Muscle -review

- Skeletal muscle, organizational hierarchy
- Sliding filament mechanism (Fig 10.7)
- Thick and thin filament structure (Fig 10.6)

Troponin on a tropomyosin (TM) rod

- One subunit binds to tropomyosin
- One subunit binds Calcium
- One subunit interacts with actin and tropomyosin

How proteins regulate cross bridge formation – depends on Calcium ions

Resting/contracting states

- Resting- no cross bridges formed because tropomyosin “in the way”
- Contracting -
  - Ca²⁺ causes conformational change
  - tropomyosin shifts into the actin groove
  - actin’s binding site revealed
  - myosin binds to form bridge
  - Myosin bridge rotates to pull actin toward sarcomere center

Power stroke

- Relaxed state - Ca²⁺ concentration is low
- Contracting state - Ca²⁺ concentration is high
- Cross bridges can form, shorten sarcomere and reform SO LONG AS Ca²⁺ concentration remains high

Now we need to understand:

- Where does energy come from and how is it used?
- Where does the calcium come from and how is it controlled?
- Excitation - contraction coupling
  - How does nerve function translate into muscle function
Cross bridge cycle (Fig 10.8)

- ATP binds cross bridge
- “charged” intermediate
  - Partial hydrolysis of ATP
  - High affinity for actin
- IF calcium is present and actin site revealed:
  - Cross bridge complete between actin and myosin

Cross bridge cycle continued

- Complete hydrolysis of ATP
- Use energy to rotate cross bridge
- Actin-myosin called a “rigor complex”
- Very stable in the ABSENCE of ATP
  - If ATP present
    - It binds to myosin head
    - This breaks the cross bridge
  - Start over

Myosin isoforms

- Myosin in different cell types comes from different genes
- Isoforms (or isoenzymes) have different speeds of cycling through cross bridge cycle
  - Fast myosin (in type IIx and IIa)
  - Slow myosins (in type I fibers)
- How does this affect muscle performance?

Calcium controls contraction.

- Source of Ca\(^{++}\) to roll the tropomyosin away - sarcoplasmic reticulum (SR)
- Control Ca\(^{++}\) release using transverse tubule system, tied to action potentials of motor neuron.
- See Figs 10.3, 10.9

- SR holds Ca\(^{++}\) inside (pump out of sarcoplasm)
- SR wraps around myofibrils like a sleeve
- What is the significance?
- T-tubes, invaginations of sarcolemma
- Protrude deep into cell, encircle myofibrils & associate with SR
- What is the significance?
Excitation - contraction coupling
- Muscle fibers are “excitable”
- Depolarize membrane due to action potential in neuron
- Depolarize the T-tubule
- Release Ca\(^{2+}\) and bind to troponin
- Reveal actin’s binding site for cross bridge
- Get contraction
- Until RESEQUESTER Ca\(^{2+}\) back into SR (requires ATP)

Neuromuscular junction (Fig 10.11)
- Somatic motor fiber
- Motor unit with ACh neurotransmitter
- Axon terminal in trough
- Synaptic cleft
- Motor end plate with ACh receptors
- Why is ACh released? What destroys ACh?

Two differences from typical neuron-neuron synapse
- Always excitatory (nothing like an IPSP)
- The EPSP is called an end plate potential
- Always great enough to reach threshold
- No summation needed at NMJ
- One action potential → one muscle twitch
- REVIEW Fig 10.12 before exam

Muscle Mechanics
- Relate whole muscle performance
- Cellular events at the sarcomere level
- Sliding filaments generate force
- Force = tension
- Exerted on load
- Tension > load = isotonic contraction
- Load > tension = isometric contraction

Length-tension relationship
- Muscle can generate greatest tension at its resting length
- Same thing is true of each individual sarcomere (see Fig 10.10)
- Tension generated proportional to # of cross bridges that can form
- Number of cross bridges available depends on overlap of thick and thin filament

Length - tension relation

[Graph showing the length-tension relationship]