Muscular System
The Muscular System

- Muscles are responsible for body movement
- Three types are found in the body
  - Skeletal muscle**
  - Cardiac muscle
  - Smooth muscle
Types of Muscle

(b) Skeletal muscle
Skeletal

(c) Cardiac muscle
Cardiac

Intercalated disks

(a) Smooth muscle
Smooth

Three types of muscle
Functions of Skeletal Muscles

- Make up “flesh” of the body
- Maintain Posture
- Voluntary movement
- Aid in breathing, eating, speech
- Provide facial expression
- Generate reflexes
- Produce body heat
Characteristics of Skeletal Muscles

- Muscle cells are elongated *(muscle cell = muscle fiber)*
- Muscles are specialized to contract
- Terminology:
  - Prefix *myo, mys* refer to muscle
  - Prefix *sarco* refers to flesh
Characteristics of Skeletal Muscles

- Most are attached by tendons to bones
- Cells are \textit{multinucleate}
- \textit{Striated} – have visible banding
- \textit{Voluntary} – subject to conscious control
- Muscles and their fibers are wrapped by connective tissue
Connective Tissue Wrappings of Skeletal Muscle

- **Endomysium** – around single muscle fiber
- **Perimysium** – around a fascicle (bundle) of fibers

![Diagram of muscle tissue with labels for endomysium, perimysium, blood vessel, muscle fiber, fascicle, and tendon.](Slide 6.4a)
Connective Tissue Wrappings of Skeletal Muscle

- **Epimysium** – covers the entire skeletal muscle
- **Fascia** – on the outside of the epimysium
Skeletal Muscle Attachments

- Epimysium blends into a connective tissue attachment
  - *Tendon* – cord-like structure
  - *Aponeurosis* – sheet-like structure
Skeletal Muscle Attachments

- Sites of muscle attachment
  - Bones
  - Cartilages
  - C. T. coverings
    - i.e., aponeuroses
Microscopic Anatomy of Skeletal Muscle

- Cells are multinucleate
- Nuclei are deep to the sarcolemma
Microscopic Anatomy

- **Sarcolemma** – specialized plasma membrane
- **Sarcoplasmic reticulum** – specialized smooth E.R.
  - Stores Ca^{++}
  - Required for contraction
Microscopic Anatomy

- **Myofibril**: organelle unique to muscle
  - Bundles of *myofilaments*
  - Myofibrils alignment produces distinct bands
    - I band = light band
    - A band = dark band

(b) **Myofibril**
(complex organelle composed of bundles of myofilaments)
Microscopic Anatomy

- Banding Pattern depends on arrangement of proteins in myofibrils
  - Actin: thin
    - A and I bands
  - Myosin: thick
    - A bands

Figure 6.3b
Sarcomere

- Contractile subunit of a muscle fiber
- From “Z to Z”
  - One A band +
  - Two “half” I bands

(b) Myofibril
(complex organelle composed of bundles of myofilaments)
Microscopic Anatomy

- Organization of the sarcomere
  - Thick filaments = *myosin filaments*
  - Composed of the protein myosin
  - Has ATP-ase enzymes

Figure 6.3c
Microscopic Anatomy

- Organization of the sarcomere, con’t…

- Thin filaments = *actin filaments*

- Composed of the protein actin

Figure 6.3c
Microscopic Anatomy

- Myosin filaments have heads (extensions, or cross bridges)
- Myosin and actin overlap

Figure 6.3d

(d) Myofilament structure (within one sarcomere)
At rest, there is a bare [“H”] zone that lacks actin filaments.
Properties of Skeletal Muscle

- **Irritability** – ability to receive and respond to a stimulus
- **Contractility** – ability to shorten when an adequate stimulus is received
Nerve Stimulus to Muscles

- Skeletal muscles require innervation

- **Motor unit**
  - One motor neuron +
  - Muscle cells innervated by that neuron
Nerve Stimulus to Muscles

- **Neuromuscular junction:**
  - communication site between a motor neuron and a muscle fiber
Nerve Stimulus to Muscles

- **Synaptic cleft**: gap between nerve and muscle

- Nerve and muscle do not make direct contact

*Figure 6.5b*
Transmission of Nerve Impulse to Muscle

- **Neurotransmitter** – chemical released by motor nerve
  - initiates contraction
    - Causes sarcolemma to depolarize
  - For skeletal muscle: *acetylcholine* (Ach)
Transmission of Nerve Impulse to Muscle

- Action of Neurotransmitter
  - Crosses synaptic cleft
  - Attaches to receptors on the sarcolemma

Fig. 7.6
Muscle Contraction

- An electrochemical event
  - Ach is the chemical
- Before contraction can occur, sarcolemma must be **polarized**
  - A polarized membrane is more “+” outside and more “-” inside
- Movement of ions creates “*action potential*”
  - The ability to do work
Muscle Contraction

- Ach attaches to receptor sites
- Sarcolemma becomes permeable to sodium ($Na^+$)
- Sodium rushes into the cell
- Initiates “sliding filament” process
Muscle Contraction

• Membrane of sarcoplasmic reticulum also depolarizes
  • Ca^{++} ions are released
  • Bind to sites on actin
  • Open attachment sites for myosin
The Sliding Filament Theory of Muscle Contraction

- Depolarization allows myosin heads to attach to binding sites on actin
  - called crossbridges
  - ATP required
The Sliding Filament Theory of Muscle Contraction

- Actin is pulled past myosin by movement of heads
  - ATP required
- Myosin heads detach
  - ATP required
- Then bind to the next site on actin
  - ATP required
The Sliding Filament Theory of Muscle Contraction

- This continued action causes a sliding of the actin along the myosin
  - I band narrows
  - H zone narrows
  - A band stays the same
The Sliding Filament Theory of Muscle Contraction

- Actin slides past myosin
- Results in shortening of the sarcomere
  - Muscle fiber has thousands of sarcomeres
  - All shorten at one time
- Muscle contracts