LOCOMOTION AND SUPPORT SYSTEMS

Chapter 39

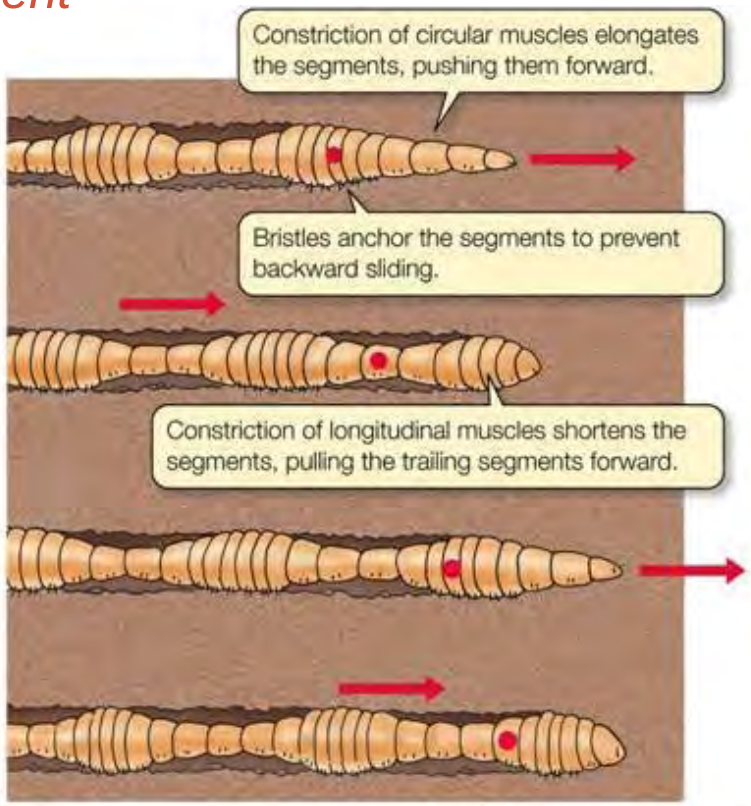
Overview

- Diversity of Skeletons
- Human Skeletal System
  - Cells, Growth
  - Anatomy
- Joints
- Human Muscular System
  - Skeletal Muscle anatomy and physiology
  - Sliding filament model
  - Muscle innervation

Diversity of Skeletons

Support system: provides rigidity, protection, surfaces for muscle attachment

- **Hydrostatic**: fluid-filled gastrovascular cavity or fluid-filled coelom. Support and resistance to contraction of muscles so mobility results.



LIFE 8e, Figure 47.13

Diversity of Skeletons

Support system: provides rigidity, protection, surfaces for muscle attachment

- Hydrostatic
- **Exoskeleton:** Composed of Calcium carbonate (mollusks) or chitin (arthropods). Protects against predators and desiccation (drying out). Arthropods have jointed and movable appendages.

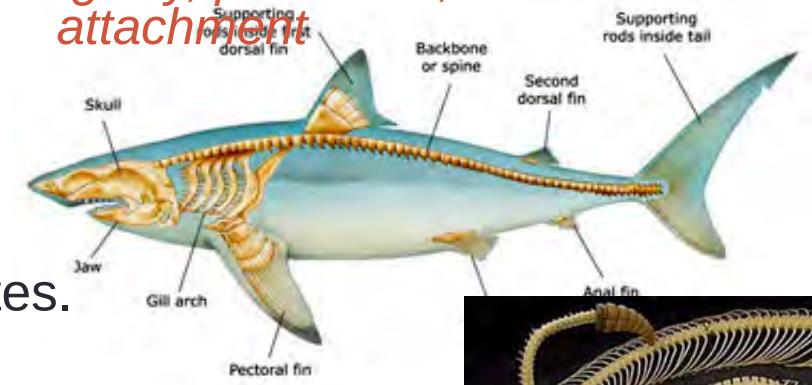
Diversity of Skeletons

Support system: provides rigidity, protection, surfaces for muscle attachment

- Hydrostatic
- Exoskeleton
- **Endoskeleton:** found in echinoderms and vertebrates.
  Verts: made of bone and cartilage, living tissue.
  Echinoderms: spicules and plates of calcium carbonate.

Advantages of Endoskeleton:

- Can grow with animal
- Supports weight of large animal
- Protects vital internal organs
- Is protected by soft tissue
- Allows flexible movements



Human Skeletal System

Functions of the Human Skeletal System:

1) Rigid skeleton supports the body and grows with the body.
2) Protects vital internal organs (e.g., brain, heart, lungs, spinal cord).
3) Provides sites for muscle attachment, making movement possible.
4) Important storage reservoir for ions such as calcium and phosphorus.
5) Produces red blood cells and other blood elements within the red bone marrow of the skull, ribs, sternum, pelvis, and long bones.

Bone Cells and Growth

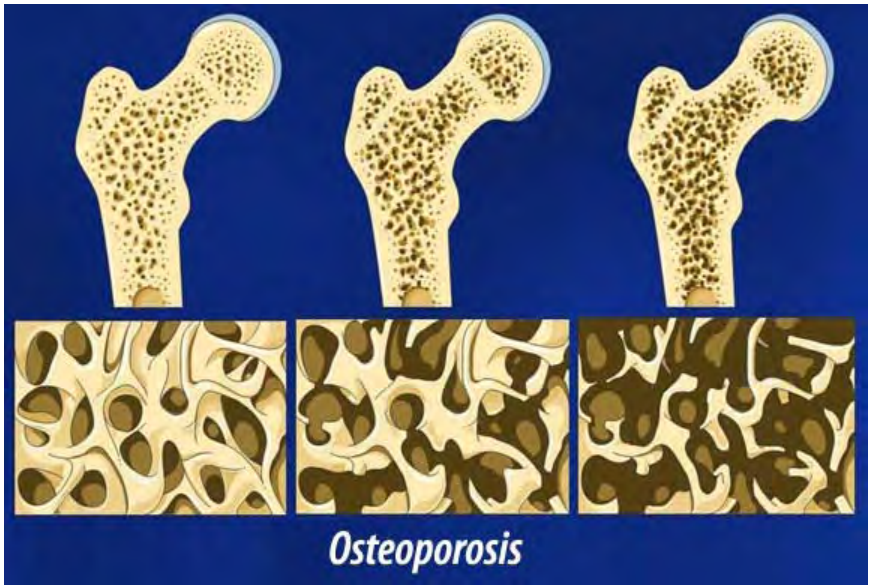
- **Osteoblasts**: bone forming cells
- **Endochondral ossification:** conversion of cartilaginous models to bone. Begins at ***Primary ossification center*** in middle of cartilaginous model. Cartilage is broken down and invaded by blood vessels; cells mature to bone forming osteoblasts.
- Later, **secondary ossification centers** form at ends of model. Cartilaginous growth plate remains between primary and secondary centers.
- As long as the plate remains, growth is possible
- Rate of growth controlled by growth hormone (GH) and sex hormones.
- Plates become ossified and bone stops growing.

