Sliding Filament Lab: Teacher Guide

mrsajdak.com/sliding-filament · Anatomy & Physiology, one lesson · © Ryan Sajdak · CC BY-NC-SA 4.0. The answer key is a separate file, off the public site.

Driving question. A muscle can get shorter by centimeters, but none of its protein threads get shorter. How?

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 bands from 8.2 (pp. 294-300): describe the sliding filament model; name the bands of a sarcomere and the filaments in each. Used from the district list: Theme Activity, The Sliding Filament Model (all three tabs), Use the Practices 8.3, Constructing Explanations (Q7 and Q16), the APR sarcomere histology (the real micrograph in the Do Now and the Learn It), and the Labeling activity, Structures within a Sarcomere (Q5). **Additions** beyond the district list: measuring the bands on a ruler, the sarcomeres-in-series math in Tab 2, and the length-tension data in Tab 3.

Not in this lab. The steps of the cross-bridge cycle (calcium, ATP, power stroke) are Thursday's lesson. Here a myosin head that reaches actin simply counts as one that can pull.

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 (filaments, sarcomere, fiber, muscle). **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 and myosin are proteins whose shape and overlap set the force).

SEP 2 Developing and Using Models: Tab 1, Questions 5 to 7. **SEP 4** Analyzing and Interpreting Data: Questions 13 to 14. **SEP 5** Using Mathematics: Questions 6, 10, 12. **SEP 6** Constructing Explanations: Question 16. **CCC 2** Cause and Effect: Tab 3. **CCC 3** Scale, Proportion, and Quantity: Tab 2. **CCC 4** Systems and System Models: the sarcomere model. **CCC 6** Structure and Function: Tab 1.

Opening: pick a phenomenon

Option	What it is	Notes
Video	Skeletal Muscle Cell Contraction (Laurie Shannon Meadows, 46 seconds): a real muscle cell under a microscope shortening, its stripes moving closer. Backup: Muscle contractions under microscope pt 2 (Caleb Schwenk, 22 seconds).	Both checked to embed. Not watched end to end: preview both.
Activity	Finger Slide: lace your fingers, tips touching, then slide them together. Your hands get closer. Did any finger get shorter? 2 minutes, no materials.	Fingers are filaments, palms are Z discs.
Photo	The Stripes: the real electron micrograph from the Do Now, bands unlabeled.	Louisa Howard, public domain.

Part by part

Part 1, Tab 1. The bands are colored but named only by letter on the strip until the Learn It. Questions 1 to 4 are explore. Students measure four bands in two states (8 checks; within 0.02 µm counts). The Learn It opens after all 8. Questions 5 to 7 are apply, with the stretched prediction in the lab. The misconception to watch: the filaments (or the A band) get shorter.

Part 2, Tab 2. Questions 8 to 10 are explore. The Learn It opens after all three fibers, one "Only one sarcomere" try and the right percent. Questions 11 to 12 are apply.

Part 3, Tab 3. Questions 13 to 14 are explore. The Learn It opens after five recorded lengths, one under 2.0 µm and one over 3.0 µm. Questions 15 to 16 are apply. The misconception to watch: a muscle pulls hardest when it is stretched most.

The model and its limits

Lengths are rounded from frog muscle (Gordon, Huxley and Julian, 1966): thick filament 1.6 µm, thin filament about 1.0 µm from the Z disc, top force from 2.0 to 2.2 µm, no force at 3.6 µm. Human filaments are a little longer, so a human sarcomere peaks nearer 2.6 to 2.8 µm; the shape of the curve is the same. The drawing shows only a few filaments and 7 heads per half per side (28 per thick filament); a real thick filament has about 300 heads. Below 2.0 µm the model uses the measured force values, because the drop there comes from crowding, not from fewer heads.

Sources

Hole's Essentials of Human Anatomy & Physiology 3e, teacher's manual, Chapter 8. Gordon, Huxley and Julian, 1966, Journal of Physiology 184:170, the length-tension curve. Huxley and Niedergerke, 1954, and Huxley and Hanson, 1954, Nature, the first sliding filament papers.

OpenStax Anatomy and Physiology 2e, Section 10.3, Muscle Fiber Contraction. Pictures are credited on the lab page.