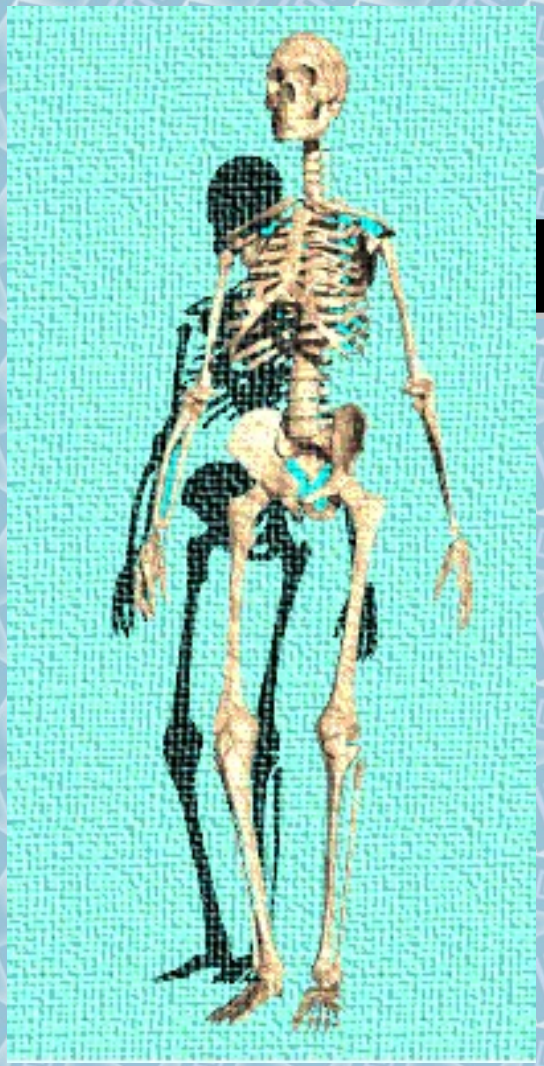


lusculoskeletal A&

(A Review)

2022

Objectives

- Relate the normal anatomy and physiology of the musculoskeletal system
- Explain the importance of normal functioning of the musculoskeletal system to the maintenance of life
- Explain the interrelationships of the musculoskeletal system to other body systems

Functions of the Skeletal System

- Support soft body tissue
- Protection of vital organs
- Movement
- Mineral storage
- Hematopoiesis

Structure of Bones

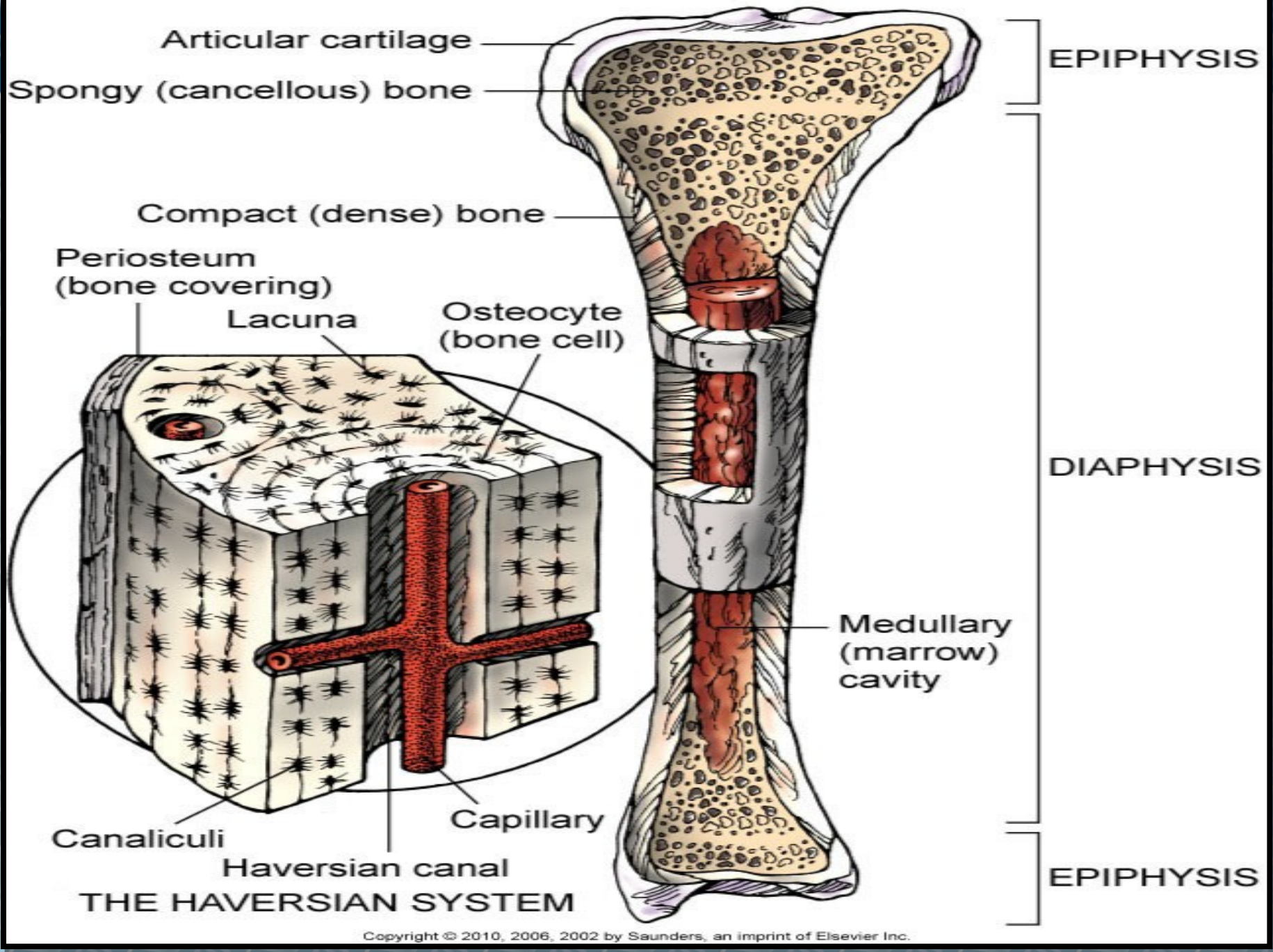
- **Composition:**
  - Bone cells
  - Protein matrix
  - Mineral deposits
- **Types of Bone Cells:**
  - Osteocytes
  - Osteoblast
  - Osteoclast