Bone Cells and Growth

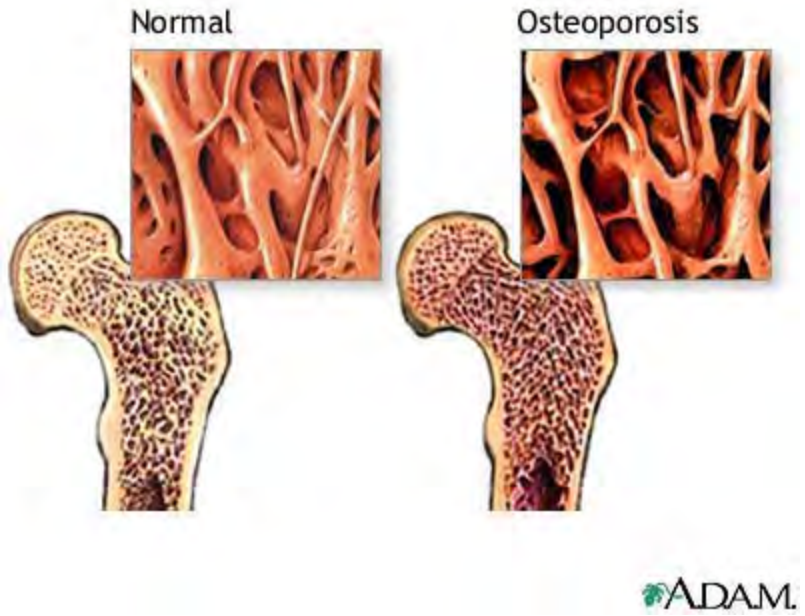
- **Osteoclasts:** Bone absorbing cells. Breaks down bone, removes worn cells, deposits calcium in the blood Destruction repaired by osteoblasts.
- **Parathyroid hormone (PTH):** promotes activity of osteoclasts
- **Calcitonin:** inhibits activity of osteoclasts
- **Osteocytes:** formed when osteoblasts are caught in matrix. Found within the lacunae of osteons.
- http://www.youtube.com/watch?v=yFJ4iswRiu4&feature=relmfu

Osteoporosis

- Condition in which bones are weakened due to decrease in the bone mass that makes up the skeleton.

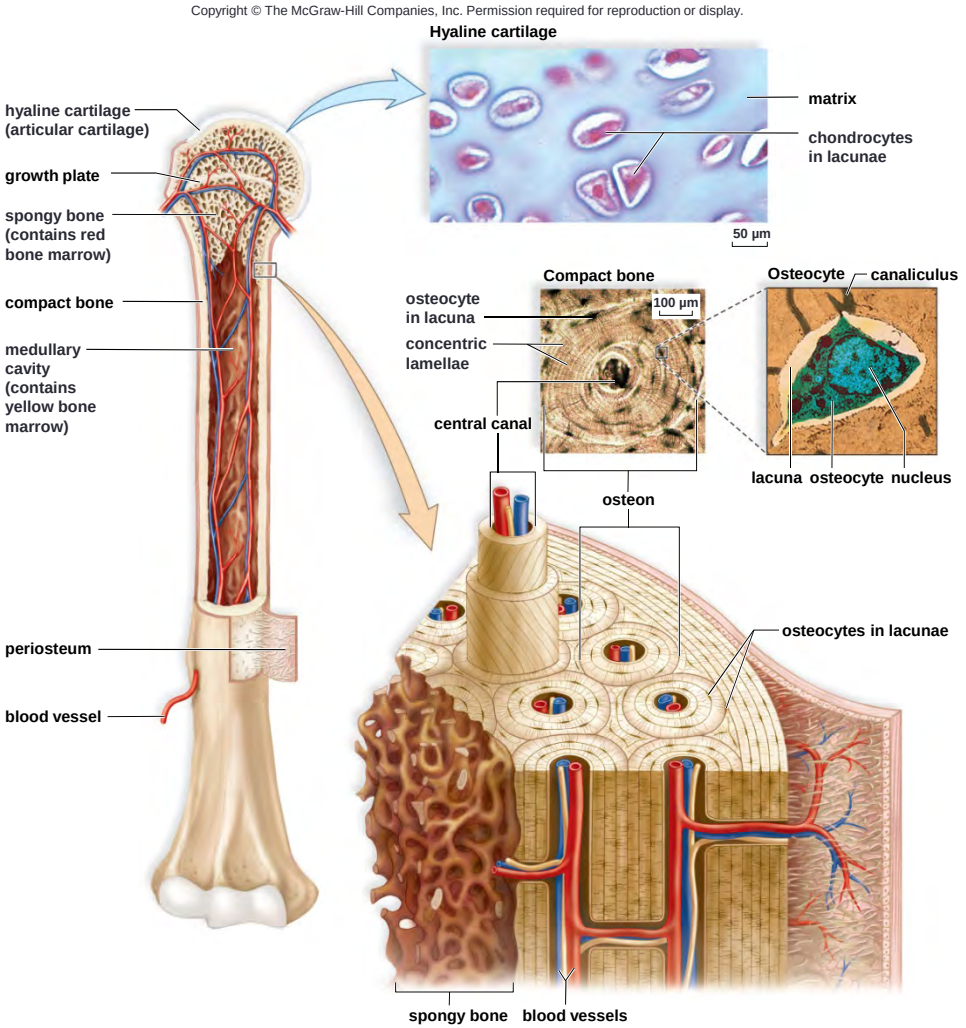


- How to avoid:
  - Adequate dietary calcium (1200-1500 mg per day
  - Vitamin D~ needed for body to use calcium correctly.
  - Exercise



Anatomy of Long Bone

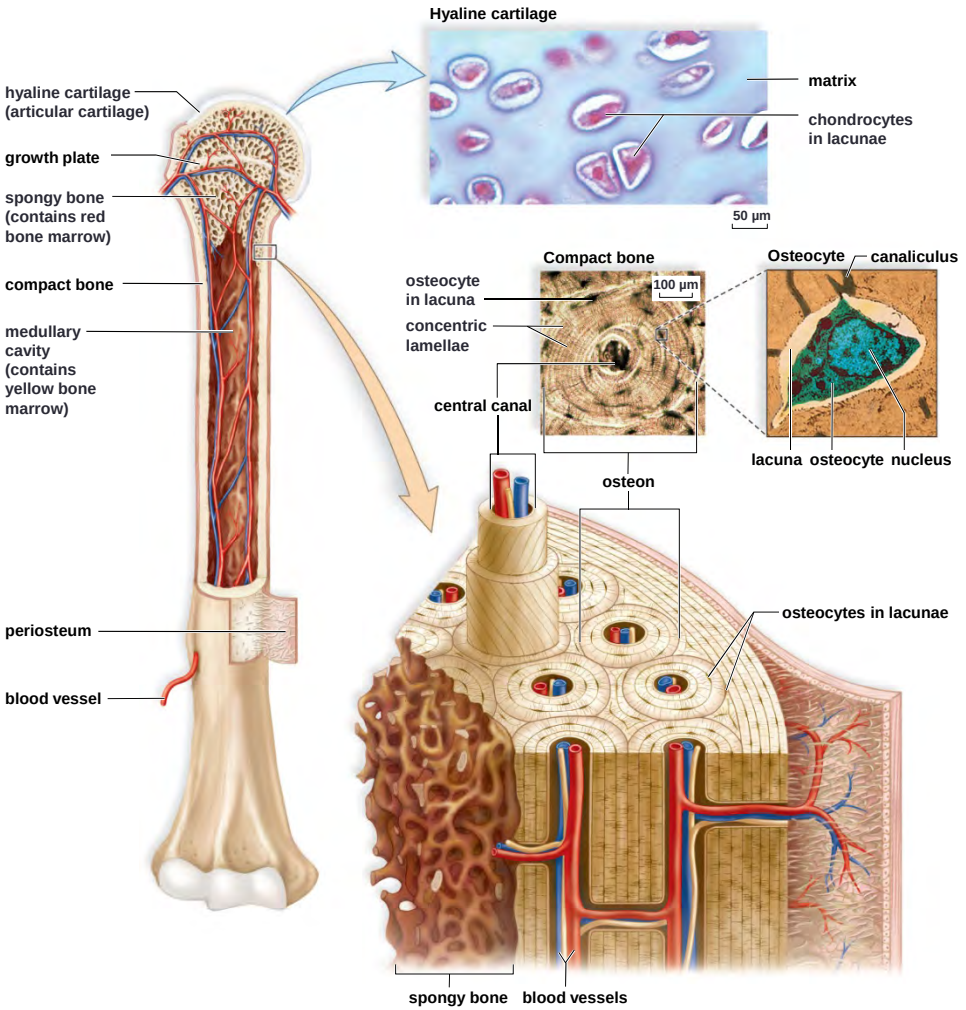
- **Medullary cavity**
- **Compact bone** contains many osteons where osteocytes lie in tiny chambers called **lacunae**. Lacunae are arranged in concentric circles around central canals that contain blood vessels and nerves.



