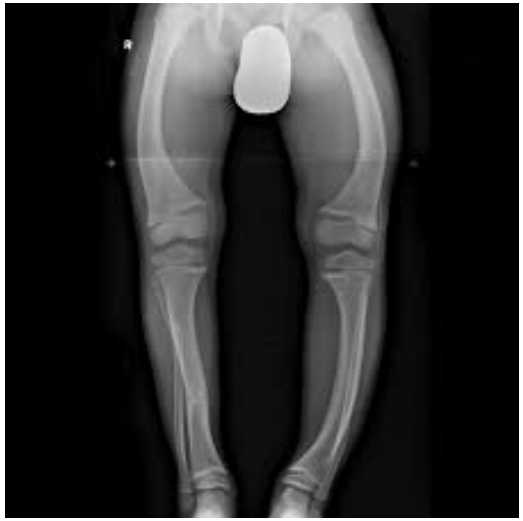
- Predisposing factors
  - Age 50+ years
  - Decreased mobility or sedentary lifestyle
  - Hormonal factors // Excess corticosteroids or parathyroid hormone (PTH) // Deficit of estrogen or testosterone
  - Deficits of calcium, vitamin D, or protein
  - Cigarette smoking & Lower BMI
  - Asian or European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

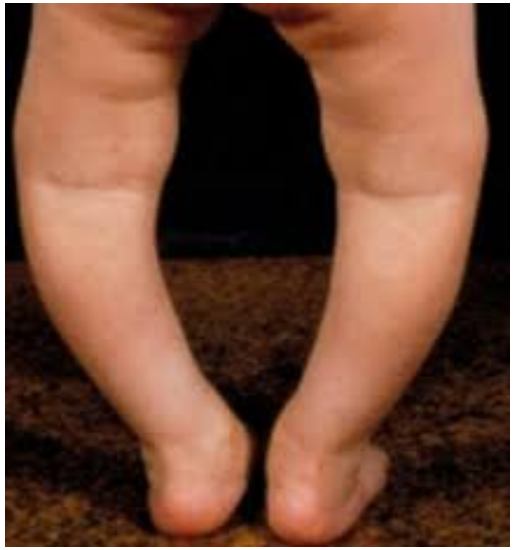
Osteoporosis

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

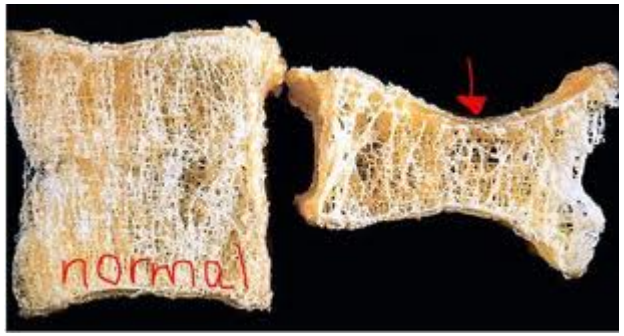
Rickets and Osteomalacia

- Rickets occurs in children when skeletal system is forming
- Osteomalacia occurs in adults as once healthy skeletal system undergoes a loss of calcium phosphate
- Result from deficit of vitamin D and phosphates (protein component OK)
- 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



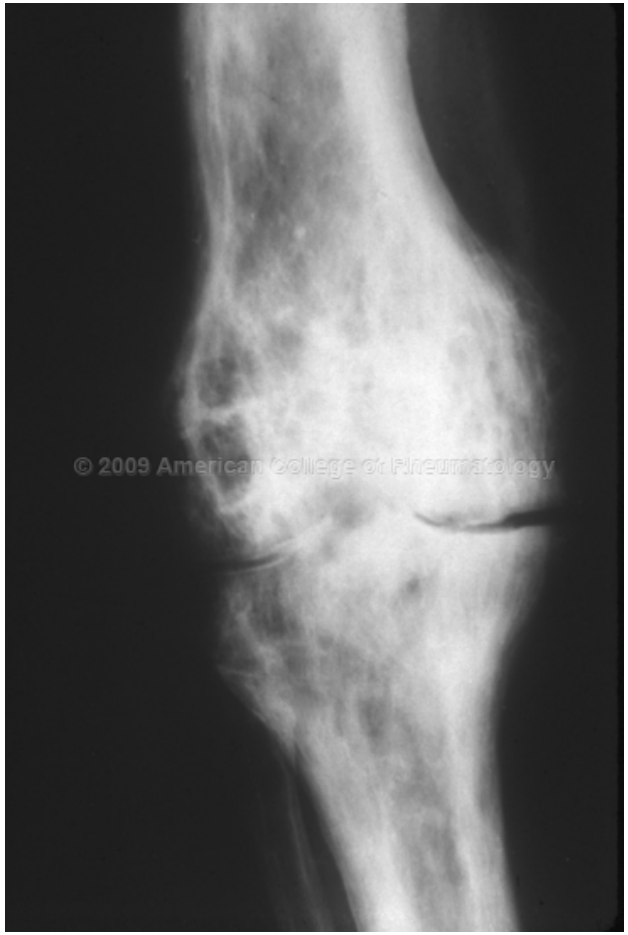


Osteomalacia



Paget's Disease

- 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.

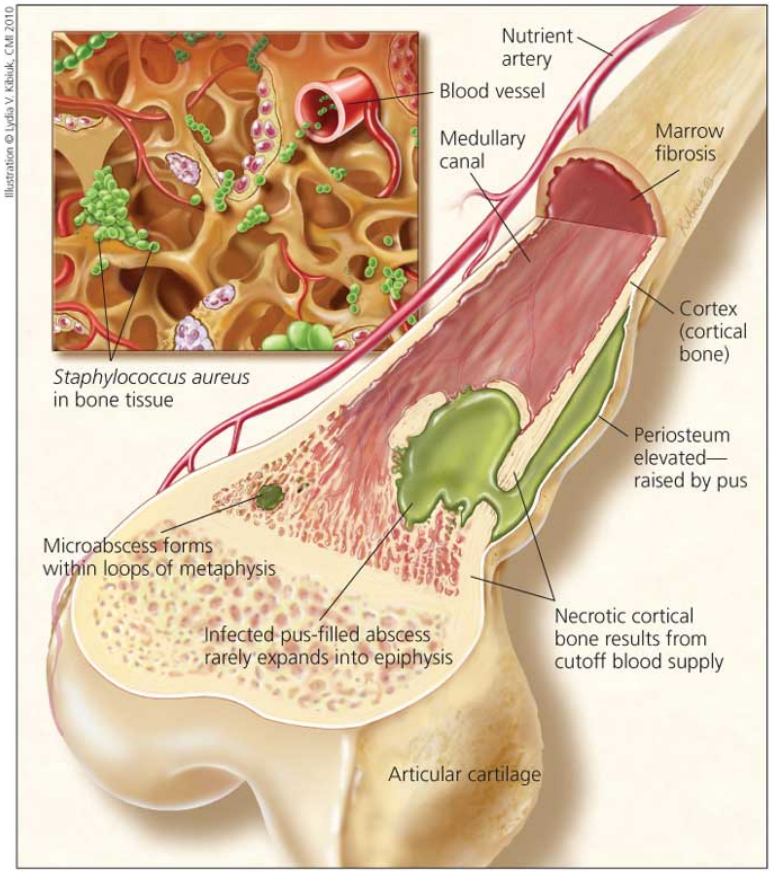
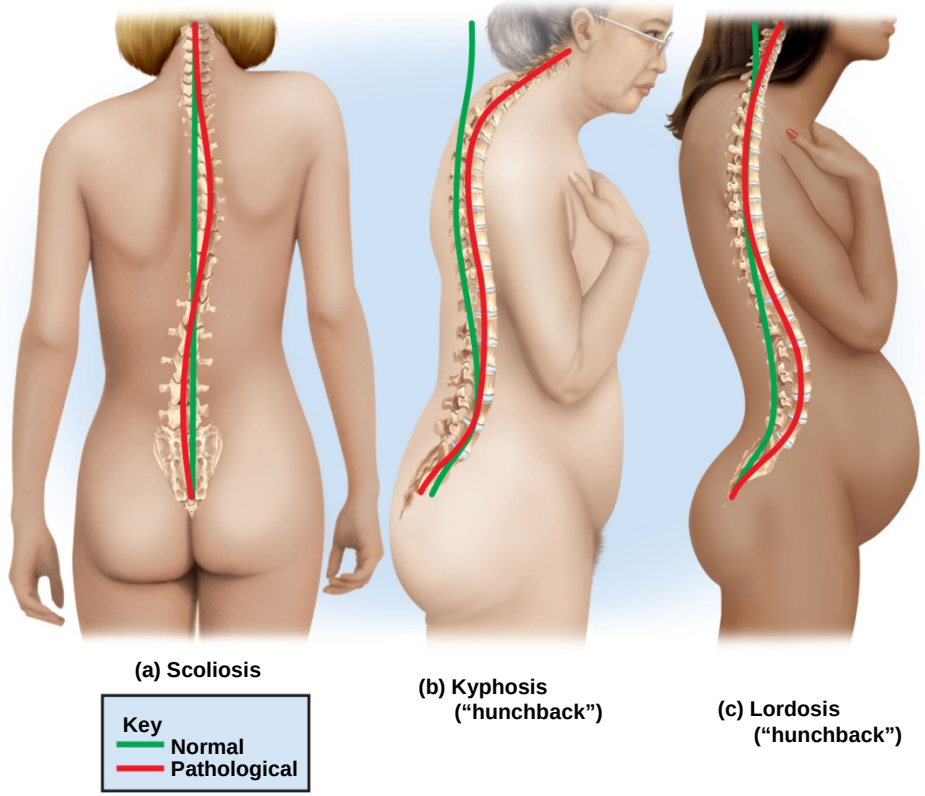


