Muscle Contractions: Micro Level

by Sophia

WHAT'S COVERED

In this lesson you will explore the micro-level view of muscle contractions, looking specifically at sarcomeres and how they act in order to produce a muscle contraction. Specifically, this lesson will cover:

1. Muscle Contraction Overview

Muscle **contractions** are the shortening of fibers within muscles, which act to generate force. The**sarcomere** is the basic unit of contraction. Muscle contractions rely on **calcium**. Calcium is stored by the **sarcoplasmic reticulum** and released during a muscle contraction.

TERMS TO KNOW

Contraction

A muscle fiber generates tension, causing the muscle to shorten.

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.

Calcium

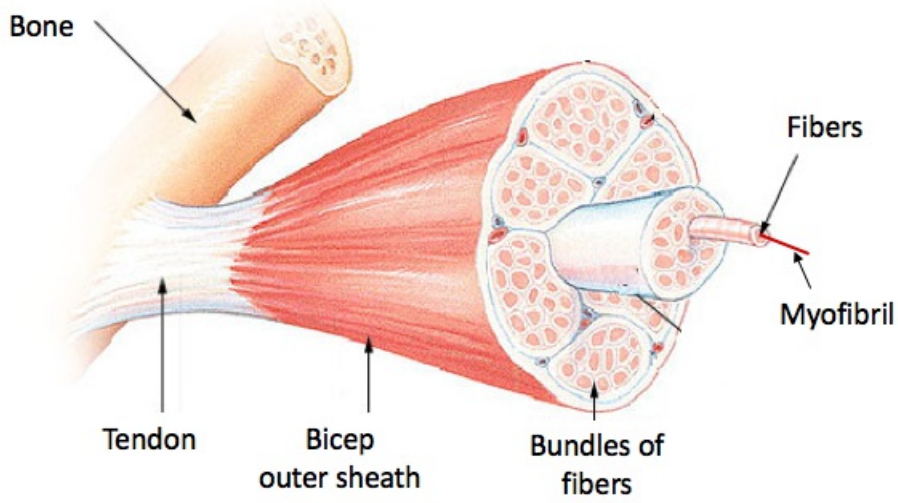
A mineral necessary for the proper development and mineralization, as well as proper nerve and muscle function.

Sarcoplasmic Reticulum (SR)

A specialized form of smooth endoplasmic reticulum (SER) found within skeletal muscles used for calcium storage.

