Muscle Contraction

By Thomas Dlugosz

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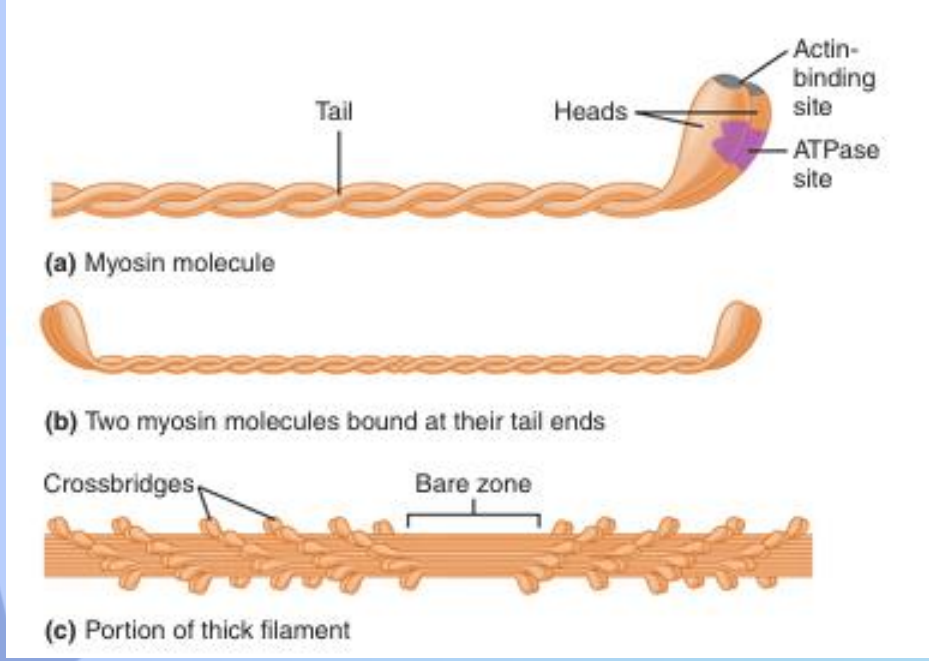
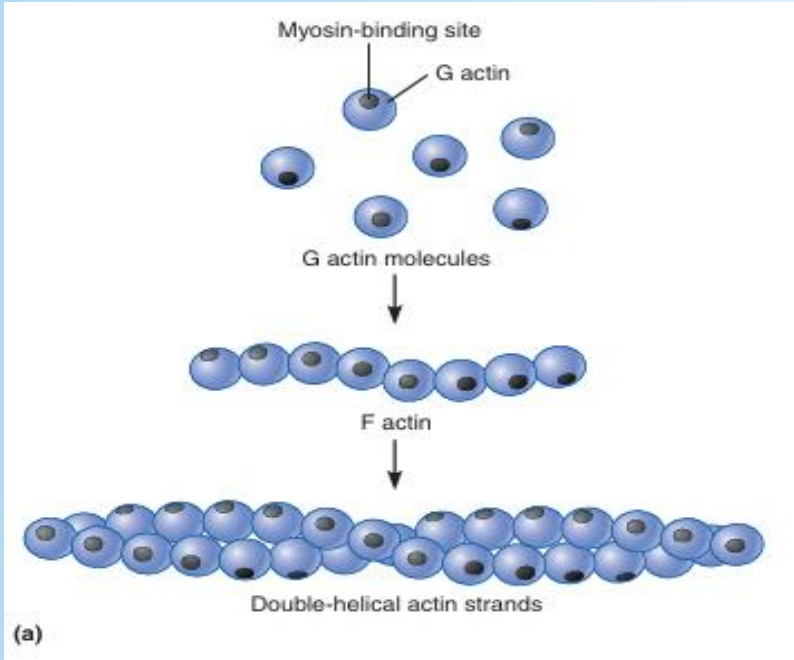
What are the 3 kinds of muscle we have?

Proteins Involved: The Filaments

All muscle cells have structures called thick filaments. They are made of hundreds of **myosin protein** molecules.



All muscle cells also have **thin filaments.** They are made of actin
Mnemonic: Acthin → Thin filaments



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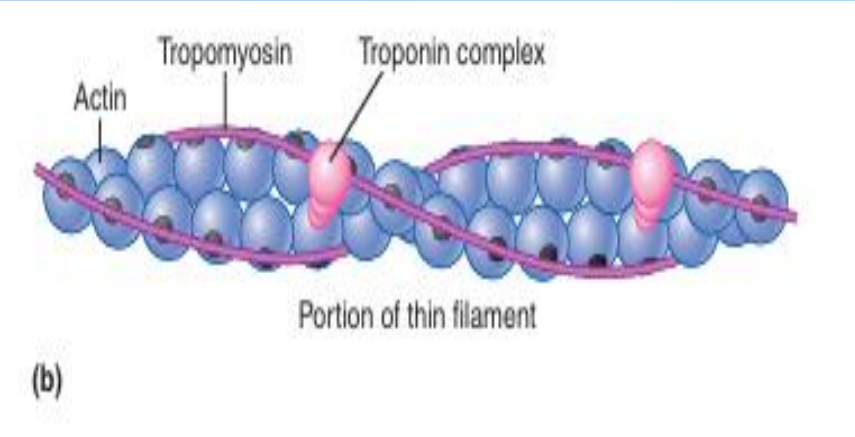
Proteins Involved: Regulatory Proteins



Cardiac and Skeletal Regulatory Proteins

Tropomyosin: A fibrous molecule that blocks the myosin-binding site of actin

Troponin Complex: Made of Troponin C, Troponin I and Troponin T

Smooth Muscle Regulatory Protein

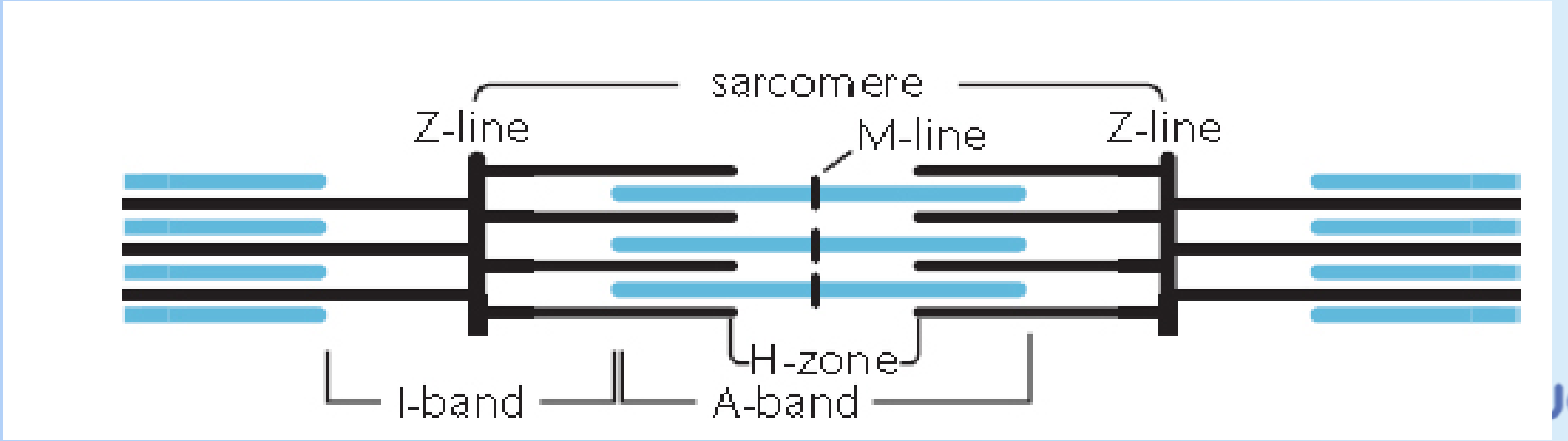
Calmodulin: Combines with calcium to activate MLCK

