Helicate

HELICATE · A-LEVEL BIOLOGY · TOPIC BANK

3.6.3 Skeletal muscles

Topic question bank · A-level only content

Version 1 · 14 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
10	68	No time limit	/ 68

Contents

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Total		**68**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA A-level Biology (7402), specification section 3.6.3. Not affiliated with or endorsed by AQA.

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Antagonistic pairs and the structure of skeletal muscle 3.6.3

0 1 . 1 Which statement about the structure of skeletal muscle is correct?
Tick (✓) one box.

[1 mark]

Each muscle fibre contains only one nucleus. ☐

Each myofibril is made of many muscle fibres. ☐

Each muscle fibre contains many myofibrils. ☐

The sarcolemma surrounds each myofibril. ☐

The quadriceps is a muscle at the front of the thigh. The hamstrings are muscles at the back of the thigh. They act as an antagonistic pair at the knee joint. When the leg straightens at the knee, the quadriceps contracts.

0 1 . 2 Describe what happens to the quadriceps and to the hamstrings when the leg bends at the knee.

[2 marks]

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0 1 . 3 Explain why skeletal muscles work in antagonistic pairs against an incompressible skeleton.

[2 marks]

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5

Turn over for the next question

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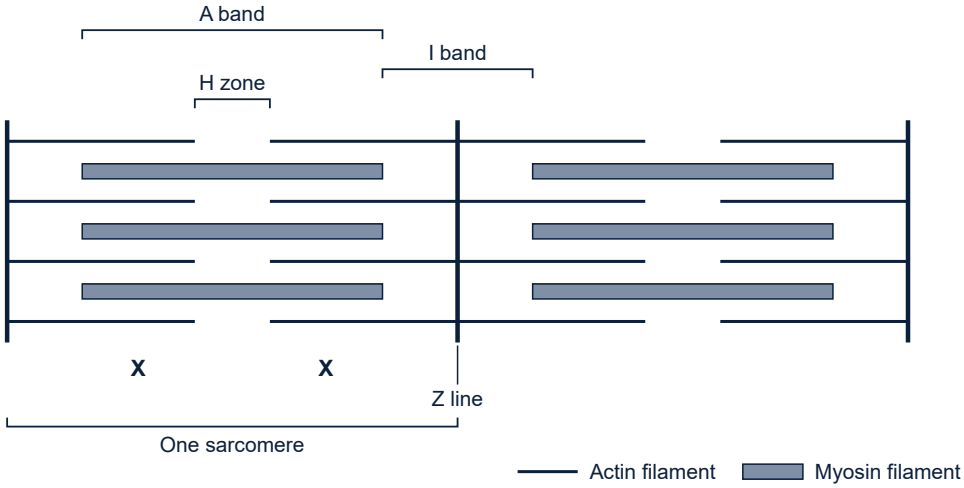
Figure 1 represents two neighbouring sarcomeres in a myofibril from a muscle fibre at rest. Each sarcomere is 2.4 μm long. The actin filaments extend 1.0 μm from each Z line, and each myosin filament is 1.6 μm long.

Figure 1



0 2 . 1 In an electron micrograph of this myofibril, the regions labelled **X** look darker than the I band and the H zone.
Explain why.

[2 marks]

Question 2 continues on the next page

Do not write outside the box

0 2 . 2 The muscle fibre then contracts until each sarcomere is 2.0 μm long.
Which row shows the length of the A band and the length of the H zone in each sarcomere after this contraction?
Tick (✓) one box.

[1 mark]

Length of A band / μm	Length of H zone / μm	
1.6	0	☐
1.2	0	☐
1.6	0.4	☐
1.2	0.4	☐

0 2 . 3 At rest, the muscle fibre in Figure 1 is 3.6 cm long. Each of its myofibrils runs the whole length of the fibre.
Calculate the number of sarcomeres in one myofibril.
Give your answer in standard form.

[2 marks]

Answer .....

Question 2 continues on the next page

Do not write outside the box

0 2 . 4 During a contraction, every sarcomere in this muscle fibre shortens to 2.1 µm. Calculate the percentage decrease in the length of the muscle fibre.

[2 marks]

Answer ..... **%**

7

A student examined a prepared slide of a longitudinal section of skeletal muscle with an optical microscope. She calibrated the eyepiece graticule with a stage micrometer: 40 eyepiece graticule divisions matched 100 µm on the stage micrometer.

She then measured the length of a row of 25 sarcomeres, next to each other, in one muscle fibre. The row was 24 eyepiece graticule divisions long.