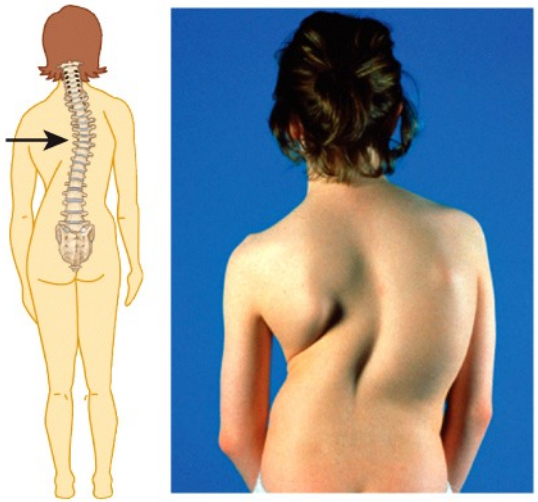
Figure 1 – *This diagram shows hematogenous osteomyelitis of a tubular bone in a child.*

Abnormal Curvatures of the Spine

- Caused from disease, paralysis of trunk muscles, poor posture, pregnancy, or congenital defect
- Lordosis // Swayback - curving inward at the lower back
- Kyphosis // Hunchback or humpback - abnormally rounded upper back
- Scoliosis // S- or C-shaped - sideways curve to the spine

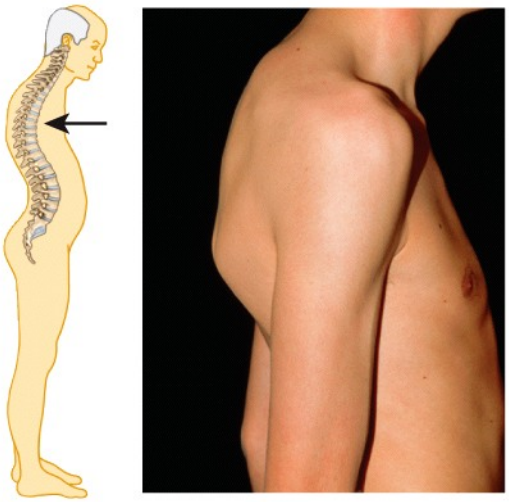


- scoliosis – abnormal lateral curvature // most common
  - usually in thoracic region
  - particularly of adolescent girls
  - developmental abnormality in which the body and arch fail to develop on one side of the vertebrae
- kyphosis (hunchback) – exaggerated thoracic curvature // usually from osteoporosis, also osteomalacia or spinal tuberculosis, or wrestling or weightlifting in young boys
- lordosis (swayback) – exaggerated lumbar curvature // is from pregnancy or obesity



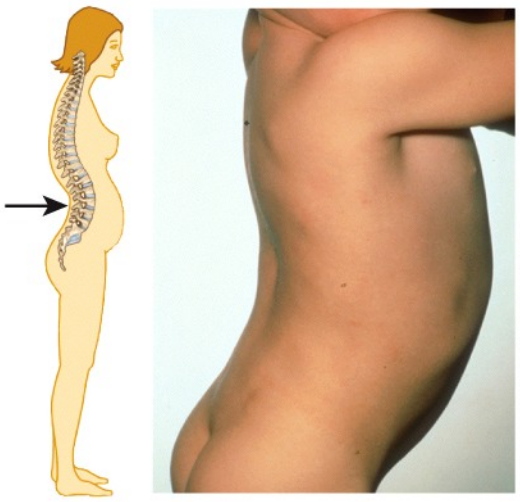
Princess Margaret Rose Orthopaedic Hospital/Photo Researchers, Inc.

(a) Scoliosis



Dr. P. Marazzi/Photo Researchers, Inc.

