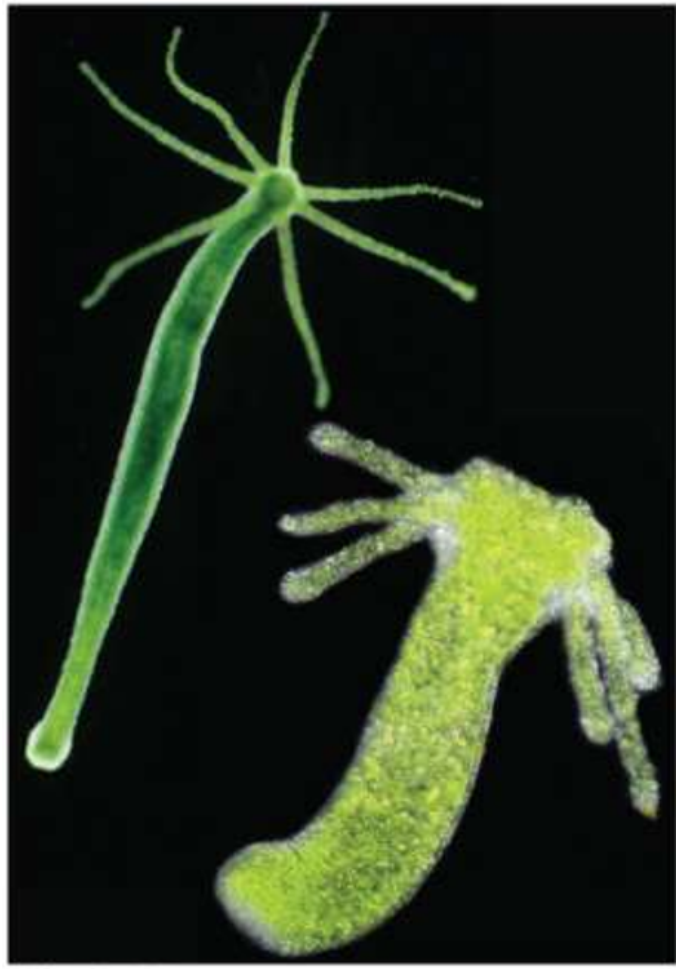
30.2 Skeletons function in support, movement, and protection

- Skeletons provide
  - body support,
  - movement by working with muscles, and
  - protection of internal organs.
- There are three main types of animal skeletons:
  - hydrostatic skeletons,
  - exoskeletons, and
  - endoskeletons.

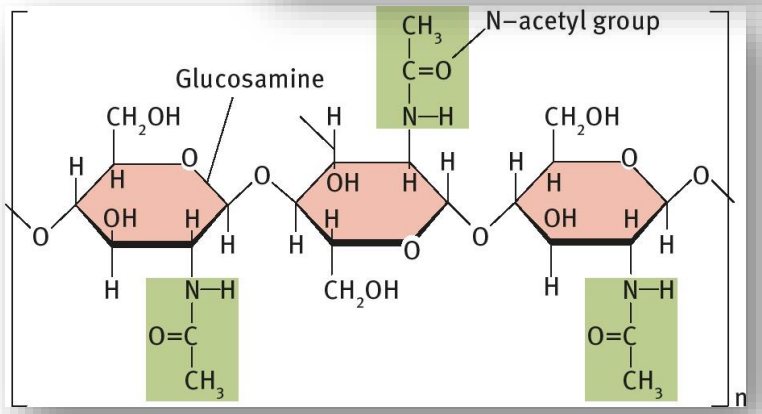
30.2 Skeletons function in support, movement, and protection

1. **Hydrostatic skeletons** are
   - fluid held under pressure in a closed body compartment
   - found in worms and cnidarians.
   - Hydrostatic skeletons
     - help protect other body parts by cushioning them from shocks,
     - give the body shape, and
     - provide support for muscle action.



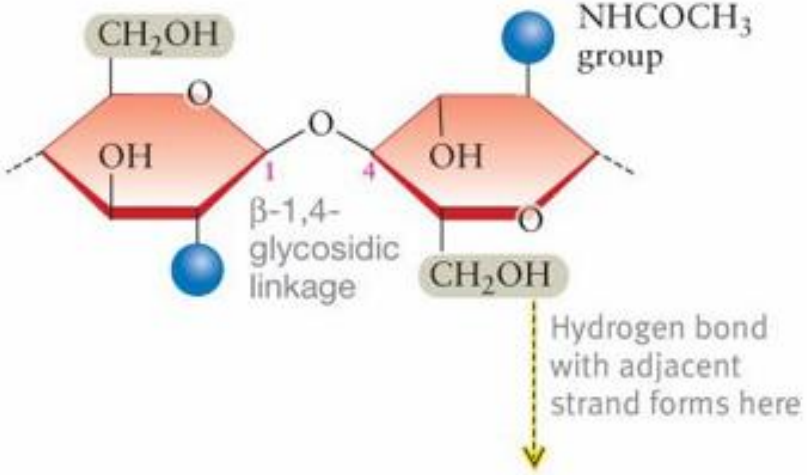
30.2 Skeletons function in support, movement, and protection

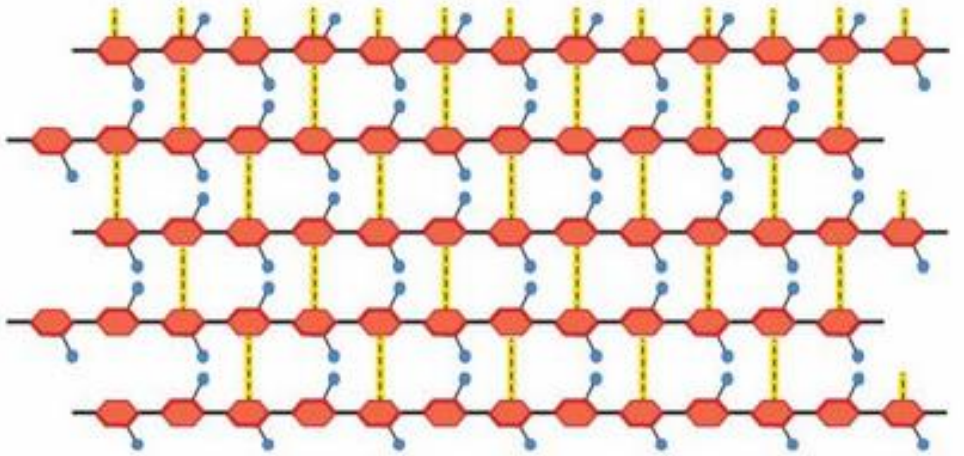
2. **Exoskeletons** are rigid external skeletons that consist of
   - chitin and protein in arthropods and
   - calcium carbonate shells in molluscs.
   - Exoskeletons must be shed to permit growth.



Chitin

Used for structural support in the cell walls of fungi and the external skeletons of insects and crustaceans.





30.2 Skeletons function in support, movement, and protection

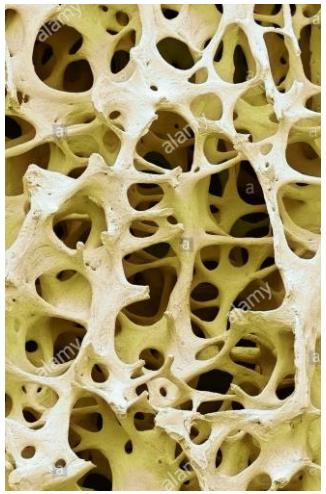
3. **Endoskeletons** consist of hard or leathery supporting elements situated among the soft tissues of an animal. They may be made of
   - cartilage or cartilage and bone (vertebrates),
   - spicules (sponges), or
   - hard plates (echinoderms).

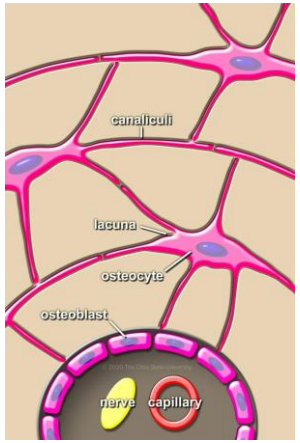
30.3 EVOLUTION CONNECTION: Vertebrate skeletons are variations on an ancient theme

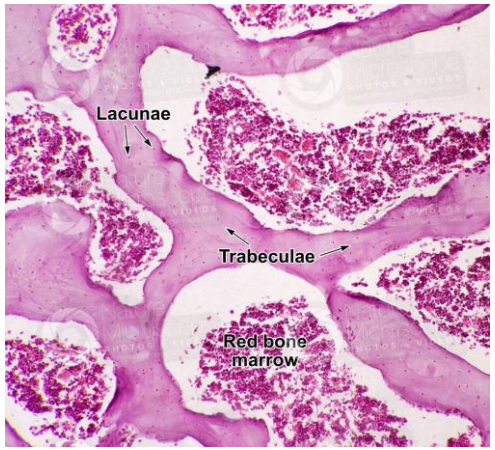
- The vertebrate skeletal system provides
  - structural support
  - means of locomotion

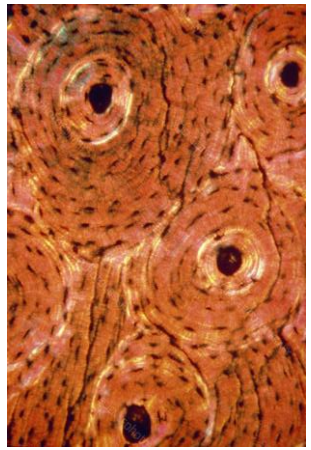
Bones of the Human Body

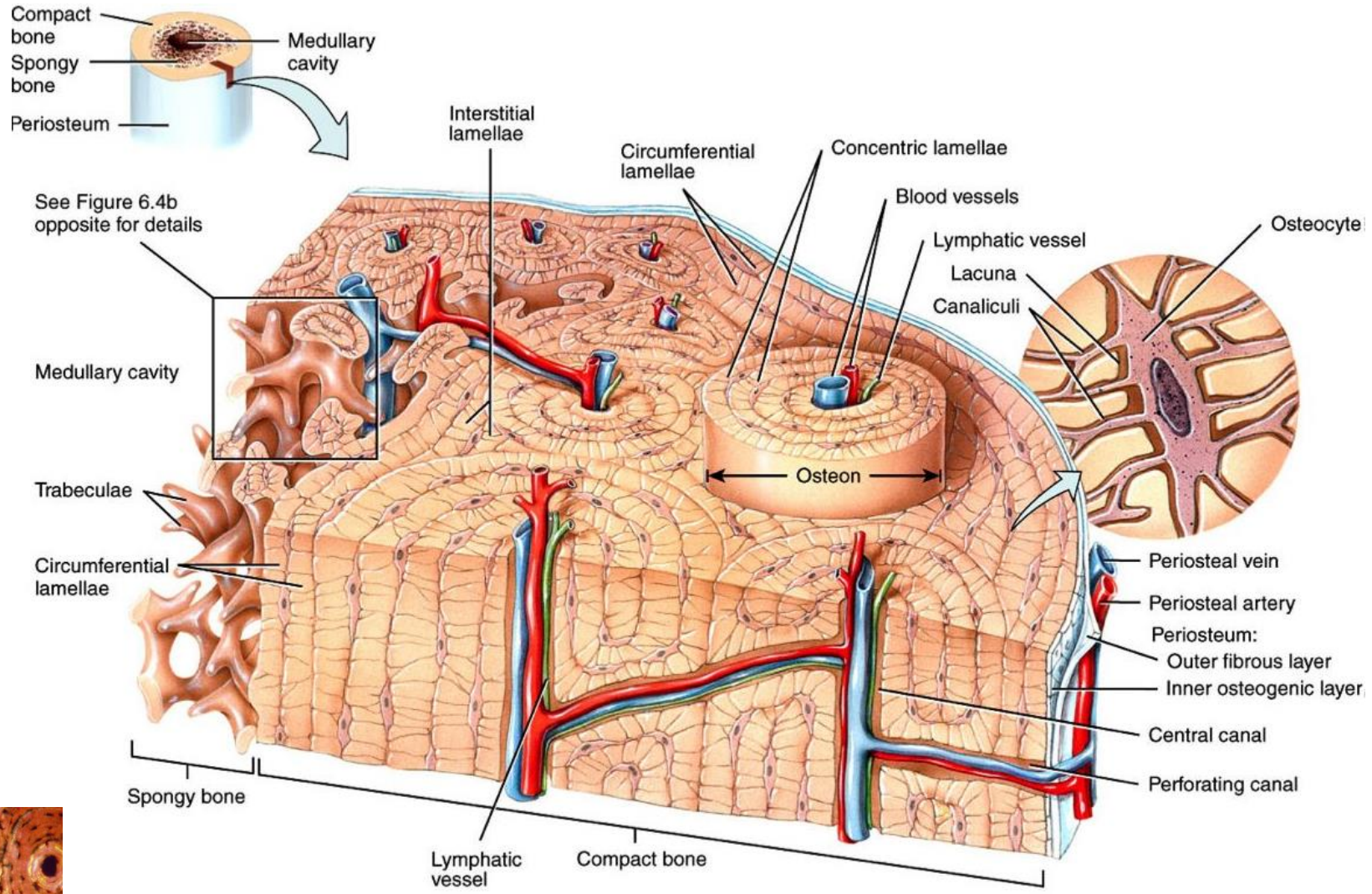
- The adult skeleton has 206 bones
- Two basic types of bone tissue
  - Compact bone
    - Homogeneous
  - Spongy bone
    - Small needle-like pieces of bone
    - Many open spaces







