**Essentials of Anatomy and Physiology** 

#### **MUSCULAR SYSTEM**



Slide 2.1

## 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**



#### 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 *multinucleate*
- Striated have visible banding
- Voluntary subject to conscious control
- Muscles and their fibers are wrapped by connective tissue

# Connective Tissue Wrappings of Skeletal Muscle



Slide 6.4a

Muscle

# Connective Tissue Wrappings of Skeletal Muscle

- Epimysium —– covers the entire skeletal muscle
- Fascia on the outside of the epimysium



Slide 6.4b

#### **Skeletal Muscle Attachments**

- Epimysium blends into a connective tissue attachment
  - Tendon cord-like structure
  - Aponeurosis sheet-like structure



Slide 6.5

#### **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



Figure 6.3a

- Sarcolemma specialized plasma membrane
- Sarcoplasmic reticulum specialized smooth E.R.
  - Stores Ca++
  - Required for contraction



- 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)



 Banding Pattern depends on arrangement of proteins in myofibrils

Fig. 7.36

- Actin: thin
  - A and I bands
- Myosin: thick
  - A bands





#### 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)

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



Figure 6.3c

Organization of the sarcomere, con't...

Thin filaments = actin filaments

Composed of the protein actin



Figure 6.3c

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



(d) Myofilament structure (within one sarcomere)

 At rest, there is a bare ["H"] zone that lacks actin filaments



(d) Myofilament structure (within one sarcomere)

#### **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

Fig. 7.6

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



#### **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<sup>+</sup>)
- 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

- Depolarization allows myosin heads to attach to binding sites on actin
  - called crossbridges
  - ATP required



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Slide 6.17a

- 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



- This continued action causes a sliding of the actin along the myosin
  - I band narrows
  - H zone narrows
  - A band stays the same



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

