

Structured Questions: Paper 2

# 11.2 Movement

11.2.1 Requirements for Movement / 11.2.2 Skeletal Muscle / 11.2.3 Mechanism of Muscle Contraction / 11.2.4 Skills: The Human Elbow & Sarcomeres / 11.2.5 Skills: Analysing Muscle Contractions in Electron Micrographs

Easy (5 questions)	/47
Medium (5 questions)	/47
Hard (5 questions)	/57
<b>Total Marks</b>	<b>/151</b>

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# Easy Questions

1 (a) State the word which is used to describe a pair of muscles that act against each other to perform opposite actions.

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(1 mark)

(b) Classify the following alphabetical list of organisms into their skeleton type in the table below.

1. Amphibians
2. Arachnids
3. Birds
4. Centipedes
5. Crustaceans
6. Fish
7. Insects
8. Mammals
9. Molluscs
10. Reptiles

Internal Skeletons	Exoskeletons

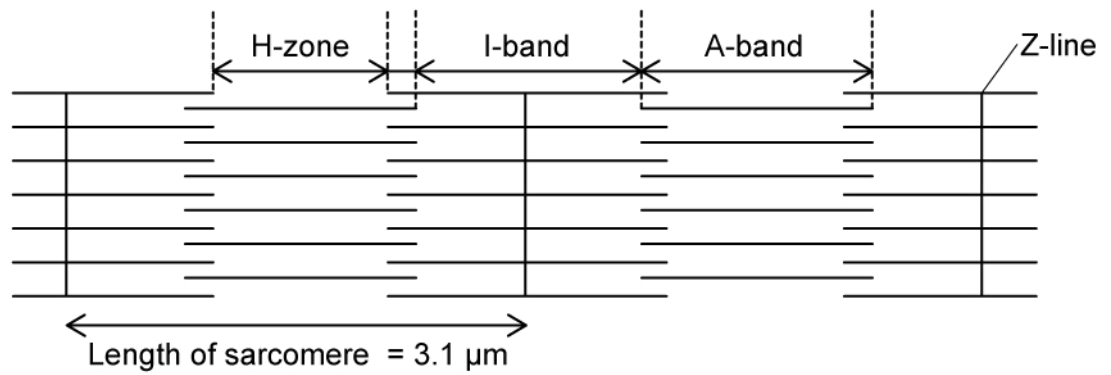
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(3 marks)

(c) The diagram shows a myofibril strand in a relaxed muscle fibre.



Describe the effect of muscle fibre contraction on the length of the A-band and the sarcomere.

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**(2 marks)**

(d) Explain the presence of a large number of mitochondria in the sarcoplasm of a muscle fibre.

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**(2 marks)**

2 (a) The smallest unit of organisation in most tissues is the cell. However, the term 'muscle fibre' is used to describe the smallest unit of skeletal muscle.

Explain why.

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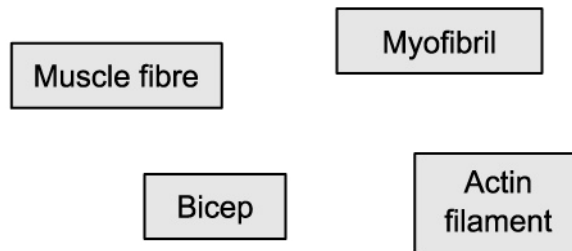
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**(2 marks)**

(b) Name the bundles of actin and myosin fibres.

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**(1 mark)**



(c) Place the four words above into descending order of size in the table below:

<b>Largest</b>	
↓	
↓	
<b>Smallest</b>	

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**(2 marks)**

(d) Define the term, sarcolemma.

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(1 mark)

**3 (a)** Myosin is a protein that has two different kinds of protein structure, fibrous and globular, in its molecule.

State where these two types of structure are found within the myosin molecule.

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**(2 marks)**

**(b)** Explain how actin filaments are formed.

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**(2 marks)**

**(c)** Complete the table to identify the molecules that carry out the following functions of muscular contraction.

Name of Molecule	Function
	Hydrolyses ATP
	Covers the binding site on the actin filament (when the muscle is relaxed)
	Required for recocking of the myosin head

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**(3 marks)**

**(d)** State the role of calcium ions during muscle contraction.

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**(2 marks)**

- 4 (a) The power stroke of muscle contraction is a short, sharp movement as a myosin head flexes and slides over an actin filament.