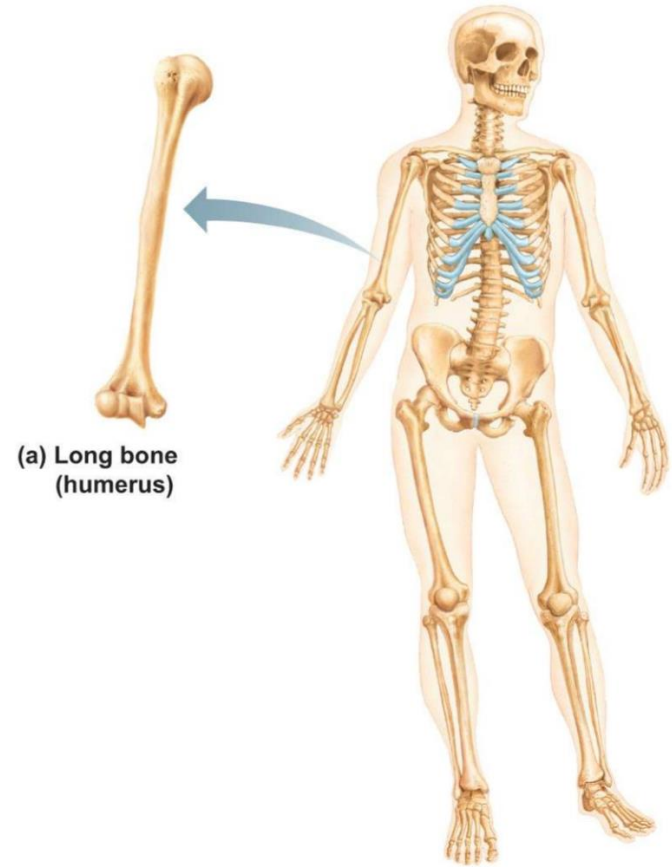




(a) Osteons (haversian systems) in compact bone and trabeculae in spongy bone

Classification of Bones

- Bones are classified by shape
- Long bones
  - Typically longer than they are wide
  - Shaft with heads situated at both ends
  - Contain mostly compact bone
  - All of the bones of the limbs (except wrist, ankle, and kneecap bones)
  - **Example:**
    - Femur
    - Humerus



Types of Bone Cells

- Osteocytes—mature bone cells
- Osteoblasts—bone-forming cells
- Osteoclasts—giant bone-destroying cells

- Bone cells
  - live in a matrix of flexible protein fibers and hard calcium salts and
  - are kept alive by blood vessels, hormones, and nerves.

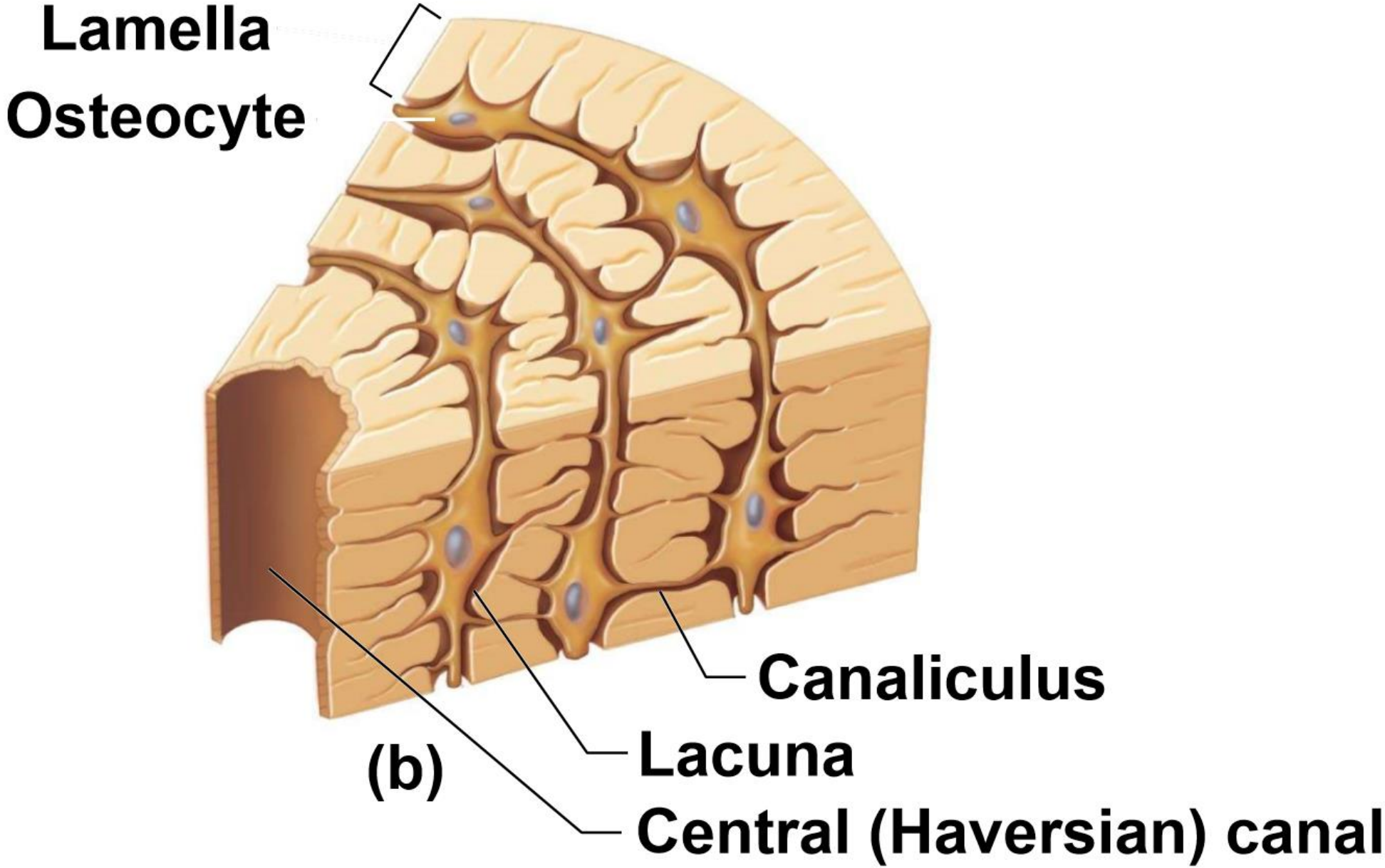
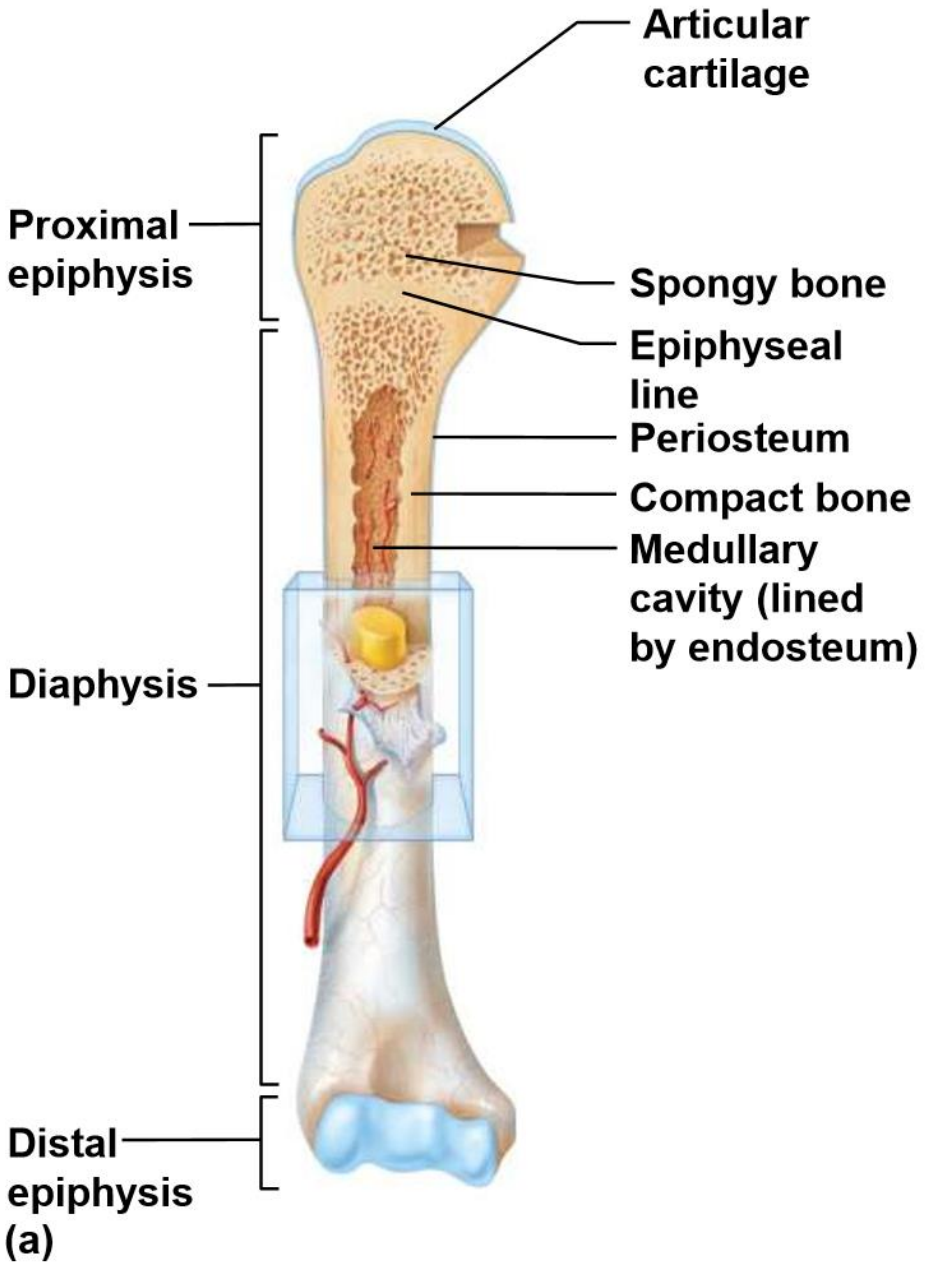