Structure of Bones

- **Types of Bones**
  - Bones are not solids
  - Categorize bone depending on the size & distribution of spaces
  - Cortical: Compact & Dense
    - Hard outer layer
    - Thicker in diaphysis than epiphysis
    - Protects & supports long bones with resisting the stress of weight
    - Haversian systems fit closely together → dense consistency

Structure of Bones

- **Types of Bones**
  - Cancellous: Spongy & Porous
    - Many large spaces filled with red marrow
    - Rich blood supply
    - No Haversian canals
    - Makes up most of the bone tissue in short, flat & irregular shaped bones and epiphysis of long bones



Bone Formation

- **Ossification**
  - The process by which intracellular material is formed & hardening minerals are deposited into the bone
  - Bone is made up of cells dispersed in a matrix of fibers & protein.
    - It is ossified with hard crystals of Ca+, Mg, phosphate & carbonate

Bone Maintenance

- Dynamic → constantly reabsorbed and reformed
- **Factors affecting this balance**:
  - Aging
  - Post Menopausal
  - Weight bearing
  - Hormonal influences
  - Minerals

Shapes of Bones

- **206 bones in the human body**
  - Long
  - Short
  - Flat
  - Irregular

Shapes of Bones

- **Long Bones**: Femur & Humerus
- Characterized by central shaft (diaphysis) and two widened ends (epiphyses)
  - ❖ Diaphysis = shaft, long main portion, a thick compact bone
  - – Medullary or Marrow Cavity = space within the diaphysis
    - Red marrow in a child → hematopoiesis
    - Fatty, yellow marrow in adults
  - – Endosteum = layer of osteoblasts that line the medullary cavities

Shapes of Bones

- **Long Bones:**
  - ❖ Epiphysis = extreme ends of the bone
    - Articulates or forms a joint
    - Spongy, cancellous bone, location of muscle attachment
  - – Articular Cartilage = thin layer of hyaline cartilage covering the epiphysis where bone forms a joint with another bone
    - Smooth surface for joint movement
    - Cushions jolts & shocks

Shapes of Bones

- **Long Bones:**
  - Metaphysis = where diaphysis joins epiphysis
    - Location of epiphyseal plate → cartilage area in children that actively produces bone = growth
  - Periosteum = dense white fibrous covering around bone, except at joint surfaces.
    - 2 layers → outer layer for ligament/tendon fiber attachment ; inner layer contains osteoblasts
      - Inner layer is needed for transverse bone growth & fx repair
    - Rich in blood & nerve supply

Shapes of Bones

- **Short Bones:**
  - Carpals & Tarsals
  - Cube shaped
  - Spongy inner core covered by a thin layer of compact bone.
- **Flat Bones:**
  - Sternum, Ribs, Skull, Scapula
  - Protect delicate organs or allow attachments of large muscles
  - 2 outer plates separated by a spongy inner layer

Shapes of Bones

- **Irregular Bones:**
  - Vertebrae, ileum, mandible
  - Variety of shapes
  - Usually connected to several other bones to allow movement
  - Inner core of spongy bone & outer layer of compact bone

Blood & Nerve Supply to the Bones

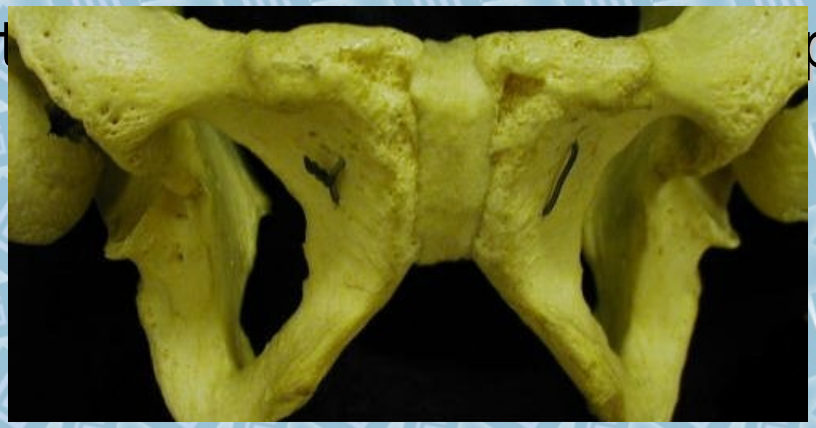
- **Provides oxygen & nutrients**
  - Via the arterioles in the Haversian canals
  - Via vessels in the periosteum that enter bone
  - Via vessels in the marrow & bone ends
- There are sensory nerve endings in the periosteum that connect with the CNS