(b) Kyphosis

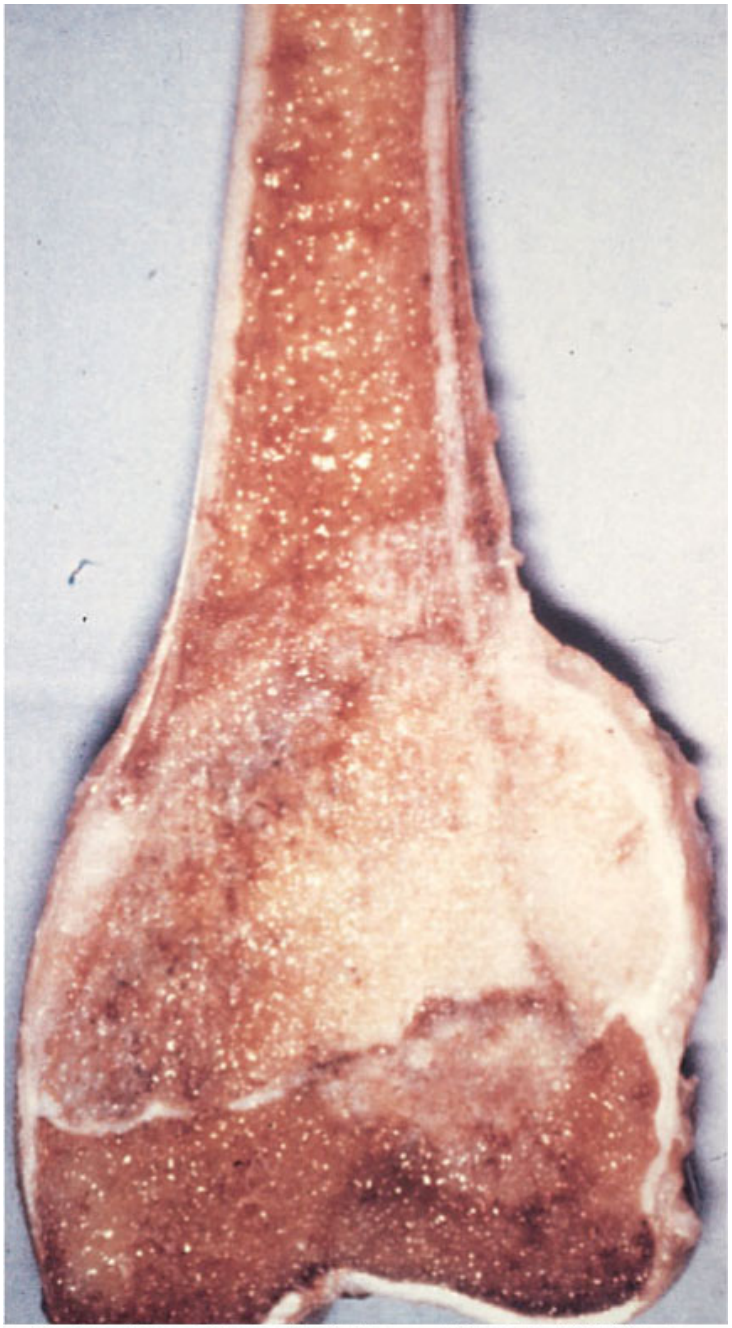


Custom Medical Stock Photo, Inc.

(c) Lordosis

Tumors

- Common site of secondary 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!



From Kumar V, Cotran RS, Robbins SL: Basic Pathology, ed 8, Philadelphia, 1997, WB Saunders.

Osteosarcoma

Tumors

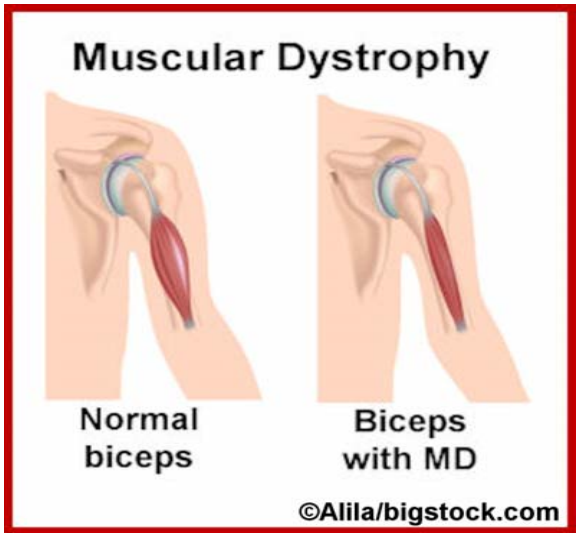
- Chondrosarcomas - arise from cartilage cells; more common in adults
- Ewing's sarcoma is common in adolescents and usually occurs in the shaft of long bones.

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



Muscular Dystrophy (MD)

- 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
  - Tendon reflexes reduced
  - Deformities develop, such as kyphoscoliosis
  - Respiratory infections common
  - Cardiac myopathy occurs commonly.

Muscular Dystrophy (MD)

- Diagnostic tests
  - Identification of common genetic abnormalities
  - Elevated creatine kinase levels
  - Electromyography
  - Muscle biopsy
  - Blood test shows abnormal dystrophin levels

Muscular Dystrophy (MD)

- 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

Types of Muscular Dystrophy

TABLE 9-1 Types of Muscular Dystrophy

Type	Inheritance	Age of Onset	Distribution	Progress
Duchenne's (variant-Becker type)	X-linked recessive (affects males)	2-3 years	Hips, legs, shoulder girdle (ascending)	Rapid
Fascioscapulohumeral (Landouzy)	Autosomal dominant	Before age 20	Shoulder, neck, face	Slow to moderate
Myotonic	Autosomal dominant (chromosome 19)	Birth to 50 years	Face, hands	Slow
Limb girdle	Autosomal recessive	All ages	Shoulders, pelvis	Varies

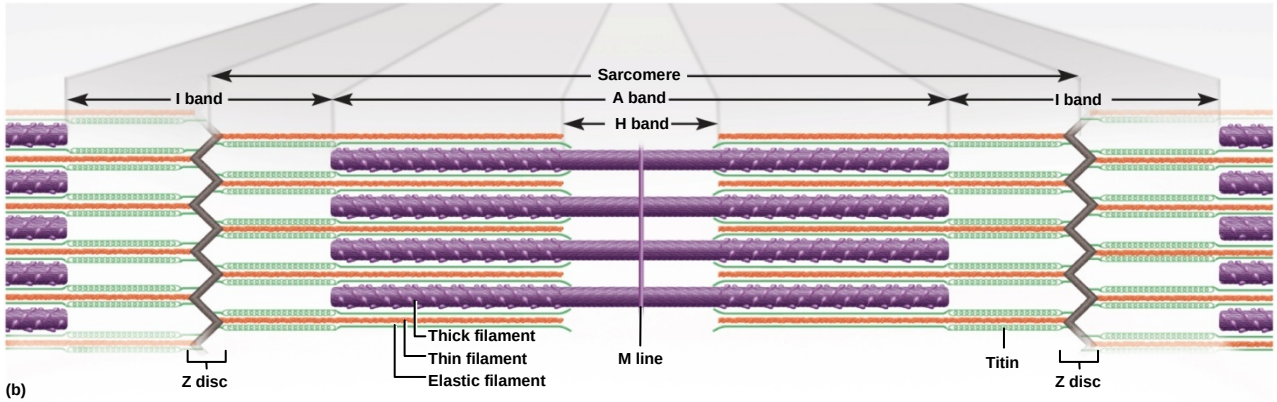
Functional Unit = Sarcomere

- myosin **and** actin **can be found in all cells /// function in cellular motility, mitosis, transport of intracellular material**

- **In skeletal fibers these proteins are contractile proteins**

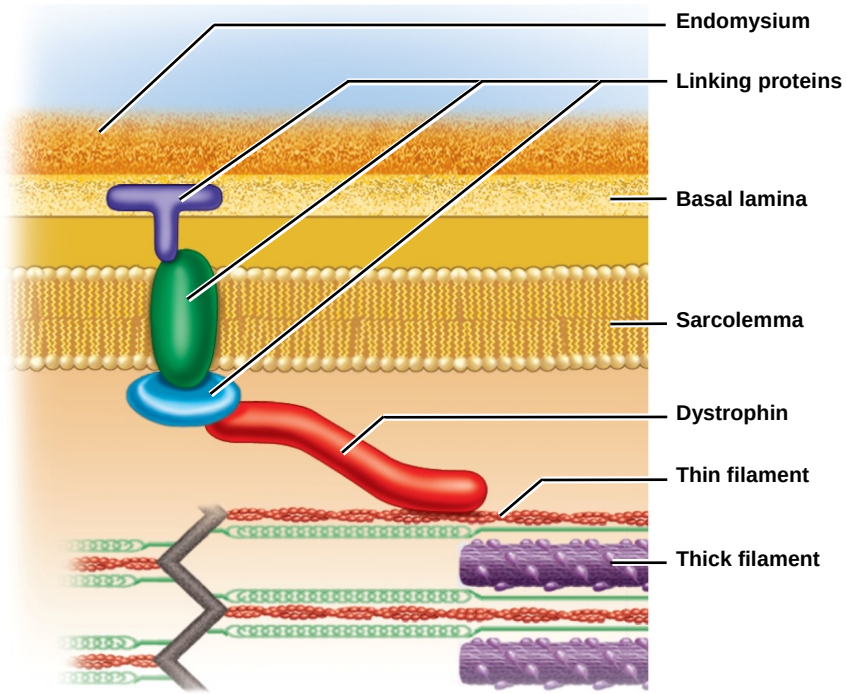
- **organized into unique pattern called sarcomere // similar pattern in cardiac muscle but differently pattern in smooth muslce**