(Osteocyte): © Biophoto Associates/Photo Researchers, Inc.; (Hyaline cartilage, compact bone): © Ed Reschke

Anatomy of Long Bone

- **Spongy bone** has numerous bony bars and plates separated by irregular spaces. Lighter than compact bone, but provide strength.
- **Red bone marrow** fills spaces in spongy bone. RBM is a specialized tissue that produces blood cells.



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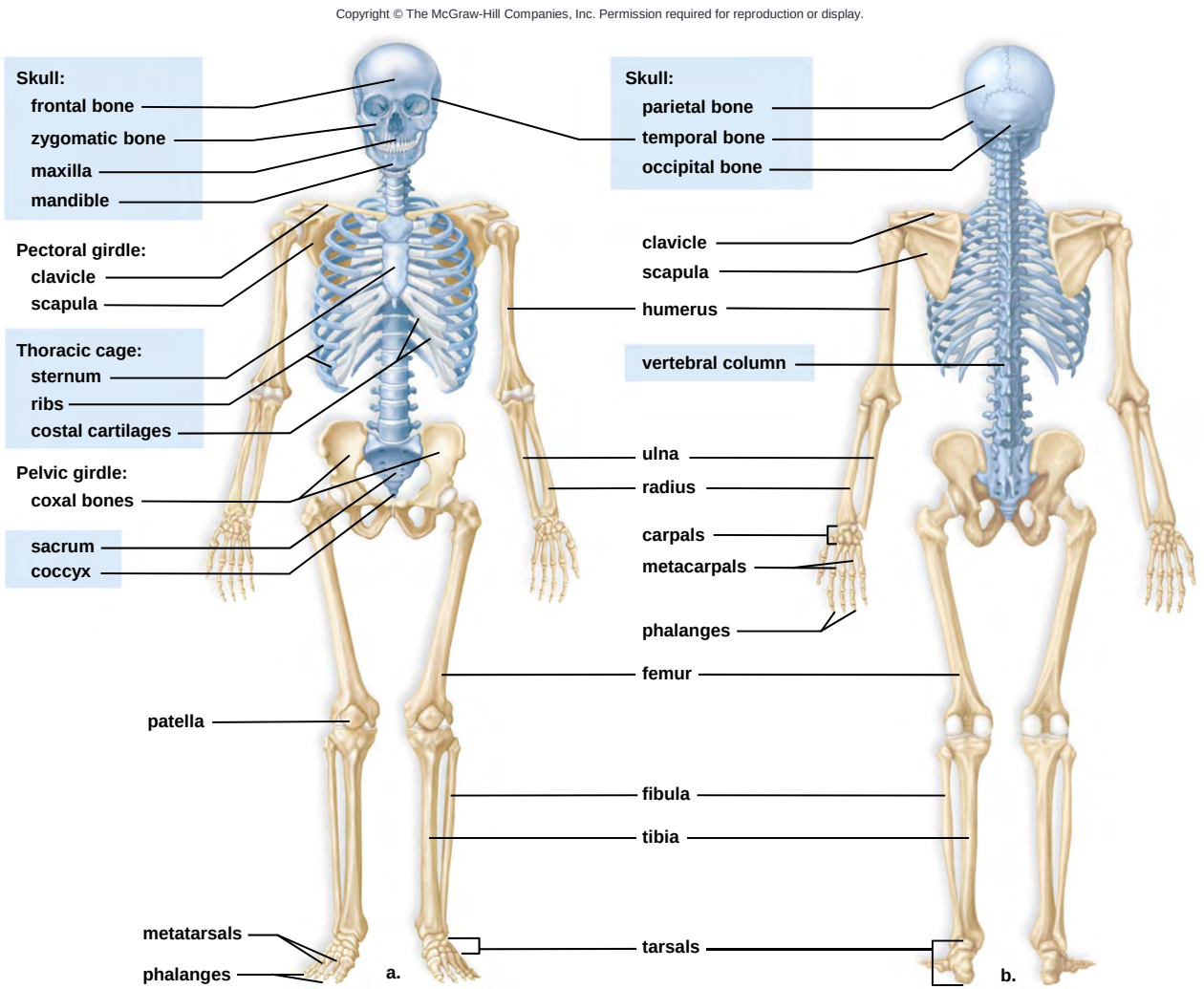
Axial Skeleton

- Skull
- Vertebral Column
- Thoracic cage
- Sacrum
- Coccyx
- 80 bones

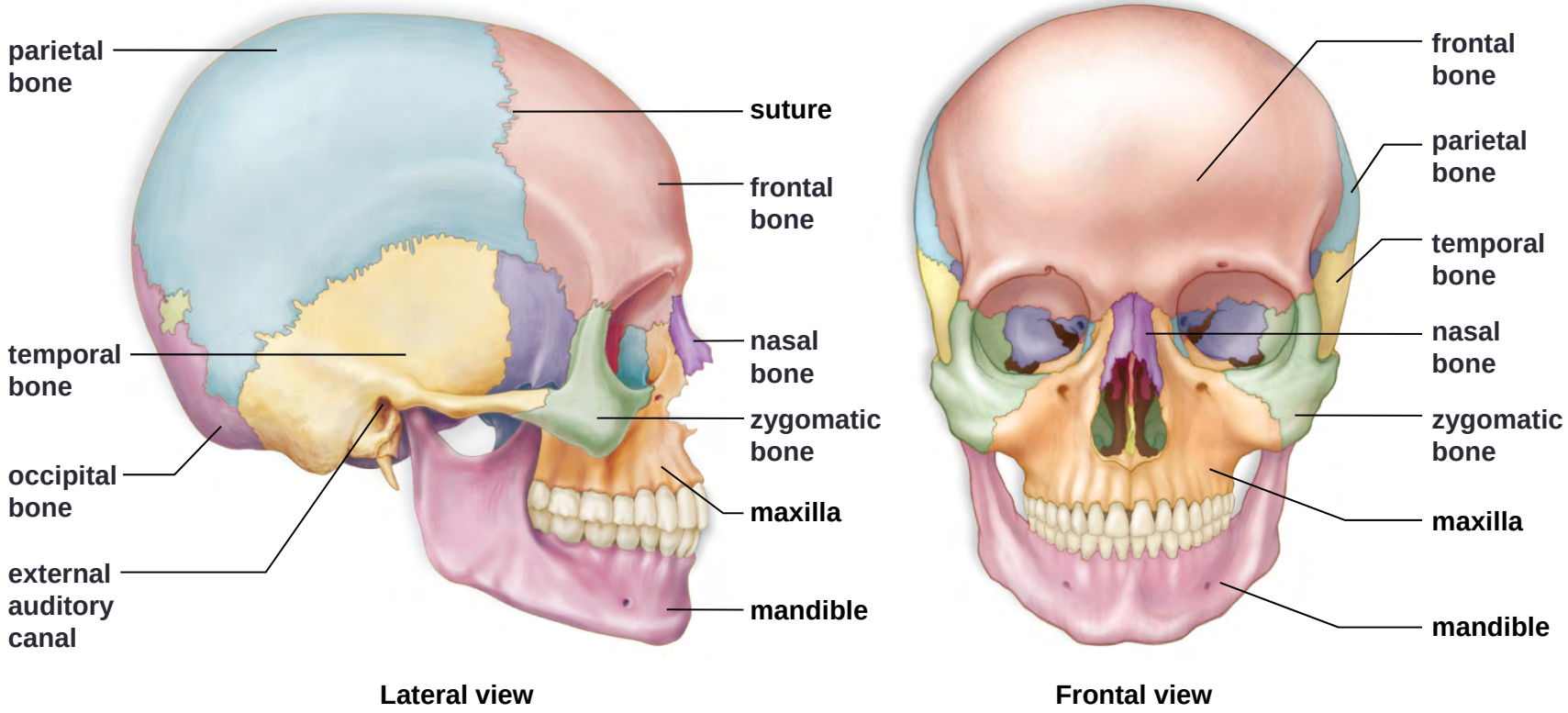


Axial Skeleton

- **Skull**: Protects brain.

Formed by cranium and facial bones.