Joints

- **Junction between 2 or more bones**
- **Classification by degree of movement**
  - Synarthroses
    - No movement
    - Bone connected to fibrous tissue or cartilage
    - ie. Sutures of the skull

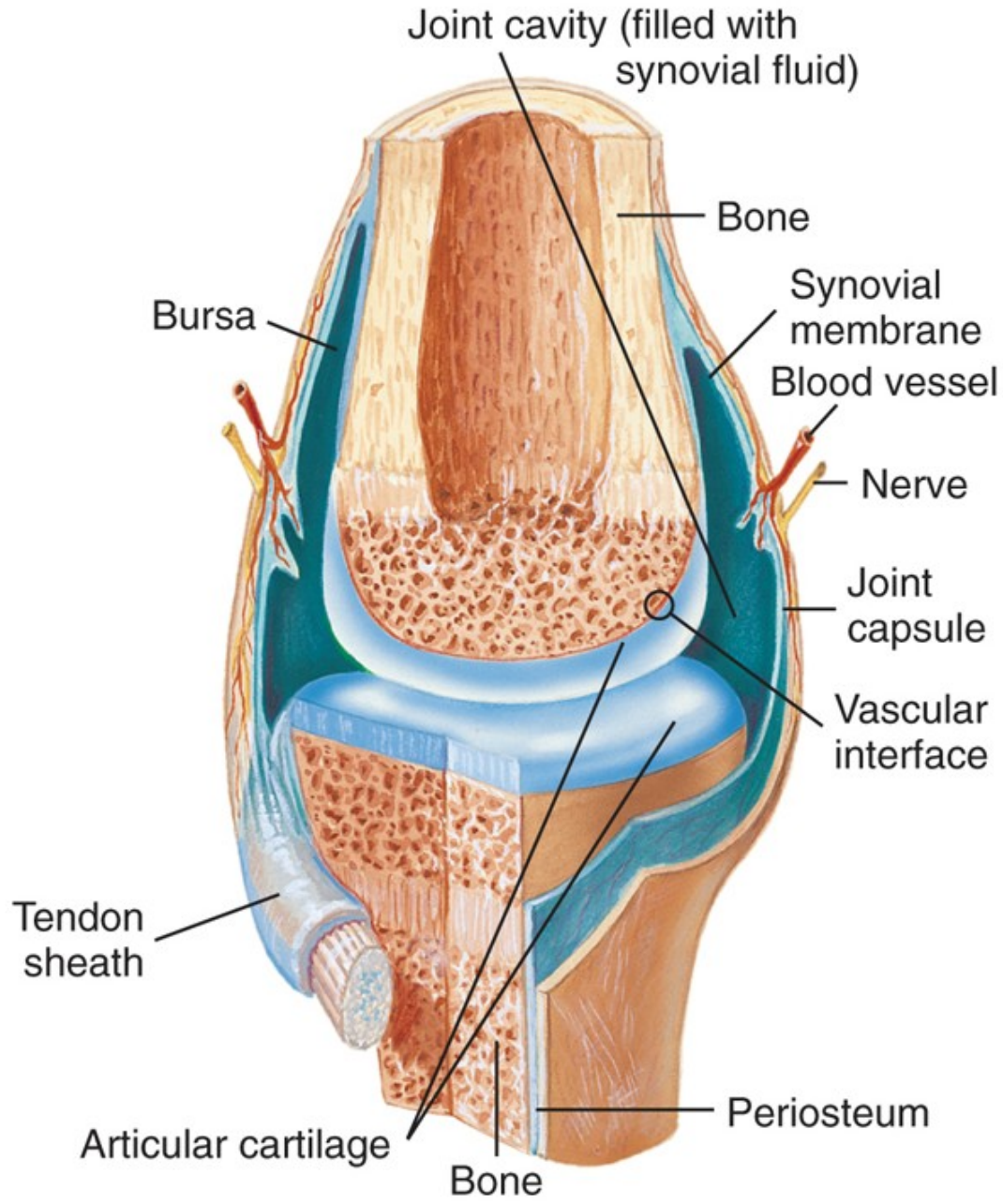
Joints

- **Classification by degree of movement**
  - Amphiarthroses
    - Slightly moveable
    - No joint cavity but cartilage found between bones.
    - Intervet[illegible]physis



Joints

- **Classification by degree of movement**
  - Diarthroses
    - Freely moveable (synovial)
    - Most of the joints in the body
    - Space between the articulating bones
    - Consists of an articular cavity which is lined with synovium
      - Synovium produces synovial fluid for joint lubrication & cartilage nourishment
      - Cavity is enclosed by a capsule of fibrous articular cartilage
      - Ligaments reinforce the capsule & help to limit motion
      - Cartilage covers the ends of the bones



Joints

- **Types of Diarthrodial Joints**
  - Hinge = concave surface fits into a convex surface
    - Usually moves in one direction only
    - Flexion or extension
    - ie. Knees & elbows
  - Pivot = one surface rotates around a peg or pivot
    - Proximal radial & ulnar joint
    - Atlas (C1) & Axis (C2) rotate the head

