Inside the Grip

Trace how a muscle fiber contracts and relaxes.

HS-AP4-2 "Develop a model to illustrate the components of a muscle fiber and how they interact in contraction and relaxation."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Circle muscle-fiber parts, underline actions that connect one part to another, and number the actions from the electrical signal through relaxation. Use your marks to build a cause-and-effect model.

Squeeze, Then Release

1. When you squeeze a bicycle brake, signals from a motor neuron reach muscle fibers in your forearm. Each fiber is one long cell enclosed by a cell membrane. Deep inside are myofibrils made of repeating units called sarcomeres. In each sarcomere, thin filaments contain actin, and thick filaments contain myosin. The sarcoplasmic reticulum, a membrane network around the myofibrils, stores calcium ions. An electrical signal travels along the fiber's membrane and down narrow tubes called T tubules. This signal causes the sarcoplasmic reticulum to release calcium into the fluid around the filaments.

2. Calcium binds to troponin on the thin filament. Troponin changes shape and shifts tropomyosin, a strand that normally blocks myosin-binding sites on actin. Exposed sites let myosin heads attach to actin. A myosin head pulls the thin filament toward the center of the sarcomere, bringing its ends closer together. ATP then binds to myosin, making it detach from actin. Myosin uses energy released when ATP is split to reset its head for another pull. If calcium and ATP remain available, repeated attachments and pulls shorten many sarcomeres, so the fiber develops force.

3. When you let go of the brake, the motor neuron stops triggering electrical signals in those fibers. Calcium release from the sarcoplasmic reticulum stops, and pumps use ATP to move calcium back into that network. As calcium levels around the filaments fall, calcium leaves troponin. Tropomyosin returns to cover the binding sites on actin, preventing new myosin attachments. Attached myosin heads can still detach when ATP binds. Without continued pulling, the fiber's active force falls. Other forces, such as a pull from an opposing muscle, can then lengthen the relaxed fiber; its filaments themselves have not shrunk or grown.

2 ANSWER WITH EVIDENCE

Use the passage

1. In a model, where would you place the sarcoplasmic reticulum and T tubules relative to the myofibrils? What action would an arrow between them show?

2. Between calcium release and the first myosin-to-actin attachment, what changes would your model need to show?

3. How would you use two arrows to show ATP's roles during repeated pulls?

4. In a relaxation model, what changes stop new myosin attachments, and what happens to the fiber's active force?

3 YOUR TURN

Your own words

A climber grips a hold, then opens their hand to release it. Draw two labeled panels for one forearm muscle fiber, gripping and released. Include actin, myosin, troponin, tropomyosin, calcium, the sarcoplasmic reticulum, and ATP; use arrows and brief notes to show what changes and what stays the same.

ANSWER KEY

Inside the Grip

HIGH SCHOOL · HS-AP4-2

PART 1 · READ AND MARK

Circle muscle-fiber parts, underline actions that connect one part to another, and number the actions from the electrical signal through relaxation. Use your marks to build a cause-and-effect model. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	In a model, where would you place the sarcoplasmic reticulum and T tubules relative to the myofibrils? What action would an arrow between them show?	**Place the sarcoplasmic reticulum around the myofibrils and show T tubules carrying the electrical signal inward. An arrow shows that the signal causes the reticulum to release calcium.**
2	Between calcium release and the first myosin-to-actin attachment, what changes would your model need to show?	**Calcium binds to troponin, which shifts tropomyosin away from the binding sites on actin. Myosin can then attach.**
3	How would you use two arrows to show ATP's roles during repeated pulls?	**One arrow shows ATP binding to myosin and causing detachment from actin. Another shows ATP splitting and supplying energy to reset the myosin head.**
4	In a relaxation model, what changes stop new myosin attachments, and what happens to the fiber's active force?	**Pumps return calcium to the sarcoplasmic reticulum. Calcium leaves troponin, so tropomyosin covers the actin sites and new attachments stop. Active force falls.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Gripping panel: Draw an actin thin filament and a myosin thick filament with a myosin head attached to actin. Label troponin with calcium bound and tropomyosin shifted off the binding site. Draw an arrow from the sarcoplasmic reticulum to calcium near the filaments, a myosin pull arrow toward the sarcomere center, and a note: ATP lets myosin detach and reset for another pull. Released panel: Draw the same filaments, troponin, tropomyosin, and sarcoplasmic reticulum. Draw an arrow showing calcium pumped back into the reticulum using ATP. Label troponin without calcium and tropomyosin covering the actin site. Show myosin detached and note that active force falls.

Accept models that show the correct sequence and distinguish ATP's roles in myosin cycling and calcium pumping. Relaxation reduces active force; the filaments do not shrink or grow.