Myosin Light Chain Kinase: A regulatory kinase that phosphorylates myosin light chains

The Sarcomere

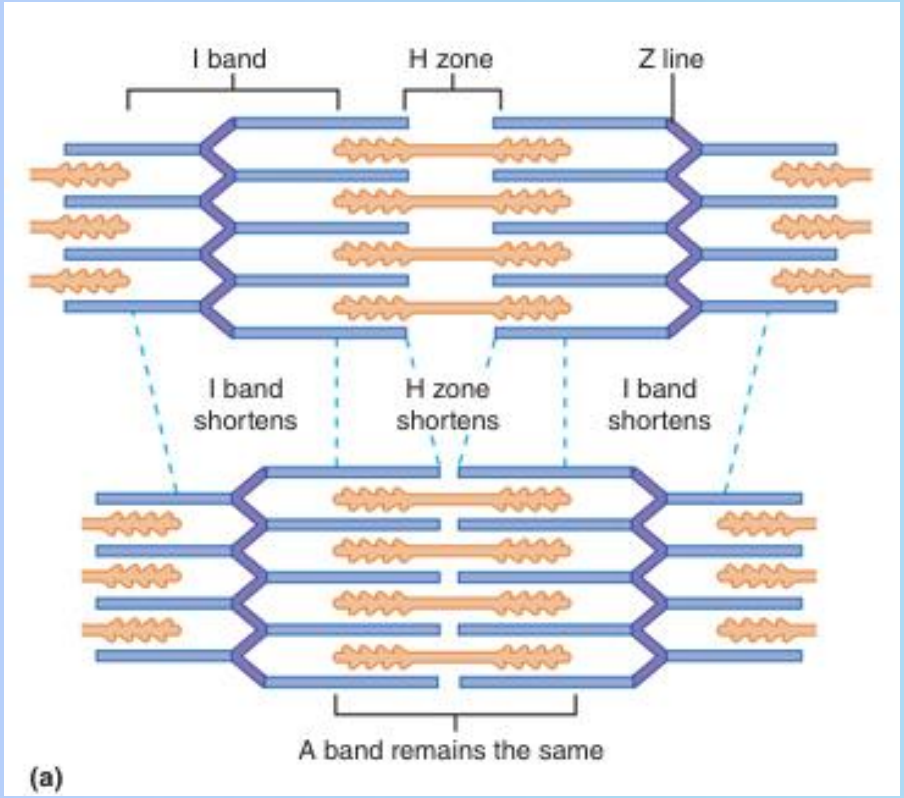
Thick and thin filaments arrange themselves in **sarcomeres,** which are the functional units of skeletal and cardiac muscle.

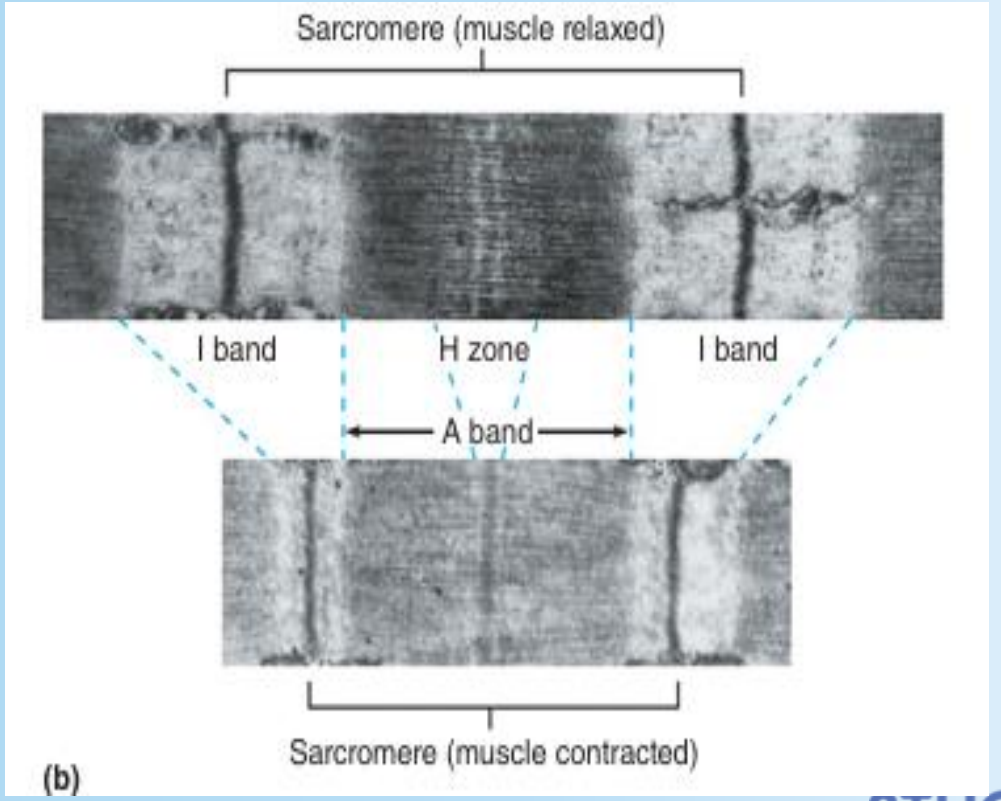
- Z line- Z is the end of the alphabet and end of the sarcomere
- M-Line- Middle of the myosin filaments
- I-band: I is a thin letter, so the I band contains only thin filaments
- H-Zone: H is a thick letter, so the H-zone contains only thick filaments
- A-band: All of the thick filament, whether it is overlapping or not



Sliding Filament Model

When our muscles contract, thin filaments are pulled to the middle of the sarcomere by sliding over thick filaments.





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Initiating Event in Skeletal Muscle Contraction

