

Exercise walk-through

# 17.1

## Muscle contraction: filaments slide

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International Baccalaureate · IB Diploma · Biology · HL

# 17.1 Muscle contraction: filaments slide

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_ **Total: 10 marks**

**KEY WORDS** sarcomere • cross-bridge

# Objective

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

## 1 Key knowledge and worked examples

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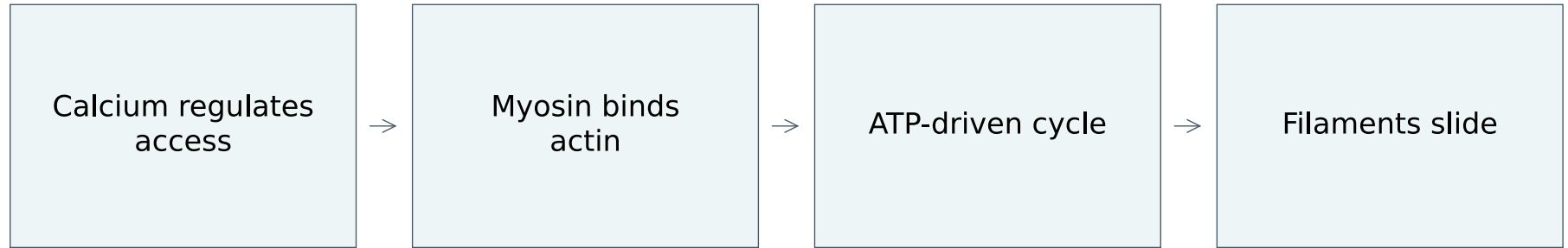
- What would explain this observation?
  - A **sarcomere** becomes shorter during contraction although its thick and thin filaments keep approximately the same length.

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## ■ 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.

**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.

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## ■ 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.

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### ■ 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.

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## Exercises 2.1·2.2

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**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]

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

[2]

## Exercises 2.1·2.2

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**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]

**2.1 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.

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

[2]

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

## Exercises 2.3-3.1

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**2.3** Decide whether this claim is true and justify: Contracting muscle shortens by shrinking every actin filament. [2]

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**2.4** The repeating contractile unit between two Z lines: write the technical term. [1]

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**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]

## Exercises 2.3-3.1

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**2.3** Decide whether this claim is true and justify: Contracting muscle shortens by shrinking every actin filament. [2]

**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.

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**2.4** The repeating contractile unit between two Z lines: write the technical term. [1]

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

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**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]

**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.