- **<u>Skeletal and cardiac muslces results in striated appearance / overlapping of proteins</u>**

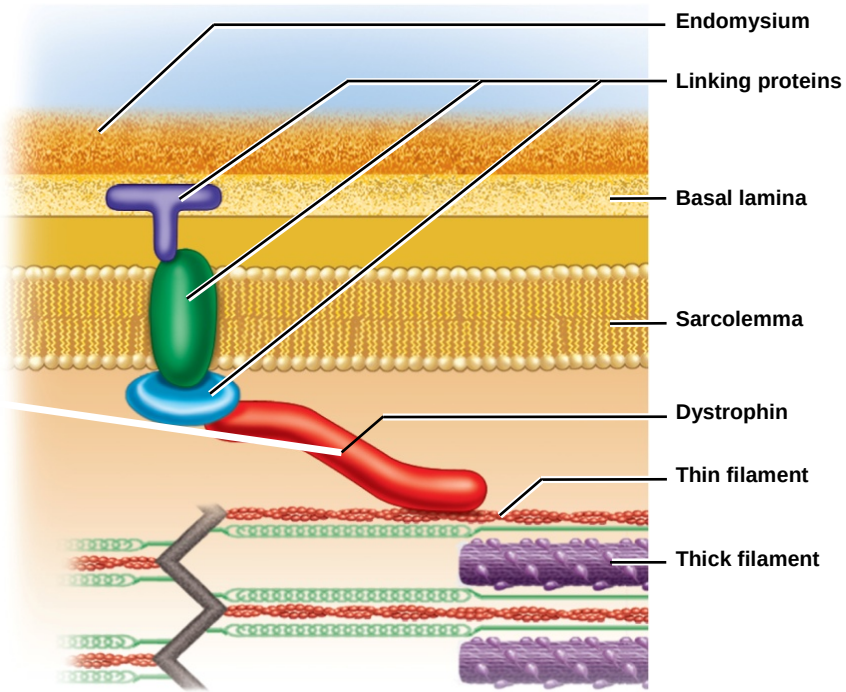


Accessory Proteins

- **at least seven other accessory proteins**
- **associated with thick or thin filaments**
  - **anchor the myofilaments**
  - **regulate length of myofilaments**
  - **alignment of myofilaments for maximum effectiveness**



Accessory Proteins



Dystrophin

- **most clinically important**
- **links actin in outermost myofilaments to transmembrane proteins**
- **eventually links to fibrous endomysium surrounding the entire muscle cell**
- **<u>transfers forces of muscle contraction to connective tissue around muscle cell</u>**
- **genetic defects in dystrophin produce disabling disease muscular dystrophy**

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.

Fibromyalgia

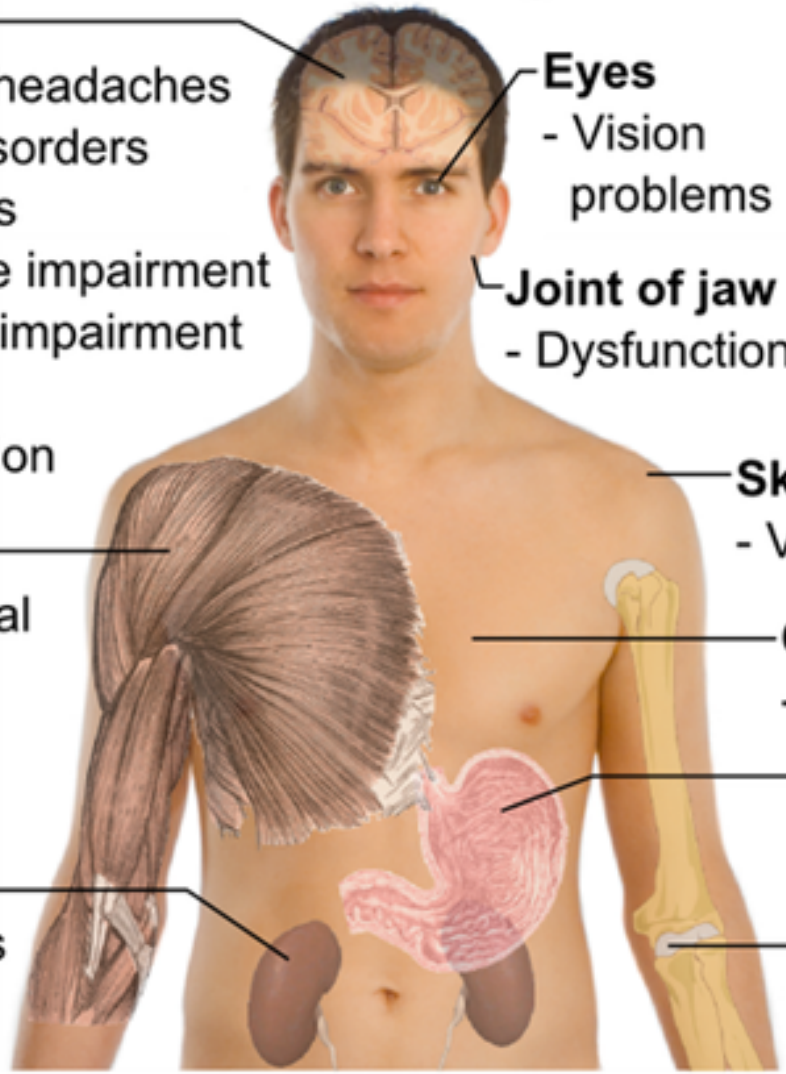
- Cause is not known
  - but hypothesized to be imbalance in serotonin and other neurotransmitters
  - or increased production of substance P

Fibromyalgia

- 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

Symptoms of

Fibromyalgia



Central
- Chronic headaches
- Sleep disorders
- Dizziness
- Cognitive impairment
- Memory impairment
- Anxiety
- Depression