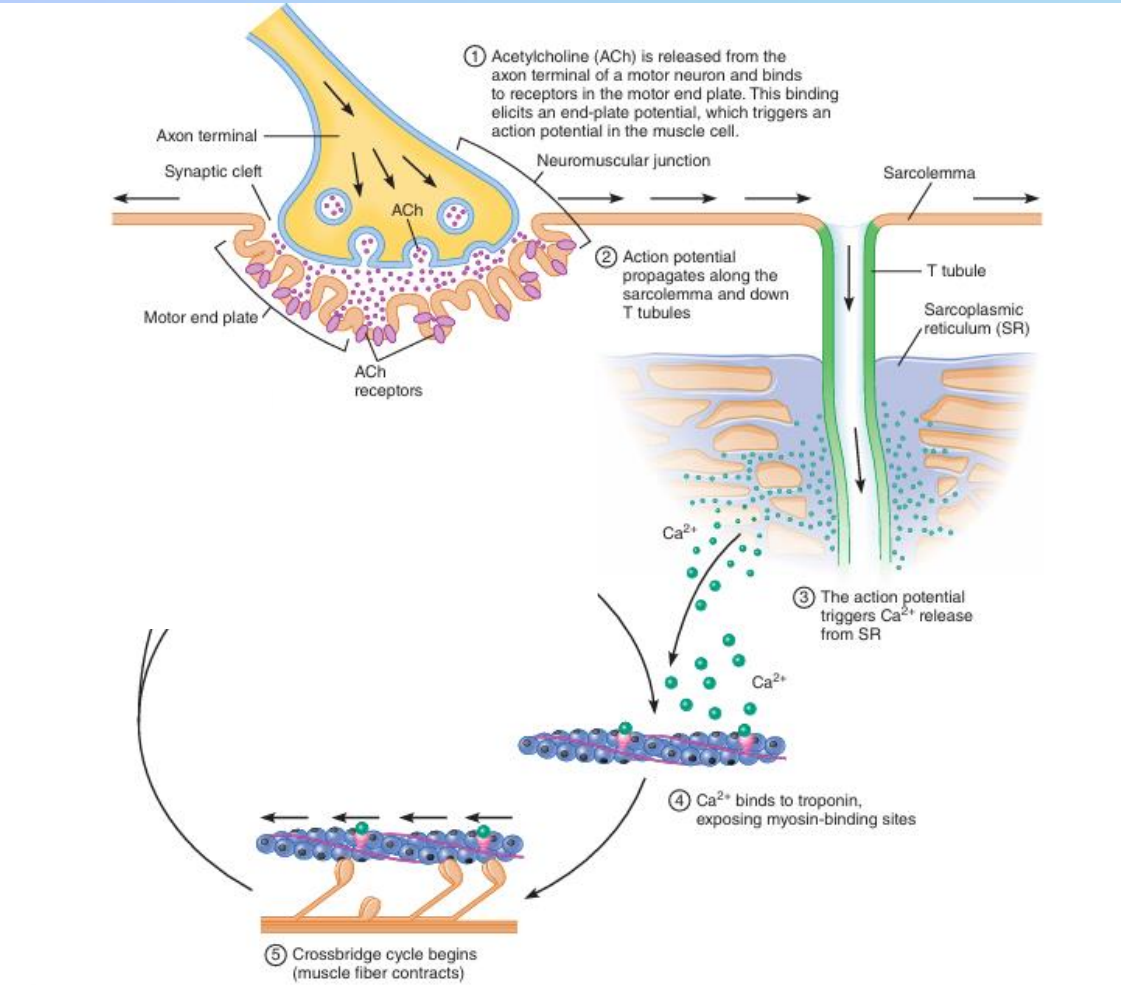


Figure 12.8 Events in excitation-contraction coupling.

Q Which enzyme breaks down acetylcholine after it is released?

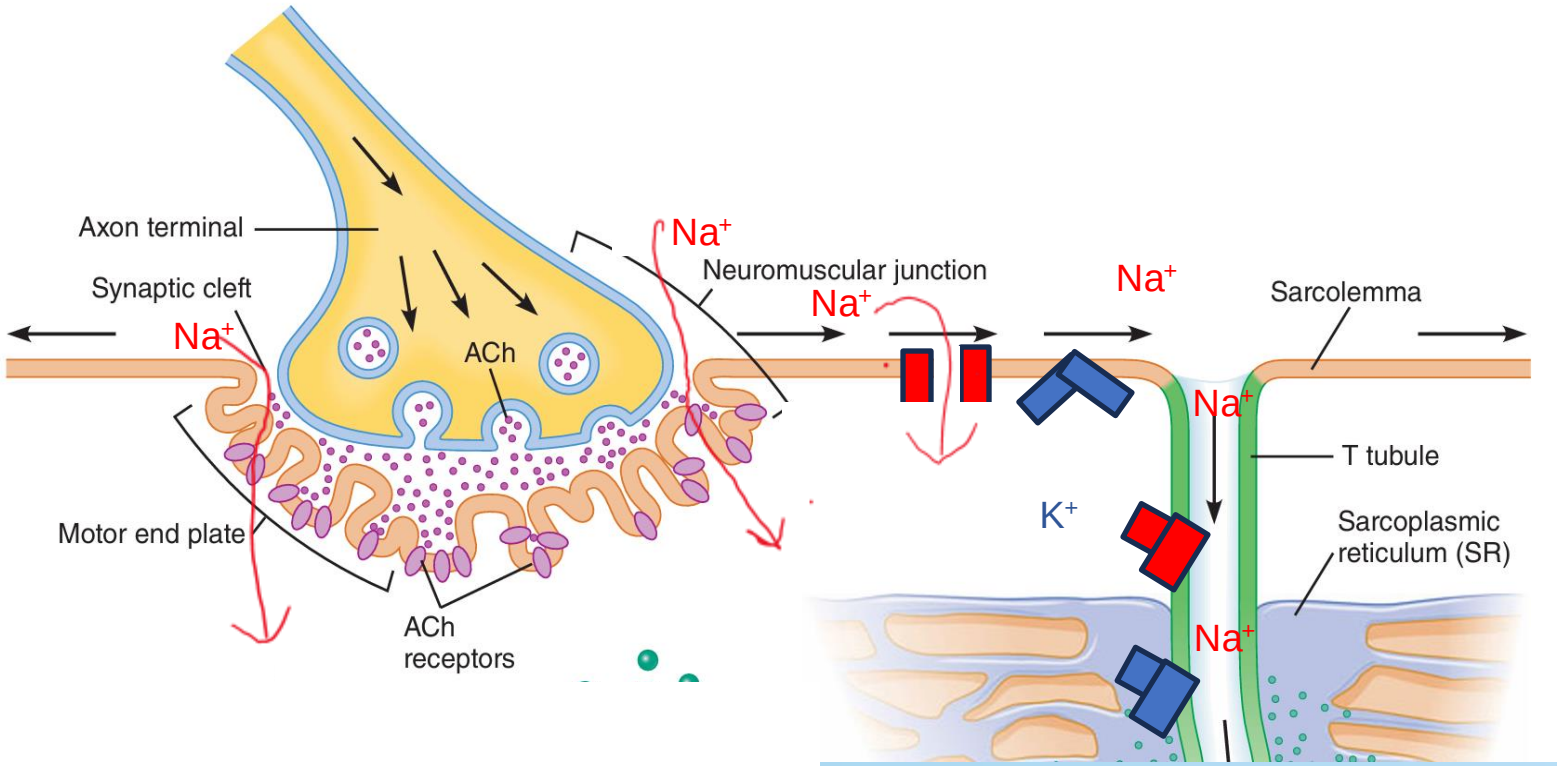
Terminology

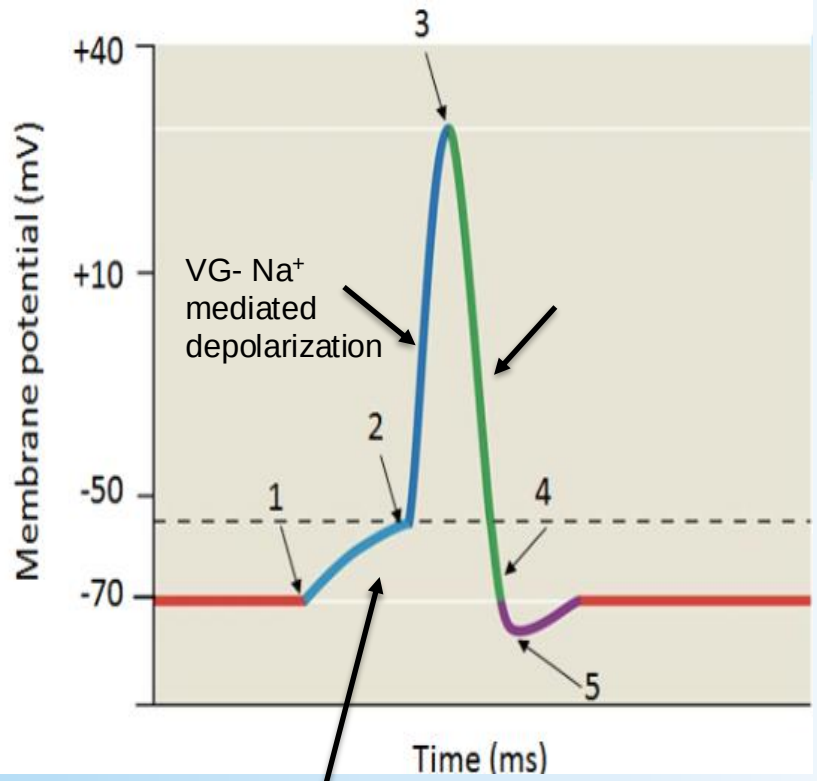
Sarcolemma- Muscle Cell membrane

T-tubule- Transverse Tubule. It is formed by a fold in the sarcolemma which APs propagate down