Joints

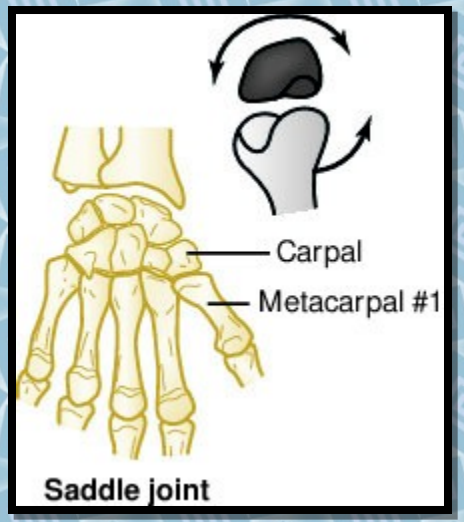
- **Types of Diarthrodial Joints**
  - Ball & Socket = Permits full freedom of movement
    - Most versatile
    - Flexion, Extension, Adduction, Abduction, Rotation
    - ie. Shoulder & Hip
  - Gliding = both articular surfaces are flat
    - One surface moves over another surface
    - No axis of movement
    - Side to side and back & forth
    - Between the carpal bones, tarsals, sacrum & ileum

Joints

- **Types of Diarthrodial Joints**
  - Condyloid / Ellipsoidal
    - An oval condyle (round bone) fits into an elliptical cavity (depression)
    - Movement is in two planes that are perpendicular to each other
    - Flex, extend, abduct, adduct, circumduction
    - ie. Wrist joint – between the radius and carpals

Joints

- **Types of Diarthrodial Joints**
  - Saddle = concave end fits onto a convex surface of another bone
    - Same movements as condyloid but no axial rotation
    - Carpal – metacarpal joint in thumb – base of the thumb



Joint	Movement	Examples	Illustration
Hinge joint	Flexion, extension	Elbow joint (shown), interphalangeal joints, knee joint	
Ball and socket (spheroidal)	Flexion, extension; adduction, abduction; circumduction	Shoulder (shown), hip	
Pivot (rotary)	Rotation	Atlas-axis, proximal radioulnar joint (shown)	
Condyloid	Flexion, extension; abduction, adduction; circumduction	Wrist joint (between radial and carpals) (shown)	
Saddle	Flexion, extension; abduction, adduction; circumduction, thumb-finger opposition	Carpometacarpal joint of thumb (shown)	
Gliding	One surface moves over another surface	Between tarsal bones, sacroiliac joint, between articular processes of vertebrae, between carpal bones (shown)	

Joints

- **Joint Motion**
  - Flexion = bending the joint so the angle ↓ and the parts come closer together
    - ie. Arm & leg
  - Extension = straightening so the angle increases and parts move farther apart
  - Hyperextension = excessive extension beyond anatomical position
    - ie. Bending the head back beyond the upward position

Joints

- **Joint Motion**
  - Abduction = move away from mid-line of the body
  - Adduction = move toward the body's mid-line
  - Rotation = moving a part around an axis
    - i.e. Ball & Socket
    - Internal rotation – turn medially
    - External rotation – turn laterally
  - Circumduction = moving in a circle

Joints

- **Joint Motion**
  - Supination = turning the hand palm up (on back)
  - Pronation = turning the hand palm down (on stomach)
  - Eversion = turning the sole of the foot outward
  - Inversion = turning the sole of the foot inward
  - Elevation = raising a part
  - Depression = lowering a part
  - Protraction = moving a part forward
  - Retraction = moving a part backward