Lamella
Osteocyte
Canaliculus
Lacuna
(b)
Central (Haversian) canal

Figure 5.4b

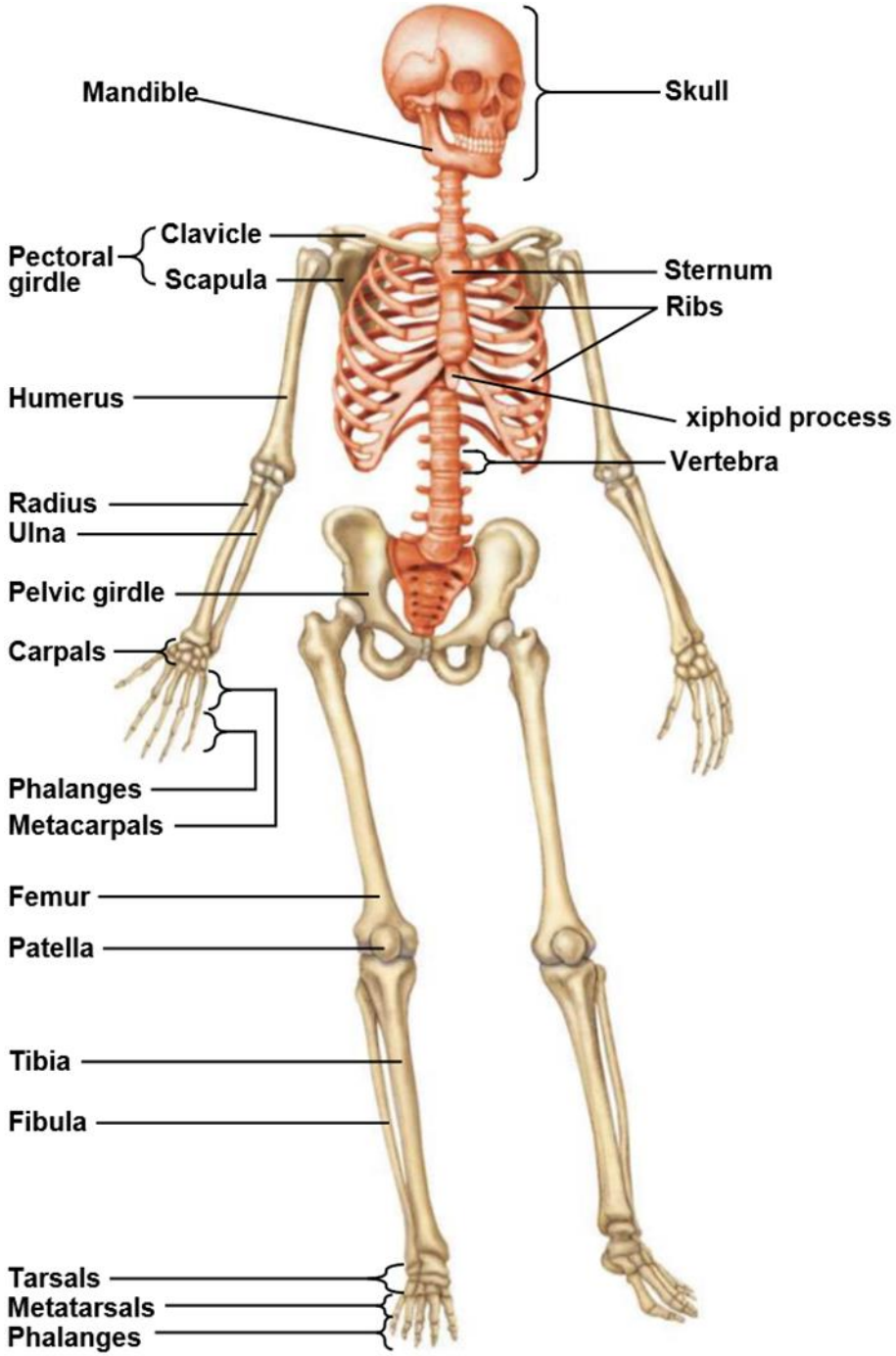
Anatomy of a Long Bone

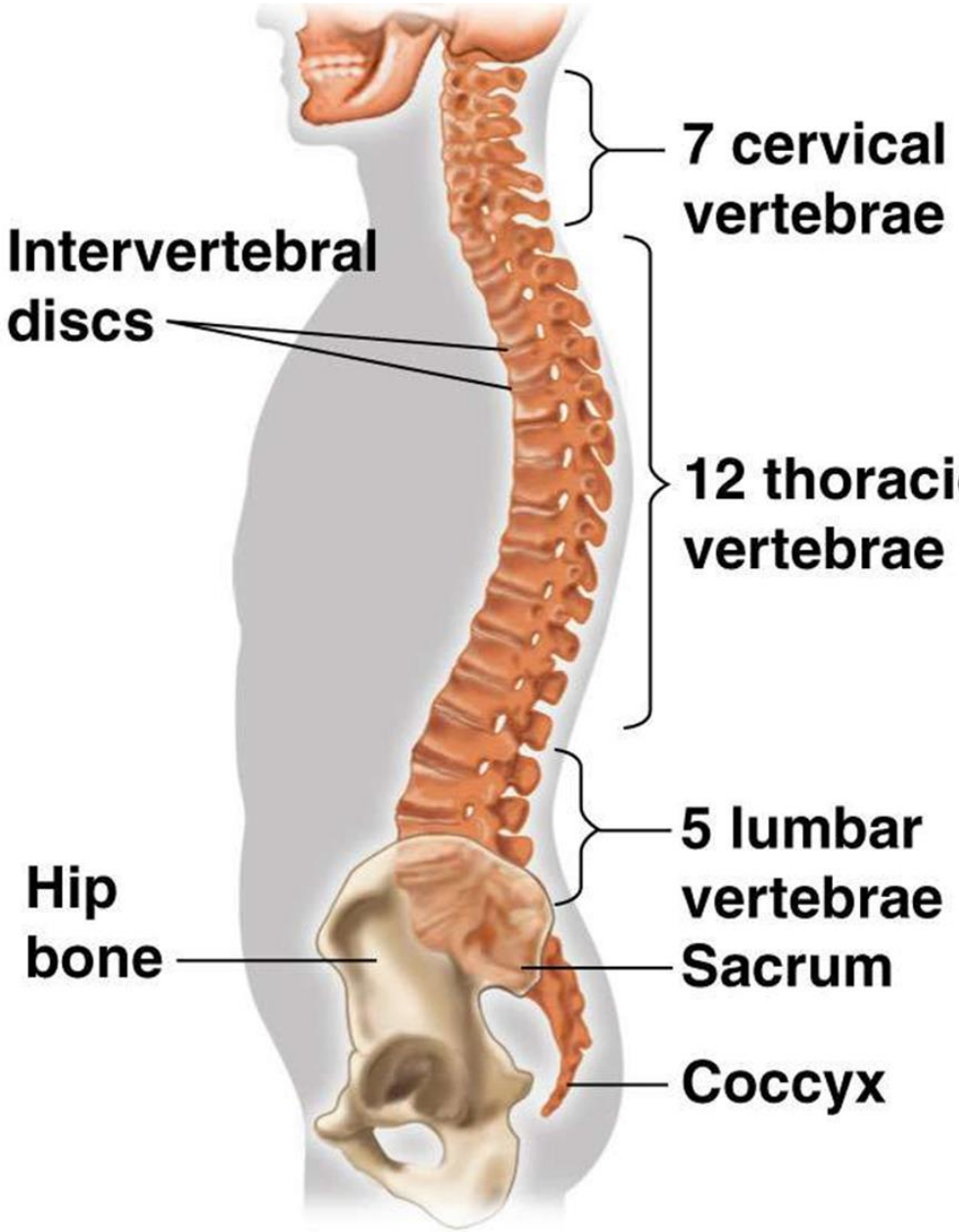
- Epiphyseal plate
  - Flat plate of hyaline cartilage seen in young, growing bone
- Epiphyseal line
  - Remnant of the epiphyseal plate
  - Seen in adult bones



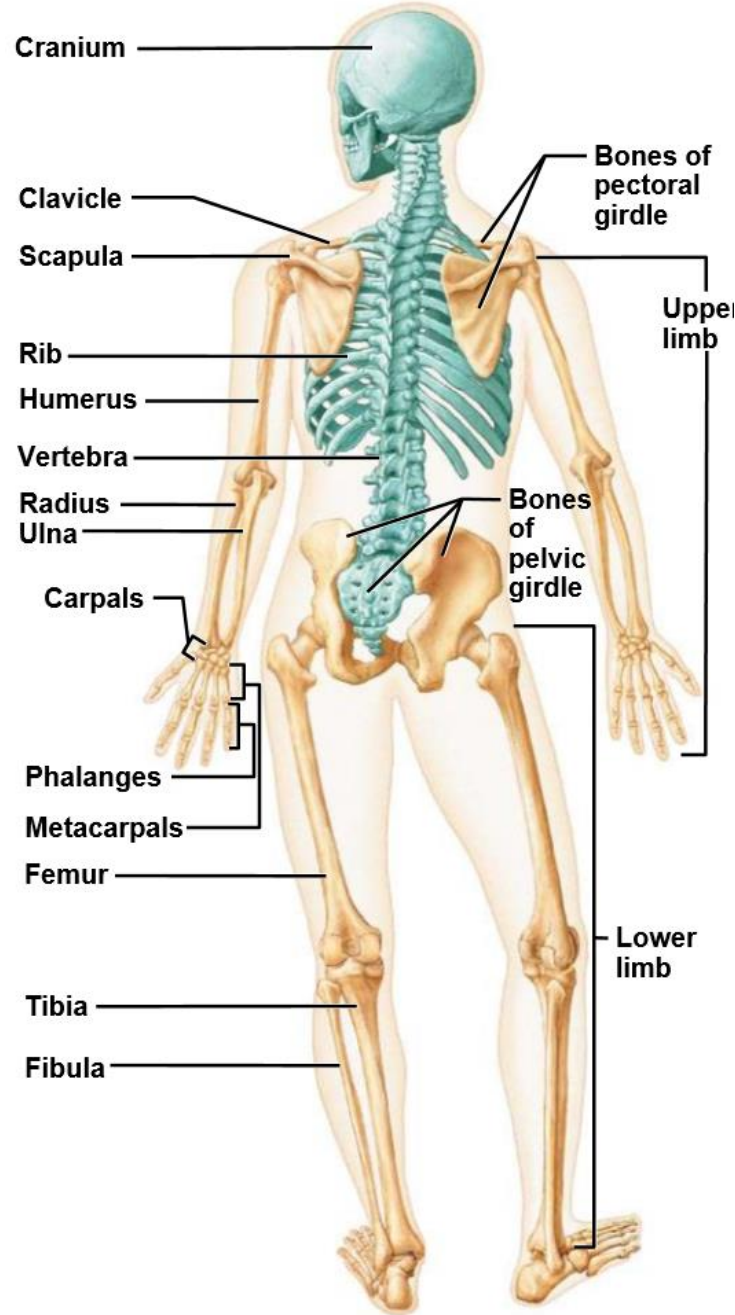
30.3 EVOLUTION CONNECTION: Vertebrate skeletons are variations on an ancient theme

- The human skeleton consists of an
  - **axial skeleton**
    - that supports the axis or trunk of the body and
    - consists of the skull, vertebrae, and ribs and
  - **appendicular skeleton**
    - that includes the appendages and the bones that anchor the appendage and
    - consists of the arms, legs, shoulders, and pelvic girdles.





