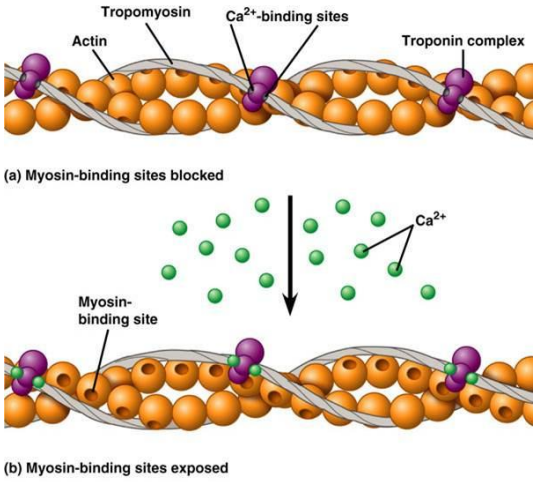
The Sliding Filament Theory & Excitation Contraction Coupling

(Text Pg 40 - 43)

There are Two Other Key Proteins Located On Actin

1. Tropomyosin
• Strand like protein wrapped around actin filament that blocks the myosin binding sites on the actin

2. Troponin
• Globular shaped molecules, that sit on top of tropomyosin.
• Have calcium ion (Ca2+) binding sites (Very Important)



The Sliding Filament Theory!

• Our muscles contract when the myosin heads binds to actin (***crossbridge formation***) causing it to slide overtop of itself.
• The length of the thin and the thick filaments have not changed.
• Rather, the myofilaments slide over top of each other.
• Hence the name "**Sliding Filament Theory**"

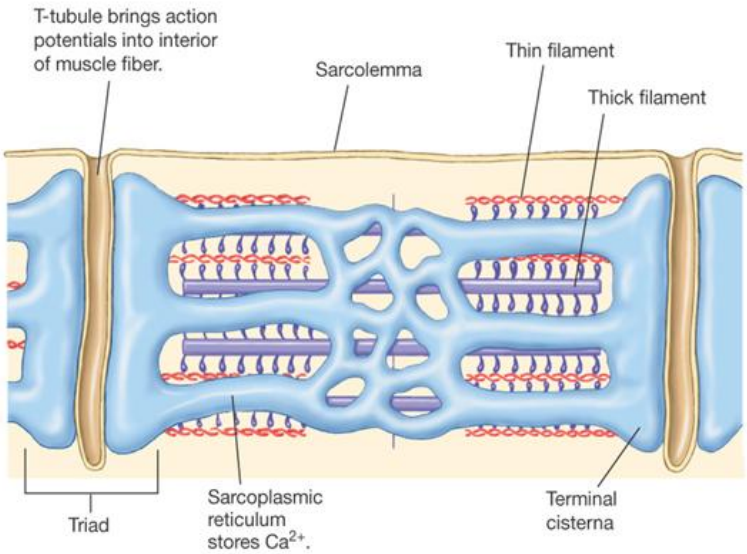
Two Problems:
o The ***binding sites on actin are blocked*** by tropomyosin!!
o Myosin needs ***energy*** to bind and move the actin.

How do we "Un-block" Actin?
• Calcium Ions (Ca2+) bind to Troponin causing tropomyosin to move and reveal the binding sites.
    o Calcium is a **regulatory molecule** for muscular contraction.

How does a muscle know when to release calcium?
• Calcium is released when the cell becomes ***depolarized.***
    o A resting muscle cell is "**polarized**"

    o When an **action potential** from the motor neuron arrives, the cell becomes **depolarized** (due to acetylcholine).

    o This wave of depolarization is transported to the interior of the muscle fibre via the ***transverse tubules*** (T-Tubules).



Where do the calcium ions come from?

• Calcium ions (Ca2+) come from the ***Sarcoplasmic Reticulum*** when the cell becomes depolarized.

Where does the energy for muscular contractions come from?

• Myosin gets its energy from a molecule called Adenosine Triphosphate (ATP - the energy currency of the cell).

• ATP allows two things to occur:

- o It **"energizes"** myosin to bind to Actin
- o It **provides the energy** necessary for the **"power stroke"** (myosin head swivels causing actin to slide overtop of myosin).

$$ATP + H_2O \rightarrow ADP + P + Energy$$

The Relationship Between Myosin and ATP!

• The myosin filaments have pivoting heads that swivel and attach to the binding sites on Actin only when ATP is present.

- o This is called a **crossbridge** (Myosin bound to Actin).
- o The energy released causes the ***power stroke*** (Myosin head swivels)**.**

• Some of the energy is also released as heat (metabolic by-product).

When do the Crossbridges break?

• The crossbridge will only break under two circumstances:

a) Another ATP binds to Myosin

b) When the Ca2+ ions return to the sarcoplasmic reticulum (tropomyosin returns to its inhibitory position)

What Happens To The Sarcomere During Muscular Contractions?

• Actin filaments on either end of the sarcomere approach each other from opposing ends and meet in the center (H-zone gets smaller).

• One **power stroke** results in a very **small displacement** of the filaments and produces a **small amount of force**.