Joint Motion

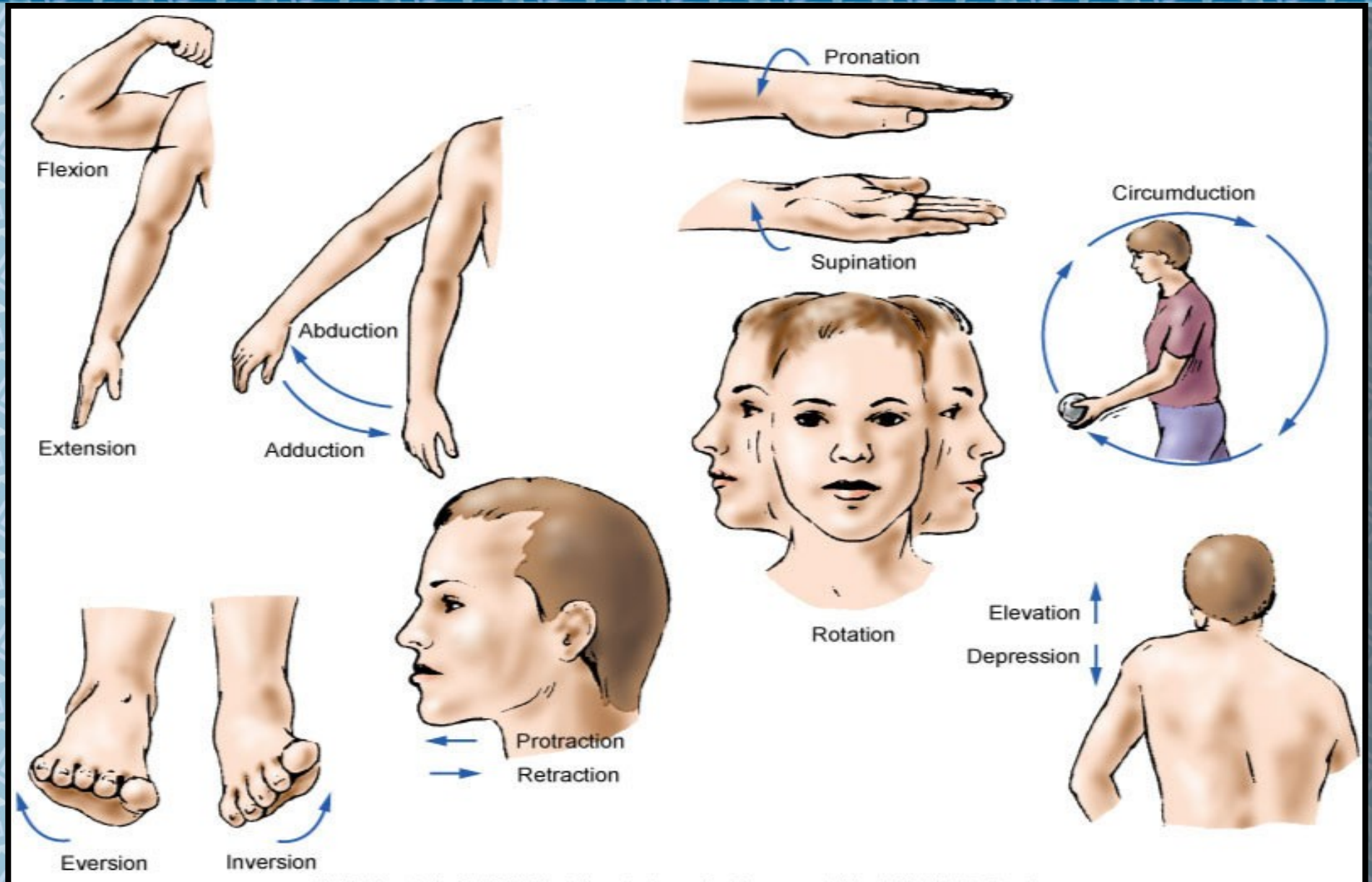
- External Rotation

Internal Rotation

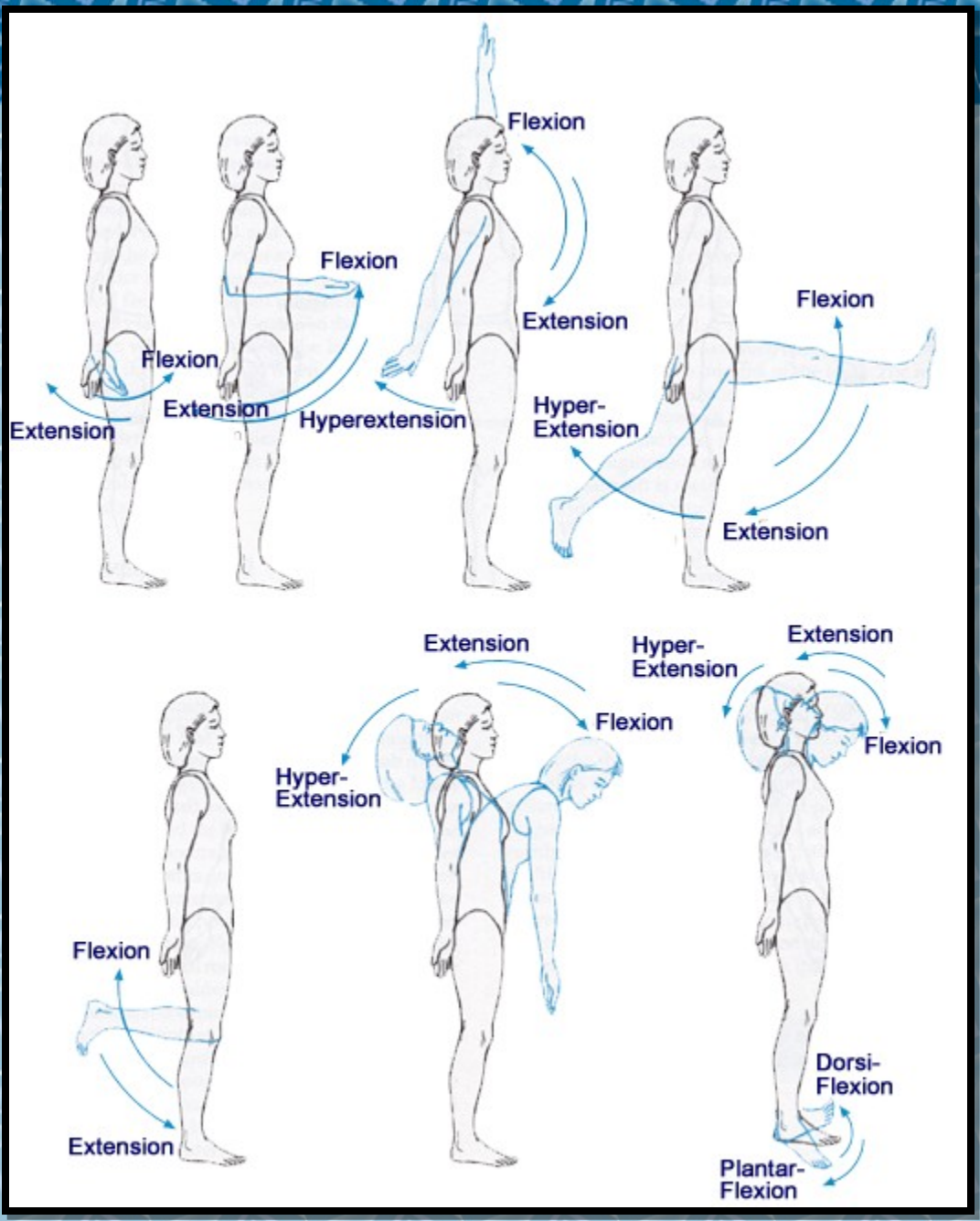
- Dorsi Flexion

Plantar Flexion

Joint Motion



Modified from Jarvis, C. (2004). *Physical examination and health assessment* (4th ed.). Philadelphia: Saunders.