Eyes
- Vision problems

Joint of jaw
- Dysfunction

Systemic
- Pain
- Weight gain
- Cold symptoms
- Multiple chemical sensitivity

Skin
- Various complaints

Muscular
- Myofascial pain
- Fatigue
- Twitches

Chest region
- Pain

Stomach
- Nausea

Urinary
- Problems urinating

Joints
- Morning stiffness

Female reproductive system - Dysmenorrhea

Fibromyalgia - 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

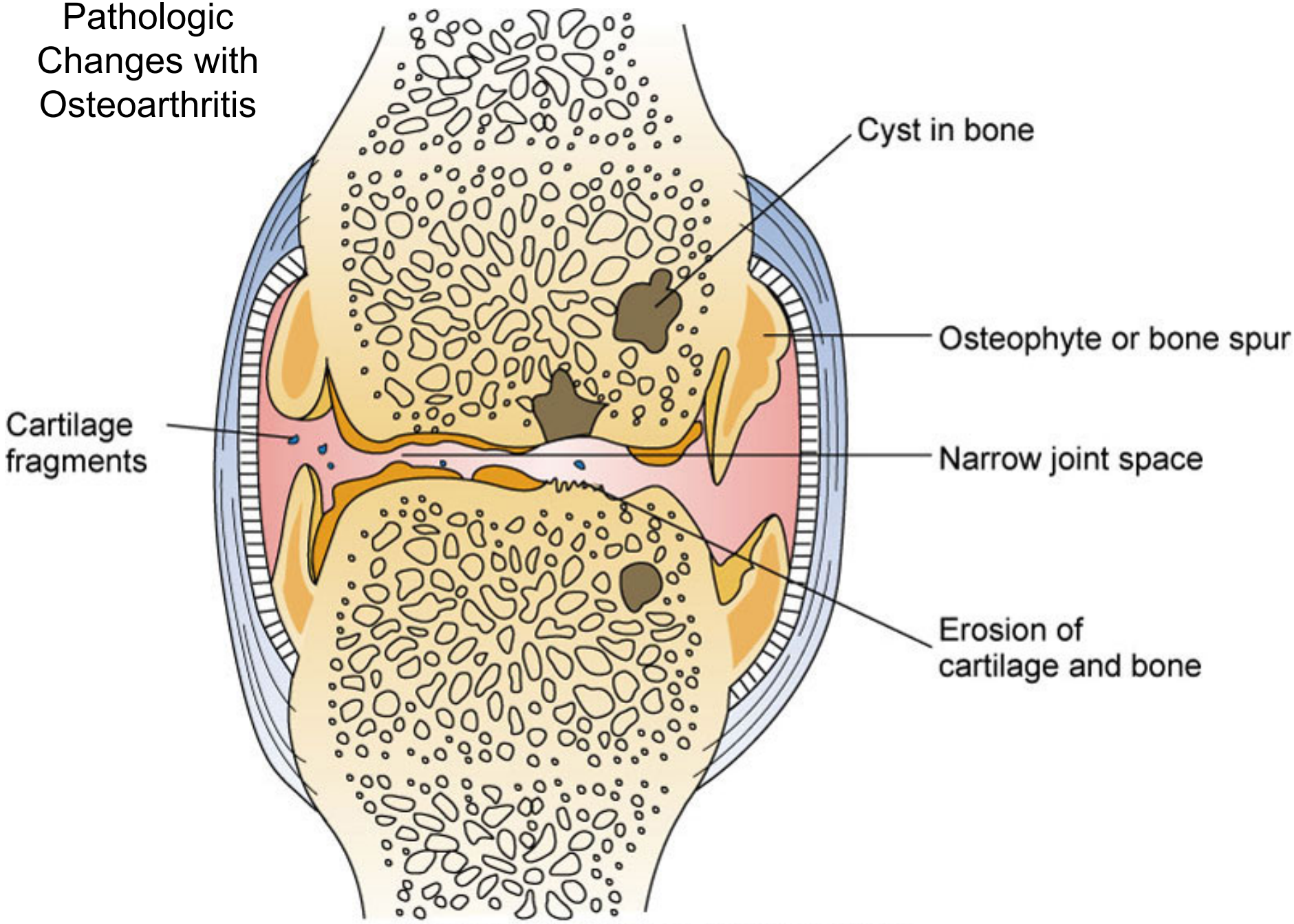
Osteoarthritis - Pathophysiology

- 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.
- Cysts, osteophytes, or new bone spurs develop.

Osteoarthritis - Pathophysiology

- 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 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 Signs and Symptoms

- Aching pain with weight-bearing and movement
- 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 Treatment

- Stress on joint minimized 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 Treatment

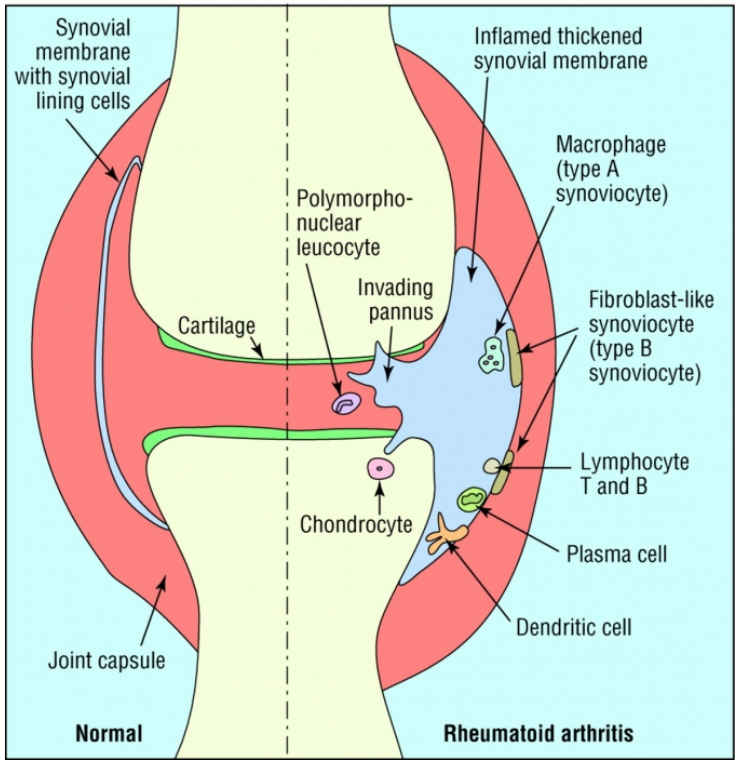
- Massage therapy // Physiotherapy // Acupuncture
- Occupational therapy
- Glucosamine chondroitin supplements
- Injection of synthetic synovial fluid (hyaluronic acid)
- NSAIDs & Analgesics
- Arthrotomy to stabilize joint
- Surgical joint replacement

Rheumatoid Arthritis

- Considered an autoimmune disorder
- Causes chronic systemic inflammatory disease
- Higher incidence in women than in men
- Affects all age groups

Rheumatoid Arthritis

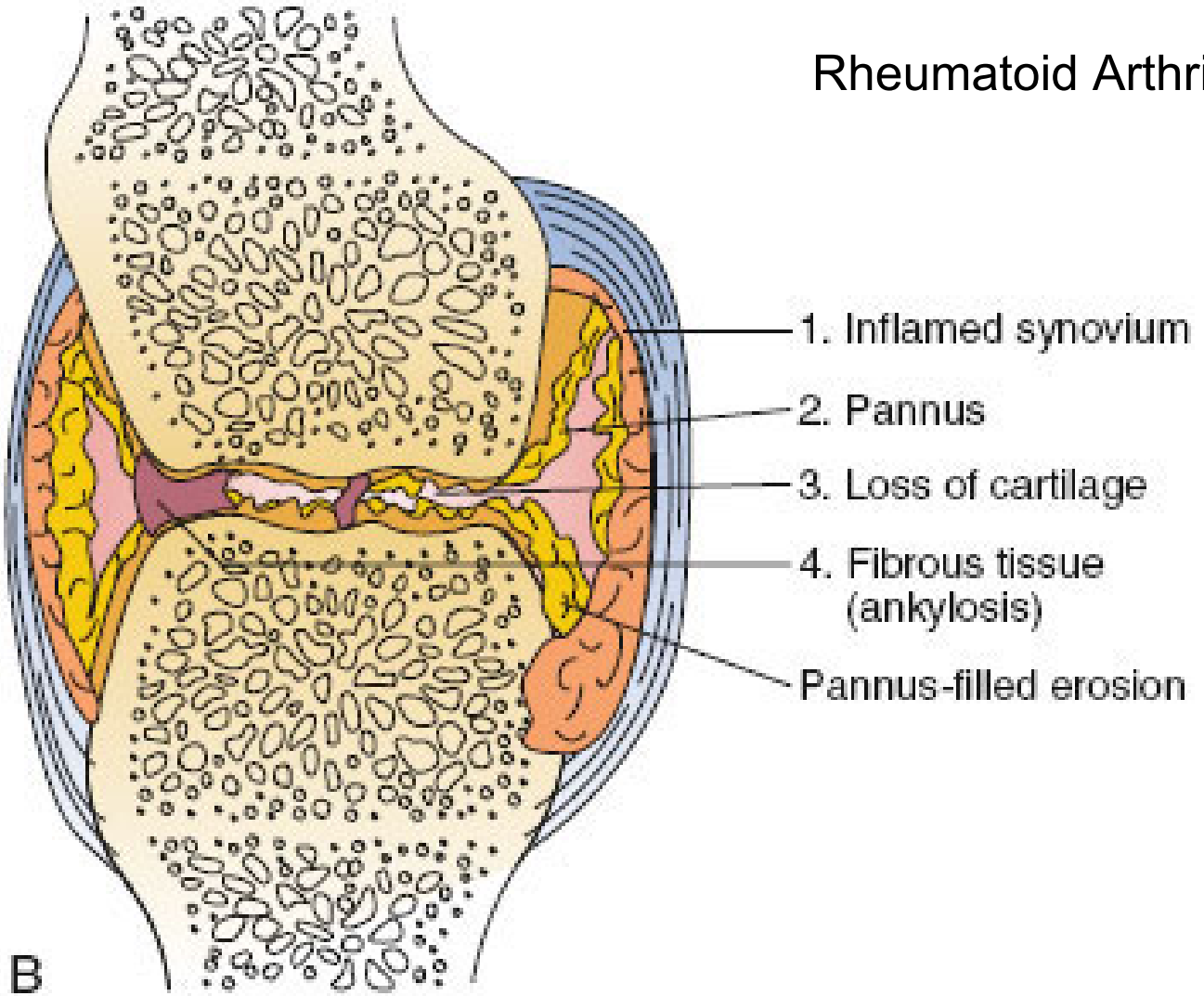
- Pathophysiology
  - Synovitis—marked inflammation, cell proliferation
  - Pannus formation—granulation tissue spreads.
  - Cartilage erosion—creates unstable joint
  - Fibrosis—calcifies and obliterates joint space
  - Ankylosis—joint fixation and deformity develop if untreated.