Fontanels: “soft spots” in newborns, close and become **sutures.**



Axial Skeleton

- **Vertebral column:** supports head&neck, protects spinal cord and roots of spinal nerves.
- Made of 24 vertebrae:

7 cervical (neck)

12 thoracic

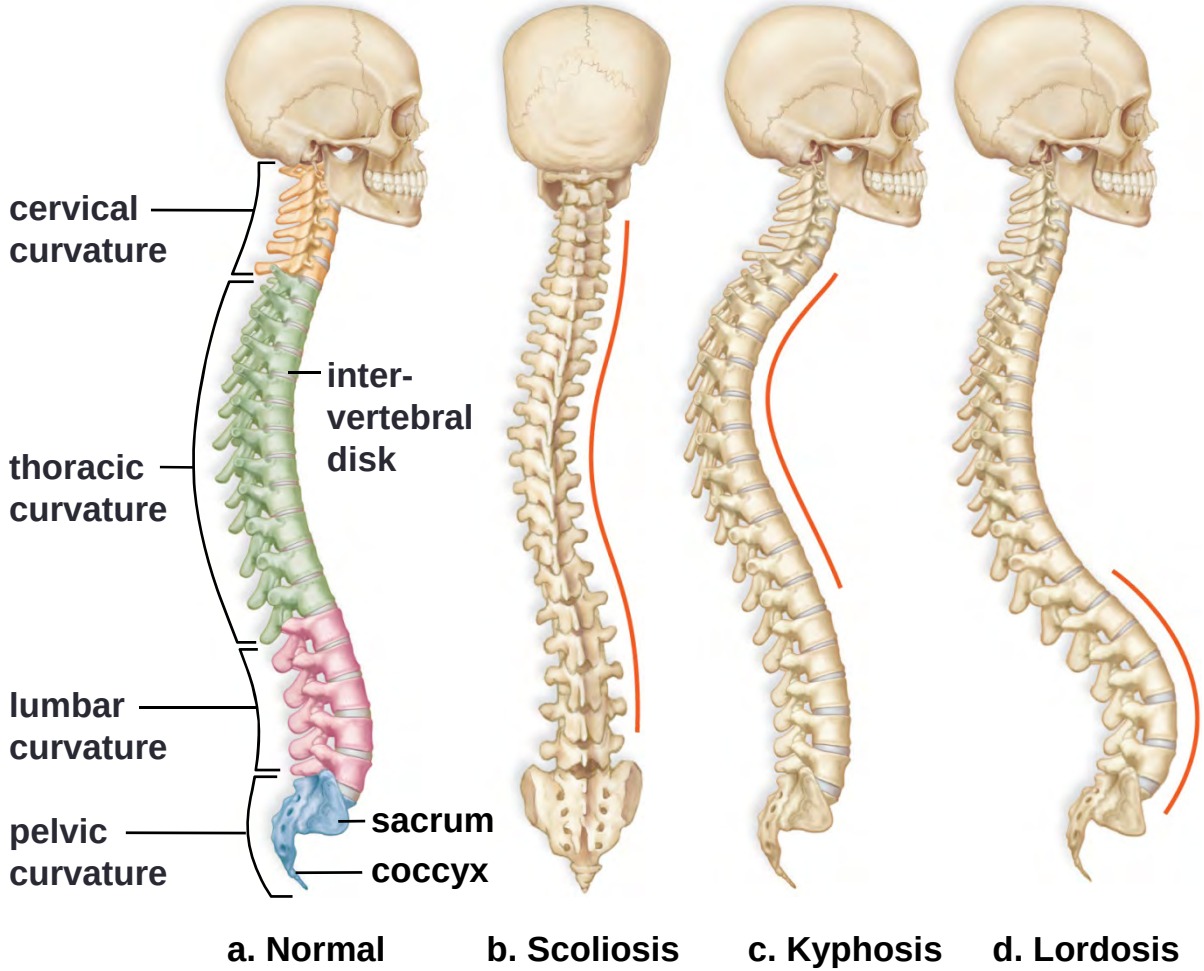
5 lumbar (lower back)

Sacrum

Coccyx

- **Intervertebral disks:**

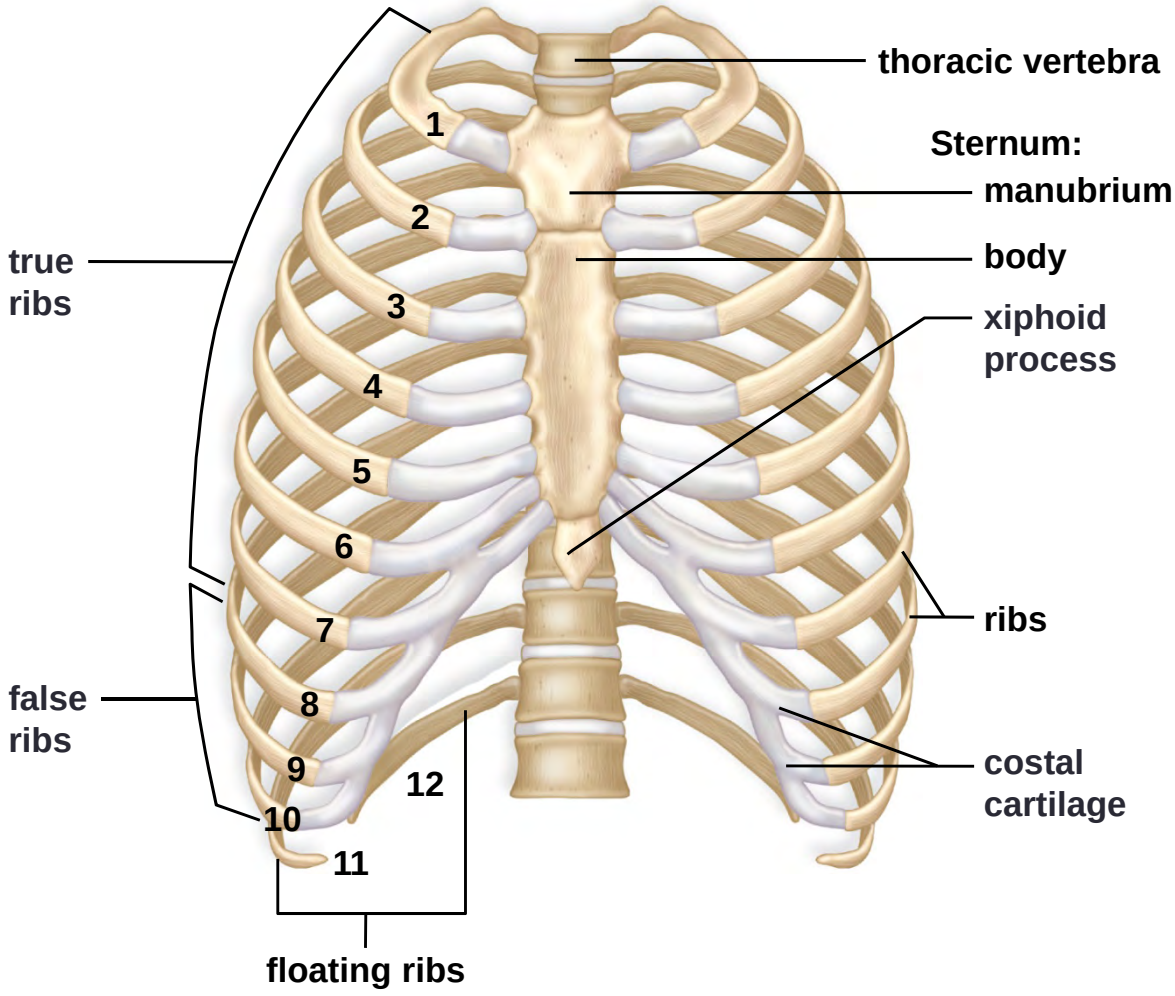
Composed of fibrocartilage between the vertebrae provide padding. Allow the vertebrae to move.



Axial Skeleton

- **Rib Cage:** attached to thoracic vertebrae. Contains ribs, costal cartilages, and sternum.

