Muscle Excitation/Contraction (E/C Coupling)

INTRODUCTION

Here, we'll learn the coupling of skeletal muscle excitation and contraction.
Muscle Cell Environment

Sarcolemma
The sarcolemma is the plasma membrane.
Myofibril
Myofibrils possess dark/light stripes. They comprise:

• **A Band,** which refers to the length of the thick filaments, "think "A" for d-a-rk.

• **I Band,** which is the region along the thin filaments, between the thick filaments. Think "I" for L-i-ght.

Sarcoplasmic reticulum
The sarcoplasmic reticulum is organized into web-like, longitudinal rows. They store calcium and are a key component to coupling muscle cell excitation to myofibril contraction.
Terminal cisternae
We show bands of transversely-oriented terminal cisternae (aka lateral sacs) of the sarcoplasmic reticulum. They flank transverse tubules (T-Tubules – tubular invaginations of sarcolemma.
Cytosol
Cytosol constitutes the internal label the internal milieu of the myofibril.
Sarcoplasm
Sarcoplasm fills the internal milieu of the muscle cell.
Mitochondria
Mitochondria are the energy powerhouses of the cell – the site of aerobic respiration, which by definition requires oxygen but is capable of generate the most amount of ATP.
Synaptic terminal
We also show a synaptic terminal (aka terminal bouton) of a typical motor nerve, which possess molecules of

MYOFILAMENTS

Thin Filaments
Thin filaments notably comprise:

- Actin, which are spherical molecules joined in pairs of double helical strands (like beads on a string),

- Tropomyosin, which are threadlike strands, and

- Troponin protein complexes that bind tropomyosin, actin, and also calcium. We show their calcium-binding sites.

Myosin Binding Sites
Next, indicate the myosin binding sites on actin.
ATPase Site
There is also an ATPase site, an ATP-splitting site.
Thick Filaments
Next, show that thick filaments of myosin, which constitute heavy and light chains form a golfclub shape, and possess a head, neck, and tail.

EXCITATION

Now, let's show the steps of excitation.
Ach binds a receptor
Show that acetylcholine binds a post-synaptic receptor on muscle, which triggers an action potential.

- The action potential proceeds along the T Tubule to a dihydropyridine receptor (it is blocked by dihydropyridine, hence its name).

- Depolarization of the dihydropyridine receptor activates the ryanodine receptor (aka foot proteins, calcium-release channels) within the terminal cisternae, which triggers the release of calcium into the cytosol.

Calcium binds troponin
Show that calcium binds troponin. This causes a shift in tropomyosin, moving it away from its blocking position along actin, which allows myosin to bind actin.
Myosin binds actin
Myosin binds actin and proceeds through thin filament sliding (muscle contraction), which we draw at the end.
Contraction cessation
Show that when the action potentials cease, calcium releases from troponin and returns to the cytoplasm. Tropomyosin shifts and myosin is now unable to bind actin. The contractions cease.

HUXLEY SLIDING-FILAMENT MODEL

Now, let's draw key steps in the Huxley Sliding-Filament Model.
Myosin binding
Draw a myosin head bound to the thin filament.
Actin release
Next, we see that ATP induces release of actin.
ATP binds myosin
Redraw myosin with ATP bound to its head.
Actin separates
Then, draw the actin molecules as separated from (no longer bound to) the myosin.
Rigor state
Thus, we see that ATP is required to move out of the rigor state. If ATP is absent, which occurs after death, rigor will persist, called **rigor mortis**.
ATP hydrolysis
Next, show that ATP is hydrolyzed to ADP and Inorganic phosphate (Pi) prompts the myosin head to rotate on the neck: it is now "cocked" – it's in its high-energy state.
"Cocked" state
Now, show that the "cocked" state causes the thin and thick filaments to again bind via their cross-bridge. Show that ADP and inorganic phosphate (Pi) are still bound to the myosin head.

Pi release
Next, show that Pi release initiates the power stroke for the myosin head to release its energy. The thin filament begins its slide.
Uncocked state
Redraw the myosin in its uncocked, low energy state. At some point after the power stroke, ADP is released.

- Note that ADP and phosphate may be release simultaneously to initiated the power stroke.