Flexion
Extension
Flexion
Extension
Hyperextension
Flexion
Extension
Flexion
Hyper-
Extension
Extension
Extension
Hyper-
Extension
Flexion
Hyper-
Extension
Extension
Flexion
Flexion
Extension
Dorsi-
Flexion
Plantar-
Flexion

Cartilage

- **Functions:**
  - Support soft tissue
  - Provide the articular surfaces for joint movement
  - Protect underlying tissue
  - Essential for long bone growth prior to maturity → the cartilage that makes up the epiphyseal plate
- **Characteristics:**
  - Rigid connective tissue with a fibrous covering (perichondrium)
  - Avascular → nourished by diffusion from capillaries
  - *Slow to reproduce & heal*

Cartilage

- **Types of Cartilage:**
  - Hyaline: most common
    - Moderate amount of collagen fibers
    - Articular surfaces of the bone – covers ends of bones in a joint
    - Trachea, bronchi, nose, articular surfaces of bone
  - Elastic:
    - Contains collagen and elastic fibers
    - More flexible than hyaline
    - Ear, epiglottis, larynx

Cartilage

- **Types of Cartilage:**
  - Fibrocartilage:
    - Mostly collagen
    - Tough tissue
    - Functions as a shock absorber
    - Between vertebral discs, knee, cushion between bones of the pelvic girdle

Muscle

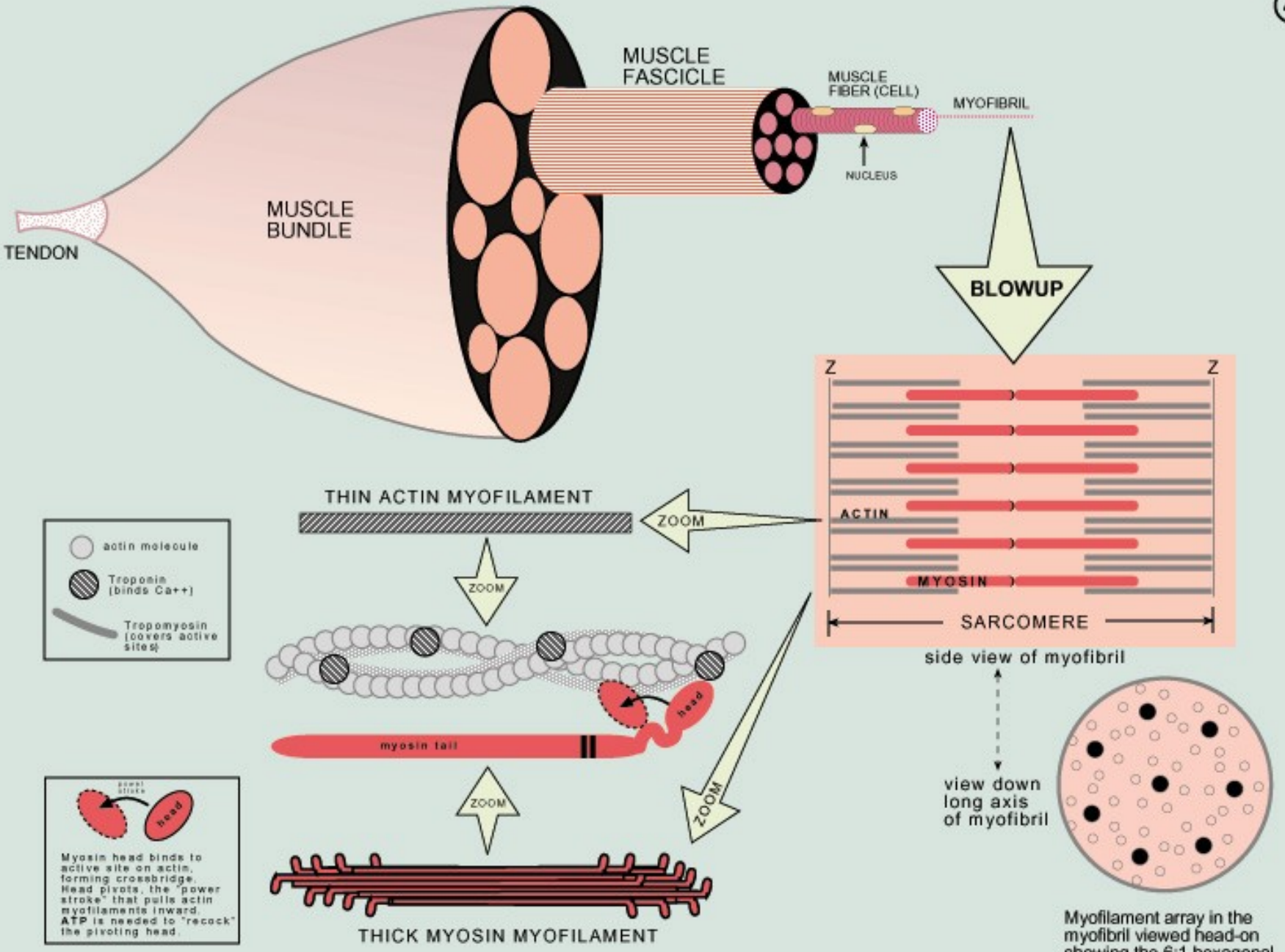
- 40-50% body weight
- Rich vascular supply
- Bones can not move without muscle contraction
- **Types of Muscle:**
  - **Cardiac:** found in the heart – involuntary – controlled by the ANS
  - **Smooth:** found in the walls of the hollow structures
    - GI tract, Bladder, Uterus, Blood vessels
    - No striations
    - Involuntary – controlled by the ANS