- 12 pairs of ribs.
  - 7 upper are “true ribs” (attached directly to sternum);
  - lower 5 are called “false ribs”. Three attach via cartilage, 2 are “floating ribs”.
- Rib cage provides protection but is flexible.



Appendicular Skeleton

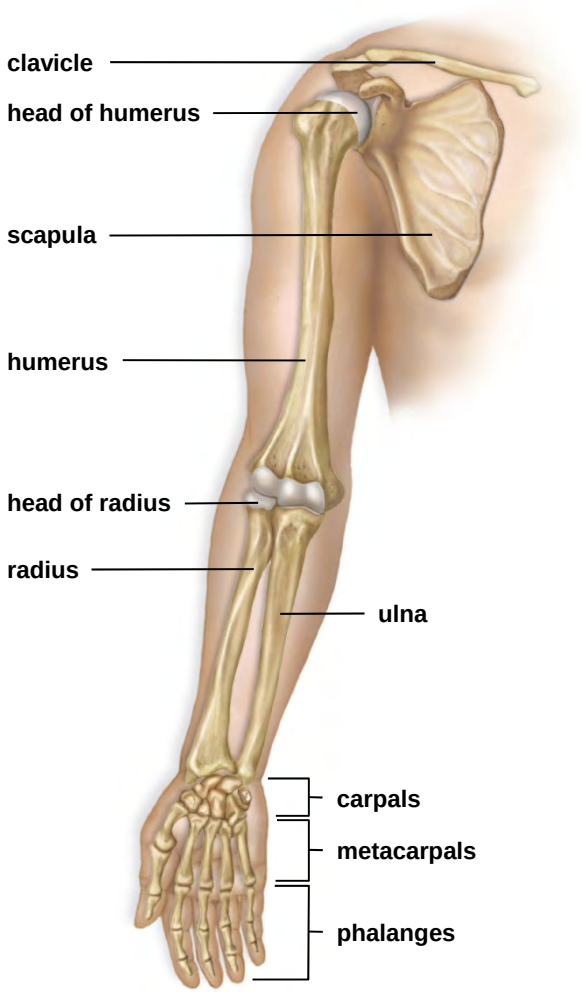
- Pectoral Girdle and Upper Limb
- Pelvic Girdle and Lower Limb
- Total of 126 bones.

Appendicular Skeleton

Pectoral Girdle and Upper Limb

Pectoral girdle: forearm. Loosely linked by ligaments. Specialized for flexibility.

Clavicle: collarbone. Connects with sternum and scapula.
Scapula: shoulder blade. Held in place only by muscles, allowing it to glide and rotate on the clavicle.
Humerus: single long bone in arm, round head fits into socket of scapula.
Ulna and **Radius**: two bones of lower arm, meets opposite end of humerus. Prominent bone in elbow is the top of the ulna. Palm foreward= radius crosses in front of ulna.
The hand is made up of eight **carpals,** from which five **metacarpals** fan out to form the palm.
Phalanges make up the fingers and thumb.

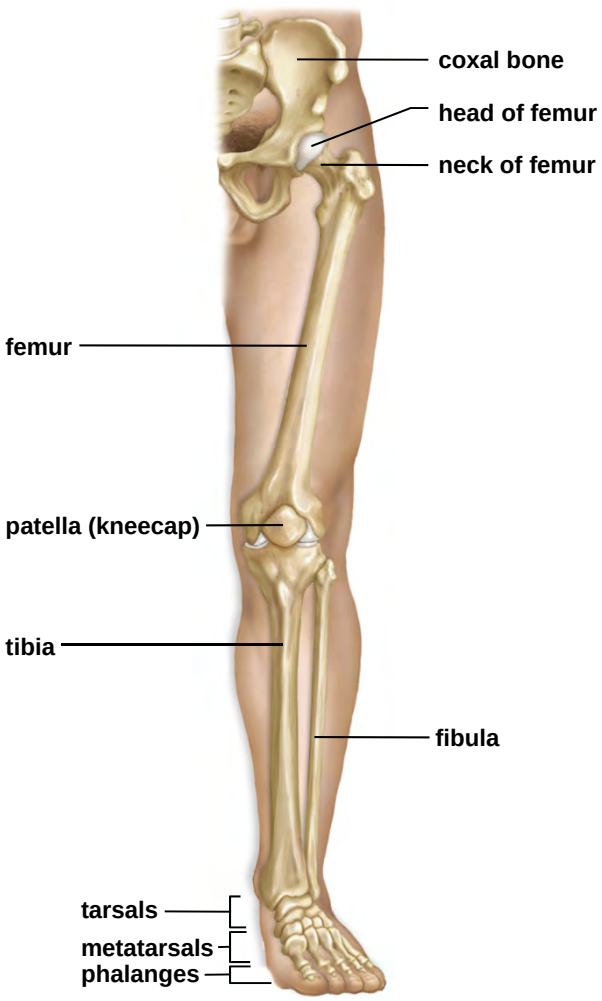


Appendicular Skeleton

Pelvic Girdle and Lower Limb

Pelvic girdle: consists of two heavy large **coxal bones** (hipbones) anchored to the sacrum and form a hollow cavity called the **pelvic cavity**.
Weight of the body is transferred through the pelvis to the lower limbs and onto the ground.

Femur: largest bone in the body. Thighbone.
Tibia: Larger of the two lower leg bones; has a ridge called the shin. Prominence becomes inside of the ankle.
Fibula: the other lower leg bone; prominence contributes to outside of the ankle.
Tarsals: seven in ankle, but only 1 receives weight and passes it to the heel and ball of foot.
Metatarsals: form the arches of the foot; Provide stable springy base for body.
Phalanges: bones of the toes.



Classification of Joints

Joints = where bones are connected.

- **Fibrous:** ex: sutures; immoveable.
- **Cartilaginous**: ex: between vertebrae; slightly moveable.
- **Synovial**: ex: knee; freely moveable. Bones separated by a cavity.

Ligaments: bind bones together. Composed of fibrous connective tissue.

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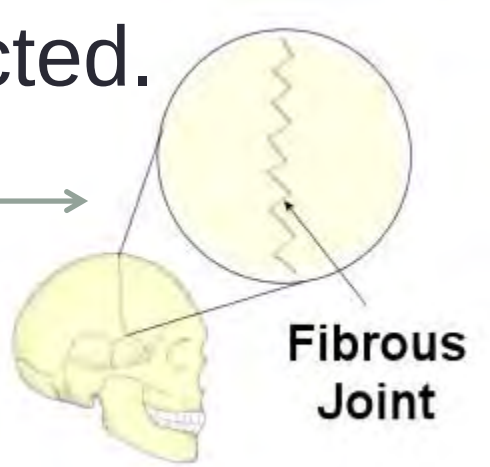

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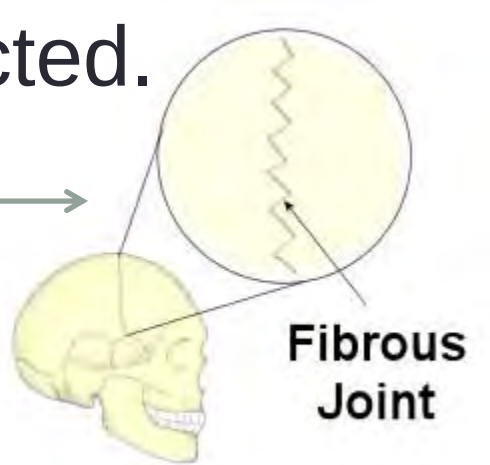

