Nervous System and Contractions

by Sophia

WHAT'S COVERED

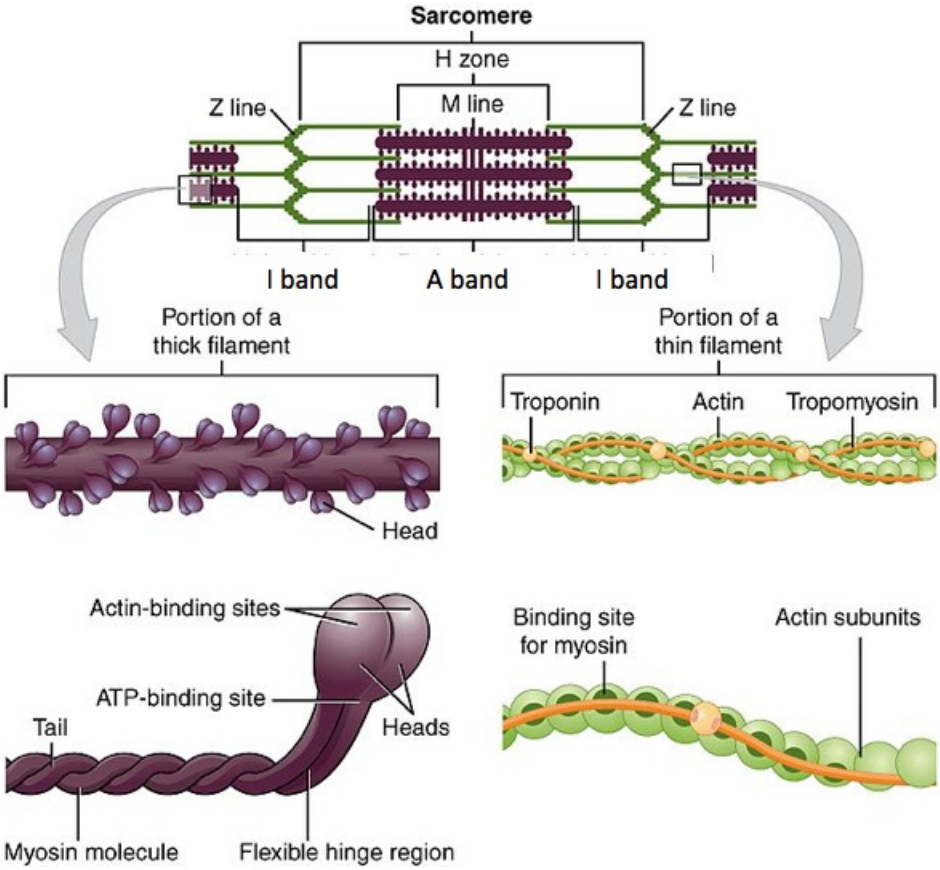
In this lesson, you will explore the role of the nervous system in muscle contraction. Specifically, this lesson will cover:

1. Components of a Muscle Contraction

Remember that skeletal muscles are voluntary muscles: You can control them. How does your thought to flex your arm get translated into movement? How does the signal get from your brain to your biceps?

Motor neurons carry the signal from your brain to specific muscle fibers, telling the**sarcomeres** within those muscle fibers when to contract.

Before discussing the steps involved in a muscle contraction, let's review the structure of a sarcomere.**Myosin** is referred to as the thick filament in a sarcomere. Myosin heads will attach to **actin**, the thin filaments, pulling the Z-bands of a sarcomere closer together. This allows for the shortening of that sarcomere, which in turn causes the shortening of the muscle fiber, and therefore a muscle contraction.



What prevents myosin from binding to actin when there's no signal to contract? After all, we don't want our muscles to randomly contract; we'd never be able to stop twitching! **Troponin** and **tropomyosin** are proteins that are found on actin filaments; they regulate when myosin can bind to actin and cause the sarcomere to contract.

TERMS TO KNOW

Motor Neuron

A neuron that delivers signals to muscles or glands.

Sarcomere

The functional and contractile units of skeletal and cardiac muscles; created by a specific arrangement of myofilaments called actin and myosin; each sarcomere is bordered by a Z-line.

Actin

A protein referred to as the thin filament of a sarcomere, creates the lighter color within a sarcomere and interacts with myosin to create movement.

Myosin

A protein referred to as the thick filament of a sarcomere, creates the darker colors within a sarcomere and contains various heads that pull on actin filaments to create movements.

Troponin

When a nerve signals a muscle fiber to contract, the sarcoplasmic reticulum releases calcium, which binds the protein troponin. Troponin then causes tropomyosin to expose actin to myosin for binding, leading to a contraction.