Muscle

- **Types of Muscle:**
  - **Skeletal:** striated (bands)
    - Voluntary
    - Attached to bones
    - Provides controlled movement, maintains posture & produces heat
    - Acts in groups

Muscle

- **Structure**
  - Muscle cell and muscle fiber = structured unit of the muscle
    - Muscle fibers are held together by connective tissue
  - Composed of myofibrils which are made of filaments
  - Sarcomere = contractile unit of the myofibril
  - Banding = arrangement of thick and thin filaments in the sarcomere
    - Sarcolemma = cell membrane
    - Sarcoplasm = cytoplasm within the cells


TENDON
MUSCLE BUNDLE
MUSCLE FASCICLE
MUSCLE FIBER (CELL)
NUCLEUS
MYOFIBRIL
BLOWUP
Z
Z
ACTIN
MYOSIN
SARCOMERE
side view of myofibril
THIN ACTIN MYOFILAMENT
ZOOM
ZOOM
ZOOM
ZOOM
actin molecule
Troponin (binds Ca++)
Tropomyosin (covers active sites)
head
myosin tail
Myosin head binds to active site on actin, forming crossbridge. Head pivots, the "power stroke" that pulls actin myofilaments inward. ATP is needed to "recock" the pivoting head.
THICK MYOSIN MYOFILAMENT
view down long axis of myofibril
Myofilament array in the myofibril viewed head-on showing the 6:1 hexagonal packing array (6 thin actin myofilaments for every thick myosin myofilament)

Muscle

- **Structure**
  - As thick and thin filaments in sarcomere slide past each other → sarcomeres shorten & muscle contracts
  - Motor Unit = neuron and muscle cell it activates
  - Neuromuscular Junction = motor end plate
    - Junction between the nerve cell & muscle cell it supplies.

Muscle

- **Structure**
  - Muscles are made up of muscle fibers held together and supported by connective tissue
  - They contain many myofibrils made up of alternating bands of actin & myosin → they slide together to shorten the muscle fibers
  - *Origin* = point of attachment on the bone, closest to the trunk
  - *Insertion* = point of attachment farthest from the trunk
  - Prime Movers = contract to produce movement
  - Antagonists = relax the muscle
  - Synergists = contract to stabilize the area involved.

Muscle

- Skeletal Muscle Contraction
  = responsible for posture & movement
  – Types:
    - Tonic: do not produce movement, hold muscles in position, maintain posture
    - Isotonic: produce movement, muscle shortens
    - Isometric: ↑ tension in muscle but does not produce movement
    - Twitch: A quick, jerky reaction to a single stimulus
    - Tetany: sustained twitch → series of stimuli in rapid succession

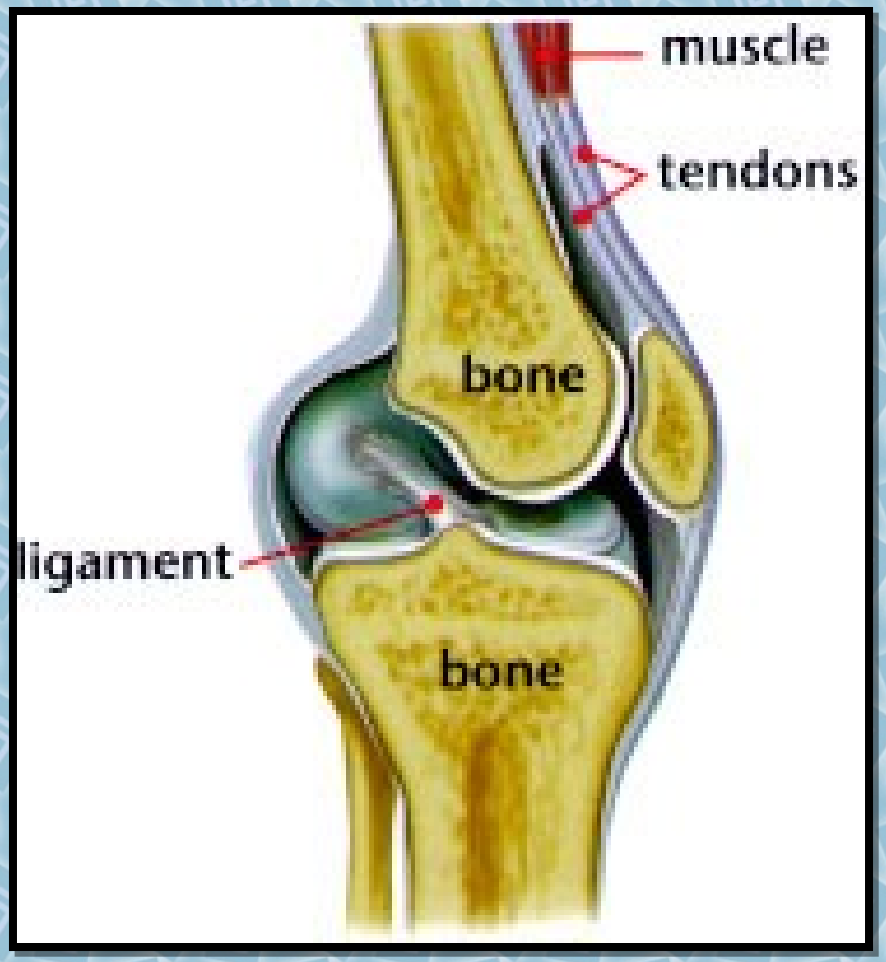
Muscle

- Skeletal Muscle Contraction
  - Types:
    - Fibrillation: asynchronous contraction of individual fibers
    - Convulsion: abnormal uncoordinated tetanic contractions in varying muscle groups
  - Energy Source:
    - ATP needed for muscle contractions
    - Muscle cells require large amounts of O_2 and glucose to generate power → have a rich vascular supply
    - If not enough O_2 to muscle, lactic acid accumulates from anaerobic metabolism = painful!

