

17.1 Muscle contraction: filaments slide

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS sarcomere • cross-bridge

Objective

Muscle contraction: filaments slide. Original classroom practice for IB HL; not an official IB paper.

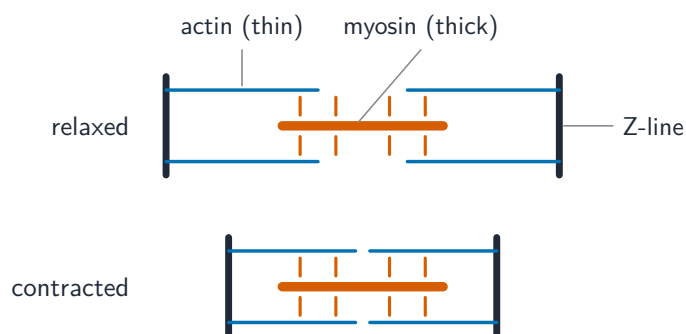
1 Key knowledge and worked examples

■ What would explain this observation?

- A **sarcomere** becomes shorter during contraction although its thick and thin filaments keep approximately the same length.

■ Build the model

- Actin and myosin interact in a sliding-filament mechanism.
- Calcium permits the interaction through regulatory proteins; ATP binding and hydrolysis support the **cross-bridge** cycle.
- Skeletal muscles pull through tendons and work in coordinated groups.
- sarcomere: The repeating contractile unit between two Z lines.
- cross-bridge: A myosin-actin interaction during the contraction cycle.



the filaments slide over each other, so the sarcomere shortens

■ **Choose evidence that can test it**

- During shortening, overlap increases.
- The A-band length stays approximately constant while I bands and the H zone become smaller.
- Movement at a joint also depends on tendon insertion, lever geometry and opposing muscle activity.

In the lab: Annotate two sarcomere diagrams at different lengths using the same scale. Track band widths separately from filament length. Use prepared models or existing images, not painful or maximal-exertion tasks.

■ **Work from known quantities**

- Known: sarcomere length changes from 2.5 to 2.0 micrometres.
- Percentage shortening = $(2.5 - 2.0)/2.5 \times 100 = 20\%$.
- This does not mean either filament shortened by 20%.

Your turn: A sarcomere shortens from 3.0 to 2.4 micrometres. Calculate percentage shortening.

■ **Check the conclusion and its limits**

- ATP is required for myosin detachment as well as the continuing cycle.
- A muscle pulling harder does not mean all its fibres become shorter under every load.

Not true: Contracting muscle shortens by shrinking every actin filament. Contraction is sliding, not shrinking: actin and myosin filaments keep their length while their overlap increases. A filament that shortened would contradict the sliding-filament evidence.

Key:

- Actin and myosin interact in a sliding-filament mechanism.
- During shortening, overlap increases.
- Watch for: ATP is required for myosin detachment as well as the continuing cycle.

■ **Write from a shortening of 25 percent**

- A sarcomere shortens from 2.0 to 1.5 micrometres.
- Find the percentage shortening. The filaments themselves do not shorten by that percentage.

2 Practice

2.1 What happens to thick-filament length during normal contraction? Choose one answer.

- **A** It halves whenever the muscle shortens
- **B** It remains approximately constant
- **C** It becomes zero

[1]

2.2 A sarcomere shortens from 3.0 to 2.4 micrometres. Calculate percentage shortening. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: Contracting muscle shortens by shrinking every actin filament.

[2]

2.4 The repeating contractile unit between two Z lines: write the technical term.

[1]

3 Exam-style questions

3.1 A fictional sarcomere shortens from 2.8 to 2.1 micrometres. Calculate shortening and explain whether the model requires actin filaments to shorten. [4]

Solutions

2.1 B In the sliding-filament model the filaments slide past each other: thick and thin filament lengths stay essentially constant while the sarcomere shortens. The overlap changes, not the filaments.

2.2 $\text{shortening} = (3.0 - 2.4) / 3.0 \times 100 = 20\%$.

2.3 False. Contraction is sliding, not shrinking: actin and myosin filaments keep their length while their overlap increases. A filament that shortened would contradict the sliding-filament evidence.

2.4 sarcomere. sarcomere means The repeating contractile unit between two Z lines.

3.1 25% shortening. Sliding-filament reasoning changes overlap and sarcomere length, not filament length. The numerical observation alone does not measure force or diagnose function.