Sarcoplasmic Reticulum- Name for the Endoplasmic Reticulum of a muscle cell

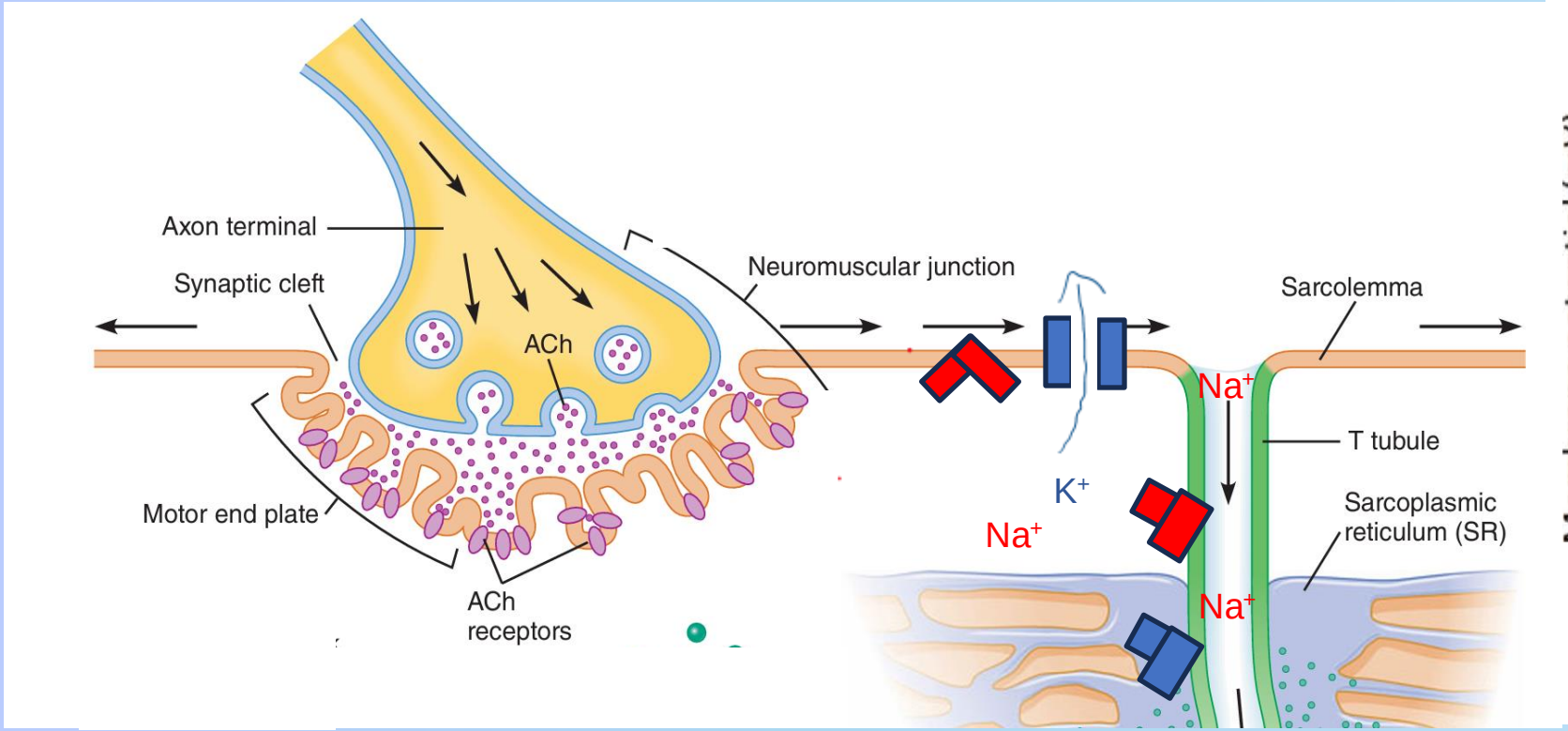
Action Potential Propagation in Skeletal Muscle Contraction