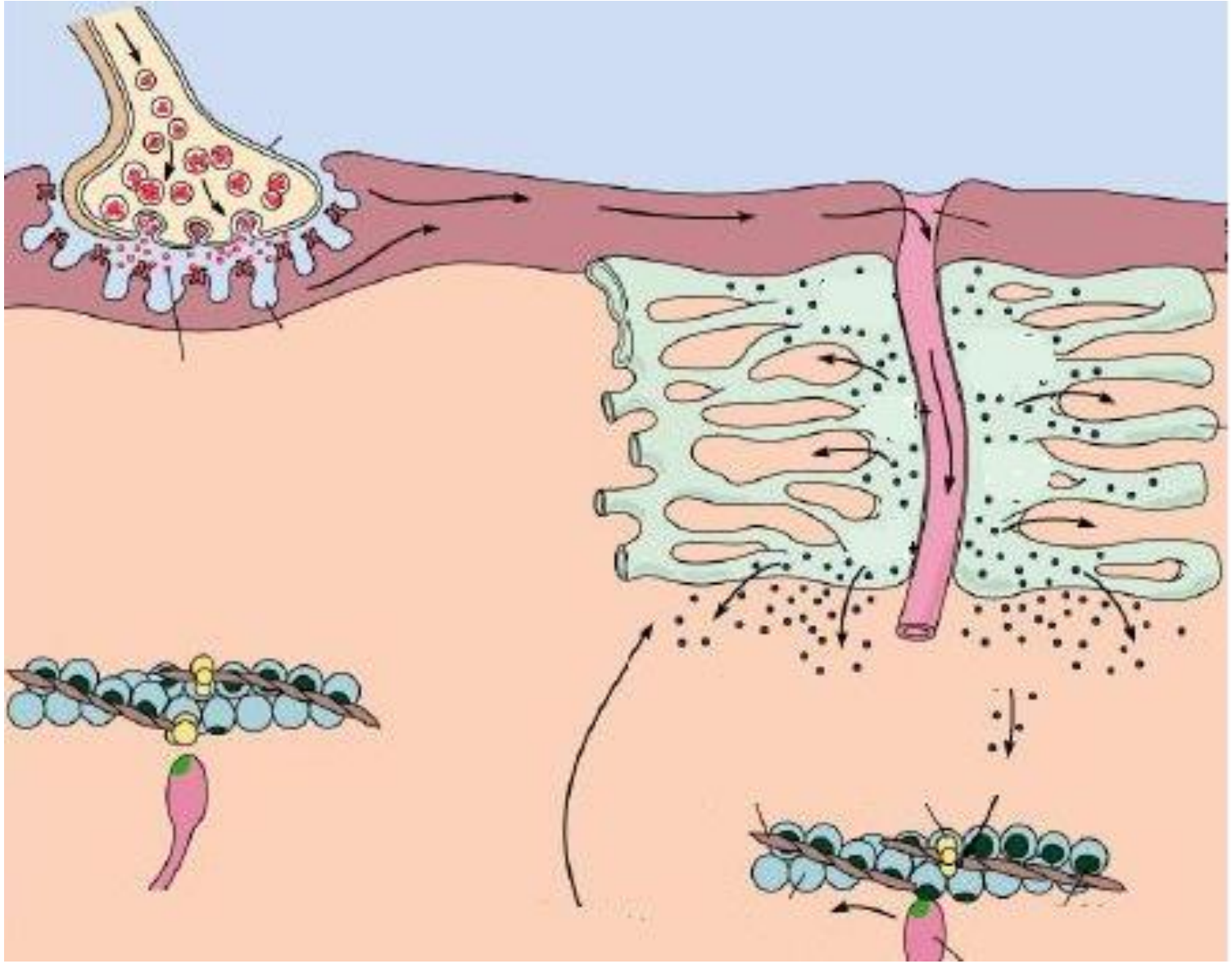
• **Crossbridge cycling** occurs very rapidly to produce larger movements and greater forces.

What Happens When We Relax Our Muscles?

• When the muscles relax:

- o Ca2+ ions return to the sarcoplasmic reticulum.
- o Tropomyosin slides back over the binding sites on Actin breaking the crossbridges
- o The Actin filaments slide back to their original position.

Instructions: Label the following diagram using the numbers for the thirteen steps to the sliding filament theory. You may need to illustrate some details e.g. ca2+, ATP binding to myosin, hydrolysis of ATP, etc.



Sliding Filament Theory: Overview

1) Brain releases a Nerve Impulse to initiate a movement

2) Nerve Impulse travels down the neuron to the neuromuscular junction (Axon Terminal)

3) The axon terminal releases the neurotransmitter acetylcholine

4) Acetylcholine crosses the synaptic cleft and binds to the receptors on the sarcolemma

5) The sarcolemma becomes depolarized

6) The action potential is transported to the interior of the muscle via the transverse tubules

7) The sarcoplasmic reticulum releases calcium ions

8) Calcium binds to troponin

9) Tropomyosin slides revealing myosin binding sites on Actin

10) ATP attaches to the head of myosin

11) Myosin attaches to Actin

12) ATP splits into ADP, P and energy

13) Power stroke occurs causing Actin to slide over myosin