# Lesson: “Why do your biceps bulge?”

## VIDEO TRANSCRIPT

### EXPLORATION VIDEO 1

Hi, it's Doug! Have you ever seen a robot in real life? It's funny, you hear about robots a lot, but you don't see very many of them, unless you count things like this. This is a Roomba vacuum cleaner robot. Or there are robotic arms like this one that can paint and put together car parts for us. But I'm talking about more humanlike robots—robots that can do all the same things that we can do. Making robots as good as human beings is very hard, as you can see from this robot competition in 2015. Now to be fair, these were really big challenges for the robots. I'm only showing you some of the robots that couldn't balance very well. But look at this—some engineers have made really amazing robots though, like this one. It can walk just like us and even keep its balance over a bunch of rocks that would otherwise trip it up. Robots like this could be used to rescue people like during a disaster. But such incredible robots aren't very easy to make. So human beings still have to do the dangerous work of things like saving someone in a disaster. The fact is, our own bodies are really the ultimate robot. We're awesome. When we were babies, we figured out how to walk and balance ourselves, and then once we've learned that, well, then we can run up hills and throw balls and climb stairs and ride bikes. We're only just beginning to make robots that can do anything like that and definitely no robot can do this. This might sound a little crazy to say that our bodies are like amazing robots, but think about it—our bodies really do have a lot in common with robots. Robots run on fuel,

like a battery. Well, the human body uses fuel too—we run on food. Robots also have sensors and a computer inside that figure out and tell the robot where to go. Well, the human body has something like that too, that's your brain and your senses. And then there's movement. You can see that this robot has something similar to legs, some kind of plates and rods that are somehow able to move. Or this robotic hand—look here, check out how this moves. You can see that each robotic finger contains tiny rods of wood, each one pulled on by strings that are attached to little motors. If we're so much like robots, how is it that our own bodies move? Like to take this hand, for example, it moves by motors pulling strings. Do we have something like that in our hands? How does our own human body, the human machine, work? Do you have any ideas? What might be going on inside your hand when you're moving your fingers?

## EXPLORATION VIDEO 2

You might not be sure if you have strings and motors in your hands, but you definitely have little rods in your hands. They're your bones. If you ever get an x-ray, like this one, you can see your bones beneath the skin. Your bones are like the frame, or structure, of your body. They are what give you support. Now, it's kind of crazy to think about, but imagine what would happen if you didn't have bones. Without your bones, you'd just be like a pile of muscles and skin and organs on the floor, kind of like a slug. If you want to stand up, you need bones. Any kind of object that stands upright needs some kind of frame or support. This is true even for objects that don't move, like skyscrapers. People sometimes even call the skyscraper's beams the skeleton of the building. But the skeleton of a building is designed to stand still. Each beam is tightly bolted into all the other beams and welded, or really tightly joined, so that it can't move or wiggle at all. A skyscraper is one solid structure. That's not true of the human body's structure. The human body has many individual bones for structure. Most of them are not tightly linked to each other,

so they're able to move at each place where the bones meet. We call these moving places the joints. Take a few moments to move the different parts of your body and see if you can find all of your joints.

## EXPLORATION VIDEO 3

Did you find all your joints? These are all the places where you can move. Notice how you can move at the fingers. You can move at the wrist, the elbow. You can move at the knee, the ankle, the toes, the shoulders, the neck, and the jaw. OK, so there are rods inside of us in the form of bones. But then how is it that we can make these bones move? You saw that this robotic hand had little motors and strings. Do we have anything like that? Is that what makes our bones move, little strings pulling on them like this? Well, if you bend your hand back like this and you move your fingers, it looks and feels like there's some strings there. Go ahead and try it. Do you see those? Do you feel them? OK, hopefully you've had time to see this on your own hand now. Are there really strings in there? It'd be great if we could look inside. Now there's not an easy way for you all to look inside your body at this moment. But you know, we're not the only thing that moves around and has bones. This is a piece of fried chicken, like you might eat for dinner. I don't want to gross you out, but you know, if we rewind in time just a little bit, this was once a raw piece of meat. It was the leg from a chicken. You See Recognize the drumstick shape there? That's part of the chicken leg. Underneath all that meat, if you carefully cut away the meat, you'll find the leg bones, which you know if you've ever eaten chicken. And if you look, you see there actually is a string that's attached to the bone. So there really are strings in the body attaching to each bone. But now, this is a leg. So what about a hand, like the robot we saw? Well, chickens don't have hands. They have wings. But they do have feet that look pretty hand-like. Even if you don't eat those parts, there's no sense in letting it go to waste, so in a

minute I'm going to show you a chicken foot and how it works. Now I understand some people might find this a little gross, but by cutting apart and observing the different body parts, that's actually how scientists have learned about how the bodies of living things work. It's called dissection. OK, you ready? So, see this? This is a chicken's foot. You can see here are the toes and you notice down here there really are strings. There they are. And just like that robot hand, look at this. If I pull on them, you see that? See how that works? I can actually control each toe by pulling on a different string. Isn't that cool? Your fingers work the exact same way. Crazy, huh? But now this is just me pulling on each string, using my fingers and a pair of tweezers. So when the chicken was alive, what was it that would have been pulling the strings? Obviously, the chicken somehow could pull on these strings, but how? In the robot hand, there were little motors pulling on the strings. Is it something like that? What do you think pulls on these strings when the chicken is alive?

