Sliding Filament Mechanism

- Increase in Ca$^{2+}$ starts filament sliding
- Decrease in Ca$^{2+}$ turns off sliding process
- Thin filaments on each side of sarcomere are pulled over stationary thick filaments toward center of A band by the movement of myosin cross bridges
- As thin filaments are pulled inward, the Z lines to which they are attached move closer together
- Sarcomere shortens… force is applied to connective tissue…… force is (eventually) applied externally

Sliding Filament Mechanism

- All sarcomeres throughout muscle fiber’s length shorten simultaneously
- Sarcomere shortening is accomplished as thin filaments from opposite sides of each sarcomere are bound to and pulled inward by activity of attached myosin cross bridges.
A diagram illustrating the structure of muscle fibers, highlighting key components such as sarcomeres, Z-lines, M-lines, H-zones, I-bands, and A-bands. The diagram also shows the process of the single cross-bridge cycle, with stages including binding, power stroke, detachment, and reattachment of myosin cross bridges to actin molecules. All cross-bridge strokes are directed toward the center of the thick filament.
Myosin binding site on actin
tropomyosin
actin
binding site for actin
Da hinge
Myosin or myosin tail
thin filament

Animation: Myosin crossbridge
Power Stroke of Myosin Cross Bridges

- Activated cross bridge bends toward center of thick filament, “rowing” in thin filament to which it is attached
- Sarcoplasmic reticulum releases Ca$^{2+}$ into sarcoplasm
- Myosin heads bind to actin
- Myosin heads swivel toward center of sarcomere (power stroke)
- ATP binds to myosin head and detaches it from actin

Power Stroke

- Hydrolysis of ATP transfers energy to myosin head and reorients it
- Contraction continues if:
  - ATP is available
  - Ca$^{2+}$ level in sarcoplasm is high
Fig. 8-8a, p. 201(a) Single cross-bridge cycle

1. Binding: Myosin cross bridge binds to actin molecule.

2. Power stroke: Cross bridge bends, pulling thin myofilament inward.

3. Detachment: Cross bridge detaches at end of power stroke and returns to original conformation.

4. Binding: Cross bridge binds to more distal actin molecule; cycle repeats.

(a) Single cross-bridge cycle

(b) All cross-bridge stroking directed toward center of thick filament
Figure 8-11
A = high energy state at rest
B = low energy state during activity; actin dragged along as myosin changes shape
C = ATP required to return to high energy state
D = myosin ATPase activity splits ATP and rephosphorylate myosin to high energy position

Animation: Excitation-contraction coupling
Animation: Muscle relaxation

Sarcoplasmic Reticulum

- Modified endoplasmic reticulum
  - network of interconnected compartments that surround each myofibril along its length
  - Segments are wrapped around each A band and each I band
  - Ends of segments expand to form saclike regions – lateral sacs (terminal cisternae) that are “Bags of Ca2+” containing regulated Ca2+ channels and Ca2+ active transporters
Transverse Tubules (T Tubules)

- Run perpendicularly from surface of muscle cell membrane into central portions of the muscle fiber
- Since membrane is continuous with surface membrane – action potential on surface membrane also spreads down into T-tubule
- Spread of action potential down a T tubule triggers release of Ca\(^{2+}\) from sarcoplasmic reticulum into cytosol
**Relaxation**

- Depends on reuptake of Ca\(^{2+}\) into sarcoplasmic reticulum (SR)
- Acetylcholinesterase breaks down ACh at neuromuscular junction
  - Muscle fiber action potential stops
  - Excitation Over
  - Ca\(^{2+}\) **actively transported** from sarcoplasm to lateral sacs
    - Relaxation requires energy expenditure (ATP\(\rightarrow\)ADP)