Become familiar with muscle anatomy
Types of contraction
Motor units and muscle action
Twitch, tetanus, latency
Muscle

- **Most Basic Function**
  - Produces force

- **3 types of muscle tissue**
  - Smooth – lines organs (involuntary muscle)
  - Cardiac – forms heart (involuntary muscle)
  - **Skeletal – rest of body** *(voluntary muscle)*
    
    → Additional function of skeletal muscle: generate voluntary movement (ex. locomotion, facial expression)
Skeletal muscle
Muscle contraction

Ex. Biceps Brachi Muscle
Types of contraction

- Concentric

- Eccentric
Types of contraction

- Isometric
- Isokinetic
- Isotonic
muscle hierarchical structure
Morphology

**FIGURE 1-6.** Structural hierarchy of skeletal muscle. Whole skeletal muscles are composed of numerous fascicles of muscle fibers. Muscle fibers are composed of myofibrils arranged in parallel. Myofibrils are composed of sarcomeres arranged in series. Sarcomeres are composed of interdigitating actin and myosin filaments.
FIGURE 1-4. Schematic representation of the muscle cell. The muscle cell, which is specialized for the production of force and movement, contains an array of filamentous proteins as well as other subcellular organelles such as mitochondria, nuclei, satellite cells, sarcoplasmic reticulum, and transverse tubular system. Note the formation of “triads,” which represent the T-tubules flanked by the terminal cisternae of the sarcoplasmic reticulum. Also note that when the myofilaments are sectioned longitudinally, the stereotypic striated appearance is seen. When myofilaments are sectioned transversely at the level of the A- or I-bands, the hexagonal array of the appropriate filaments is seen.
Neuromuscular Junction (SEM):
* Cell is depolarized by nerve at synapse
* $\text{Ca}^{+2}$ released from SER, called sarcoplasmic reticulum
Neuromuscular Junction (SEM)

* NERVE REMOVED: note footprint of nerve and folds
Motor unit =
Single motor neuron + Associated muscle fibers

spinal cord

motor unit 1
motor unit 2
motor unit 3
A single motor unit has one axon that innervates multiple muscle fibers (10-600 fibers depending on which muscle)
Twitch & tetanus

- Twitch – muscle response to a single stimulus
- Summation effect
- Tetanus – threshold for tension plateau

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**Fig. 1.3.** Two-twitch experiments. (a) When two identical electrical stimuli, $S_1$ and $S_2$, are given with a suitable time interval separating them, the two transient force events (twitches) are identical. (b and c) When the stimuli are moved closer together, the second twitch reaches a higher force maximum than the first.

**Fig. 1.4.** Twitch and tetanus. When a series of stimuli is given, muscle force rises to an uneven plateau (unfused tetanus) which has a ripple at the frequency of stimulation. As the frequency is increased, the plateau rises and becomes smoother, reaching a limit as the tetanus becomes fused.
Latency

- Force generation (after activation): ? ms
- Force decay (after deactivation): ? ms
Figure 9.4 Microscopic anatomy of a skeletal muscle fiber. (a) Photomicrograph of portions of two isolated muscle fibers (250×). Notice the obvious cross striations (alternating light and dark bands). (b) Diagram of part of a muscle fiber (cell) showing the myofibrils it contains. One myofibril is shown extending from the cut end of the muscle fiber. (c) A small portion of one myofibril is enlarged to show the myofilaments responsible for the banding pattern. Each sarcomere, or contractile unit, extends from one Z line to the next. (d) Enlargement of one sarcomere (sectioned lengthwise). Notice the myosin heads on the thick filaments. (e) The latticelike arrangement of the thick and thin filaments becomes obvious when the myofibril is cross-sectioned. (1) In a cut made through the I band, only thin filaments are seen; (2) in a cut made through the H zone, only thick filaments are seen; (3) in a cut made through the M line, thick filaments and connecting fibers are obvious; (4) if a cut is made through a portion of the A band containing both thin and thick filaments and this region is enlarged, we see (5) the hexagonal arrangement of thin filaments around each thick filament and the triangular arrangement of thick filaments around each thin filament.
Physiological model of crossbridge cycle between myofilaments (actin & myosin)

Where does Calcium (Ca\(^{2+}\)) come from?

Figure 2.7.14 Schematic illustration of the cross-bridge cycle. (a) the muscle is at rest. The attachment site on the thin filament is covered by the tropomyosin-troponin complex. ATP is bound to the myosin cross-bridge. (b) upon activation, calcium concentration increases in the sarcoplasm and calcium (Ca\(^{2+}\)) binds to troponin C, thereby, causing a configurational change which exposes the actin binding site. (c) the cross-bridge attaches to the actin and goes through a configurational change. The splitting of ATP into ADP and P\(_i\) provides the energy which results in contraction, i.e., movement of the thin past the thick filaments. (d) a new ATP attaches to the cross-bridge and the cross-bridge can detach from the thin filament and is ready for a new interaction with (another) attachment site on the thin filament.
A. F. Huxley’s 1957 Crossbridge Model for isotonic shortening

See McMahon Chap 4 reading