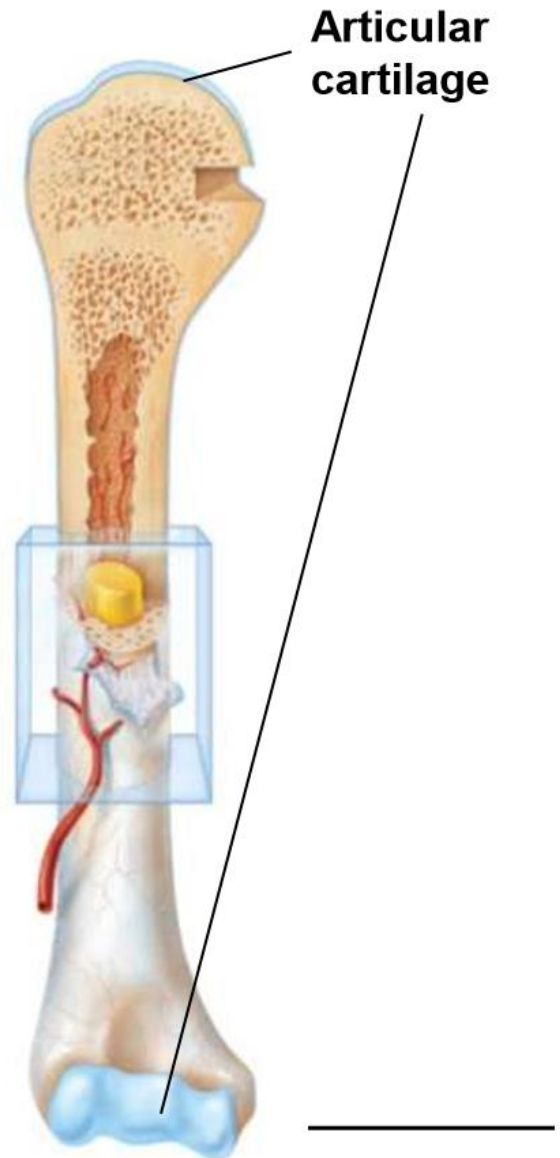
Education, Inc.



(b) Posterior view

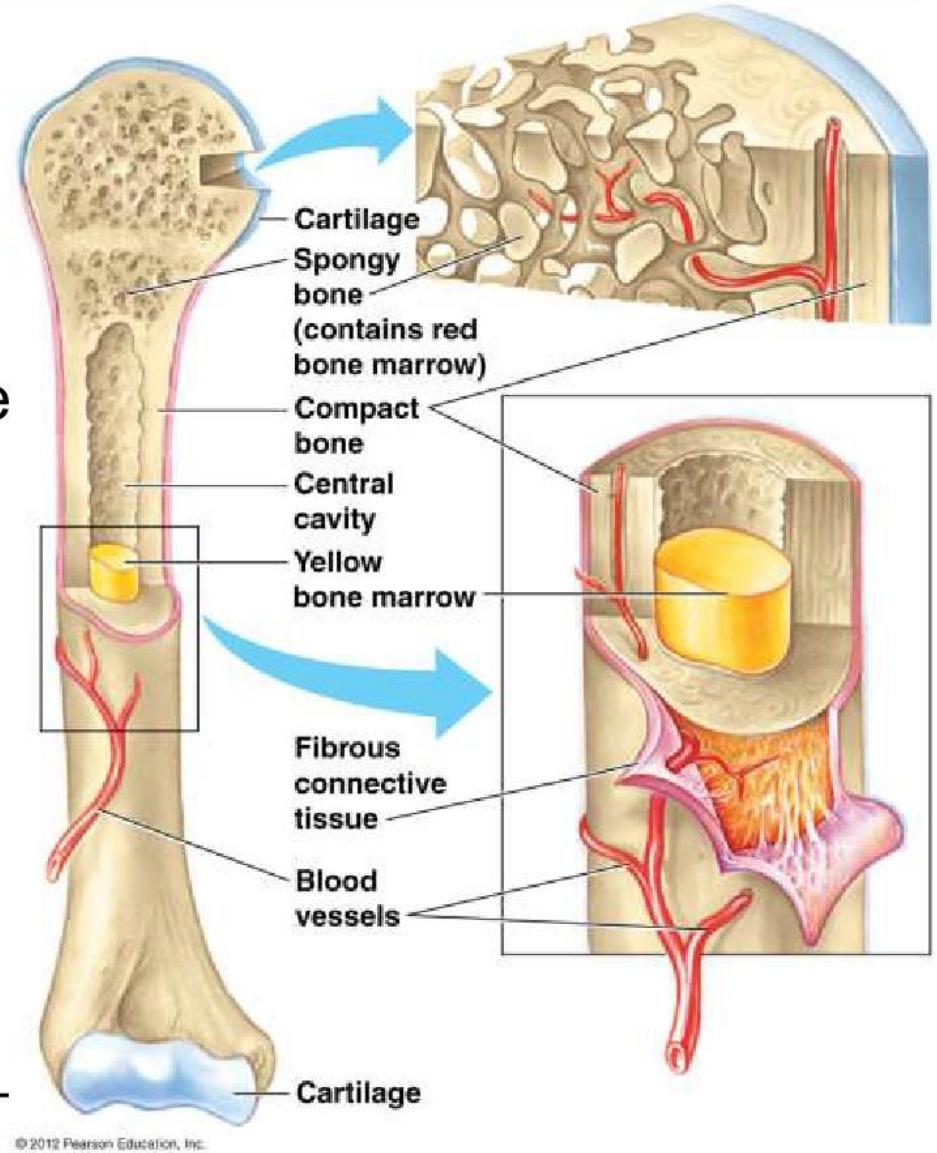
30.4 Bones are complex living organs

- Cartilage at the ends of bones
  - cushions joints and
  - reduces friction of movements.



30.4 Bones are complex living organs

- Long bones have
  - a central cavity storing fatty **yellow bone marrow**
  - spongy bone located at the ends of bones containing **red bone marrow**, that produces blood cells.

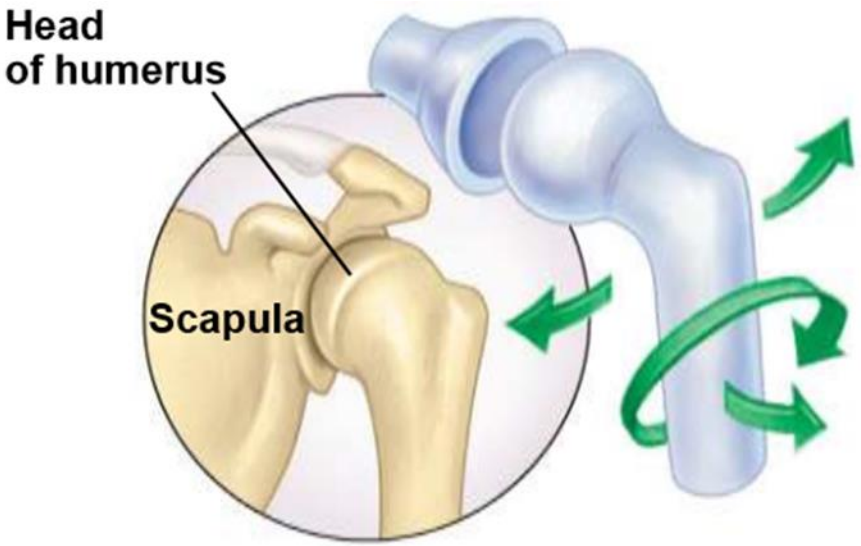


30.5 CONNECTION: Healthy bones resist stress and heal from injuries

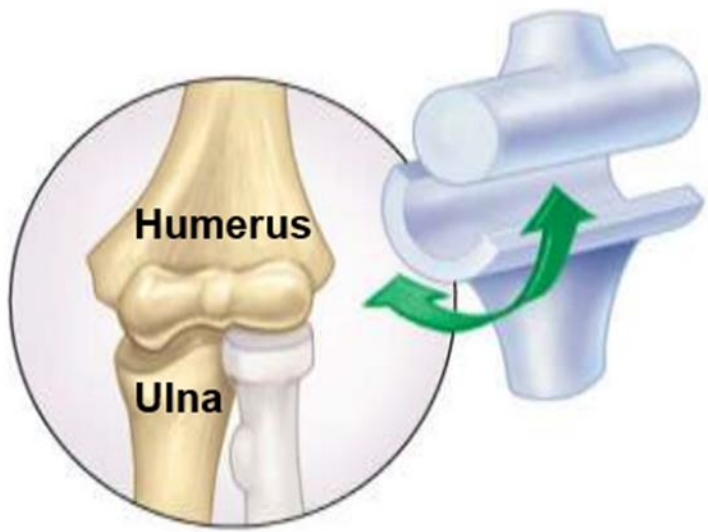
- **Osteoporosis** is
  - a bone disease,
  - characterized by low bone mass and structural deterioration, and
  - less likely if a person
    - has high levels of calcium in the diet,
    - exercises regularly, and
    - does not smoke.

30.6 Joints permit different types of movement

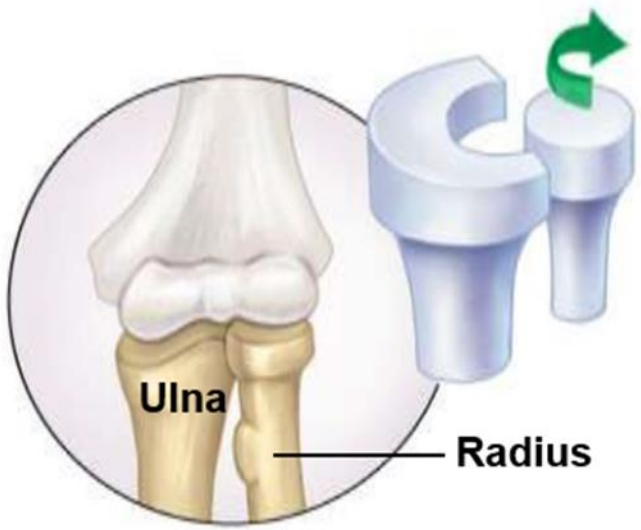
- Joints allow limited movement of bones.
- Different joints permit various movements.
  - **Ball-and-socket joints** enable rotation in the arms and legs.
  - **Hinge joints** in the elbows and knees permit movement in a single plane.
  - **Pivot joints** enable the rotation of the forearm at the elbow.