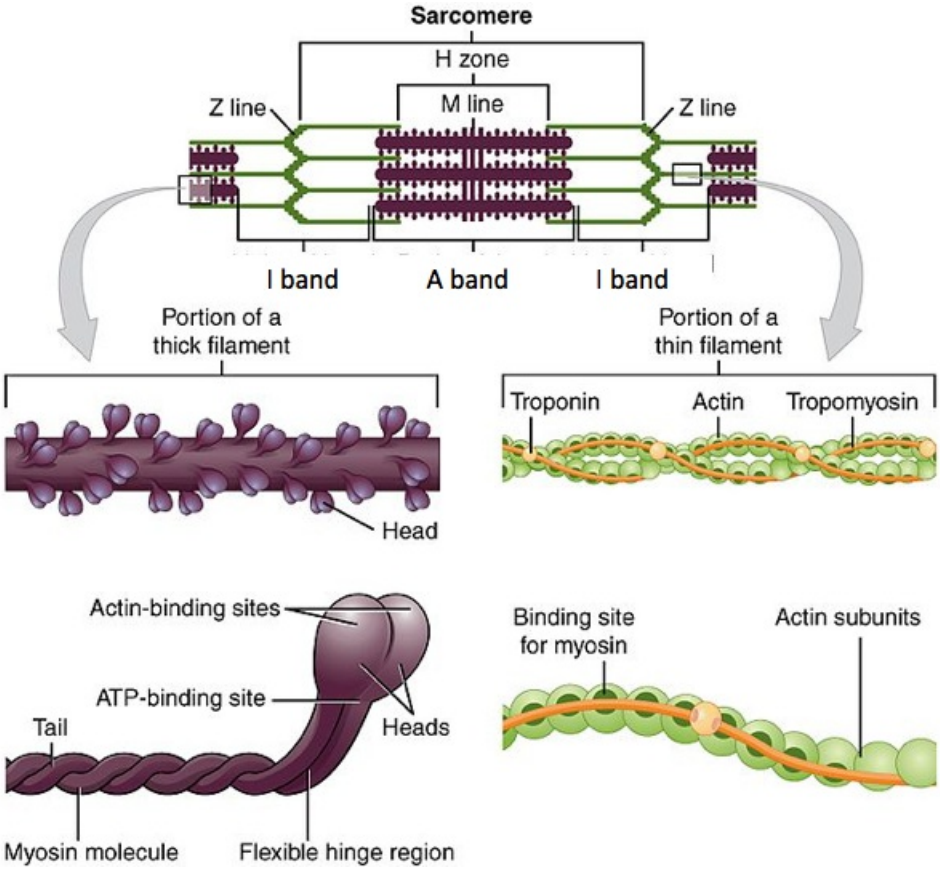
2. Structure of a Sarcomere

Use this diagram below to give you a general idea of what the sarcomere looks like. Remember from the previous lesson that a muscle cell (aka muscle "fiber") contains many **myofibrils**. Myofibrils have a banded appearance; when bundled together, they give muscles their striated, or striped, look. Sarcomeres, the basic unit of contraction, are portions of myofibrils.



The sarcomere has three regions:

- Z-bands: Mark the ends of sarcomeres. When a sarcomere shortens, or when a contraction happens, it's because Z-bands are moving closer together.
- I-bands: These are bands on either side of the Z-band where actin is not overlapped by myosin.
- A-bands: When a contraction happens, the thick and thin filaments are overlapping each other within our A-band region.



Within our sarcomere, we have something called thick and thin filaments. Those thick and thin filaments work together to produce a contraction. **Actin** is a protein that's referred to as the thin filament in a contraction, whereas **myosin** is the protein referred to as a thick filament.

Actin looks like a strand of beads, and the above image shows several molecules of myosin together. Just one molecule of myosin is composed of two heads and a tail. The heads play an important role in contraction.

TERMS TO KNOW

Myofibrils

Muscle cells (AKA muscle "fibers") contain myofibrils, which are long chains of myofilaments.

Myofilaments

Myofilaments are made up of proteins (mostly actin and myosin). Myofilaments make up myofibrils within muscle cells (aka muscle "fibers").

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.

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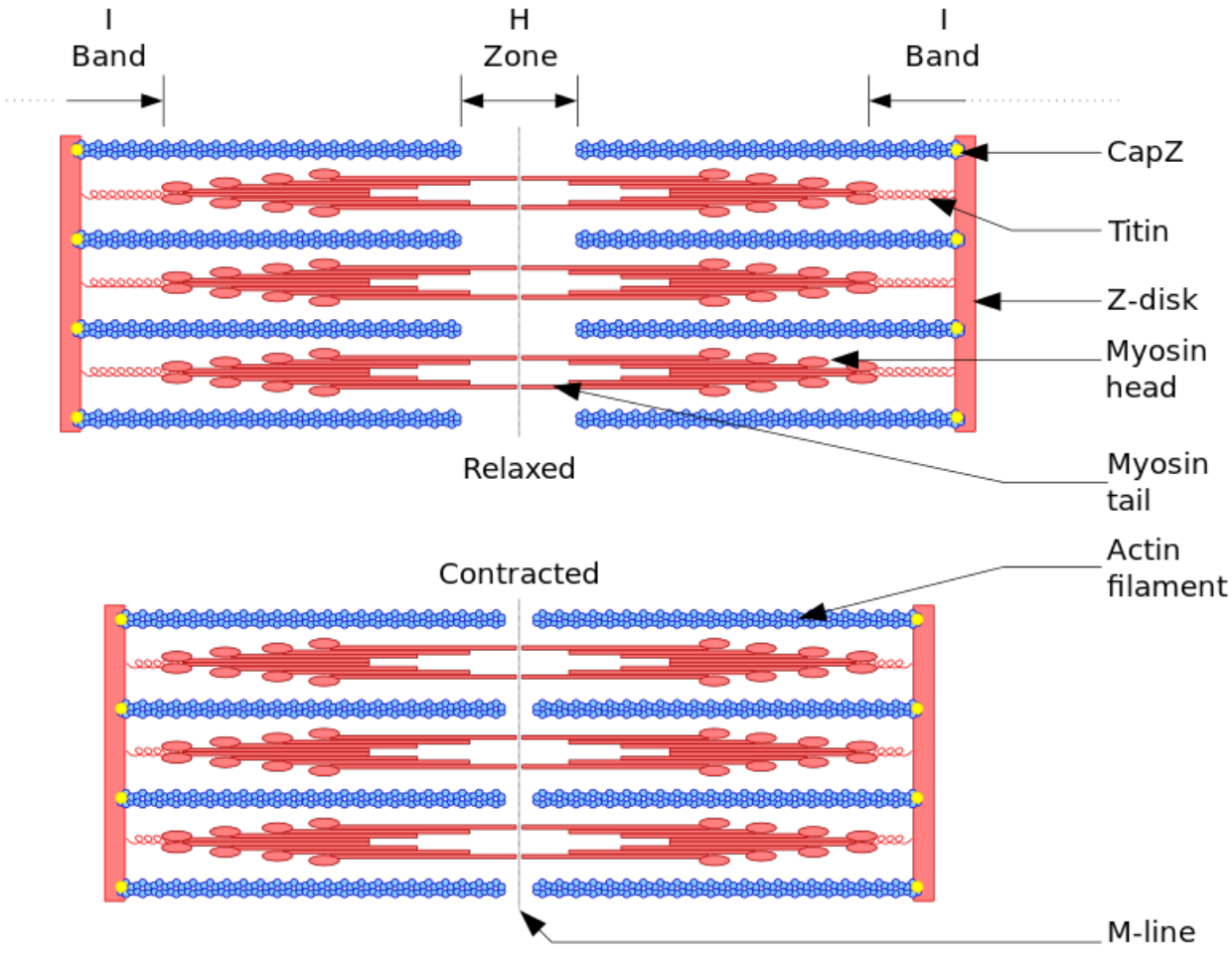
3. How Contractions Happen