Suggest why a muscle movement is a smooth process, rather than a series of short, jerky movements as this model might indicate.

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(2 marks)

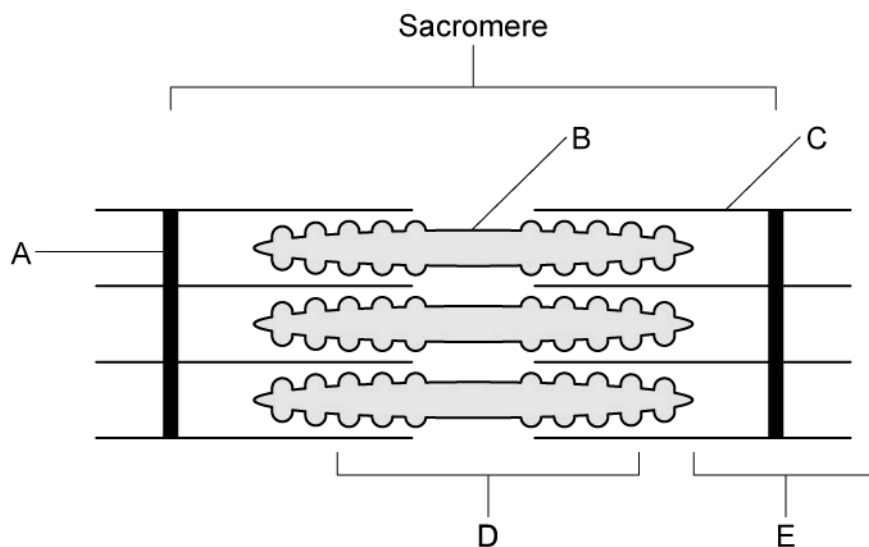
- (b) Identify the **two** successive events that cause a contracting muscle to stop contracting when the motor neurone stops sending impulses to the muscle fibre.

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(2 marks)

- (c) Identify parts **A - E** on the diagram of a sarcomere below.



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(5 marks)



**5 (a)** One mark is available for clarity of communication throughout this question.

Whilst making a school poster of the human elbow, a student dropped his annotation cards. He gathered them up and randomly allocated an annotation to each part of the elbow but many got mixed up, as shown in the table below.

Part of the elbow	Annotation
Humerus	Anchorage point for biceps
Triceps	Lubricates the joint between cartilage and bone ends
Cartilage	Shock-absorbing tissue that reduces friction in the joint
Synovial fluid	Extends the joint
Biceps	Surrounds the joint and holds in synovial fluid
Radius	Flexes the joint
Ulna	Anchorage point for biceps and triceps
Joint Capsule	Anchorage point for triceps

Re-sort the annotations to match the correct parts of the elbow joint below.

Part of the elbow	Mixed-up Annotation	Correct Annotation
Humerus	Anchorage point for biceps	
Triceps	Lubricates the joint between cartilage and bone ends	
Cartilage	Shock-absorbing tissue that reduces friction in the joint	
Synovial fluid	Extends the joint	
Biceps	Surrounds the joint and holds in synovial fluid	
Radius	Flexes the joint	
Ulna	Anchorage point for biceps and triceps	
Joint Capsule	Anchorage point for triceps	



# Medium Questions

1 (a) Compare and contrast bones and exoskeletons.

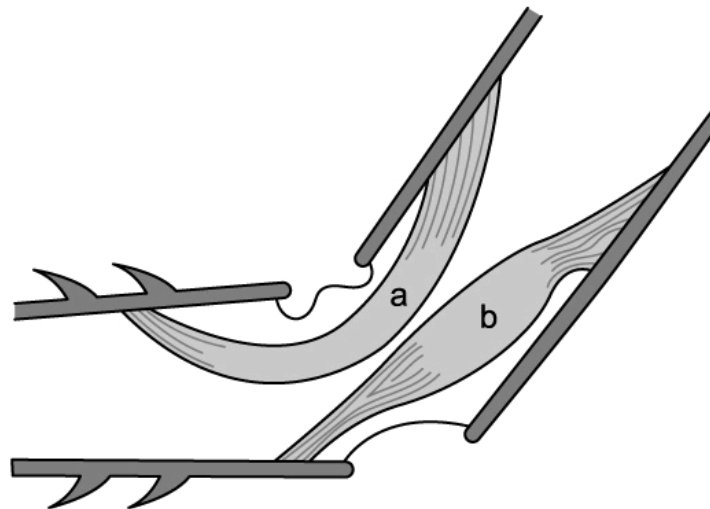
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(3 marks)

(b) The image below shows two muscles in the leg of a jumping insect.



