The Muscular System

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Let's talk about the muscular system. So the muscular system is responsible for body movement, stabilizing joints, generating heat, moving substances within the body, and the muscles generate those forces to cause those movements by contracting. And that's a process will spend some time talking about specifically.

In addition to whole body movement, again, keep in mind that muscles move substances inside the body, and that could be the action of skeletal muscle. For example, the diaphragm pulling air into the lungs. Could be the function of smooth muscle like the muscle in the digestive tract moving food through the digestive system. Or the function of cardiac muscle pumping blood through the blood vessels.

So here are learning outcomes for this chapter. If you want to read through these right now you can pause the video, if you want to come back to them you can do so later.

Now remember the muscular system is composed of three kinds of muscle. We have touched on these before in our discussion of cells and tissues. So we have skeletal muscle, cardiac muscle, and smooth muscle.

Now as far as muscle characteristics, most muscle cells are elongated. Those that are elongated are called fibers. Now as we contract a muscle we typically shorten a muscle due to the movement of substructures called microfilaments, which we'll talk more about in a minute.

All muscles share terminology. So I would pay particular attention to these three prefixes. "Myo-" and "mys-" refer to muscle, and "sarco-," refers to flesh. So things like epimysium, myoglobin, sarcoplasm etc. all of those. If you see those prefixes you're talking about muscle.

Now, let's review characteristics of each kind of muscle just to refresh your memory. So remember skeletal muscles are typically attached to bones by tendons. Cells tend to be multinucleate because they're so long they are called muscle fibers. They have a striated or striped appearance, they are voluntary, that's a key, so they're subject to conscious control, and the cells are surrounded and bundled by layers of connective tissue. So if we look at a connective tissue wrapped skeletal muscle, we start with endomysium, which is here around one muscle fiber. Then we take a bundle of muscle fibers wrapped in endomysium and wrap them in perimysium. This is called a fascicle. That word makes me think muscle-sickle like popsicle. So a fascicle is wrapped in perimysium. And then the entire muscle, a group of fascicles are wrapped in epimysium, and then on the outside of that is a structure called fascia.

Now, skeletal muscle attachments are where epimysium blends into a connective tissue attachment like a tendon or an aponeurosis. So back in this figure, this epimysium, right, came off the muscle and then became this rope of that connective tissue covering, which is a tendon and is attaching that muscle to this bone.

Now we have two kinds of attachments, we can have a tendon, which is that rope-like structure, or we can have a sheet-like structure called an aponeurosis. So I just cropped out part of an image from your book to show you these sheet like structures which are aponeuroses. Even these small ones, they're not rope-like structures. So these are aponeuroses. Now sites of muscle attachment could be on bone, could be into cartilage, or could connect to another connective tissue covering from another muscle.

Now smooth muscle remember is not striated. It has spindle shaped fibers. So here in the center is one that's sort of tapered at both ends, there is only one nucleus per cell. This is involuntary muscle, and it's found in the walls of hollow organs like the GI tract, blood vessels, the uterus, the ureters, the bladder, etc.

Cardiac muscle is probably the easiest because it's only found in the heart. It is striated, so there's still that striped appearance, and a single nucleus per cell. But they also have these structures that are these dark pink lines. So these are stained intercalated discs, and these are intercalated discs or special gap junctions, so that when each of these cardiac muscle fibers gets the signal to contract it's immediately passed on to the next cell through this intercalated disc. So they all contract together. Again, cardiac is involuntary muscle and we already mentioned it is found only in the heart.

Now the function of muscles include movement production. That's the main one, but it's important that you keep in mind there are different kinds of movement. So muscle movement might move your leg to kick a ball, move your arm to wave, walk, right, do a back flip. Those are all skeletal muscle movements. Then we have smooth and cardiac muscle which contract to move substances through the body.

Now here are some examples of what muscles can do. They can contract to protect fragile organs. Have you ever had a sibling or friend say “Hit me in the stomach” and then they contract their abs really hard. So that's meant to protect their internal organs. Some muscles form valves to regulate the flow of things. Those valves are called sphincters. I know that's a funny word. It's good, you can giggle alone at home, but sphincters control the flow of everything from food leaving your stomach to the excretion of fecal material or urine. The way that you control when you go to the bathroom is through sphincters. Muscles can dilate or constrict the pupils of your eyes. Muscles can cause hairs to stand on end. (Remember arrector pili muscles are smooth muscle.) We just finished talking about the integumentary system where we talked about arrector pili muscles. And other functions of skeletal muscles include maintaining posture, stabilizing joints, and generating heat.

Let's zoom in on a skeletal muscle fiber. So we're going to talk about microscopic anatomy. But definitely make note we're only talking about skeletal muscle at this point. Now we said these cells are multinucleate, so underneath the sarcolemma, which is a muscle fiber membrane, we have three nuclei represented. We also have myofibrils. So we pulled one out here so you can see what it looks like. These are the organelles inside of muscle fiber and they are composed of tiny structures called sarcomeres, which we'll talk about shortly. So myofibrils pretty much fill the cell. There's also going to be sarcoplasmic reticulum spread throughout, which is a special kind of smooth ER that stores calcium. And calcium, as we will discuss shortly, is required for the final go signal for muscle contraction.

So myofibrils, if we zoom in on one myofibril, are composed of myofilaments right, so smaller proteins, that are lined up. That's what gives this pinstripe appearance. So when we were zoomed way out, this would be the dark stripe this would be the light stripe dark stripe and so on. Now, I would spend some time learning the terminology of the myofibril, because we have both thin myofilaments called actin, that's the protein that makes them up. Actin is the only protein found in the I band, which is also called the light band. So in our pin-striping, this is the light spot. This is the dark spot. So the light band or "I band" has actin. The A band or dark band also has some actin but mostly myosin. So they overlap there. And then we have a sarcomere. So I mentioned the sarcomere is the structural and functional unit of muscle, and we're going to talk about its borders being the Z discs. So half of this I band, this A band, and half of this I band at the Z disc, that is one sarcomere, one contractile unit of muscle fiber.

Now a sarcomere, and this is the same stuff just represented with different drawings. So we have myosin. So this would be the A band. And then we have a Z disk with actin, so this would be an I band. It's a quick easy way to remember that is that an A band, there's an A in dark and there is an I in light. And then we have our Z disc proteins. Now this particular drawing shows one other protein, which is the yellow spring, and that is the protein titin, which attaches myosin to the Z disc. So the thick filaments are myosin that's in pink here, and the protein myosin is an ATP enzyme. So each of these little heads is a little round bulb and has an ATP enzyme function. And what they will do during contraction is attach to the actin and force the actin toward the M line, toward the middle, so that there is more overlap. That will result in this Z discs coming closer together, or shorten, during contraction. Thin filaments, the actin, are in blue and they are composed of the protein actin plus some regulatory proteins that either block myosin from binding during relaxation, or in the presence of calcium move out of the way to allow myosin to bind to actin.

So we talked about how during contraction there will be more overlap. Which this drawing is still the same, but I have some better drawings that are going to illustrate that for you in a couple of short video Flix free to watch. So this is one figure that I think is very valuable. So as you look through the parts of a sarcomere and you read that section in your text, refer to this figure. So during relaxation we have a very clear H zone which is only myosin, in our A band, which is where they overlap. And then we have our I band out here around the Z disc where there's only actin and titin. But during contraction as myosin has contacted actin and pulled it inward toward the middle, we have more overlap. So during contraction, the area known as the H zone kind of goes away temporarily because there's no place where there's only myosin anymore. And the Z discs are closer together.