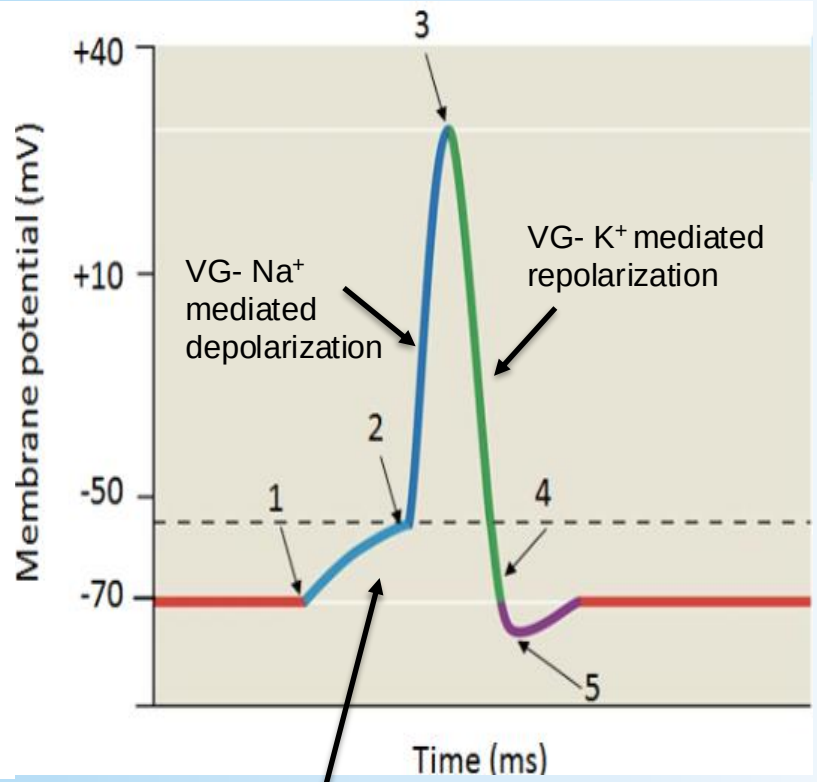




nAChR mediated depolarization from NMJ

Action Potential Propagation in Skeletal Muscle Contraction





nAChR mediated depolarization from NMJ

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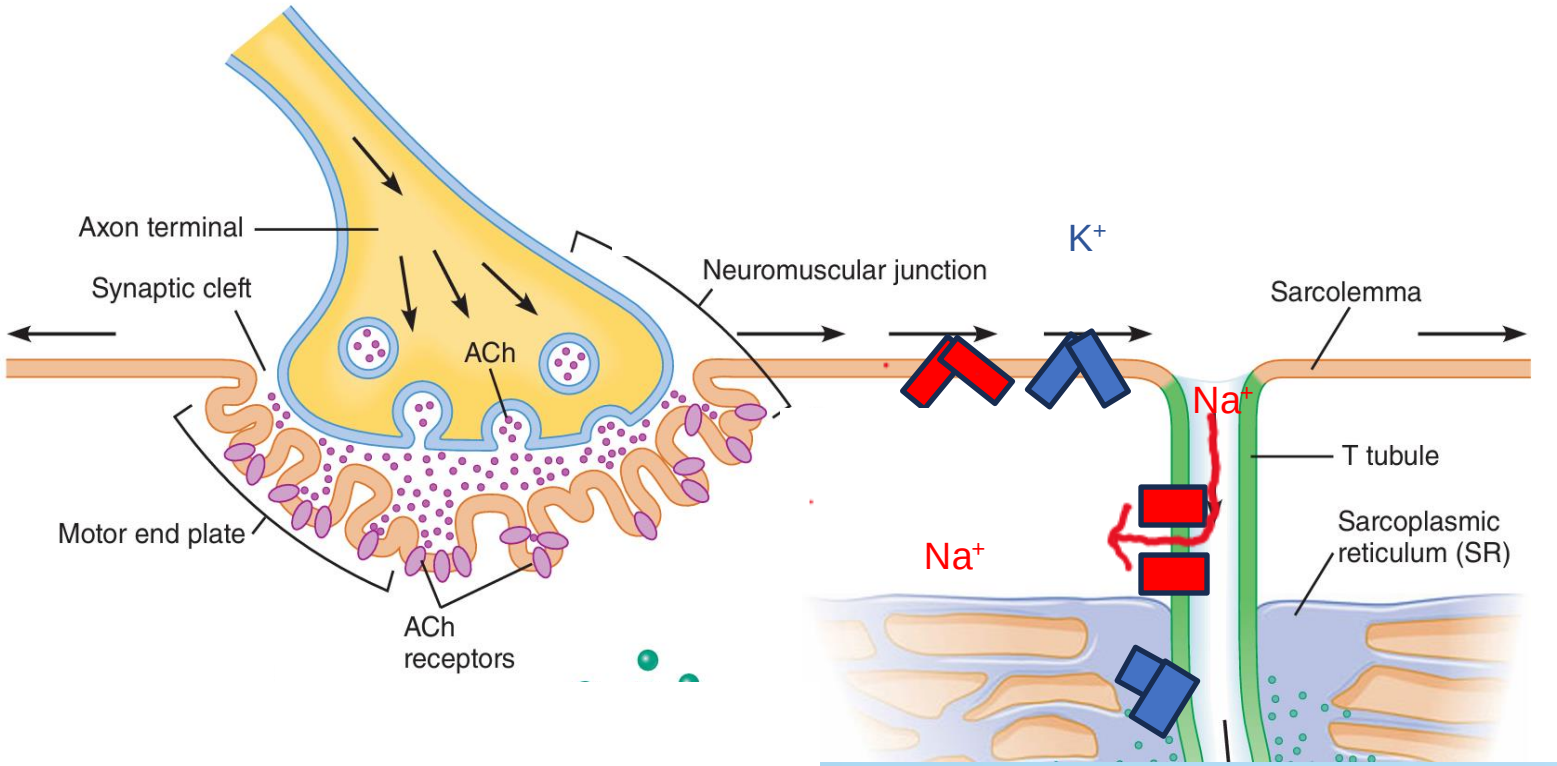
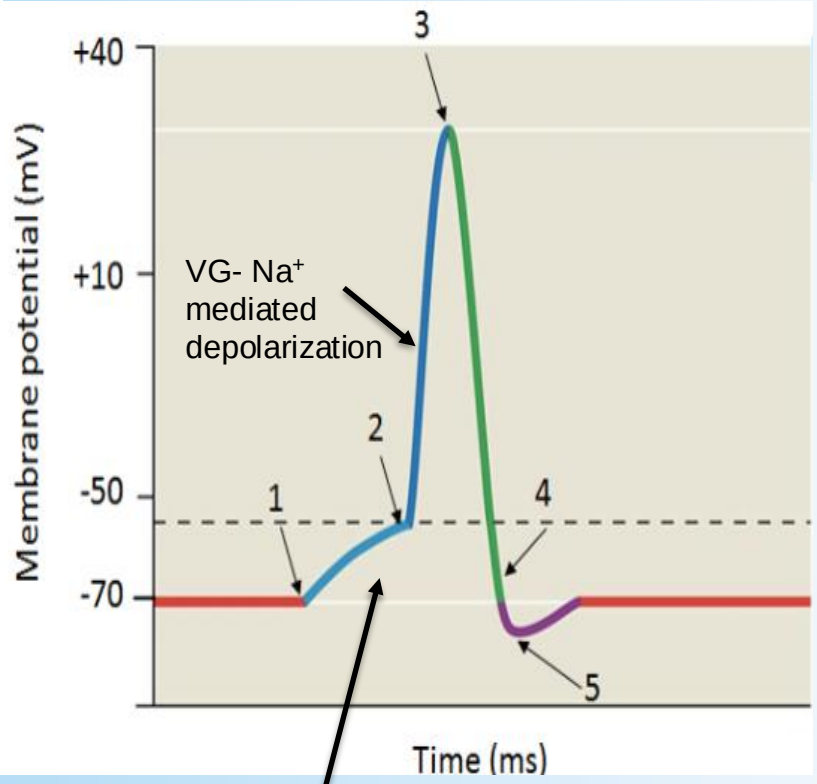
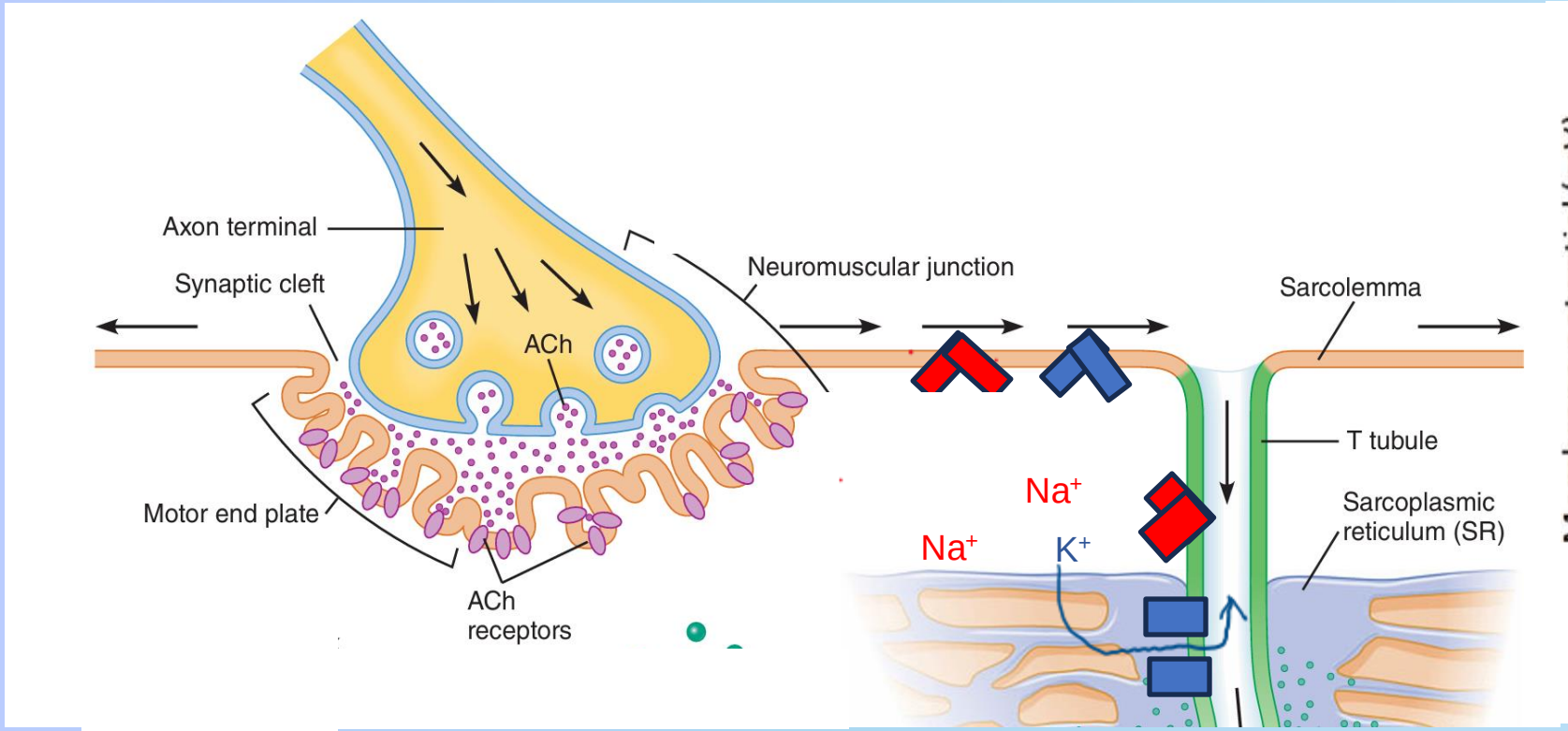
Action Potential Propagation in Skeletal Muscle Contraction