Describe the roles of muscles **a** and **b** in altering the insect's leg position.

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(2 marks)

(c) Explain how this would be different for the equivalent muscles in the arm of a human.

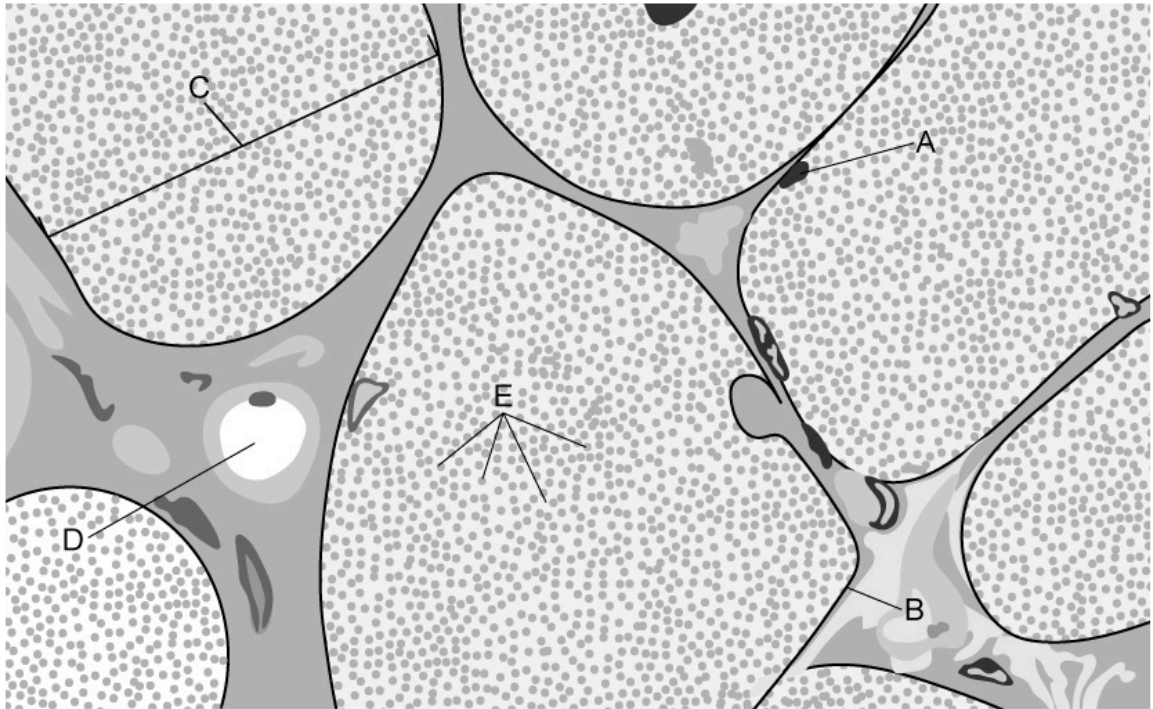
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(3 marks)

2 (a) The image below shows an electron micrograph cross section through a skeletal muscle.



Identify structures **A-C** labelled in the image above.

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(3 marks)

(b) The structures labelled **E** in the image in part a) are called myofibrils.

Describe the structure of a myofibril.

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(2 marks)

(c) The structure labelled **C** in the image in part a) is 30 mm long when relaxed, but only 22.5 mm long when contracted.