Rheumatoid Arthritis

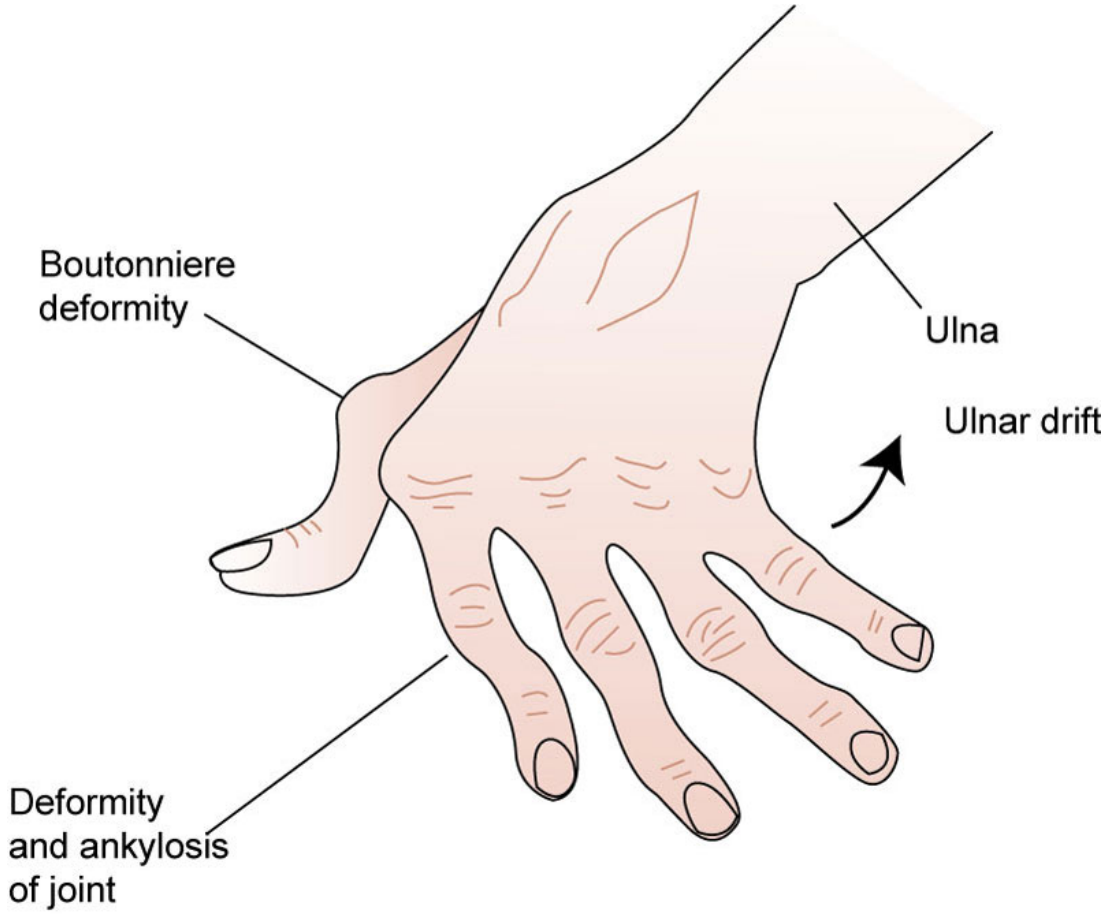
- Other changes frequently occur around the joint.
  - Atrophy of muscles
  - Bone alignment shifts
  - Muscle spasms caused by inflammation and pain
  - Contractures and deformity develop.

Rheumatoid Arthritis (Cont.)



Pathologic Changes in Rheumatoid Arthritis

Typical Deformity in a Hand with Rheumatoid Arthritis



Rheumatoid Arthritis

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

Rheumatoid Arthritis

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

Rheumatoid Arthritis - 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 - Signs and Symptoms

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

Rheumatoid Arthritis - 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

Juvenile Rheumatoid Arthritis (JRA)

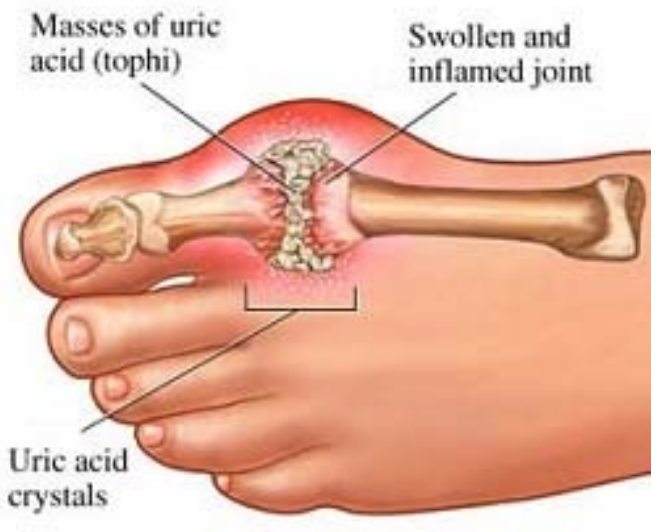
- Still's disease (systemic form)—fever, rash, lymphadenopathy, hepatomegaly, joint involvement
- Second form of JRA causes polyarticular inflammation
- Third form of JRA involves four or fewer joints but causes uveitis (inflammation of iris, ciliary body, and choroid of eye)