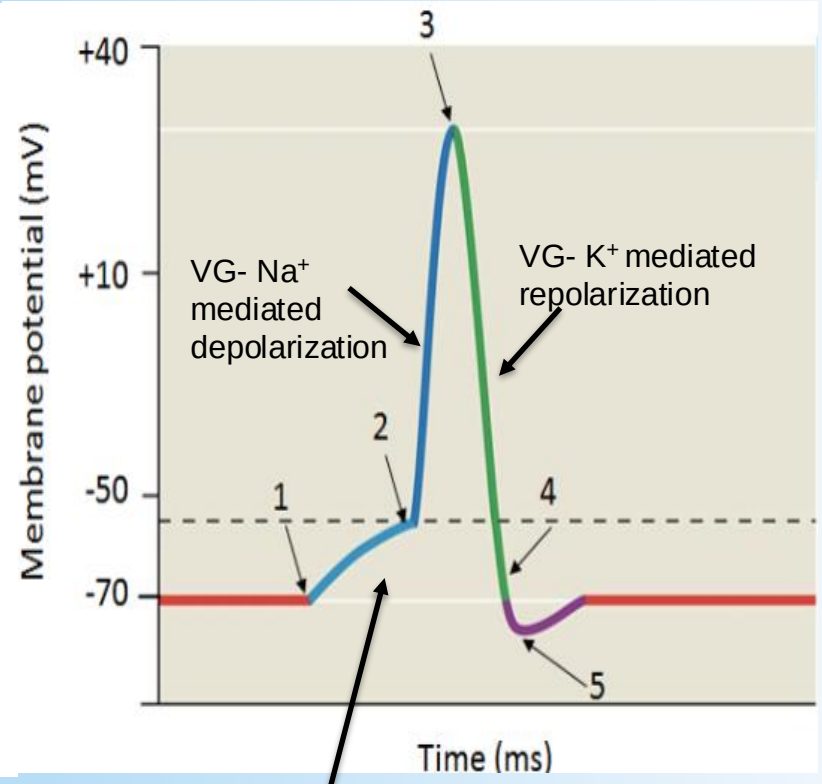




VG-Na⁺ mediated depolarization

Action Potential Propagation in Skeletal Muscle Contraction





VG-Na⁺ mediated depolarization

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Initiating Event in Skeletal Muscle Contraction

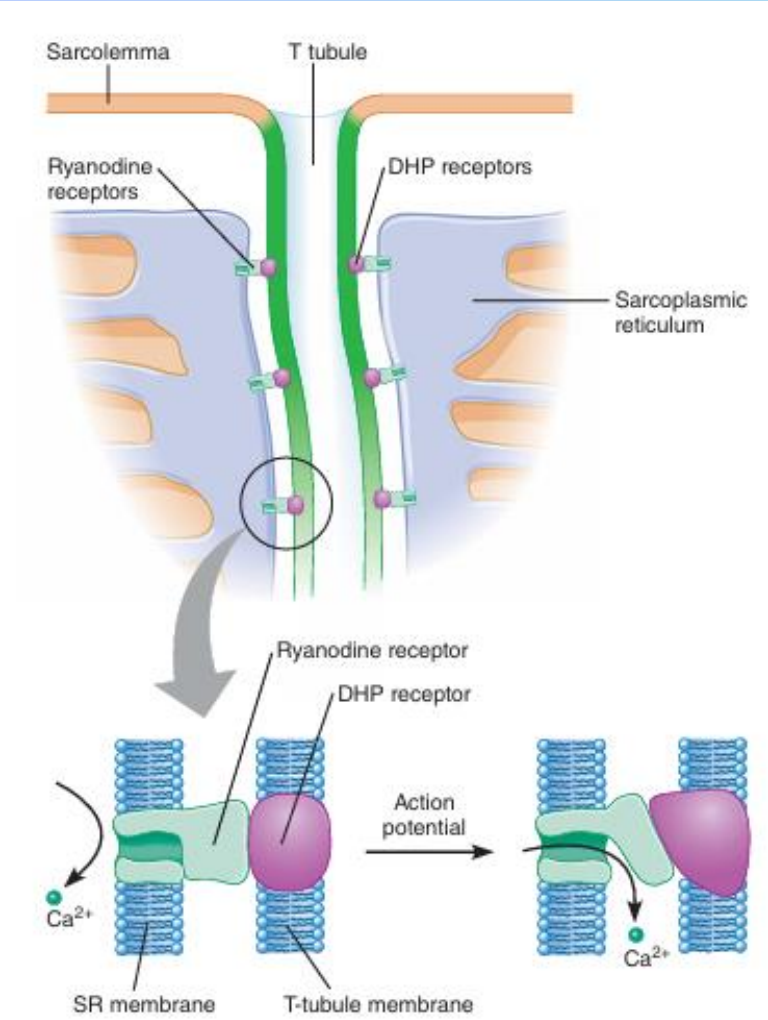
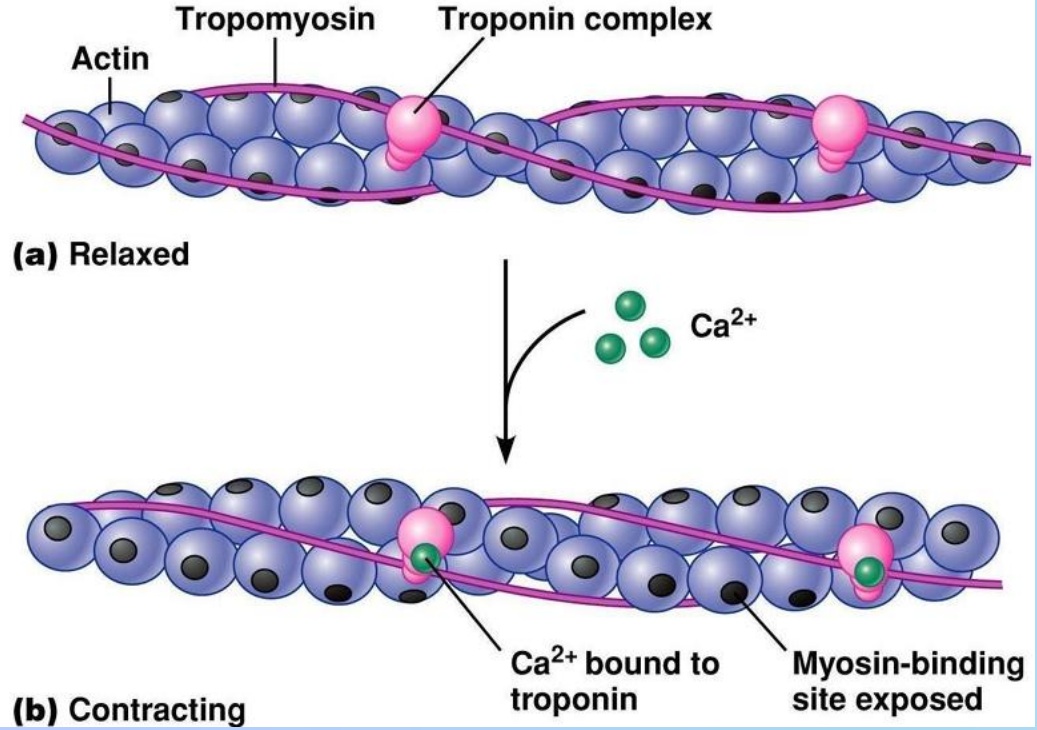


Figure 12.10 Gating of sarcoplasmic reticulum calcium channels.

- **DHPR-** Dihydropyridine Receptor. It is a voltage gated receptor that changes conformation when depolarized.
- **Ryanodine Receptor-** Mechanically gated by DHP receptors. They conduct calcium into the cytosol.

Troponin-Tropomyosin Interaction



- Calcium binds Troponin C
- Troponin C causes Troponin I to change conformation
- Troponin I pulls tropomyosin off the myosin binding sites of **actin**

Crossbridge Cycle

- With tropomyosin removed, we can undergo **The Crossbridge Cycle**
- **The crossbridge cycle is universal for all muscle contraction**

Clinical Correlation

Rigor Mortis- Spastic paralysis of the muscles occurs upon death because we no longer make ATP to cause myosin to detach from actin!