Ball-and-socket joint



Hinge joint

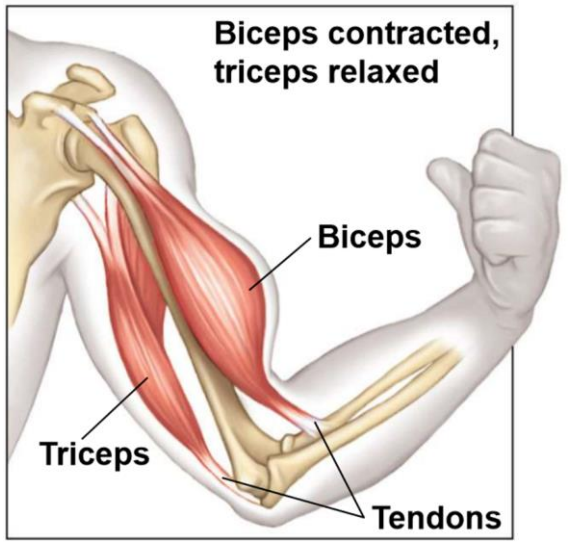


Pivot joint

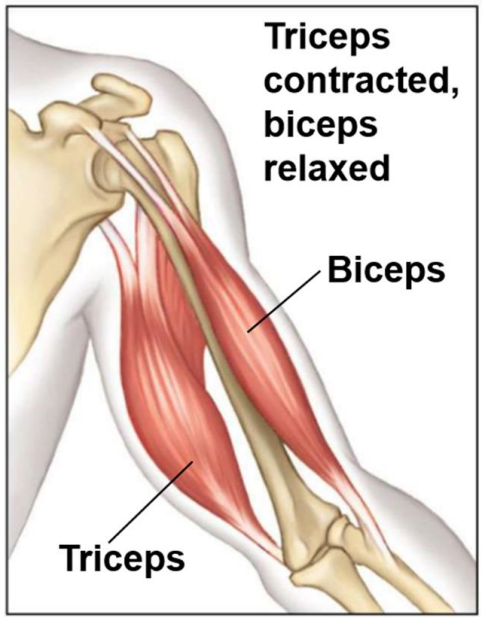
30.7 The skeleton and muscles interact in movement

- Muscles and bones interact to produce movement.
- Muscles
  - are connected to bones by **tendons**
  - can only contract, requiring an antagonistic muscle to reverse the action
    - Example: Flexion of forearm – biceps brachii, extension of forearm – triceps brachii

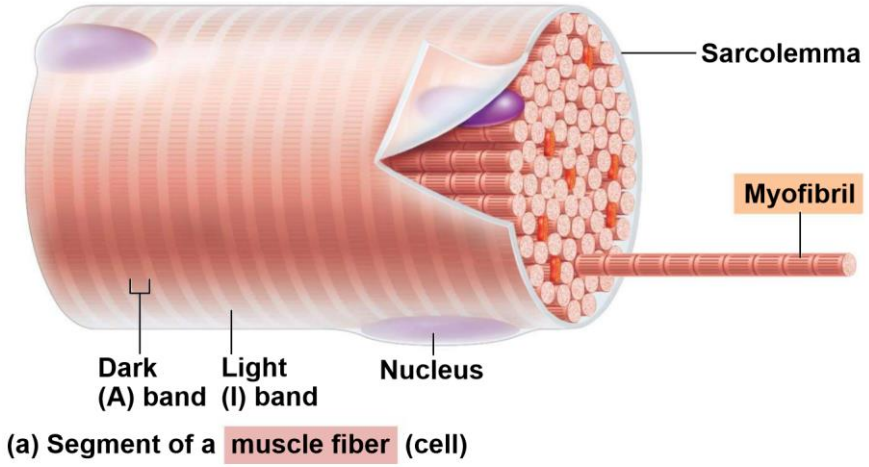
Flexion

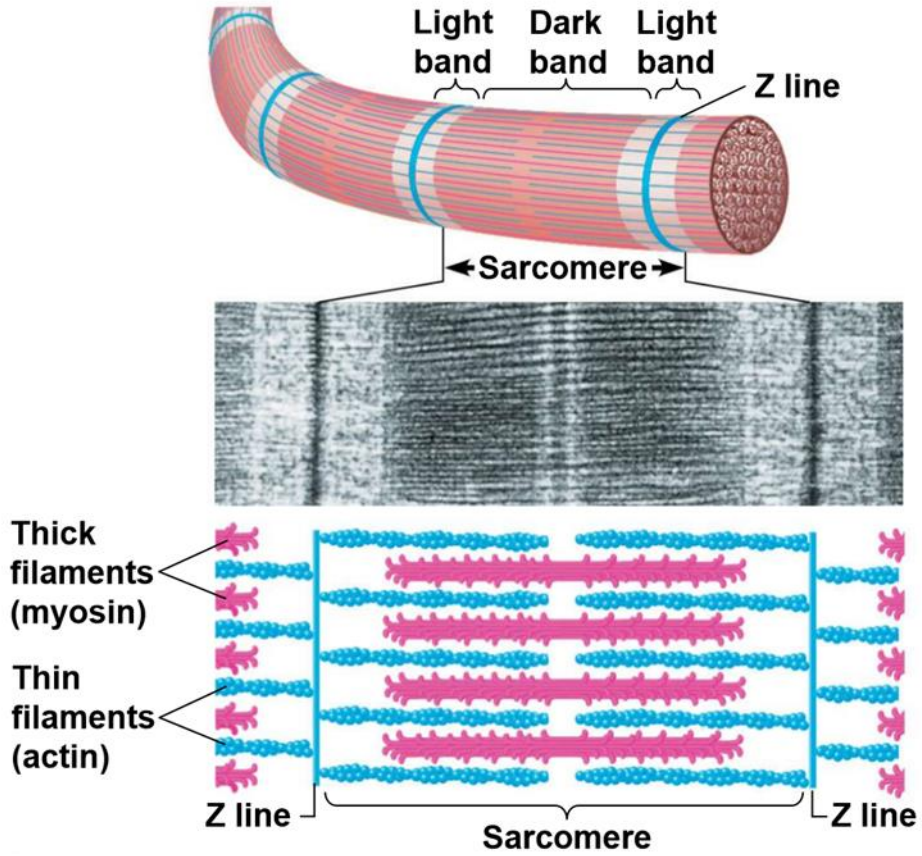


Extension



30.8 Each muscle cell has its own contractile apparatus

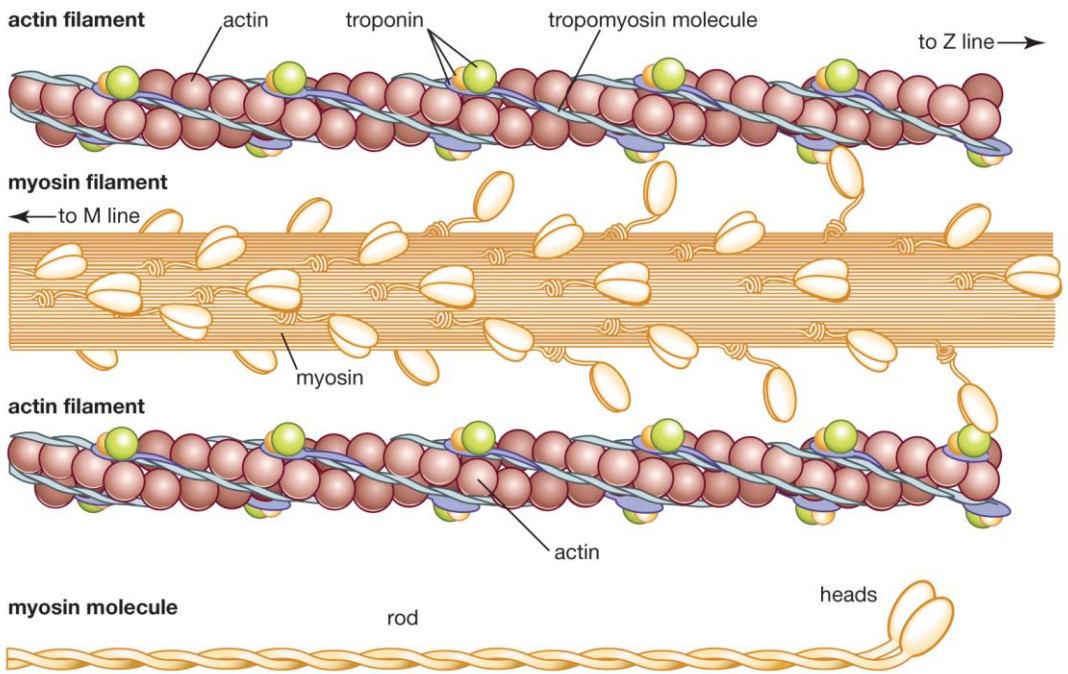


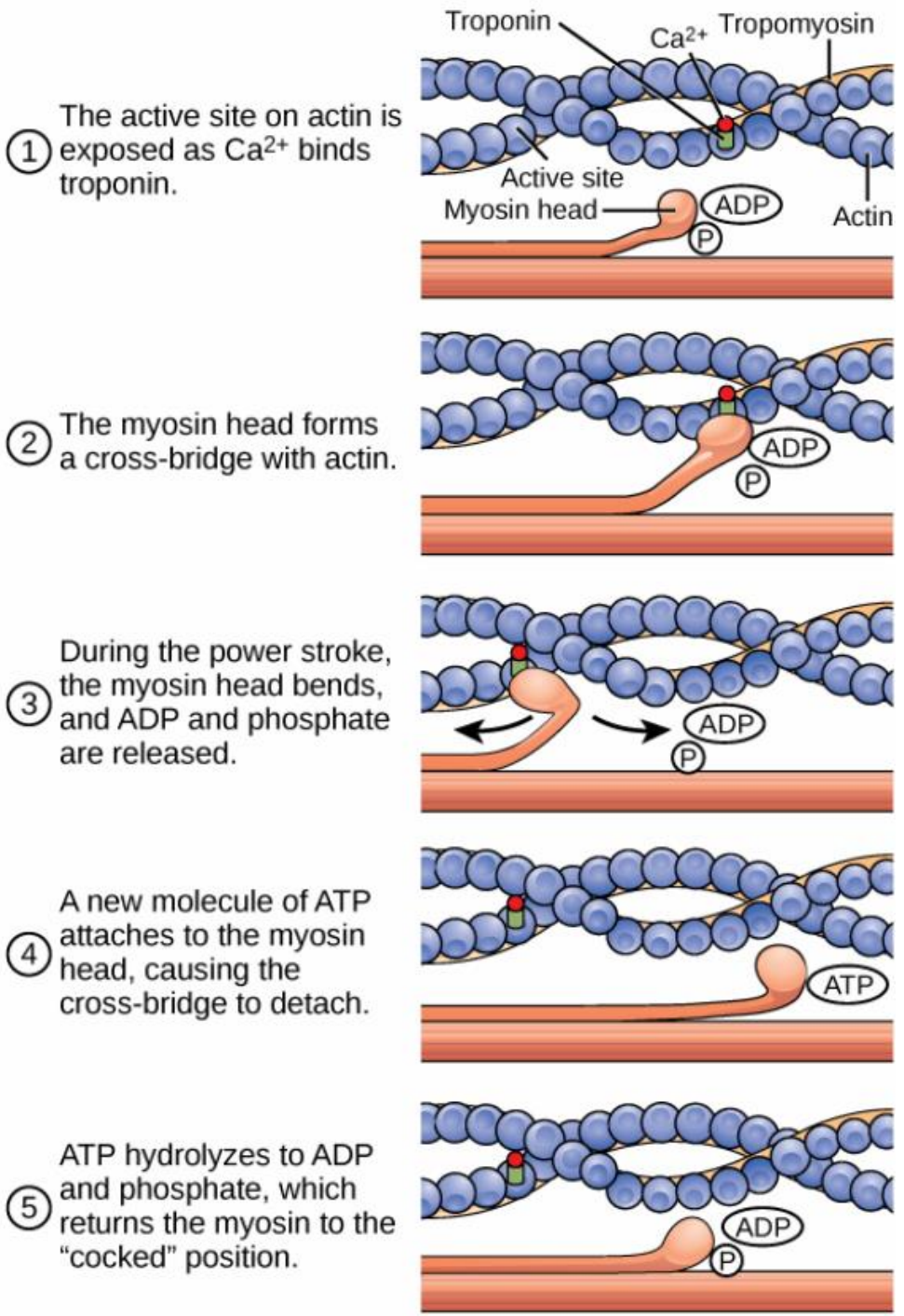


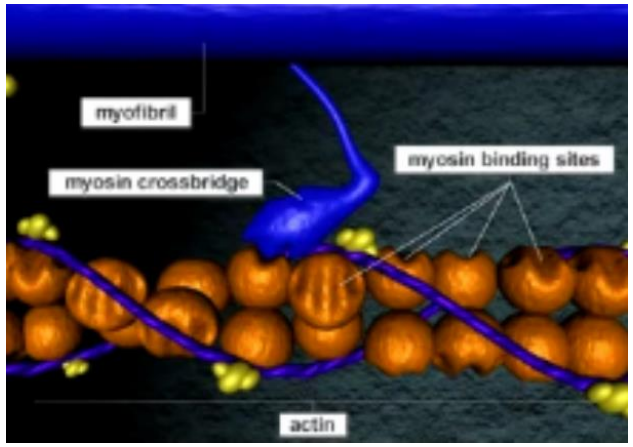
- **Muscle fibers** (skeletal muscle cells) are cells that consist of bundles of myofibrils
  - are cylindrical,
  - have many nuclei, and
  - are oriented parallel to each other.
- **Myofibrils** contain sacromeres
  - **thick filaments** composed primarily of the protein **myosin**
  - **thin filaments** composed primarily of the protein **actin**.
- **Sarcomeres** are
  - repeating groups of overlapping thick and thin filaments
  - the contractile unit—the fundamental unit of muscle action.

