

17.1 Muscle contraction: filaments slide

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS sarcomere • cross-bridge

Objective

Muscle contraction: filaments slide. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

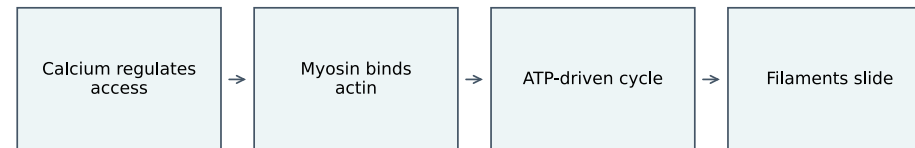
1 Key knowledge and worked examples

■ What would explain this observation?

- A **sarcomere** becomes shorter during contraction although its thick and thin filaments keep approximately the same length.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ 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.



■ 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.
- 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

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- 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%.

Example:

A sarcomere shortens from 3.0 to 2.4 micrometres. Calculate percentage shortening. Use the same sequence: known quantities → model → relation → substitution → unit and interpretation.

■ 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.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

Contracting muscle shortens by shrinking every actin filament. This claim is false: 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.

Key:

Muscle contraction: filaments slide: 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.

2 Practice

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

- **A** It remains approximately constant
- **B** It halves whenever the muscle shortens
- **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 A 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.

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

2.3 False. 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.

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.