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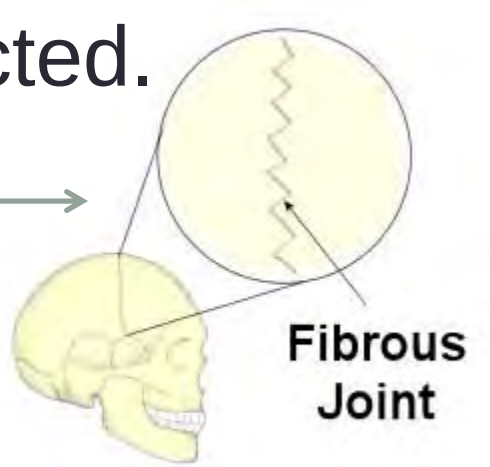
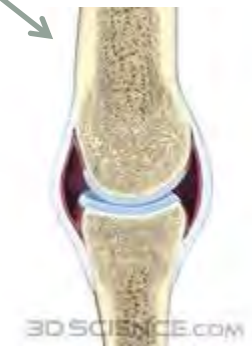
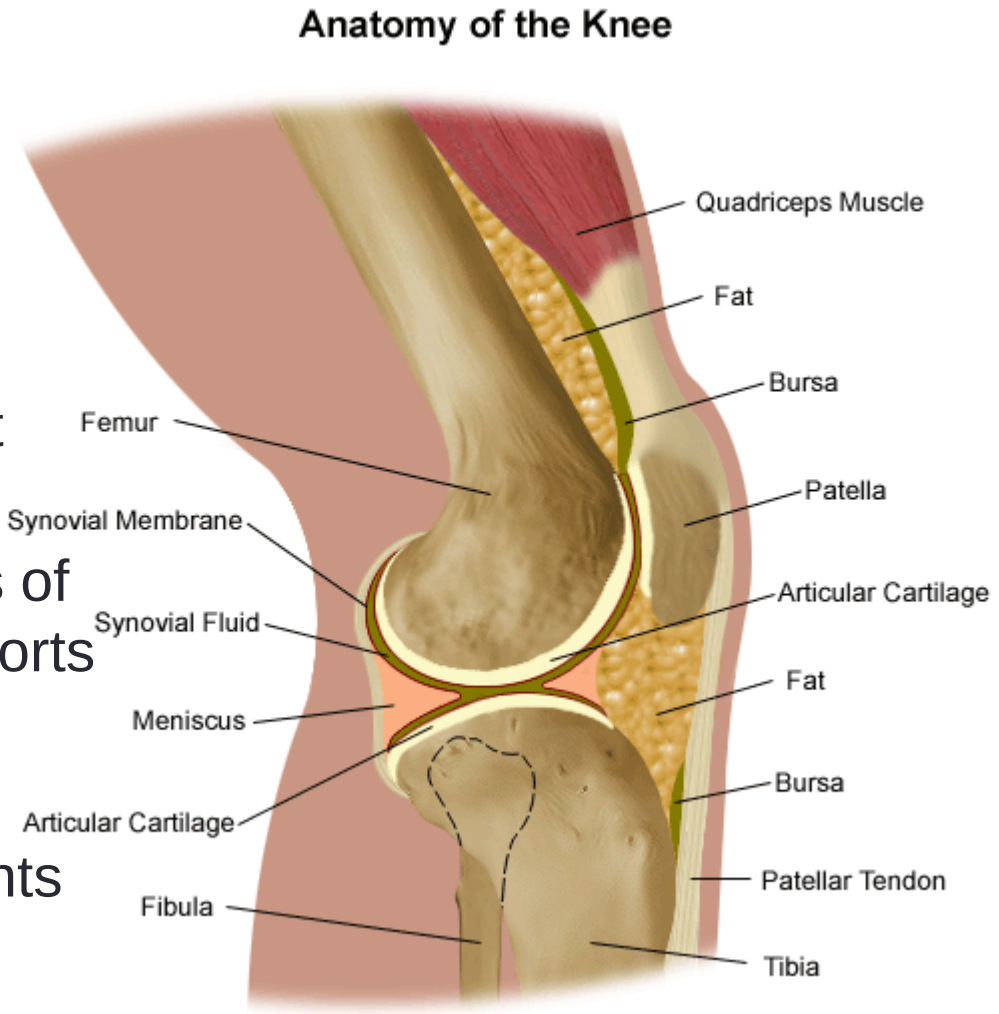




Knee Joint

A synovial joint

- **Joint capsule**: lined by **synovial membrane**
- **Synovial fluid**: lubricant for joint, produced by synovial membrane
- **Articular cartilage**: caps bone at joint
- **Menisci**: crescent-shaped pieces of cartilage; gives stability and supports weight
- **Bursae**: fluid-filled sacs, ease friction between tendons&ligaments and tendons&bones



Classification of Joints

Types of moveable joints

- **Hinge Joints**: knee, elbow. Permit movement in one direction.
- **Pivot Joint**: small cylindrical projection of one bone pivots within the ring formed of bone and ligament of another bone, making rotation possible.
- **Ball-and-socket Joint**: allow movement in all planes and rotational movement. Ex: ball of femur fits into a socket on the hipbone.

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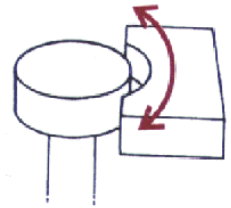
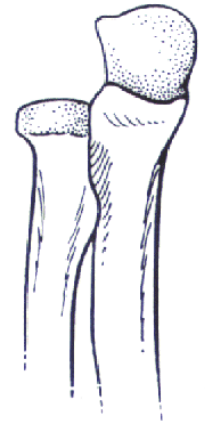




http://www.youtube.com/watch?v=VNbrvU7MgY0&feature=related

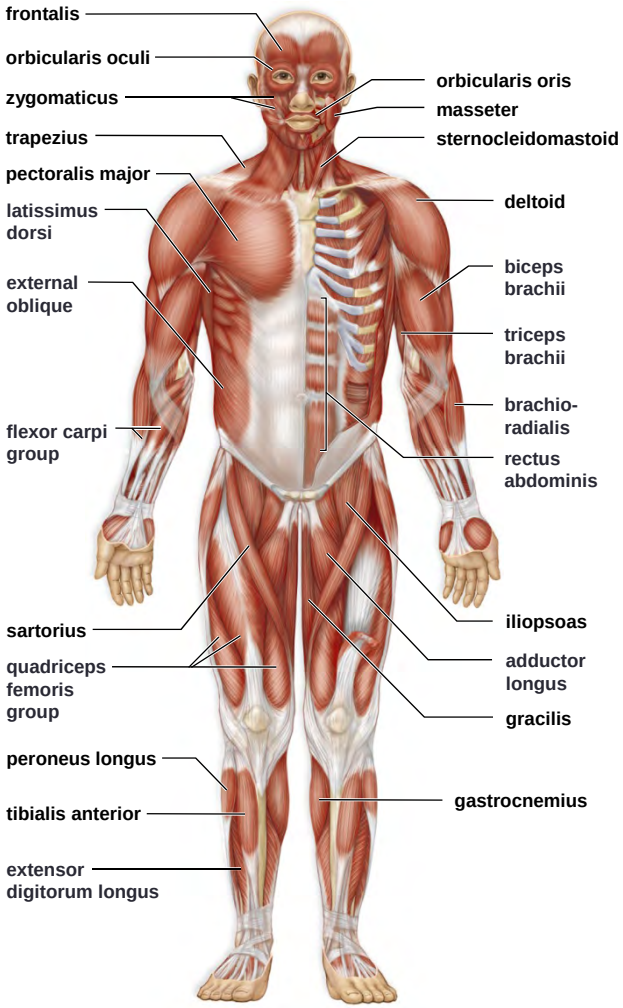
Human Muscular System

Three types of muscle tissue: skeletal, cardiac, smooth.

- Skeletal Muscle: aka striated voluntary muscle.
  - Important in maintaining posture, providing support, allowing movement, homeostasis through maintaining body temperature.
  - Contraction of skeletal muscle causes ATP breakdown, releasing heat which is distributed throughout the body.