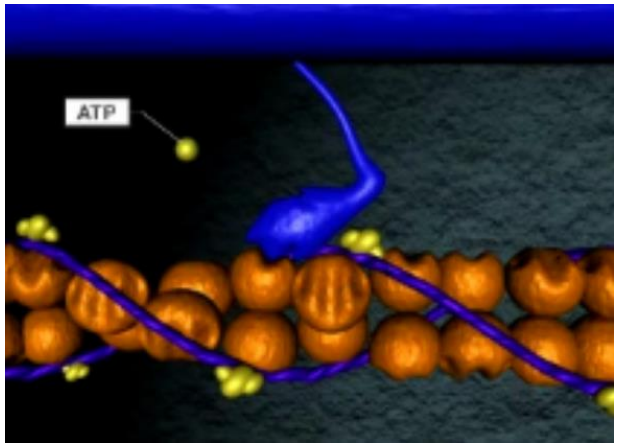
30.9 A muscle contracts when thin filaments slide along thick filaments

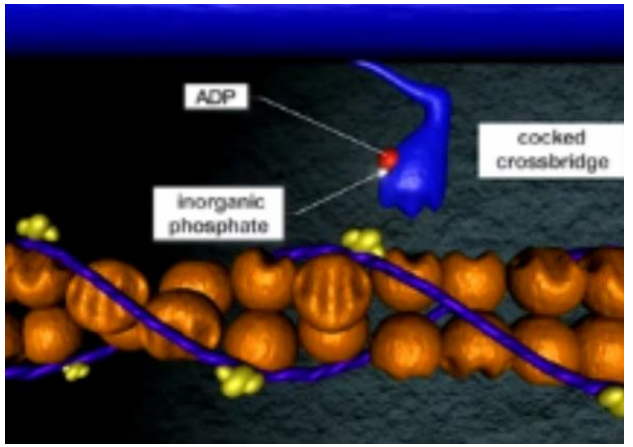
- According to the sliding-filament model of muscle contraction, a sarcomere contracts (shortens) when its thin filaments slide across its thick filaments.
  - Contraction shortens the sarcomere without changing the lengths of the thick and thin filaments.
  - When the muscle is fully contracted, the thin filaments overlap in the middle of the sarcomere.