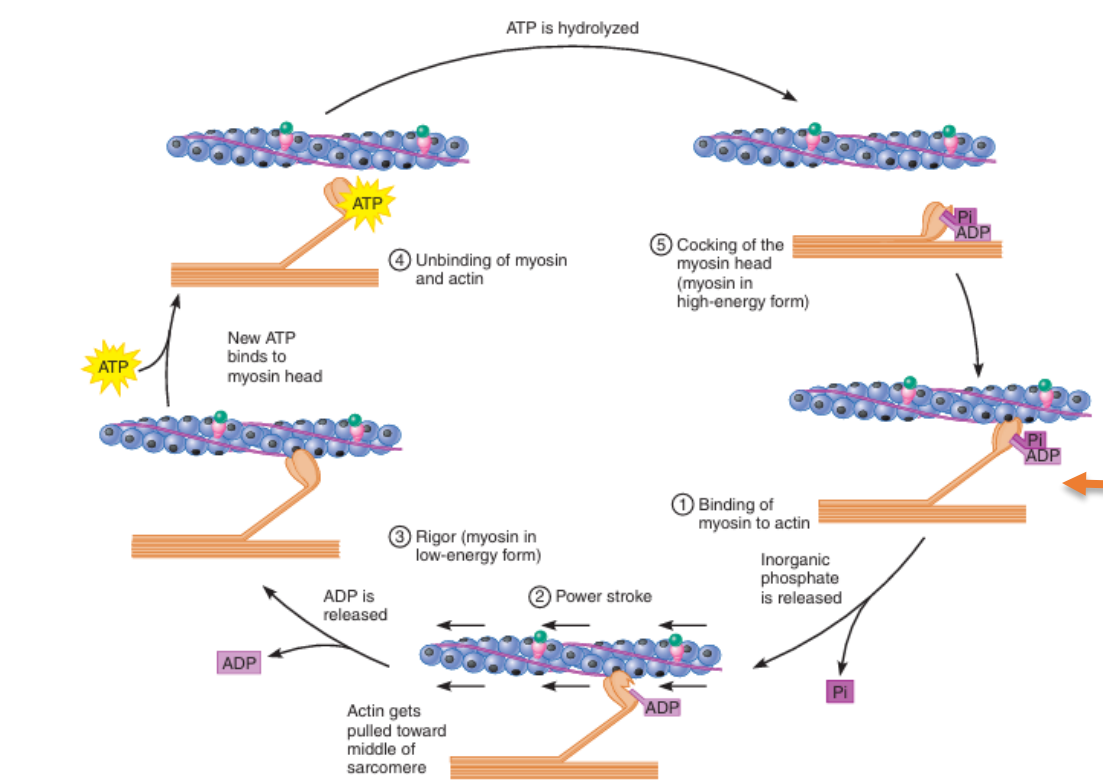


Figure 12.7 The crossbridge cycle.

Crossbridge!

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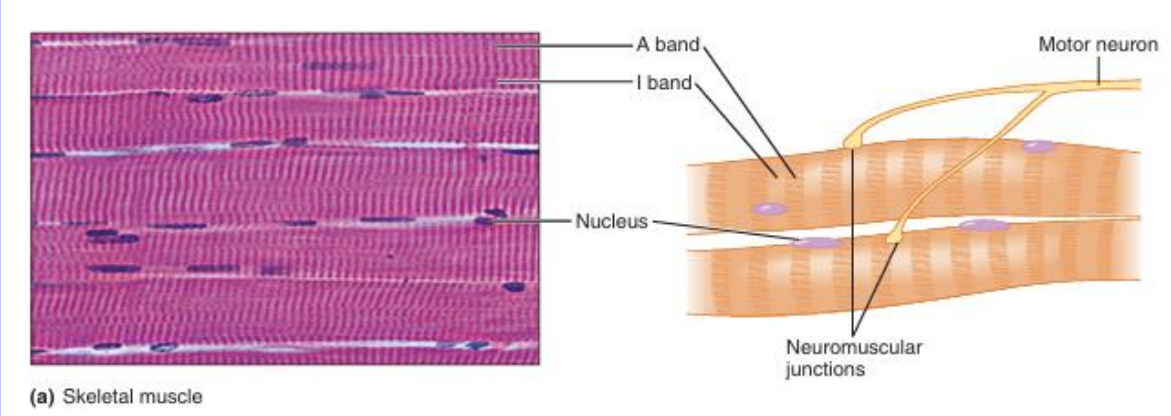
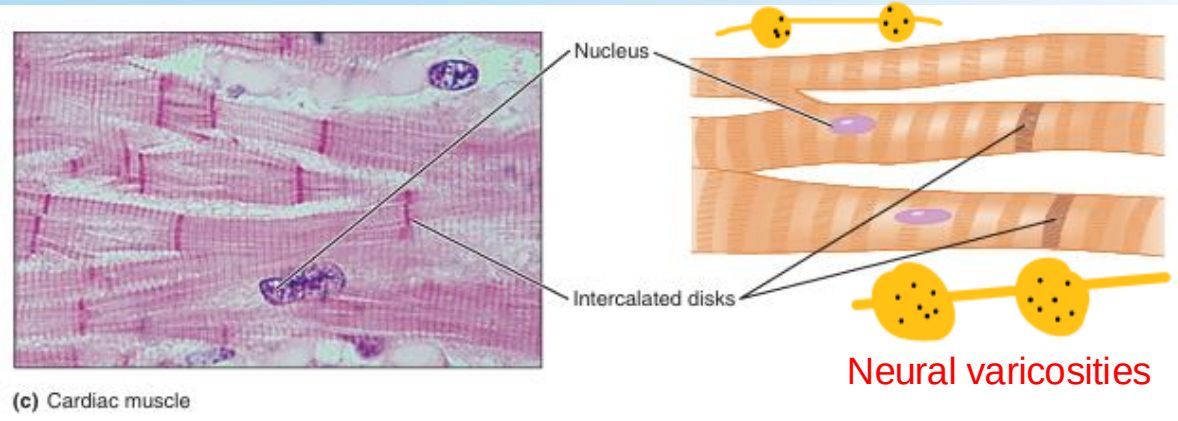
Cardiac Muscle Contraction

- Fundamentally, cardiac muscle contraction occurs by the same sliding filament theory like in skeletal muscle

- The heart has its own pacemaker cells in the **sinoatrial node** that can produce APs independent of its innervation (~100 bpm)