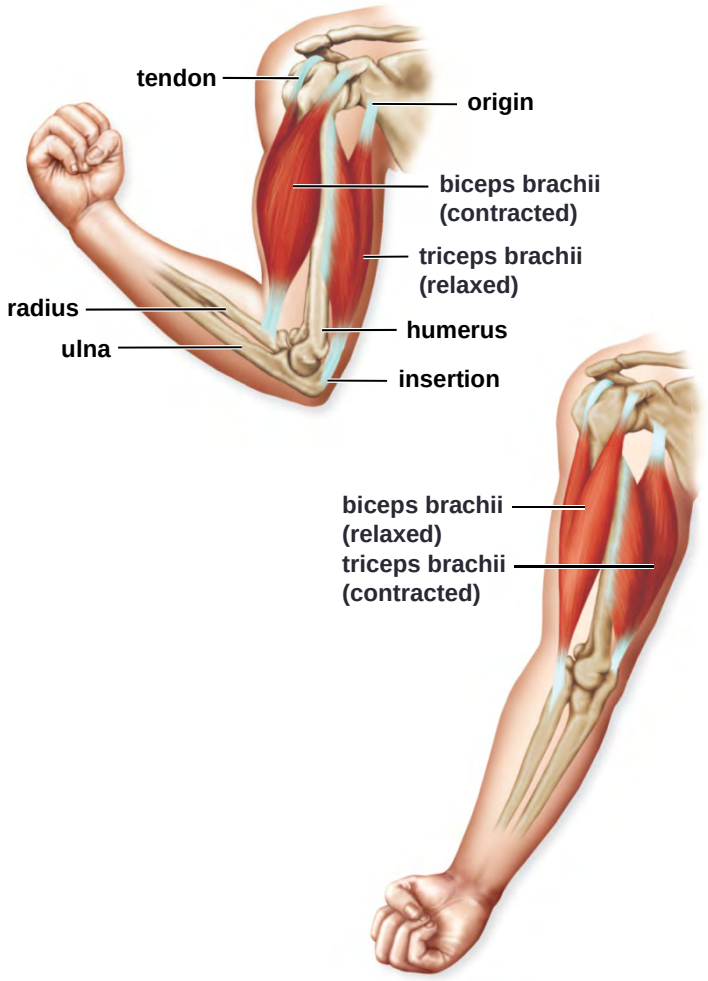
Skeletal Muscle

- Fun fact: the nearly 700 skeletal muscles and associated tissues make up ~40% of the weight of an average human.
- **Tendons**: fibrous connective tissue that attaches skeletal muscle to bone.



Skeletal Muscle Physiology

- When muscles contract, they shorten; therefore muscles can only pull.
- Muscles must work in **antagonistic pairs**: one flexes the joint and bends the limb, the other extends the joint and straightens the limb.
- When one muscle contracts, it stretches it antagonistic partner.
- Even when muscles appear “at rest”, they exhibit **tone**, in which some of their fibers are contracting. Important for posture.



Microscopic Anatomy of Skeletal Muscle

- Vertebrate skeletal muscle is composed of a number of muscle fibers in bundles. Each muscle fiber is a cell.
- **Sarcolemma:** plasma membrane, forms a **T system** (transverse). T tubules penetrate into cell so they contact expanded portions of **sarcoplasmic reticulum**: a modified ER that serves as storage for Ca^{2+} needed for muscle contraction.
- **Myofibrils:** encased in sarcoplasmic reticulum; contractile portions of muscle fiber. Cylindrical, run length of muscle fiber; light and dark bands (striations) formed by the placement of protein filaments within contractile units called **sarcomeres**.
- Types of protein filaments**: myosin** (thick) and **actin** (thin)

Microscopic anatomy

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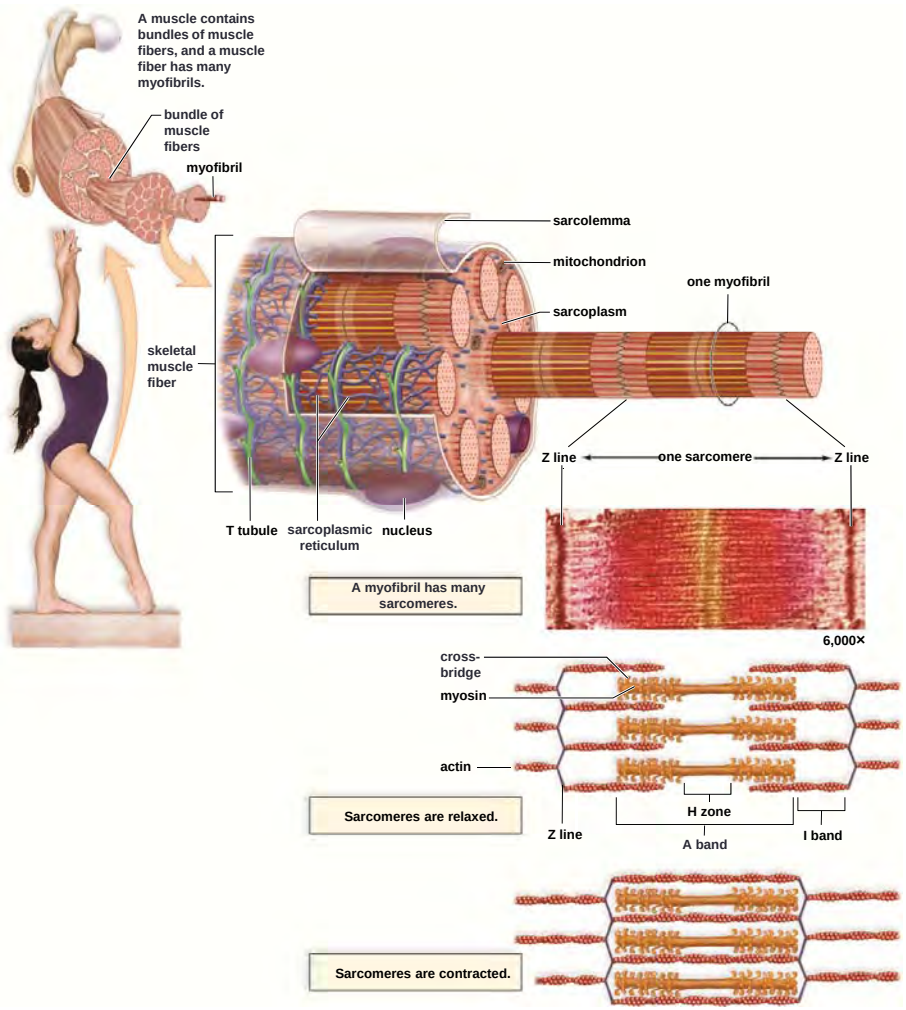
- **Sarcomeres** extend between two dark lines called **Z lines**.
- Within sarcomeres, there are two types of protein filaments: **myosin** (thick) and **actin** (thin)
- **I-band**: light colored, contains only actin filaments attached to a Z-line.
- **A-band**: dark region containing overlapping actn and myosin filaments
- **H-zone**: only myosin filaments



Sliding Filament Model

- When muscle fibers contract, sarcomeres within the myofibrils have shortened.
- When sarcomere shortens, actin (thin) filaments slide past the myosin (thick) filaments, causing the I-band to shorten and the H-zone to nearly disappear.

- http://www.youtube.com/watch?v=XoP1diaXVCI&feature=endscreen

ATP and Muscle Contraction

- Myoglobin: molecule that stores O2
- Creatine phosphate: storage form of high-energy phosphate. Anaerobically regenerate ATP.
- When CP is depleted, mitochondria may have produced enough ATP for muscle contraction without consuming O2. If not, **fermentation** occurs, causing **lactate** build up.
- Oxygen debt: may occur after exercise.
- Lactate is broken down into 20% CO2 and H2O
- ATP produced by respiration used to reconvert 80% of lactate to glucose.

Muscle Innervation

- Muscles are stimulated to contract by **motor nerve fibers**.
- Nerve fibers have several branches, each ends at an **axon terminal** that lies near the sarcolemma of a muscle fiber.
- The **synaptic cleft** is a small gap separating the axon terminal from the sarcolemma.

This region is called a **neuromuscular junction**.