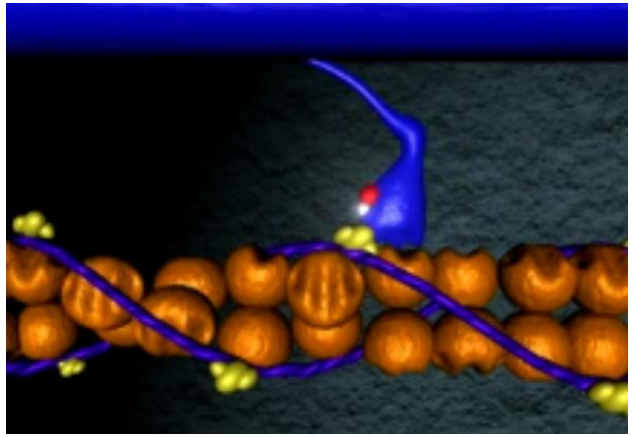


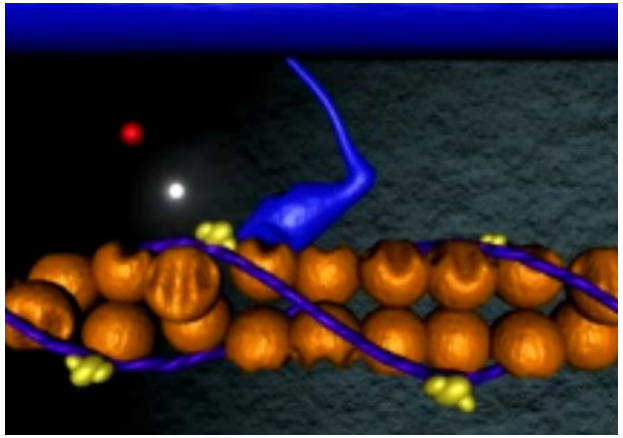


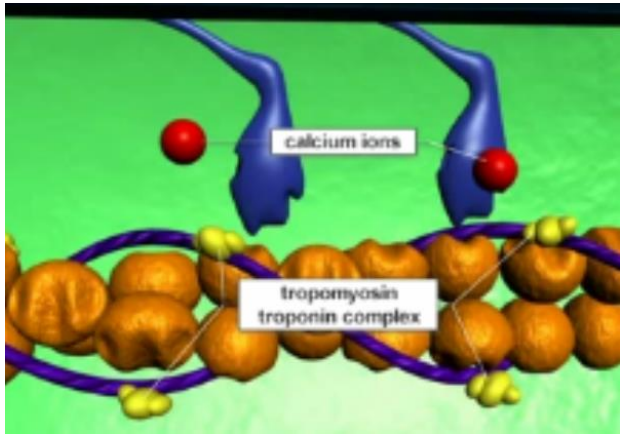

myofibril
myosin crossbridge
myosin binding sites
actin

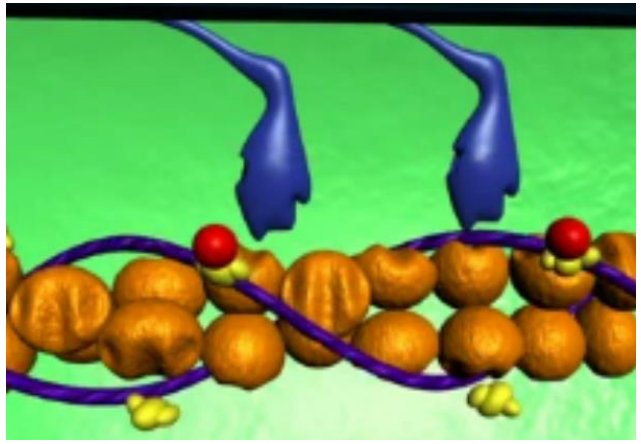

ATP

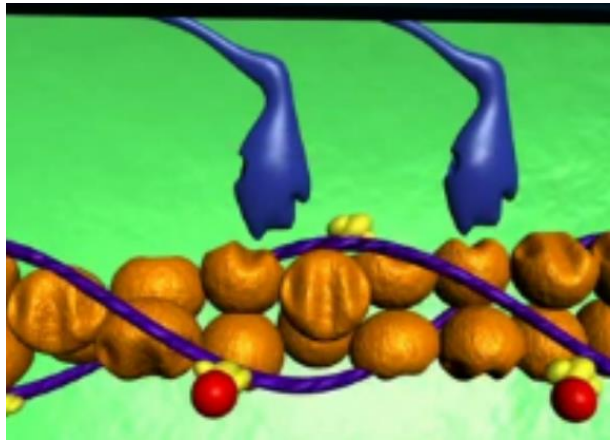

ADP
cocked crossbridge
inorganic phosphate

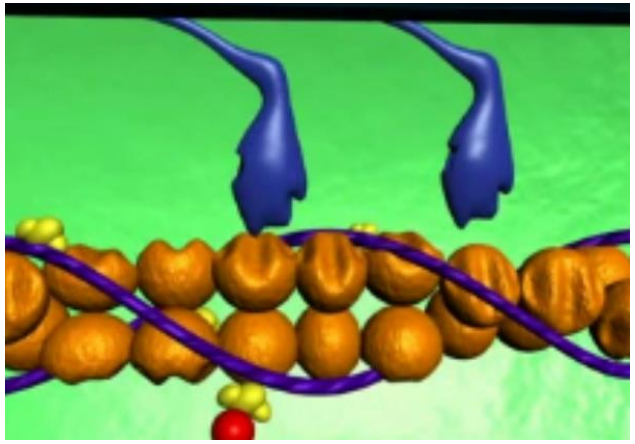




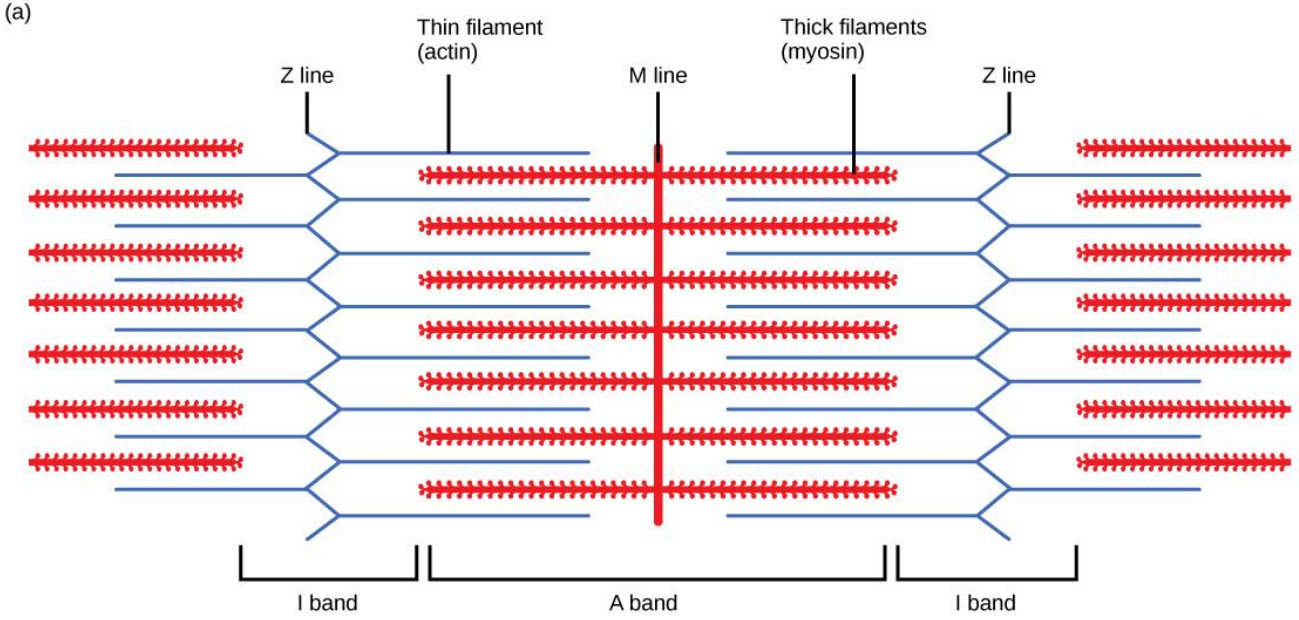

calcium ions
tropomyosin
troponin complex



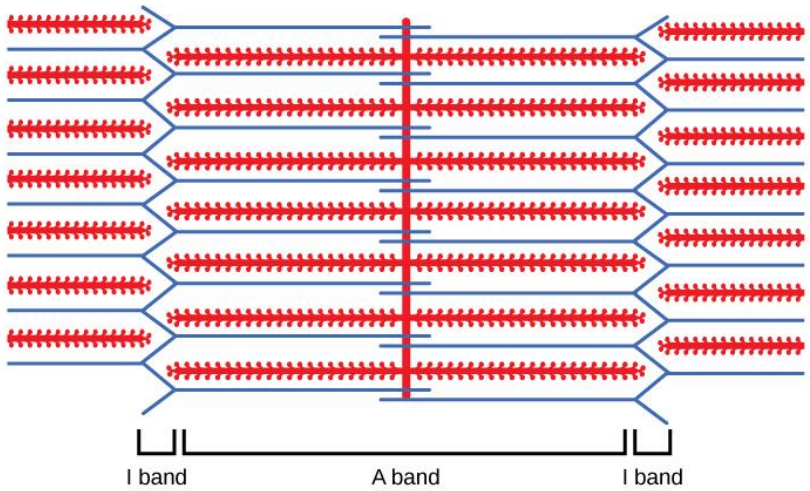


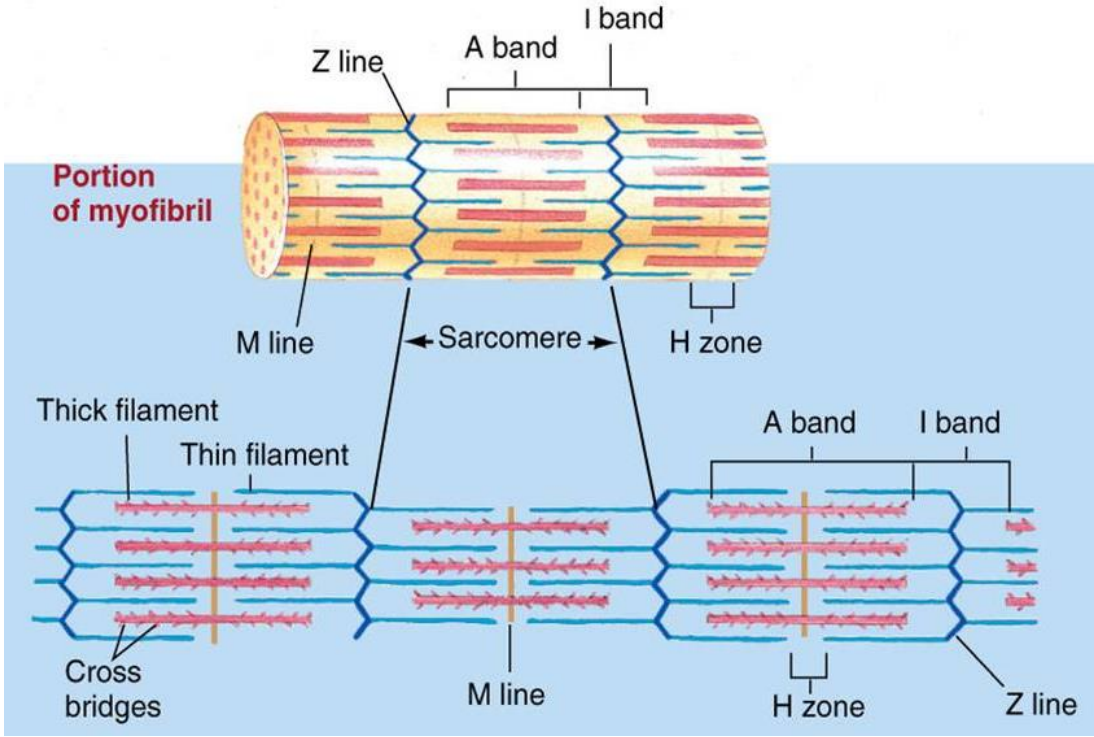


(a)


Thin filament
(actin)
Thick filaments
(myosin)
Z line
M line
Z line
I band
A band
I band

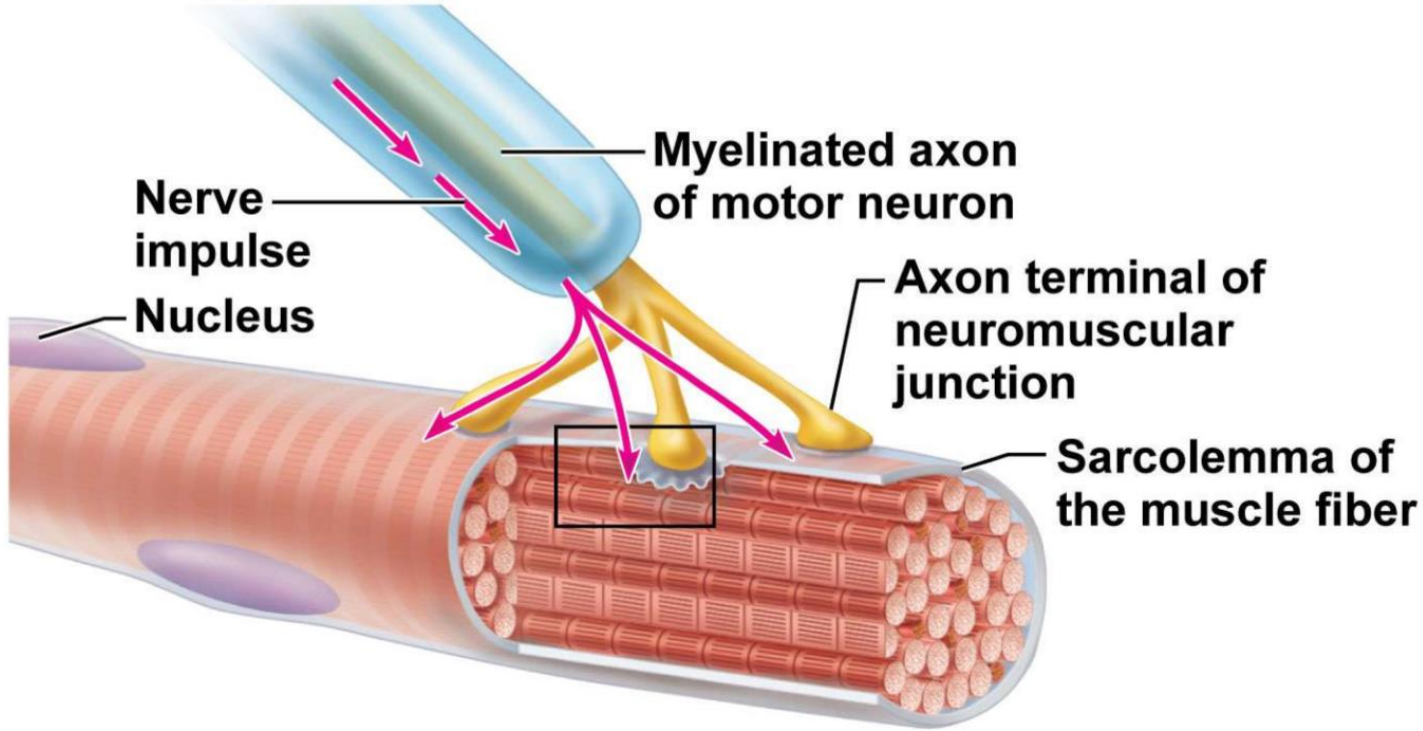
(b)


I band
A band
I band


I band
Z line
A band
Portion
of myofibril
M line
Sarcomere
H zone
Thick filament
Thin filament
A band
I band
Cross
bridges
M line
H zone
Z line

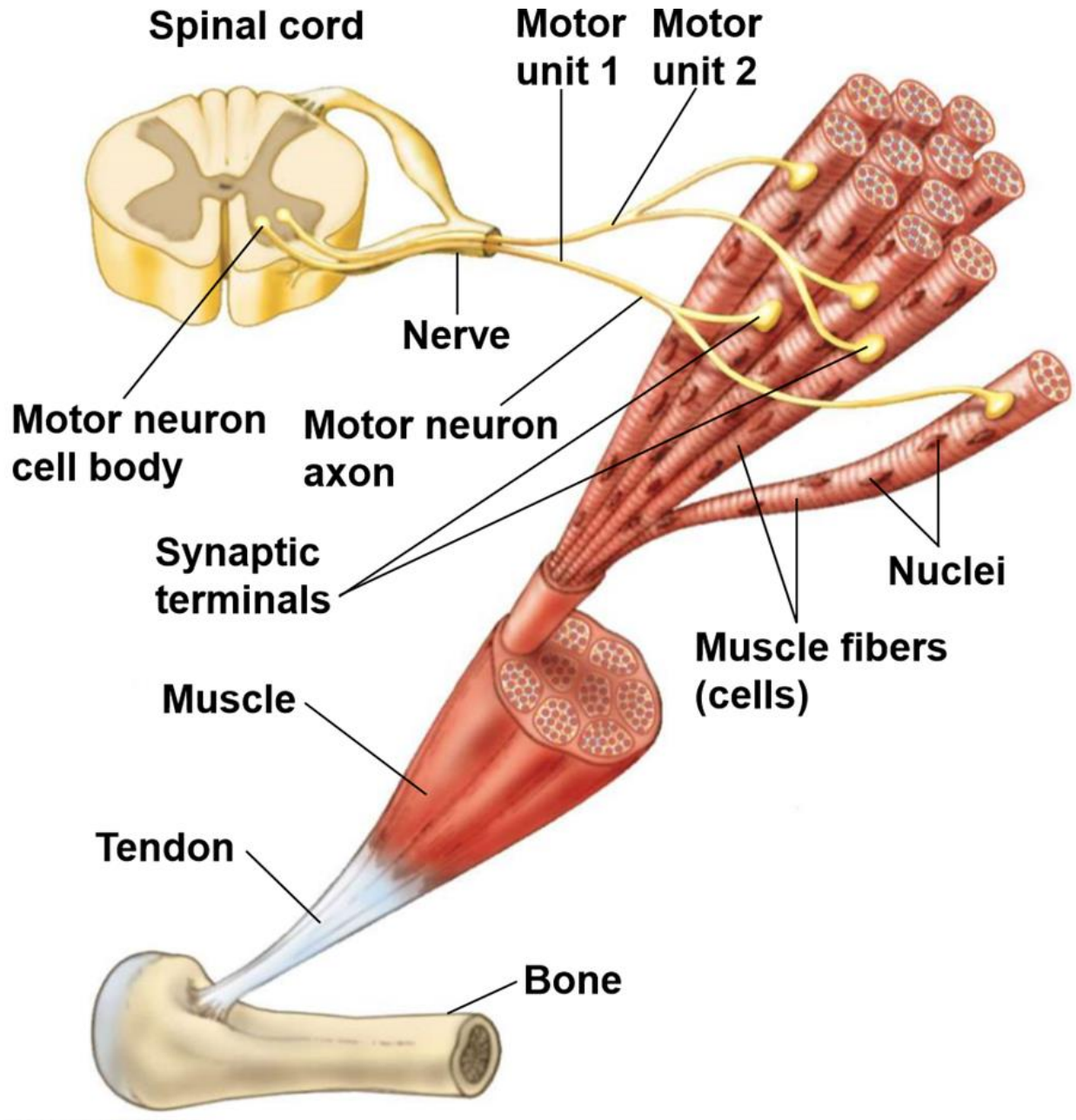
30.10 Motor neurons stimulate muscle contraction