0 3 . 1 Calculate the mean length of one sarcomere in µm.

[2 marks]

Answer ..... **µm**

0 3 . 2 Suggest why the student measured a row of 25 sarcomeres instead of measuring one sarcomere.

[1 mark]

Question 3 continues on the next page

Do not write outside the box

0 3 . 3 The student could see light and dark bands in the muscle fibres but could not see individual actin and myosin filaments.
Explain why.

[2 marks]

5

Turn over for the next question

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Muscle contraction: actin, myosin, calcium ions and ATP 3.6.3

0 4 . 1 What is the role of calcium ions in the contraction of a myofibril?
Tick (✓) one box.

[1 mark]

- They cause tropomyosin to move, exposing binding sites on actin. ☐
- They bind to binding sites on actin so that myosin heads can attach. ☐
- They break the actinomyosin bridges between actin and myosin. ☐
- They cause depolarisation of the sarcolemma. ☐

0 4 . 2 Calcium ions are released from the sarcoplasmic reticulum into the sarcoplasm of a muscle fibre.
Describe how this leads to the shortening of a sarcomere.

[5 marks]

Question 4 continues on the next page

Do not write outside the box

A few hours after death, ATP is no longer produced in skeletal muscle fibres. The muscles become stiff and cannot be stretched.

0 4 . 3 Explain why a lack of ATP causes the muscles to become stiff.

[2 marks]

8

Turn over for the next question

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Malignant hyperthermia is an inherited condition. In affected people, some drugs used in anaesthesia cause calcium ion channel proteins in the membrane of the sarcoplasmic reticulum to stay open.

During an operation, an affected patient's skeletal muscles become rigid, the rate of oxygen uptake and the rate of carbon dioxide production increase, and body temperature rises quickly.

0 5 Use your knowledge of muscle contraction and respiration to explain these symptoms.

[6 marks]

6

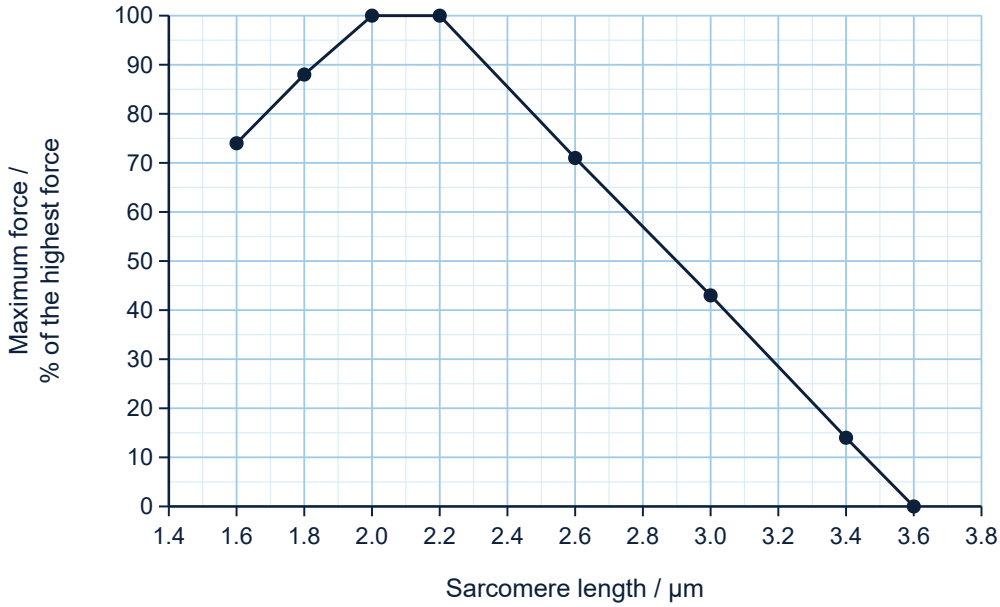
Turn over for the next question

Do not write outside the box

Scientists isolated single muscle fibres from a frog. They held each fibre at a fixed length, stimulated it and measured the maximum force it produced. They also measured the sarcomere length. Figure 2 shows their results.

In these fibres, the actin filaments extend 1.0 μm from each Z line and each myosin filament is 1.6 μm long.

Figure 2



0 6 . 1 Calculate the sarcomere length at which the actin filaments would no longer overlap with the myosin filaments.

[1 mark]

Answer ..... **μm**

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 Explain the change in force as the sarcomere length increases from 2.2 μm to 3.6 μm.