Tropomyosin

In skeletal muscles, protein shields actin, preventing myosin from binding unless there's a signal

from a nerve.

2. The Steps of a Muscle Contraction

STEP BY STEP

1. *Electrical signal travels along the motor neuron*

   The thought to flex your arm travels down the motor neuron in the form of an electrical signal. This electrical signal reaches the **neuromuscular junction**—the place where the end of the motor neuron meets the muscle fibers. A tiny gap called a **synapse** is the only thing that separates the nerve ending from the muscle cell. The synapse is where the motor neuron's electrical signal gets translated to a chemical signal that the muscle fiber can understand.

2. *Chemical signal travels from the motor neuron to the muscle fiber*

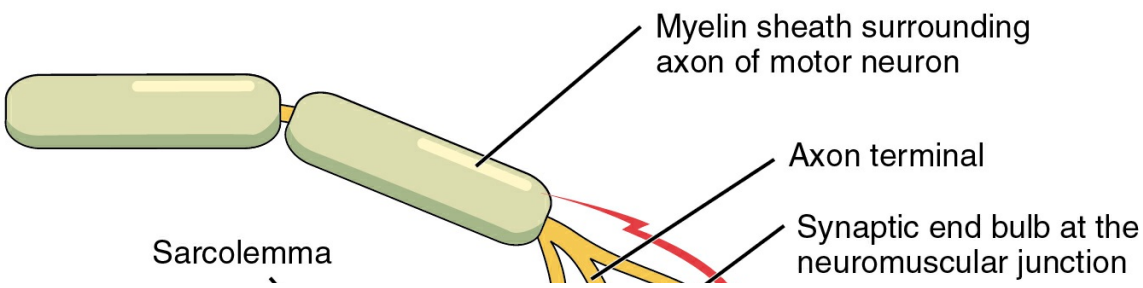
   When the motor neuron's electrical signal reaches the neuromuscular junction, it's converted to a chemical signal: The **neurotransmitter** acetylcholine (ACH). Acetylcholine lives in vesicles within the motor neuron; when the motor neuron is ready to signal muscle fibers, the vesicles merge with the neuron's plasma membrane, releasing ACH into the synapse. ACH crosses the synapse, binds the muscle fiber and stimulates the sarcoplasmic reticulum to release **calcium**.

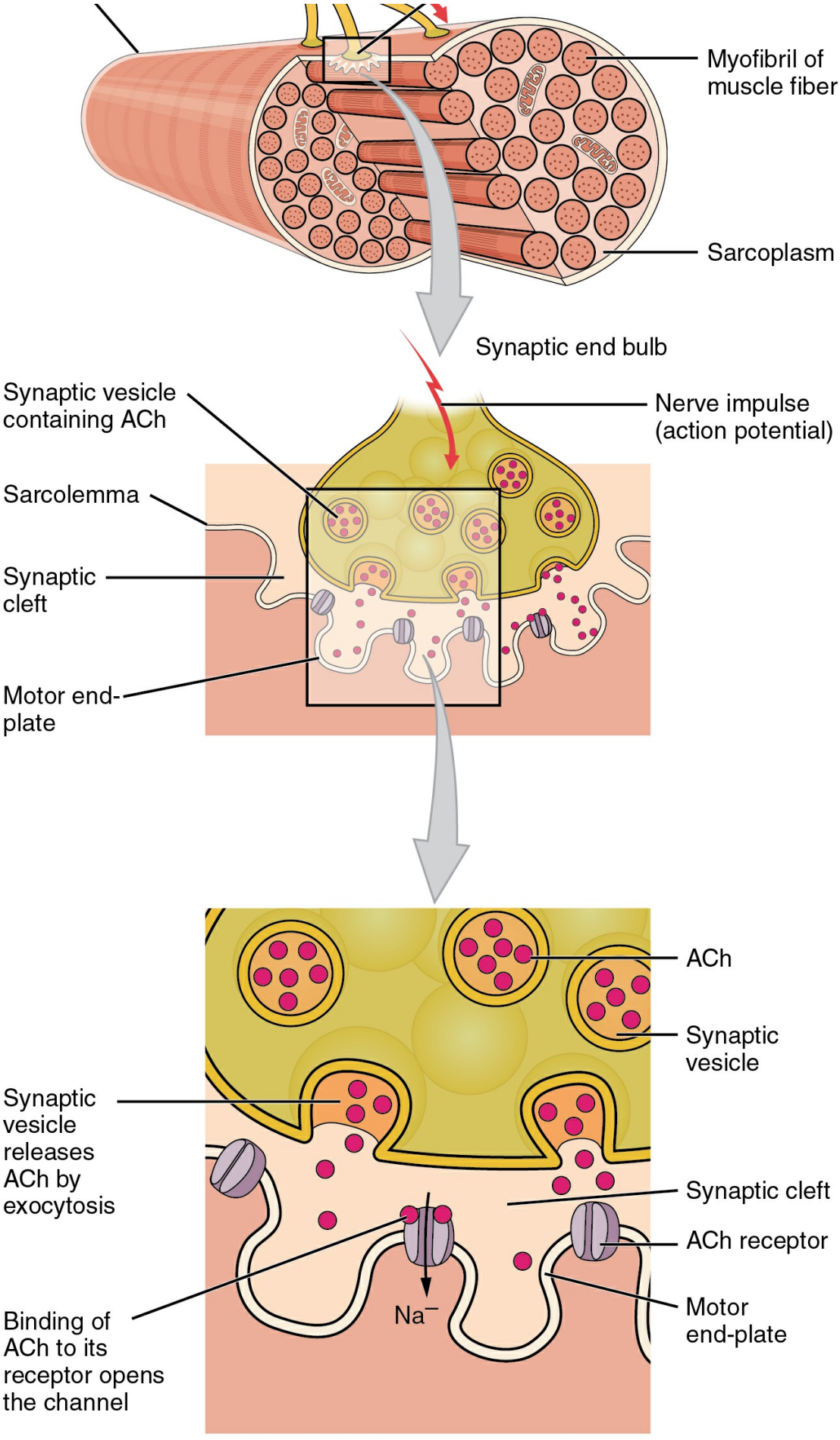
3. *The muscle fiber converts the chemical signal into mechanical work*

