The Muscle Switch

Trace the molecular events that make a muscle pull and release.

HAP.5.3 "Explain the molecular mechanism of muscle contraction and relaxation."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Circle every mention of calcium and ATP. Then number the events that explain how the muscle fiber contracts and relaxes in the order they occur.

Lifting and Releasing a Bag

1. When you lift a grocery bag, your forearm flexor fibers shorten because tiny myosin heads repeatedly pull on actin filaments. A motor neuron releases acetylcholine at the neuromuscular junction. This chemical binds receptors on the muscle fiber, starting an electrical impulse along its membrane and into narrow T tubules. The impulse causes the sarcoplasmic reticulum, an internal storage network, to release calcium ions into the fiber. In each sarcomere, actin and myosin are arranged in overlapping filaments. The filaments do not shrink. Instead, they slide past one another, shortening the sarcomere and producing force.

2. At rest, tropomyosin covers binding sites on actin, so myosin heads cannot grab actin. Released calcium binds troponin, a protein attached to tropomyosin. Troponin changes shape and moves tropomyosin away from those sites. A myosin head energized by ATP hydrolysis binds exposed actin. It then releases phosphate and pivots, pulling actin toward the sarcomere's center; this movement is the power stroke. ADP leaves the head. A new ATP molecule binds myosin, making it detach from actin. Myosin breaks down that ATP to reset the head, ready to bind actin again while calcium remains available.

3. When you set the bag down and stop contracting, the motor neuron stops releasing acetylcholine. Acetylcholinesterase breaks down acetylcholine in the junction, so new electrical impulses stop. Calcium pumps in the sarcoplasmic reticulum use ATP to move calcium out of the cell fluid and back into storage. As free calcium falls, it separates from troponin. Tropomyosin again blocks the binding sites on actin, preventing new cross-bridges. Existing myosin heads detach when ATP binds, and cycling ends. The filaments can slide back toward their resting positions as opposing muscles or other forces lengthen the relaxed fiber.

2 ANSWER WITH EVIDENCE

Use the passage

1. How does a signal from a motor neuron cause calcium to enter the muscle fiber's cell fluid?

2. Why can myosin bind actin after calcium is released, but not before?

3. Explain how ATP helps myosin heads repeat their pulls on actin.

4. How does stopping the nerve signal lead to the end of cross-bridge cycling?

3 YOUR TURN

Your own words

A student says, "A muscle relaxes because its filaments shrink back when ATP runs out." Write 5 or 6 sentences correcting the claim. Explain how calcium and ATP affect pulling and relaxation, why running out of ATP would not cause normal relaxation, and what can lengthen a relaxed fiber.

The Muscle Switch

PART 1 · READ AND MARK

Circle every mention of calcium and ATP. Then number the events that explain how the muscle fiber contracts and relaxes in the order they occur. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	How does a signal from a motor neuron cause calcium to enter the muscle fiber's cell fluid?	**The neuron releases acetylcholine, which binds muscle fiber receptors and starts an electrical impulse. The impulse travels into T tubules and causes the sarcoplasmic reticulum to release calcium.**
2	Why can myosin bind actin after calcium is released, but not before?	**Calcium binds troponin, causing tropomyosin to move away from the myosin-binding sites on actin.**
3	Explain how ATP helps myosin heads repeat their pulls on actin.	**A new ATP molecule binds myosin and makes it detach from actin. Myosin then breaks down ATP to reset its head for another pull.**
4	How does stopping the nerve signal lead to the end of cross-bridge cycling?	**Acetylcholine is broken down, so new impulses stop. ATP-powered pumps return calcium to storage; calcium leaves troponin, and tropomyosin blocks actin's binding sites again.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Actin and myosin filaments slide during contraction; the filaments themselves do not shrink. Calcium binds troponin, shifting tropomyosin and exposing actin sites so myosin can pull. ATP lets myosin detach from actin and resets myosin for another pull. When nerve signals stop, ATP-powered pumps move calcium back into storage, so tropomyosin blocks actin again. If ATP runs out, myosin cannot detach normally and the calcium pumps cannot work. An opposing muscle or another external force can lengthen a relaxed fiber.

Accept answers that describe the same causal sequence without naming every protein. For the final task, look for the distinction between stopping molecular pulling and an external force lengthening the relaxed fiber.