[3 marks]

0 6 . 3 The central 0.2 μm of each myosin filament has no myosin heads.
Use this information to suggest why the force is the same at 2.0 μm and at 2.2 μm.

[2 marks]

0 6 . 4 Suggest **one** reason why the force is lower at 1.6 μm than at 2.0 μm.

[1 mark]

7

Turn over for the next question

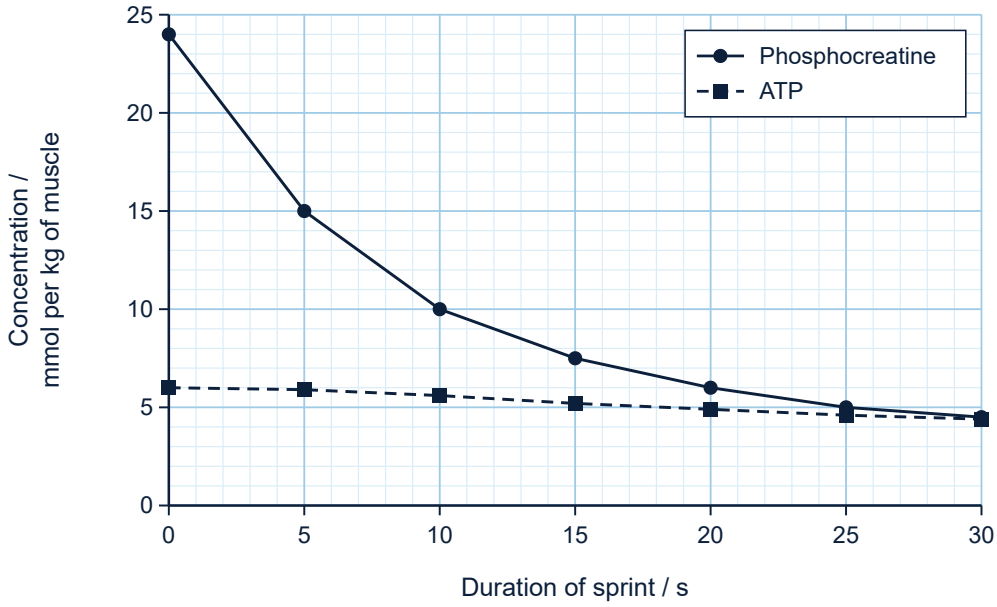
Do not write outside the box

ATP and phosphocreatine 3.6.3

Volunteers did sprints at maximum effort on an exercise bike, on separate days. Each sprint lasted 5, 10, 15, 20, 25 or 30 seconds. A small sample of thigh muscle was taken from each volunteer at rest before the sprint and again immediately after it.

Figure 3 shows the mean concentrations of ATP and of phosphocreatine in the muscle samples.

Figure 3



0 7 . 1 ATP is used rapidly during a sprint.
Use Figure 3 to explain why the ATP concentration after a 5-second sprint was only slightly lower than at rest.

[2 marks]

Question 7 continues on the next page

Do not write outside the box

0 7 . 2 Calculate the mean rate of phosphocreatine use during a 10-second sprint.
Give the unit.

[2 marks]

Answer .....

Unit .....

0 7 . 3 In the 30-second sprints, the volunteers' power output fell steadily after the first 10 seconds.
Use Figure 3 to suggest why.

[2 marks]

0 7 . 4 After a 30-second sprint, the phosphocreatine concentration returned to its resting value within a few minutes, but only if the muscle had a good supply of oxygen.
Explain why oxygen was needed.

[2 marks]

8

Turn over for the next question

Do not write outside the box

Scientists investigated whether creatine supplements improve sprint performance. They divided 20 volunteers into two groups of 10. For 5 days, one group took a creatine supplement and the other group took a placebo. The placebo was a powder that looked and tasted the same but contained no creatine. Neither the volunteers nor the scientists knew which group each volunteer was in.

After the 5 days, the scientists measured the resting concentration of phosphocreatine in each volunteer's thigh muscle and the mean power output in a 6-second sprint. Table 1 shows their results.

Table 1

Group	Resting concentration of phosphocreatine in thigh muscle / mmol per kg of muscle		Mean power output in a 6-second sprint / W	
	Mean	Standard deviation	Mean	Standard deviation
Placebo	24.0	2.0	820	70
Creatine	29.0	2.4	870	80

0 8 . 1 Suggest why the scientists:

[2 marks]

gave one group a placebo

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did not know which group each volunteer was in.