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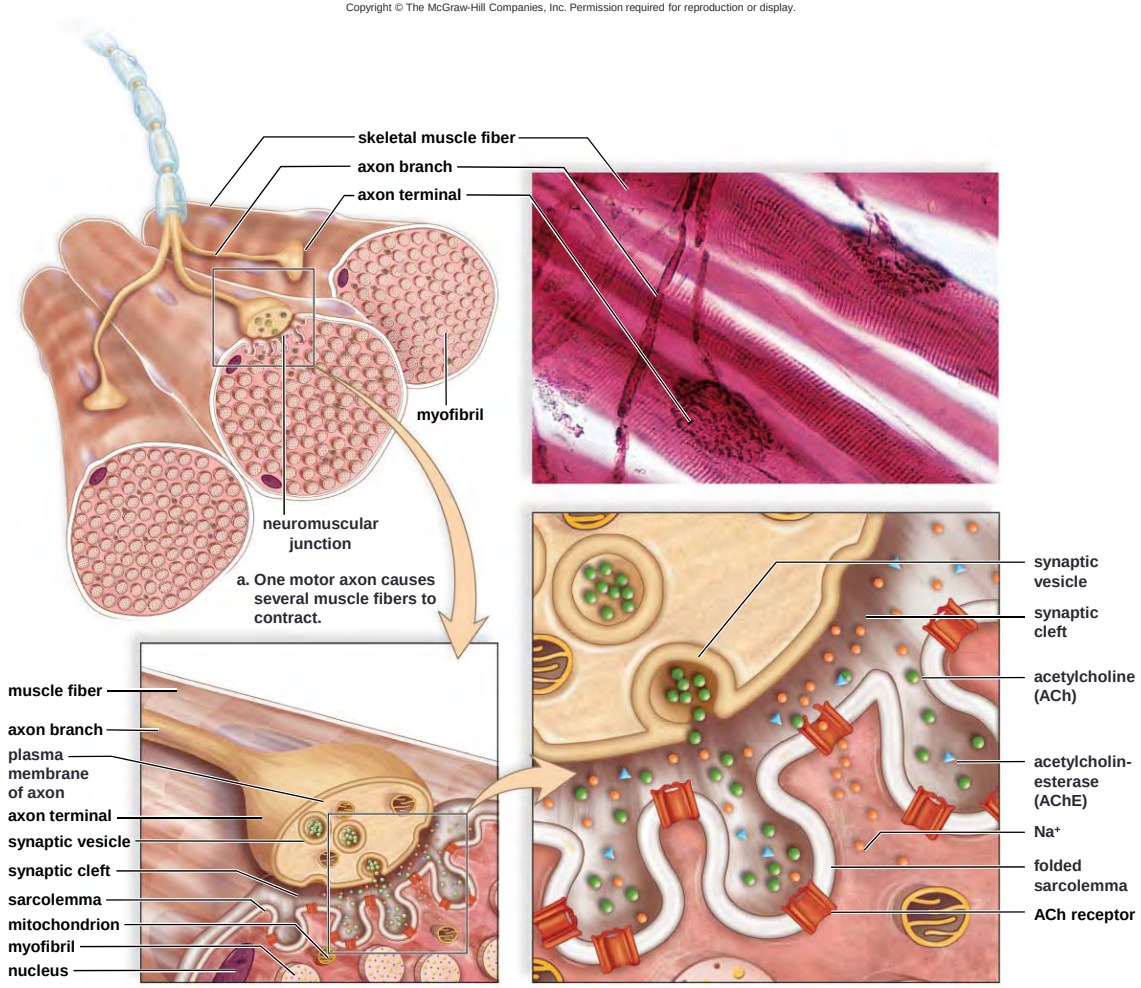
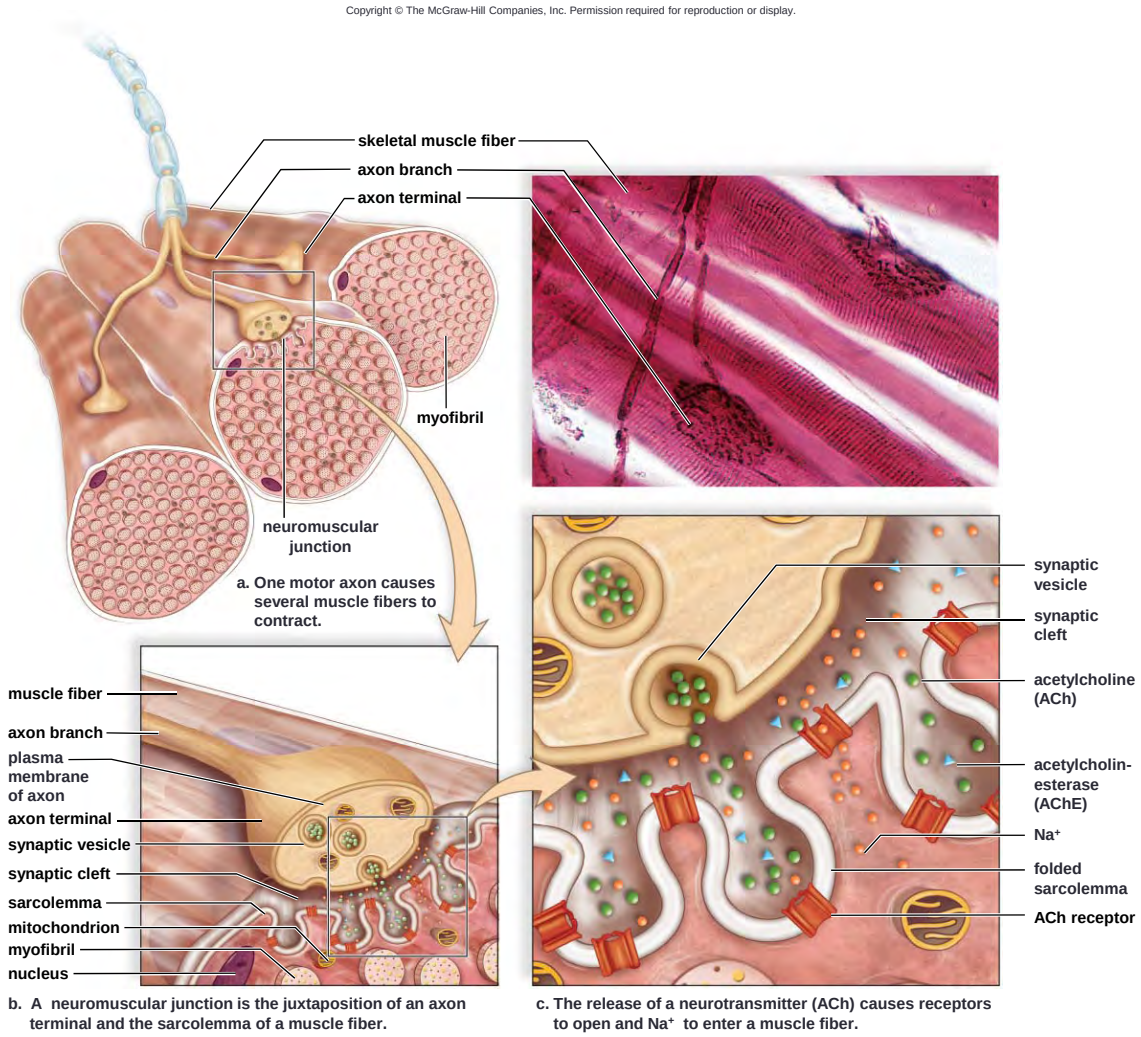
Axon terminals contain **synaptic vesicles** filled with the neurotransmitter **acetylcholine** (ACh).



Muscle Innervation

- Nerve impulse travels down motor neuron to axon terminal.
- Synaptic vesicles release Ach into synaptic cleft
- Ach diffuses across cleft and binds to receptors in the sarcolemma.
- Sarcolemma generates impulses that spread to sarcoplasmic reticulum.
- Filaments within sarcomeres slide past one another.
- Sarcomere contraction results in myofibril contraction, which results in muscle fiber and muscle contraction.
- http://www.youtube.com/watch?v=9FF6UKvDgeE



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- Joints
  - Fibrous, cartilaginous, synovial
  - Moveable joints: Hinge, pivot, ball-and-socket
- Human Muscular System
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