   The sarcoplasmic reticulum's released calcium binds to the protein troponin. Calcium-bound troponin forces tropomyosin to move, revealing the binding sites of actin, thereby allowing myosin to bind. In other words, troponin and tropomyosin normally wrap around actin like a shield, preventing myosin from binding and causing the muscle fiber to twitch when it's not supposed to. Calcium tells troponin to tell tropomyosin to drop the shield and allow actin and myosin to interact. This interaction pulls myosin along actin, causing the sarcomeres to shorten and the muscle fiber to contract.

4. *Relaxation*

   When the muscle contraction is done, the motor neuron will stop signaling to the muscle fiber. This causes calcium to move back into the sarcoplasmic reticulum. This means there's no calcium binding troponin, which means no troponin is telling tropomyosin to back off from the actin-myosin interaction. Tropomyosin returns to its position shielding actin from interaction with myosin, and the sarcomere relaxes.





IN CONTEXT

Think back to the lesson on homeostasis and bone remodeling. Remember how bone remodeling allows for our blood calcium levels to stay within a certain range? That range is necessary for these muscle contractions to occur. If blood calcium levels are too low, calcium will be removed from the bones so that the blood calcium level can increase. If blood calcium levels are too high, then that extra calcium will be deposited into bone.

TERMS TO KNOW

Neuromuscular Junction

The area where the end of a motor neuron comes close to a muscle fiber.

Synapse

The gap between the end of a motor neuron and a muscle fiber.

Neurotransmitter

A chemical messenger that carries signals across the synapse between cells.

Calcium

A mineral necessary for the proper development and mineralization, as well as proper nerve and muscle function.

MAKE THE CONNECTION

If you're taking the Human Biology Lab course simultaneously with this lecture, it's a good time to try the Muscle tissues: An overview Activity in Unit 3 of the Lab course. Good luck!

SUMMARY

There are several **steps of muscle contraction**. An electrical signal from the brain or spinal cord is sent along a motor neuron. When this signal reaches the neuromuscular junction (the tiny gap or synapse between the motor neuron and muscle fiber) electrical signal is converted to a chemical signal: A neurotransmitter called acetylcholine (ACH). This chemical signal stimulates the sarcoplasmic reticulum within the muscle fiber to release calcium. Calcium binds troponin, which forces tropomyosin to "un-shield" the active sites of actin. Myosin is now able to bind to actin, pulling the Z-discs of the sarcomere together, converting the chemical signal into mechanical work, and causing the muscle fiber to contract. Keep up the learning and have a great day!

Source: This work is adapted from Sophia Author Amanda Soderlind

ATTRIBUTIONS

- Thick and Thin Filaments | **Author:** Wikipedia | **License:** Creative Commons
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