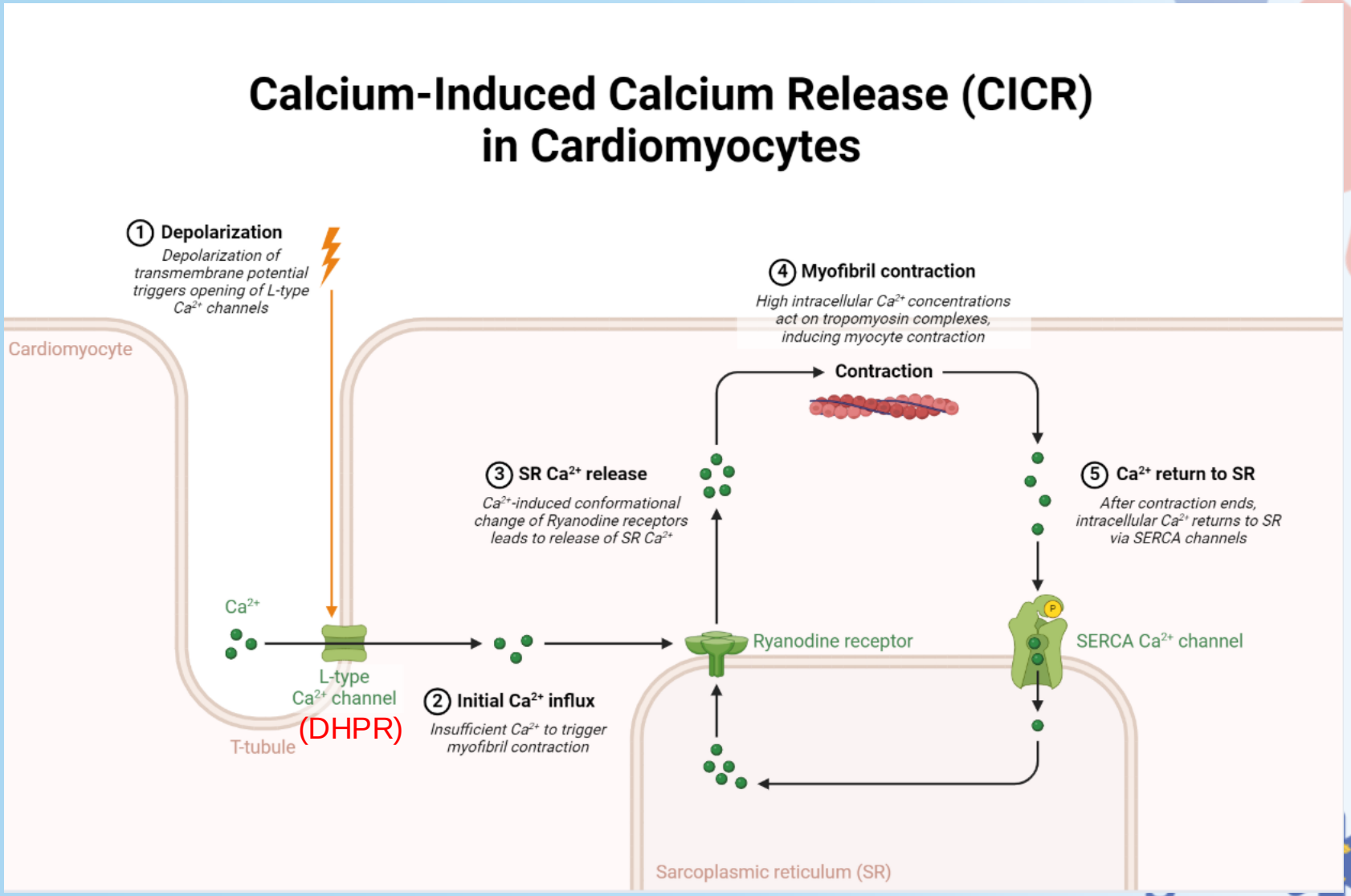




Intercalated disks in cardiac muscle have gap junctions that allow for coordinated rhythmic contraction throughout the entire tissue

Cardiac Muscle Contraction Initiating Event

Cardiac Muscle Contraction is reliant on Calcium Induced Calcium Release!



Smooth Muscle Contraction

- Also Calcium Induced Calcium Release, but not as central as Cardiac Muscle.
- **Calmodulin and MLCK are the regulatory proteins**
- Myosin Light chain is a regulatory part of the myosin protein that regulates ATPase activity
- There are no sarcomeres in smooth muscle
- Smooth muscle contains troponin but does not contain tropomyosin. The function of troponin is unknown.

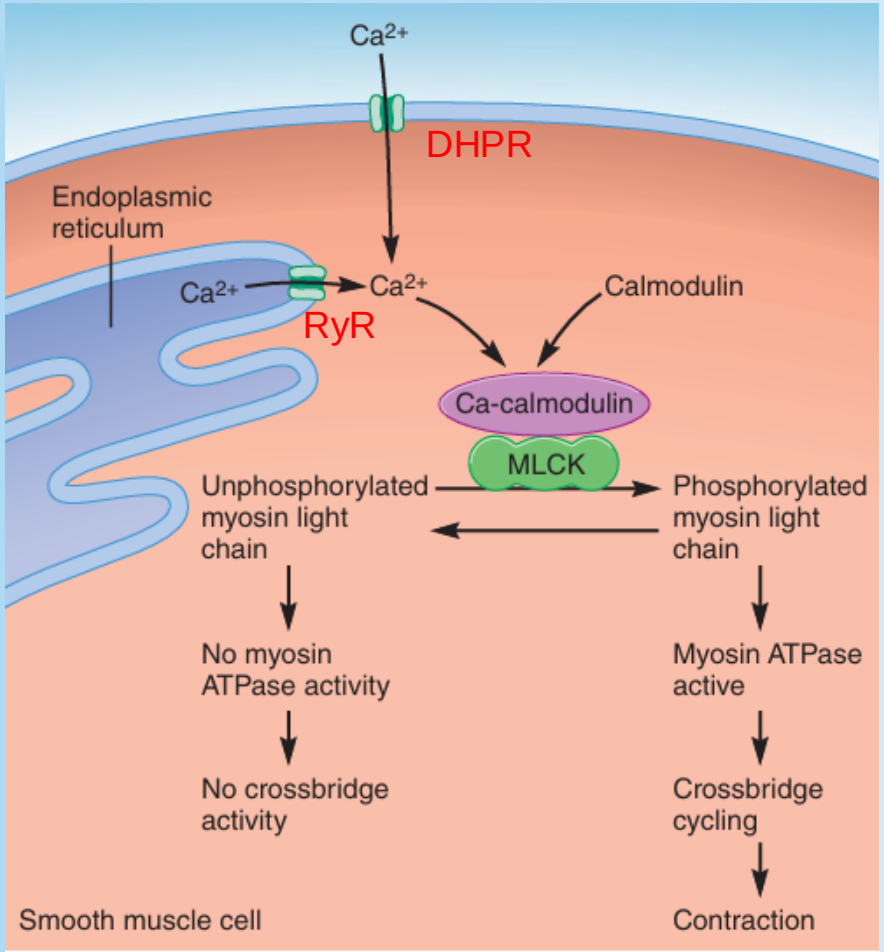


Figure 12.35 Excitation-contraction coupling in smooth muscle.

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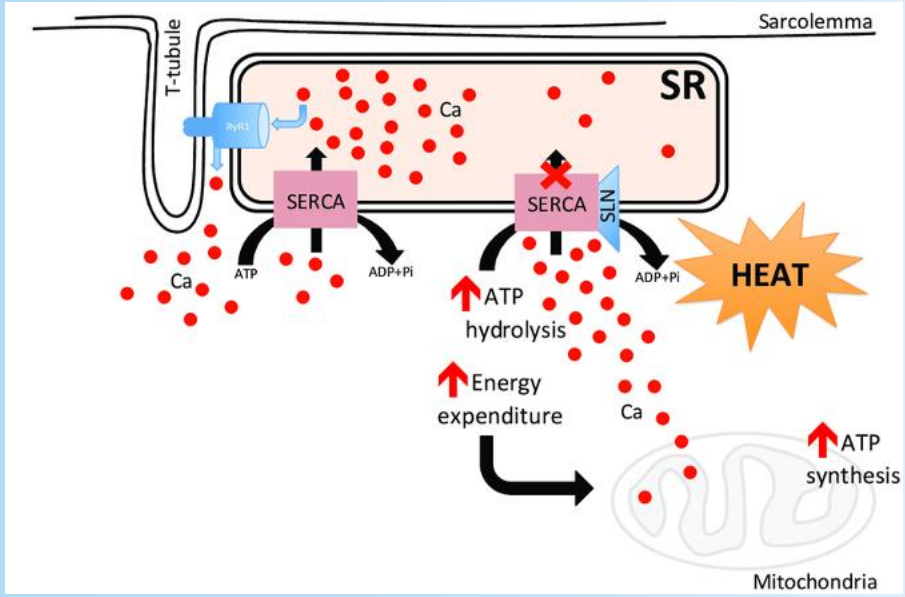
How Does Contraction Stop in Muscle?

- We have **Sarcoendoplasmic Reticulum Calcium ATPase (SERCA) on the SR membrane**
- It removes cytosolic Calcium and moves it back into the SR
- What would happen if we didn't have SERCA?



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