Inside the Push

Trace how one muscle fiber contracts and relaxes.

HAP.4.a "Model the cellular physiology of skeletal muscle, including how the cell functions in muscle contraction and relaxation."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each signal or ion movement, circle the cell structures it affects, and number the events from the motor neuron's signal through relaxation.

A Runner Pushes Off

1. At the starting line, a runner hears the gun and pushes off the track. The command to a leg muscle travels along a motor neuron. At its ending, the neuron releases acetylcholine into the narrow space beside a skeletal muscle fiber. Acetylcholine binds receptors on the fiber's surface, starting an electrical signal. The signal spreads across the membrane and down narrow tunnels called T tubules. This change makes the sarcoplasmic reticulum, a storage network inside the fiber, release Ca^{2+} into the cell fluid. The ion's arrival connects an electrical message to a mechanical response.

2. Inside the fiber, repeating units called sarcomeres contain thin actin filaments and thick myosin filaments. At rest, tropomyosin covers binding sites on actin. Released Ca^{2+} binds troponin, which shifts tropomyosin aside. Myosin heads can now attach to actin. A head pulls actin toward the sarcomere's center, then a new ATP molecule binds the head and releases it from actin. Energy from ATP breakdown resets the head for another pull. Repeated cycles make the filaments slide past each other and shorten the sarcomere. Neither filament itself gets shorter; many shortening sarcomeres create tension in the whole muscle.

3. When the motor neuron stops firing, acetylcholine is broken down and the fiber's electrical signals end. Pumps in the sarcoplasmic reticulum use ATP to move Ca^{2+} back into storage. As Ca^{2+} leaves troponin, tropomyosin again covers actin's binding sites. Myosin can no longer make new attachments. ATP also lets attached myosin heads release actin, so active pulling ends and tension falls. Relaxation is not simply a lack of energy: moving Ca^{2+} and releasing myosin both require ATP. A muscle may then be stretched toward its earlier length by an opposing muscle or an outside force.

2 ANSWER WITH EVIDENCE

Use the passage

1. Trace the path from acetylcholine binding to Ca^{2+} entering the fiber's cell fluid. Which structures carry or respond to the signal?

2. Explain how released Ca^{2+} allows a sarcomere to shorten without either filament getting shorter.

3. Model two different jobs ATP performs in this fiber, one during repeated pulling and one during relaxation.

4. Suppose the Ca^{2+} pumps stop working after the nerve signal ends. Predict what happens to the actin binding sites and explain why.

3 YOUR TURN

Your own words

Draw three labeled panels showing one skeletal muscle fiber before a nerve signal, while it contracts, and after the signal ends. In each panel, show where Ca^{2+} is, whether myosin can attach to actin, and what ATP does or is available to do.

Inside the Push

PART 1 · READ AND MARK

Underline each signal or ion movement, circle the cell structures it affects, and number the events from the motor neuron's signal through relaxation. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Trace the path from acetylcholine binding to Ca^{2+} entering the fiber's cell fluid. Which structures carry or respond to the signal?	**Acetylcholine binds receptors on the fiber's surface. An electrical signal spreads across the membrane and down T tubules, causing the sarcoplasmic reticulum to release Ca^{2+}.**
2	Explain how released Ca^{2+} allows a sarcomere to shorten without either filament getting shorter.	**Ca^{2+} binds troponin, shifting tropomyosin away from actin's binding sites. Myosin heads attach and pull actin, sliding the filaments past each other and shortening the sarcomere.**
3	Model two different jobs ATP performs in this fiber, one during repeated pulling and one during relaxation.	**During repeated pulling, ATP binds myosin to release it from actin, and ATP breakdown resets the head. During relaxation, pumps use ATP to return Ca^{2+} to storage.**
4	Suppose the Ca^{2+} pumps stop working after the nerve signal ends. Predict what happens to the actin binding sites and explain why.	**Ca^{2+} would remain in the cell fluid and bound to troponin. Tropomyosin would not fully cover actin's binding sites, so myosin could keep making attachments while ATP is available.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Panel 1, before the signal: Most Ca^{2+} is stored in the sarcoplasmic reticulum. Tropomyosin blocks actin, so myosin cannot attach. ATP is available, but no pulling cycle occurs. Panel 2, contraction: Ca^{2+} has entered the cell fluid and bound troponin. Myosin attaches to actin and pulls; ATP releases and resets the heads for more pulls. Panel 3, after the signal: ATP-powered pumps return Ca^{2+} to storage. Tropomyosin blocks actin again, and ATP releases attached myosin heads, so active pulling ends.

Accept models that show Ca^{2+} release exposing actin binding sites and ATP supporting myosin cycling. For relaxation, look for ATP-powered Ca^{2+} return, blocked binding sites, and an end to active pulling.