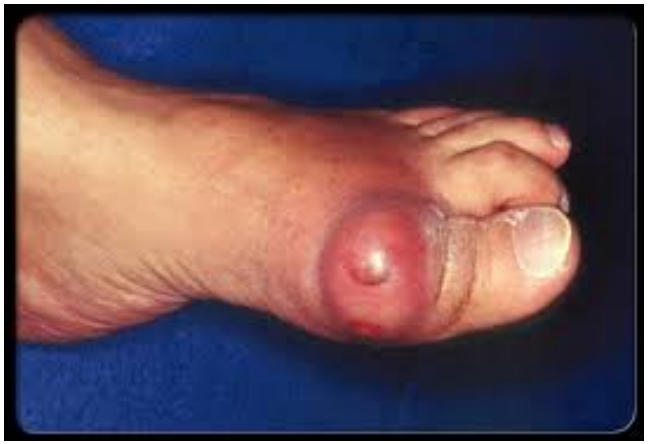
Infectious Arthritis

- 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

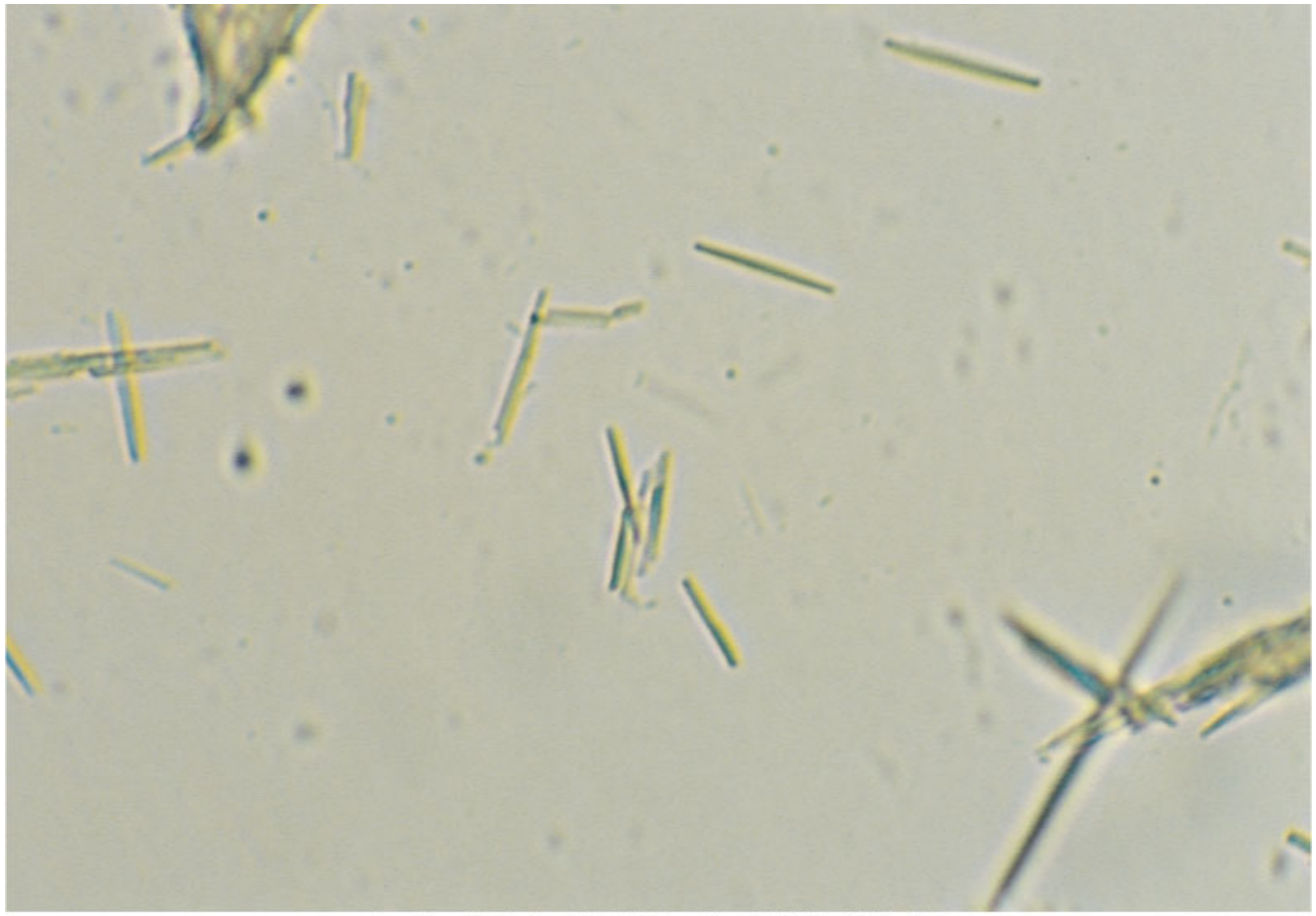
Gout

- 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: Urate Crystals



From Stevens ML: Fundamentals of Clinical Hematology, *Philadelphia, 1997, Saunders.*

Gout

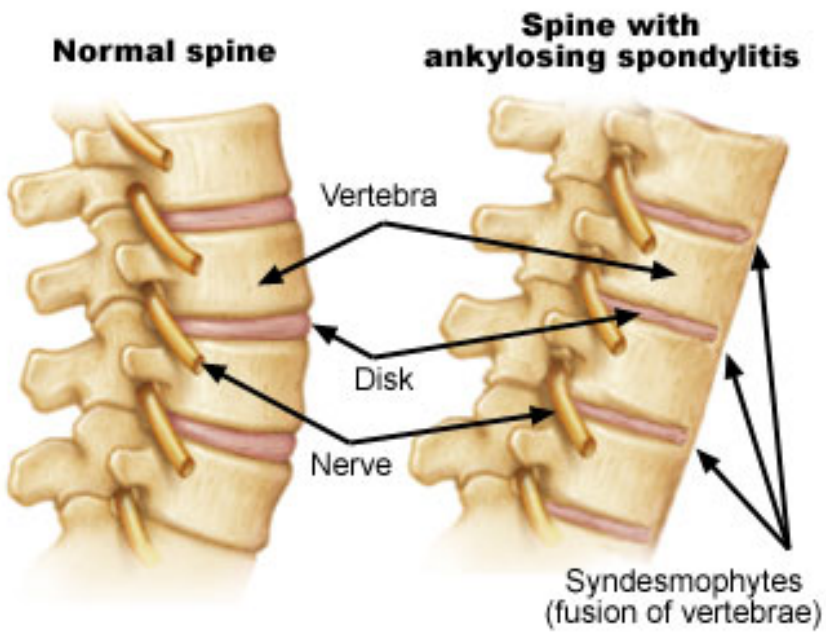
- Uric acid and crystals form because of inadequate renal excretion, chemotherapy, metabolic abnormality, and/or genetic factors // Linked to excess fructose intake.
- Inflammation causes redness, swelling, and pain.
- Treated by reducing uric acid levels with drugs and dietary changes
- Diagnosed by 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