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Question 8 continues on the next page

Do not write outside the box

0 8 . 2 The scientists concluded that creatine supplements improve sprint performance. Use Table 1 and your knowledge of phosphocreatine to evaluate this conclusion.

[4 marks]

6

Turn over for the next question

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Slow and fast skeletal muscle fibres and muscle fatigue 3.6.3

0 9 . 1 Which row correctly describes slow skeletal muscle fibres compared with fast skeletal muscle fibres?

Tick (✓) one box.

[1 mark]

Number of mitochondria	Concentration of myoglobin	Number of capillaries	
Higher	Higher	Higher	☐
Higher	Lower	Higher	☐
Lower	Higher	Lower	☐
Higher	Higher	Lower	☐

Question 9 continues on the next page

Do not write outside the box

Scientists compared two muscles in the leg of a rat. Muscle **A** keeps the body upright and contracts for long periods. Table 2 shows some of their results.

Table 2

Property	Muscle A	Muscle B
Mean number of capillaries per muscle fibre	2.8	1.2
Volume of mitochondria / % of fibre volume	7.5	3.0
Myoglobin concentration / mg g^{-1} of muscle	3.6	1.2
Time for a single contraction to reach maximum force / ms	70	22
Force after 3 minutes of repeated stimulation / % of starting force	85	20

0 9 . 2 Use Table 2 to explain how muscle **A** is adapted to contracting for long periods.

[4 marks]

Question 9 continues on the next page

Do not write outside the box

0 9 . 3 The leg muscles of elite sprinters contain a higher proportion of fast fibres than the leg muscles of elite marathon runners.
Explain how this benefits the sprinters.

[3 marks]

8

Turn over for the next question

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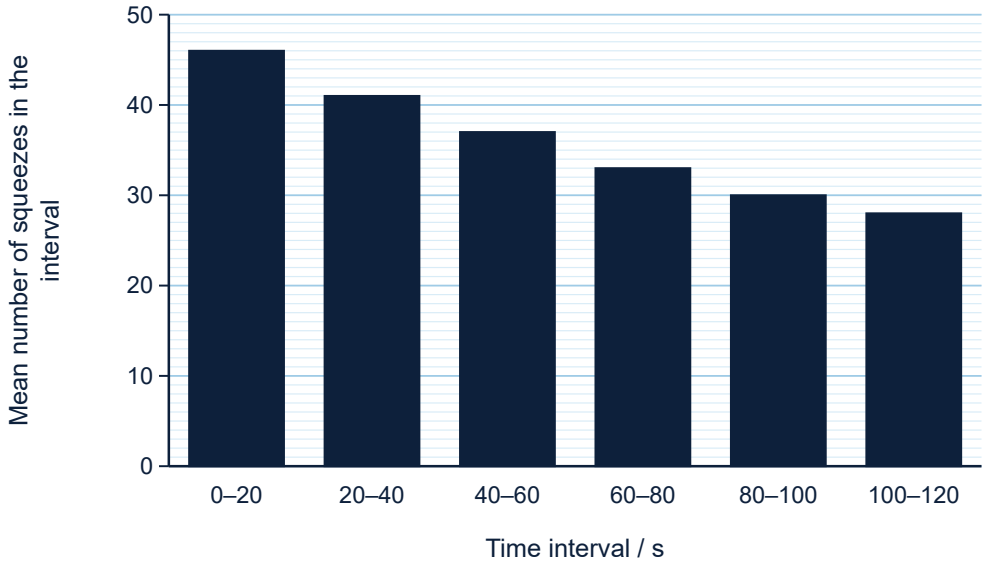
A student investigated the effect of repeated muscle contraction on muscle fatigue. Each volunteer held a clothes peg between the thumb and index finger of one hand, then squeezed it fully open and let it close again as many times as possible for 2 minutes without a rest.

The student counted the number of squeezes in each 20-second interval. Figure 4 shows the mean results for 8 volunteers.

Figure 4



10.1 Give **two** variables the student should have controlled.

[2 marks]

1 .....

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2 .....

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Question 10 continues on the next page

Do not write outside the box

1 0 . 2 Calculate the percentage decrease in the mean number of squeezes between the first and the last interval.

[2 marks]

Answer ..... **%**

1 0 . 3 Suggest an explanation for the decrease in the number of squeezes.

[2 marks]

1 0 . 4 The student predicted that, if the investigation had continued for another 2 minutes, the number of squeezes would have continued to decrease at the same rate.
Use Figure 4 to evaluate this prediction.

[2 marks]

8

END OF QUESTIONS

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