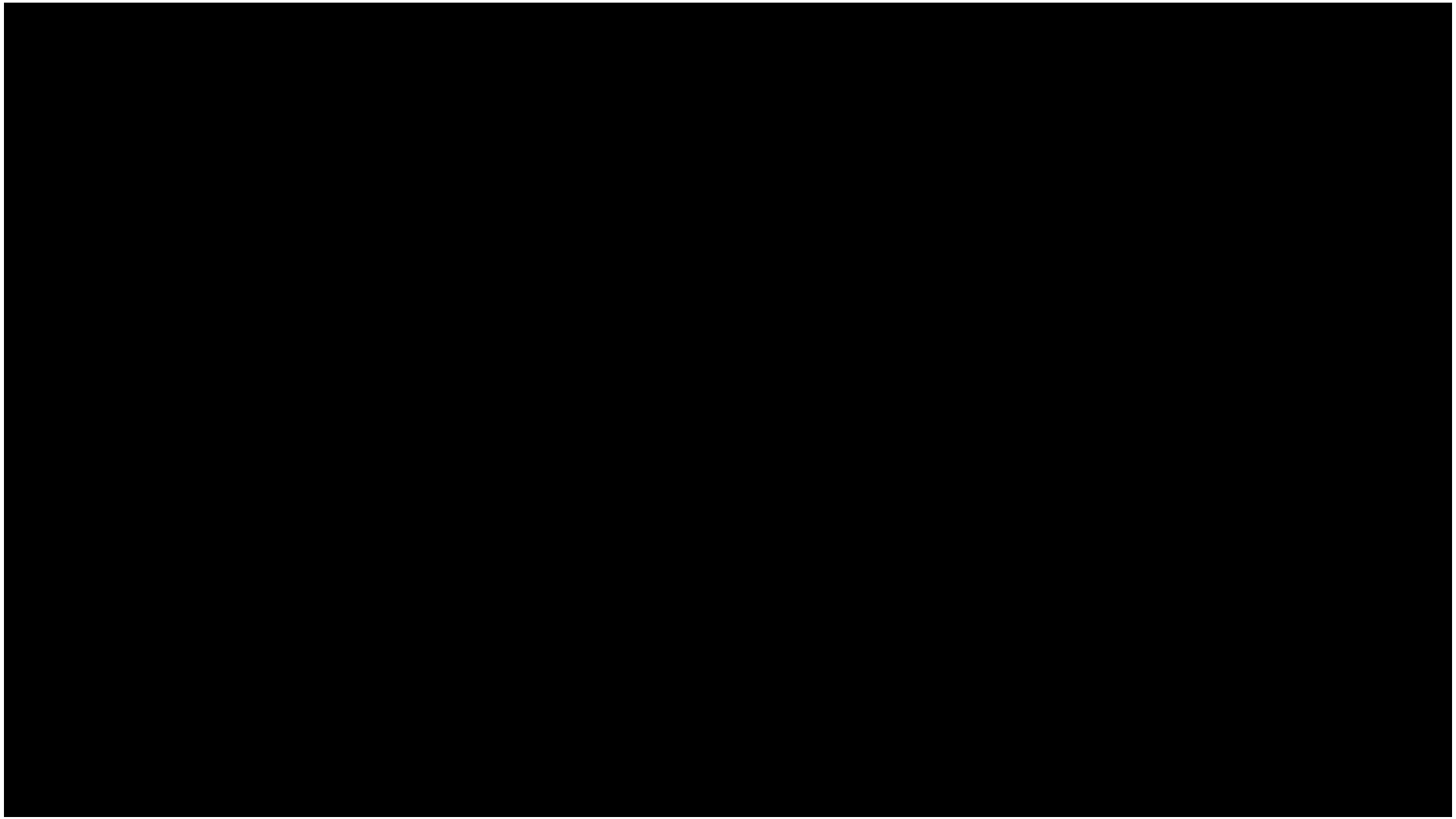
- A motor neuron
  - carries an action potential to a muscle cell,
  - releases the neurotransmitter acetylcholine (Ach) from its synaptic terminal, and
  - initiates a muscle contraction.

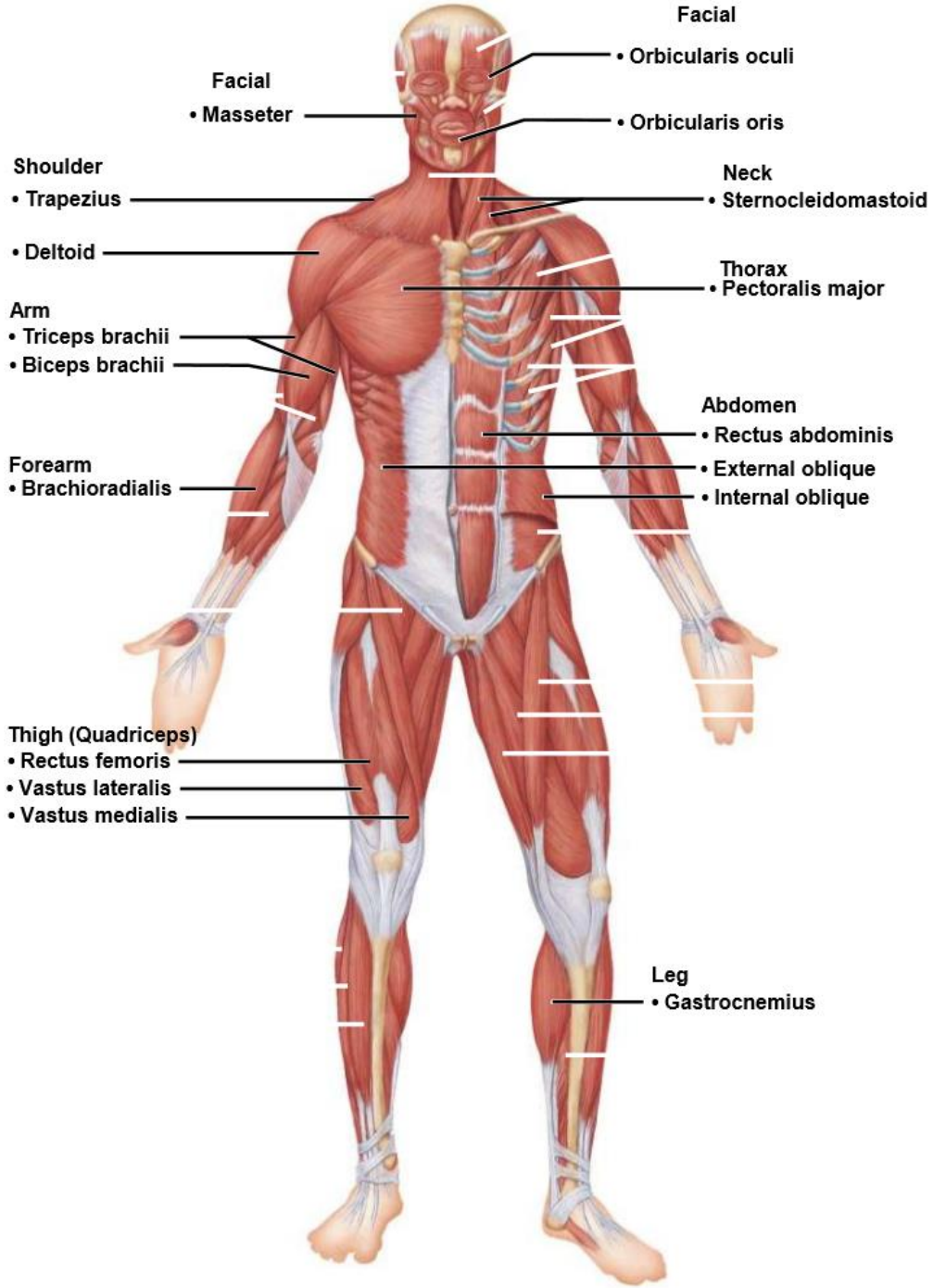


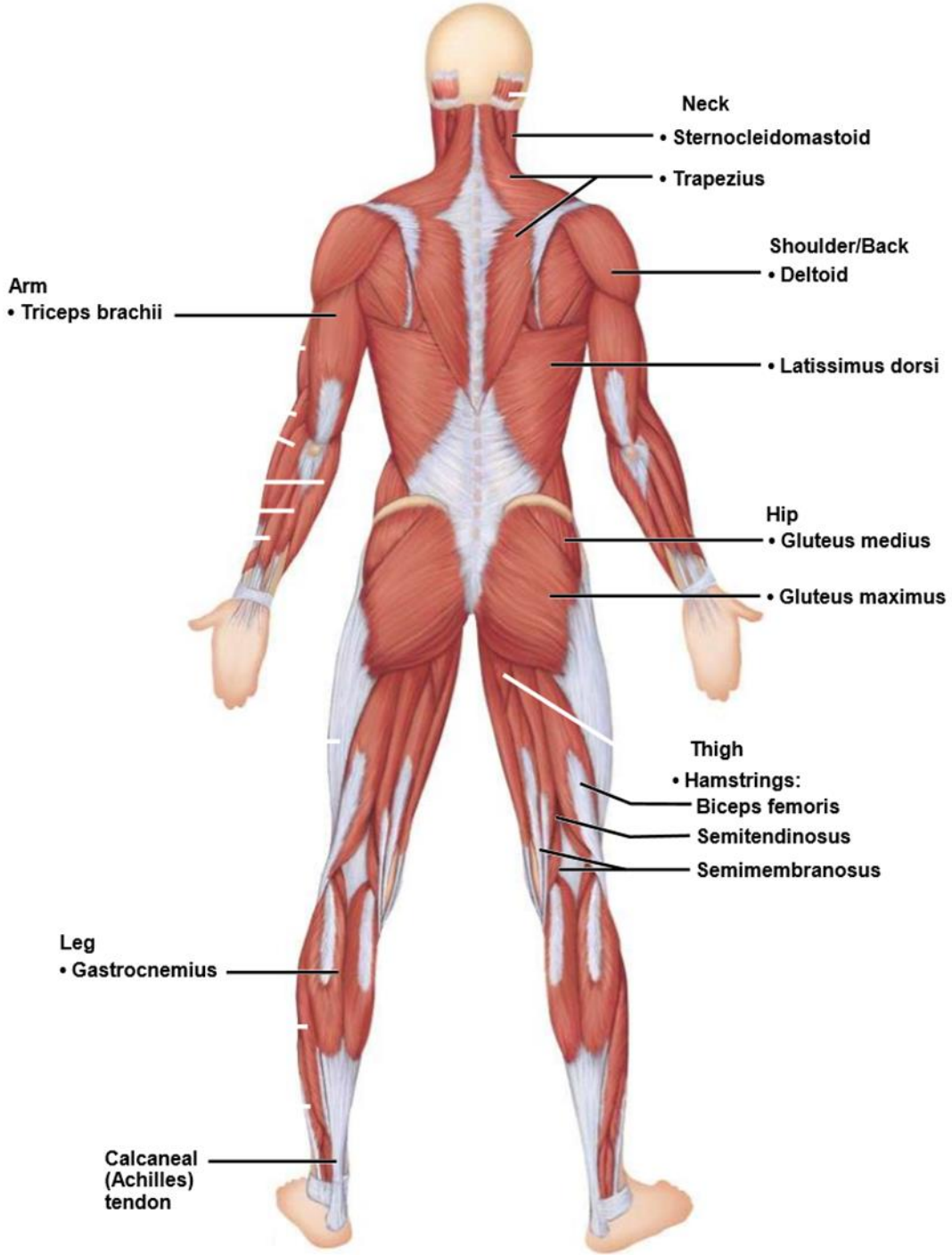
30.10 Motor neurons stimulate muscle contraction

- A **motor unit** consists of
  - a neuron and
  - the set of muscle fibers it controls.
- More forceful muscle contractions result when additional motor units are activated.






Facial
• Orbicularis oculi
Facial
• Masseter
• Orbicularis oris
Shoulder
• Trapezius
Neck
• Sternocleidomastoid
• Deltoid
Thorax
• Pectoralis major
Arm
• Triceps brachii
• Biceps brachii
Abdomen
• Rectus abdominis
Forearm
• Brachioradialis
• External oblique
• Internal oblique
Thigh (Quadriceps)
• Rectus femoris
• Vastus lateralis
• Vastus medialis
Leg
• Gastrocnemius


Neck
• Sternocleidomastoid
• Trapezius
Shoulder/Back
• Deltoid
Arm
• Triceps brachii
• Latissimus dorsi
Hip
• Gluteus medius
• Gluteus maximus
Thigh
• Hamstrings:
Biceps femoris
Semitendinosus
Semimembranosus
Leg
• Gastrocnemius
Calcaneal
(Achilles)
tendon