Ligaments & Tendons

- Both composed of dense, fibrous connective tissue → large collagen fibers packed closely together.
  - Therefore….*poor vascular supply & slow healing process*
- Tendons = attach muscle to bones
  - ie. achilles
- Ligaments = connect bones to bones at joints
  - Permit movement & provide stability
  - ie. knee

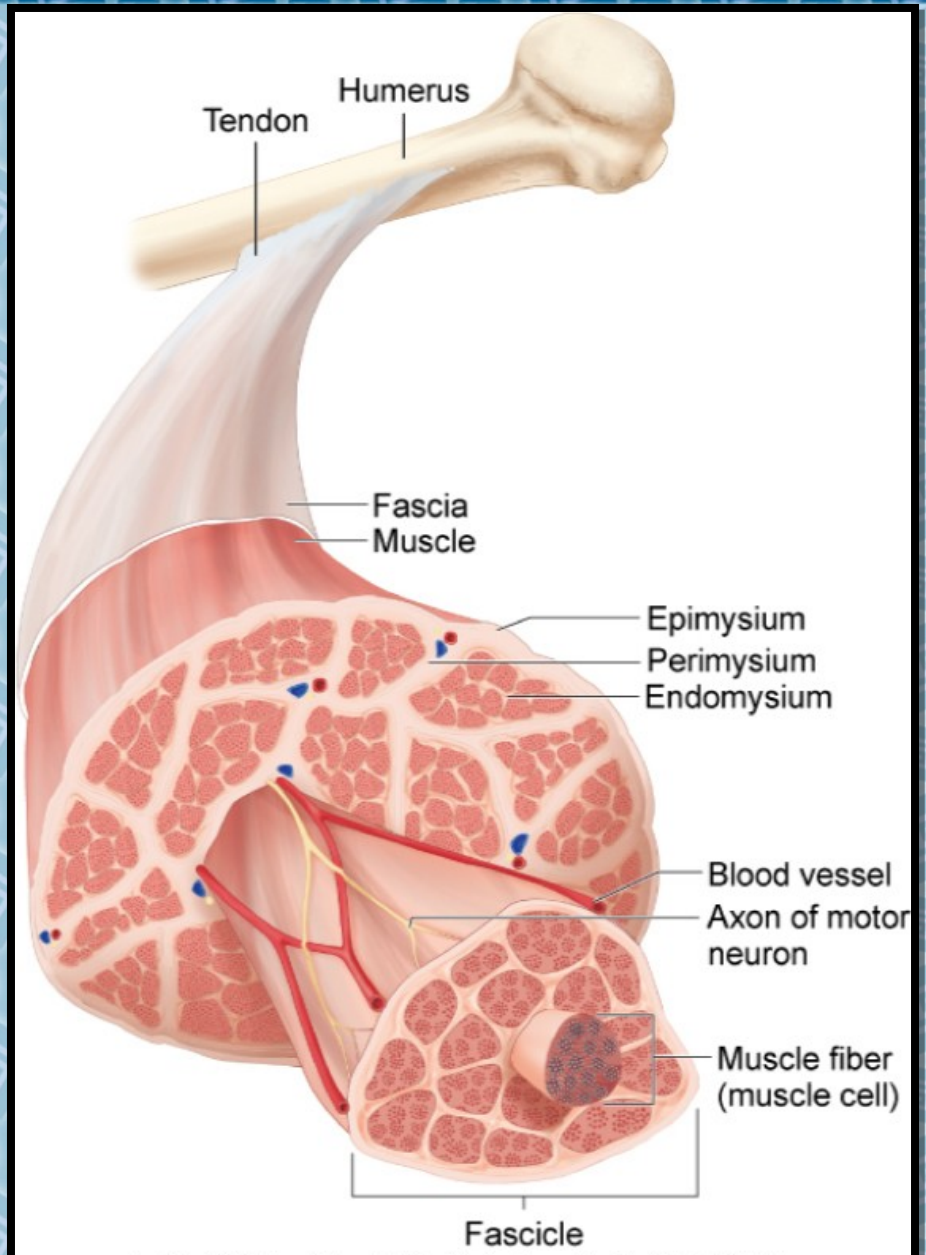
Ligaments & Tendons



Fascia

- Layers of connective tissue
- Function: separates one muscle from another
  - Provides strength to muscle tissue
- Superficial Fascia - found directly under the skin
- Deep Fascia – dense fibrous connective tissue that surrounds muscles
  - Found between muscles, around nerve & blood vessel bundles
- Compartment Syndrome

Fascia



From Patton KT, Thibodeau GA, Douglas M: *Essentials of anatomy and physiology,* St Louis, 2012, Mosby.

Bursae

- Small sacs of connective tissue located wherever pressure is exerted over moving parts
  - Usually at joints to ↓ friction
- Cushion between moving parts
- Lined with synovial membrane and contains synovial fluid
- Bursitis = inflammation of the bursa due to mechanical injury or excessive use
  - ie. Tennis elbow