## EXPLORATION VIDEO 4

When we find one of these strings, like this one, one end of the string is attached to the bone over here. But if we follow the string back, we can see it attaches to this. This is the part that people eat. You might call it the meat. Now, I don't know if you've thought about this before, but this is actually the muscle. Anytime someone eats meat, they're eating muscle. So if you were ever curious what real muscle looks like, just look in a kitchen where meat is being prepared. The one you've been looking at here is chicken muscle. But here's what the muscle of a fish looks like. And here's the muscle of a cow, or what we call beef. Our own human muscles look similar to this, reddish-colored, and kind of like raw meat. So unlike a robot, your body doesn't have little motors that pull on strings. It's muscles that pull on the strings, which then causes the bones to move. That's what makes you move. You can actually feel this. Go ahead and observe

now what happens when you move your arm like this. Can you feel which muscle you're using to do this movement? Feel all around your arm, like this, as you're moving it. Look for the muscle that's tensing up beneath the skin. Did you find it yet? The muscle you're using to move your arm is right here. It's called your biceps. Do you feel your biceps tensing up as you move your arm? This is how your body moves. You really are like a robot. Let me show you. Here's a drawing of the inside of your arm. Now, if we could watch what happens on the inside as you tense your biceps—watch this—you see that? By tensing up the muscle, you're making it bulge. You might notice it's getting all bunched up when it bulges. But look here on the end of the biceps, where the arrow is pointing. When the muscle bulges, it gets shorter. You see that? That's the key to understanding how the muscle controls your bones. Because remember, as we saw in the chicken bone, there's a string that connects each muscle to the bone in front of it. So when the biceps bulge, they shorten. And so the string pulls on the bone in front of it, like this, making that part of the arm move at the joint. You see how that works? All your other muscles work this exact same way. Here's a drawing of what it would look like inside your leg at the knee. You can see the muscle bulges, which pulls on the string, which moves the bone at the joint. The string part even has a scientific name. It's called a tendon, if you've ever heard people use that word. So now you know what's going on inside your body whenever you move. You're tensing up your muscles, which pulls on tendons and makes your bones move. Think back to the hand and fingers now. Which muscle or muscles do you think pull on the tendons or strings that control each of your fingers? Take a moment right now. See if you can figure it out. Feel all around your arm while you wiggle your fingers, just like this. And see if you can find any muscle that's bulging. Do you feel it? Can you feel how it's the muscle right here in your lower arm? Put one hand on it now, and feel it as you wiggle those fingers. Now, you might be able to feel it tensing up as it pulls the strings, or tendons, that pull your finger bones. So now, what do you

think? If you were going to design your own robot hand, do you know enough now that you could create your own model? How could you create a robot hand that works just like yours?

## ACTIVITY INTRODUCTION VIDEO

In today's activity, you're going to make one of these—a robot finger. It's a lot bigger than your real finger, but it works the same way. It's divided into three sections at the top, just like in a real finger. The robot finger also has a fourth section at the bottom, which in a real hand, is right here. It's the long bone in your palm that connects to your wrist. The finger bends in the same places as your real finger. The joints are here, here, and here, where the bones meet. Each of the joints acts like a hinge, allowing the robot finger to bend in those places. Notice there's also a string that runs all the way through the finger, connecting the paper bones. That string is just like the tendons in your real hand. When the string is pulled, the paper bones bend, moving the finger. Here's how you can make one, step by step.

## ACTIVITY STEP 1

Get your supplies. When you're done with this step, click the arrow on the right.

## ACTIVITY STEP 2

Look at the picture of the finger bones on your handout. Try to feel these bones in your own pointer finger.

## ACTIVITY STEP 3

Cut along the dashed lines to cut out the rectangle.

## ACTIVITY STEP 4

Put the rectangle on your notebook. Trace all six gray lines. Use a ruler to help you make the line straight, like this. Tracing these lines will make folding much easier in the next step.

## ACTIVITY STEP 5

Turn your paper over. Then fold all six lines you just traced, like this. Make a good crease on each fold. The better you fold, the better your robot finger will work.

## ACTIVITY STEP 6

Fold the paper in half lengthwise, like this. Use your scissors to cut out the triangles.

## ACTIVITY STEP 7

Get your three-by-five card. Then follow the steps below to cut off a two-centimeter strip.

## ACTIVITY STEP 8

Use the strip to cover the gray rectangle on the paper. Then, tape it down with a sticker at the bottom, like this.

## ACTIVITY STEP 9

Take a paperclip and look for the end that has only one loop. Tie the string to that end, like this. Make sure it looks like this when you're done. Set this paperclip aside.

## ACTIVITY STEP 10

The next steps are tricky. Find a partner to help.

## ACTIVITY STEP 11

Watch this whole step before you do anything. Fold the paper into a triangular tube like this, with the bones on the outside. Partner, you're going to slide the paperclip with no string over bone number 4 to hold the tube closed.

## ACTIVITY STEP 12

Watch this whole step before you do anything. Turn the tube like this. And partner, slide the paperclip down the tube while holding the string. Then put the paper clip over bone number 1, like this. Your robot finger will work best if the knot is right at the tip of the finger.

## ACTIVITY STEP 13

Hold the palm end of the tube and pull the string. Compare the robot finger to your finger. How are they the same?

## ACTIVITY STEP 14

Do the following with your partner and then with your class.

## ACTIVITY STEP 15

If you have time, look in the Extras to find out how to turn four robot fingers into a robot hand. It can move each finger independently and even throw a ball. Have fun!