The Contraction Cycle Lab: Teacher Guide

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Driving question. How does one nerve signal make a muscle pull, and what lets it let go?

District section

BPS A&P Unit 2, Support and Movement, Chapter 8, Section 8.3 Skeletal Muscle Contraction (Student Edition pp. 300-311), with the nervous stimulation part of 8.2 (pp. 294-300): identify the major events of skeletal muscle fiber contraction. Used from the district list: Visual Literacy: Storyboard Activity (Tab 1 event log and Question 1), Labeling Activity: Structures Involved in Muscle Contraction (Tab 1 labels, Questions 4 and 5), Virtual Lab: Skeletal Muscle Electrical Stimulation (Tab 1 Send signals), Use the Practices 8.3: Constructing Explanations (Question 16) and Additional Discussion Questions (Question 15). **Additions** beyond the district list: the one-head cross-bridge stepper with an ATP count (Tab 2) and the break-one-step cases (Tab 3). Energy sources, oxygen debt and fatigue are left for the later 8.3 lessons. Band measurement and the sliding filament model come on Friday.

NYSSLS alignment

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms (nervous system to muscle fiber to proteins, Tab 1). **HS-LS1-1.** Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells (actin, myosin, troponin and tropomyosin each do one job, Tab 2).

SEP 2 Developing and Using Models: Tab 1, Question 5. **SEP 5** Using Mathematics: Questions 3 and 8. **SEP 6** Constructing Explanations: Questions 11, 15, 16. **CCC 2** Cause and Effect: Tab 3, Question 14. **CCC 4** Systems and System Models: Tab 1. **CCC 6** Structure and Function: Questions 6, 10, 11.

Opening: pick a phenomenon

Option	What it is	Notes
Video	Greg Gage, How to control someone else's arm with your brain (TED, 2015). Watch 0:00 to 2:30: one person's nerve signal makes another person's arm move. Backup: Backyard Brains Human-Human Interface demo.	Both checked to embed. Times picked from the talk outline, not watched end to end: preview first. Stop before the explanation.
Activity	Catch the Ruler: a partner drops a 30 cm ruler between your fingers; read where you caught it. 3 minutes, one ruler per pair.	A catch at 10 cm is about 0.14 s. Most of that is the brain; the muscle part takes milliseconds.
Photos	Galvani's frog legs (1791 engraving) and a sprinter in the blocks.	Both real images. Ask: what makes a muscle pull, even in a dead frog?

Part by part

Part 1, Tab 1. Questions 1 to 3 are explore: students read the event log and the graph. The Learn It opens after the full run and the SR click. Questions 4 to 6 are apply, with the order chips in the lab.

Part 2, Tab 2. Questions 7 to 8 are explore. The Learn It opens after 3 strokes, one blocked grab and rigor. Questions 9 to 11 are apply, with the step order and ATP chips in the lab.

Part 3, Tab 3. Questions 12 to 13 are explore. The Learn It opens after all six runs. Questions 14 to 16 are apply; the lab adds three new cases (krait venom, Lambert-Eaton, Brody disease).

Misconceptions to watch. "A muscle needs energy to pull but not to relax" (Question 15 and the after-death run answer it). "The nerve signal itself slides the filaments" (it skips calcium; the dantrolene run shows a full impulse but a weak pull).

The model and its limits

Tab 1 times are rounded for a fast human fiber and slowed down; one fiber stands for a whole muscle. Tab 2 shows one head on one actin thread; real fibers have millions of heads cycling at different times, so a real muscle never lets go all at once. Tab 3 pull values are chosen to show each case, not measured; real patients vary. The after-death case is shown as locked stiff, not as an active pull. The illustrations are AI-generated and checked; not to scale.

Sources

Hole's Essentials of Human Anatomy & Physiology, Chapter 8 (order of events). Katz and Miledi, 1965, Proceedings of the Royal Society B, synaptic delay at the neuromuscular junction (about 0.5 ms). Finer, Simmons and Spudich, 1994, Nature, single myosin molecule steps of about 11 nm. Drachman, 1994, New England Journal of Medicine, myasthenia gravis (antibodies against ACh receptors). Montecucco and Schiavo, 1994, Molecular Microbiology, botulinum toxin blocks ACh release. Krause and others, 2004, Anaesthesia, dantrolene.

Organophosphate nerve agents block acetylcholinesterase (Eddleston and others, 2008, Lancet). Rigor mortis timing from Saukko and Knight, Knight's Forensic Pathology. Pictures are credited on the lab page.