Use the diagram below to visualize what's happening during a contraction.

Imagine this is one sarcomere. When a contraction happens, actin and myosin overlap with each other, and the Z-bands will move closer together. The top image is a relaxed muscle fiber, and the bottom is one that has contracted.



There are five main steps to a muscle contraction (called the **sliding filament mechanism**):

1. 1. A motor neuron sends an impulse (an **action potential**) to all the muscle fibers it innervates (together, the motor neuron and its muscle fibers are called a **motor unit**).
2. 2. Each muscle fiber's sarcoplasmic reticulum (SR—a type of endoplasmic reticulum-like organelle with muscle cells) releases calcium.
3. 3. Calcium prepares actin (the "thin" myofilaments) and myosin (the "thick" myofilaments) for interaction.
4. 4. Myosin binds to actin, and the myosin heads pull the actin filaments toward the center of the sarcomere (and the Z discs toward each other).
5. 5. **ATP** binds to myosin, allowing myosin to detach from actin, the sarcomere will lengthen (Z discs will move further apart), and the muscle will relax.

TERMS TO KNOW

Sliding filament mechanism
A theory used to describe how the microfilaments within the sarcomere interact with one another; actin and myosin cling together and slide past one another.

Action potential
The technical term for a nervous impulse; when a wave of depolarized electrical energy travels down the length of a cell/tissue.

Motor unit
The term used to describe one motor neuron and all of the muscle fibers it innervates at once.

ATP
The primary form of energy used by cells to perform work; is the nucleotide adenine (A) with three phosphate groups instead of one.

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4. Types of Contractions

There are two types of contractions that can occur:

- **Twitch**: a single contraction that happens in response to the firing of a motor neuron.
- **Tetanus**: a sustained contraction that's caused by repeated muscle twitches.

In other words, if a muscle twitches over and over again, it can sustain that contraction. Contractions are caused by impulses from the nervous system. An action potential is the technical term for these impulses, and a motor unit describes one motor neuron and all of the muscle fibers it innervates at once.

TERMS TO KNOW

Twitch
The way a skeletal muscle contracts, sarcomeres quickly pull inward and create a quick, jerky twitch.

Tetanus
A term used to describe a prolonged muscle contraction; often used to describe a person who has been exposed to the bacteria Clostridium tetani toxin.

SUMMARY

The sarcomere is the basic unit of contraction within muscle fibers and is made up of myofibrils. The **structure of the sarcomere** includes three regions: Z-bands, I-bands, and A-bands. Sarcomeres also have thin and thick filaments. **Contractions happen** when calcium is released, and myosin, the thick filament, binds to actin, the thin filament. They overlap in the A-band region, pulling the Z-bands closer together. There are two **types of muscle contractions**: twitch and tetanus. A twitch is a single contraction, while a tetanus is a prolonged contraction made up of multiple twitches. Keep up the learning and have a great day!

Source: THIS WORK IS ADAPTED FROM SOPHIA AUTHOR AMANDA SODERLIND

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Action Potential
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