Ankylosing Spondylitis

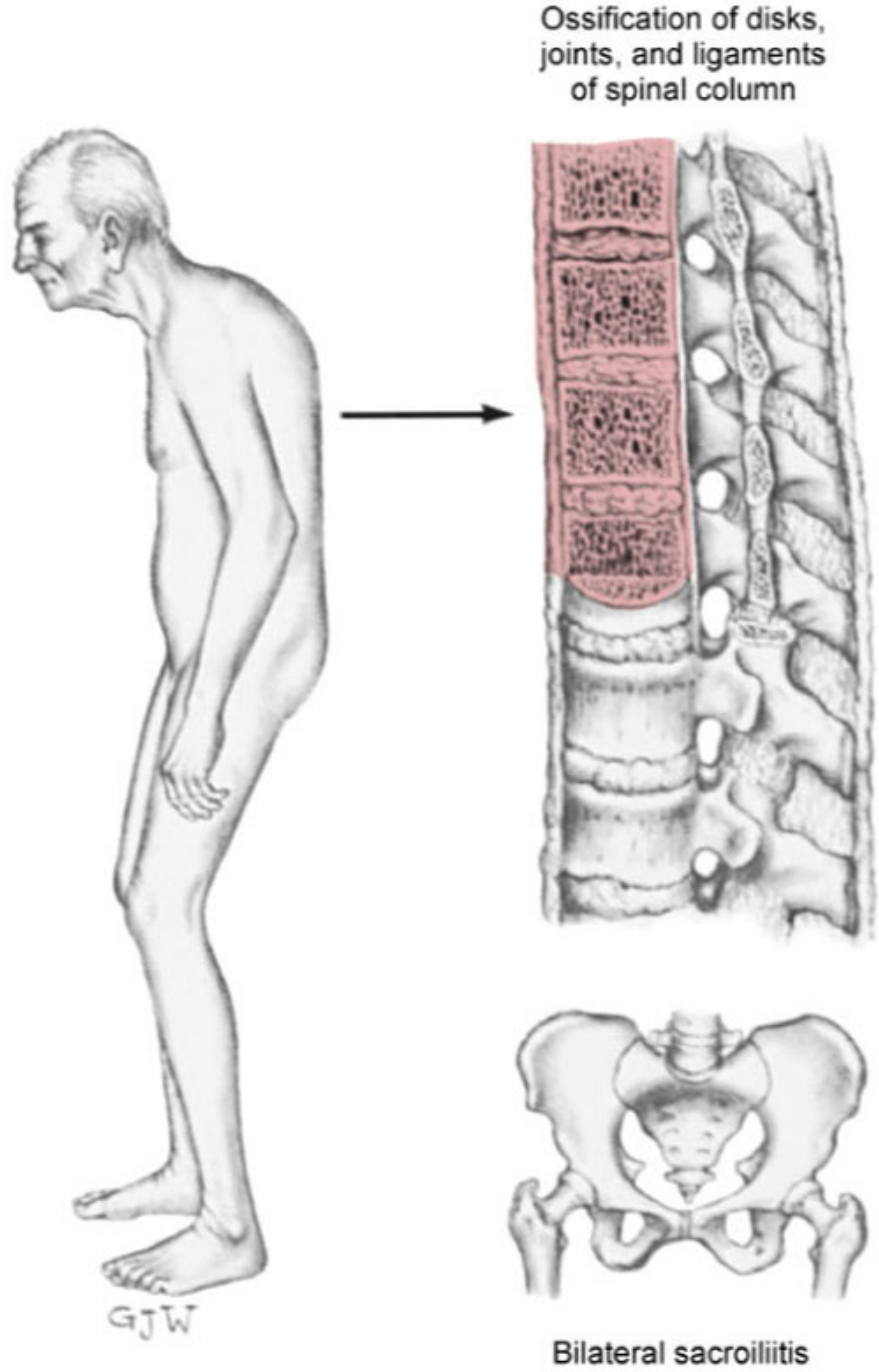
- Progression of condition
  - Vertebral joints inflamed
  - Fusion of joint—loss of mobility
  - Inflammation in lower back, then up spine
  - Kyphosis develops
  - Osteoporosis common
  - Lung expansion limited



Ankylosing Spondylitis

- Signs—lower back pain, morning stiffness, pain when lying down, spine becomes rigid
- Systemic signs—fatigue, fever, weight loss, uveitis
- Treated by drugs to relieve pain, daily exercise, physiotherapy, occupational therapy

Characteristic Posture and Sites of Ankylosing Spondylitis

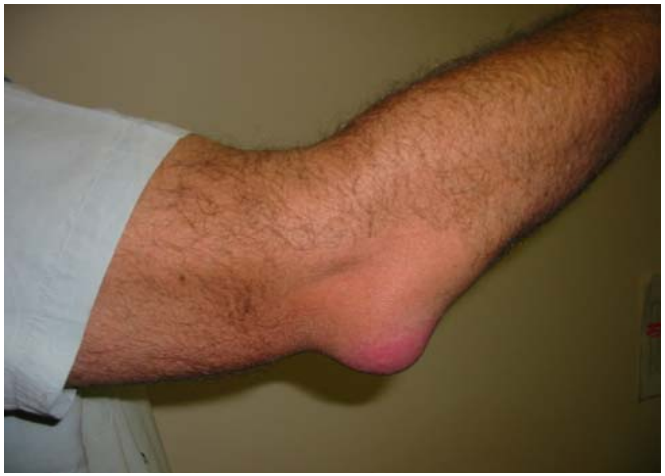


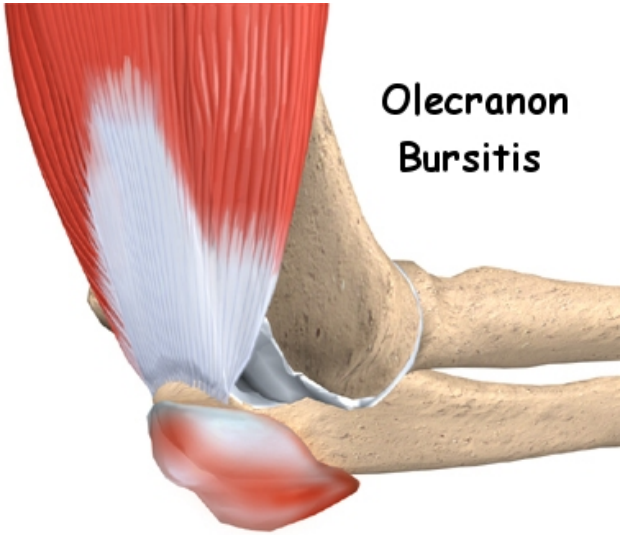
From Mourad L: Orthopedic Disorders, *St. Louis, 1991, Mosby.*

Other Inflammatory Joint Disorders

Bursitis

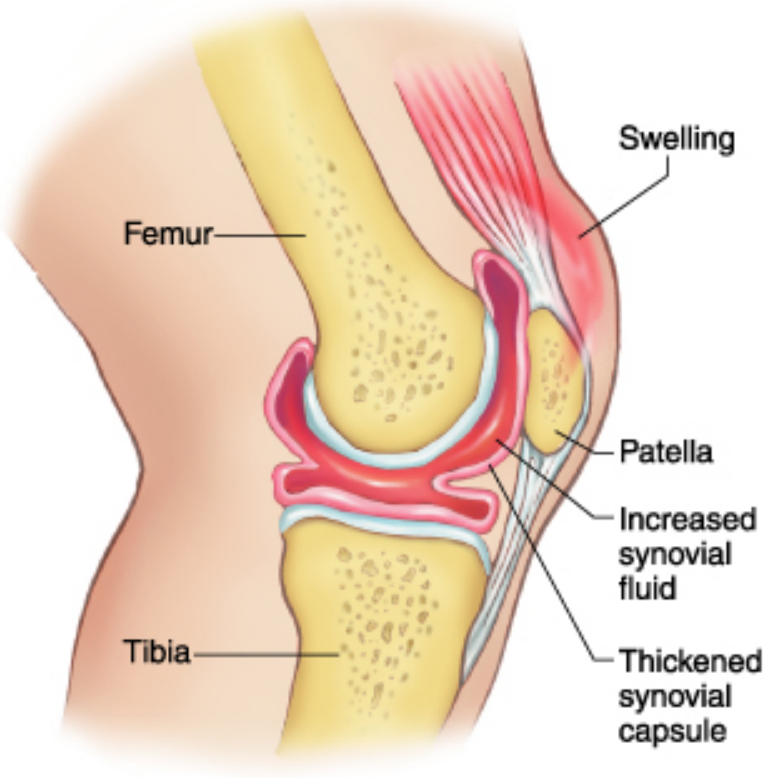
- Inflammation of the bursae associated with bones, muscles, tendons, and ligaments of various joints
- Most common cause // Repetitive motion on a particular joint
- Diagnosis // Physical examination & Ultrasound and/or MRI
- Treatment options // Rest &Anti-inflammatory drugs





Synovitis

- Inflammation of the synovial membrane
- Movement of joint is restricted and painful
- Diagnosis // Swollen, red, and warm joint // Analyzing synovial fluid (for signs of infections)
- Treatment // Anti-inflammatory drugs // Identification and treatment of underlying cause



Tendinitis

- Irritation or inflammation of the tendon
- Manifestation // Dull ache and mild swelling
- Cause // Single trauma or repetitive motion
- Diagnosis // Made by physical examination
- Treatment
  - Rest, application of ice
  - Pain relievers—maybe anti-inflammatory drugs
  - Physical therapy