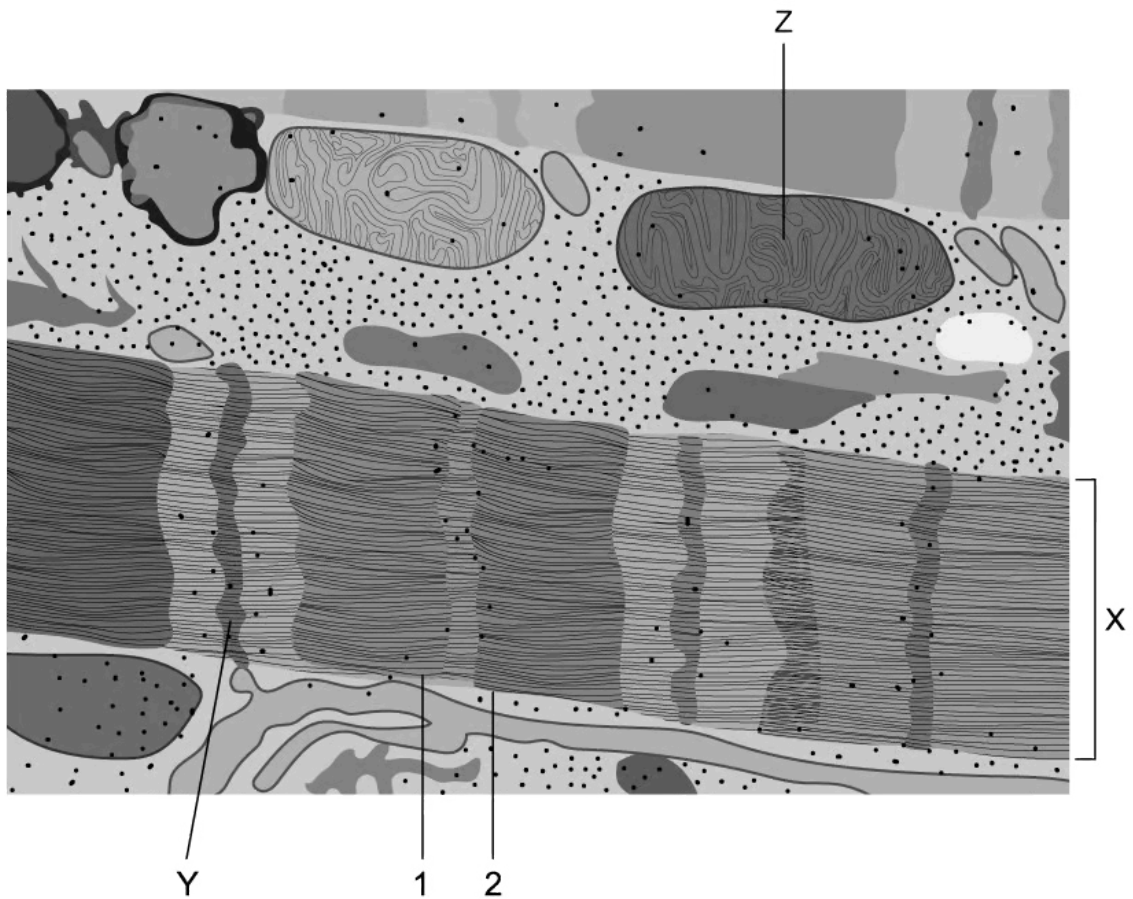
Calculate the percentage decrease in length of the contracted structure **C**.

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.....  
**(2 marks)**

**(d)** Suggest **two** reasons why it may be beneficial to study skeletal muscle fibres using an electron microscope rather than an optical microscope.

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**(2 marks)**

3 (a) The image below is a transmission electron micrograph of a longitudinal section of skeletal muscle.



Identify structures **X**, **Y** and **Z**.

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**(3 marks)**

(b) Identify the molecules present in the regions labelled **1** and **2** in the image in part a).

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**(1 mark)**

- (c) During intense exercise the pH of skeletal muscle tissue falls sharply, causing alterations in the 3D structure of some calcium receptors within muscle fibres and lowering their contractile ability.

Use the information provided and your own knowledge to explain the reduced contractile ability of muscle fibres that results from intense exercise.

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**(3 marks)**



4 (a) The table below describes three molecules involved with muscle contraction.

Identify molecules **A-C** below.

Description	Molecule
Attaches to M line at the centre of the sarcomere	<b>A</b>
Hydrolysis of this molecule is required for the recovery stroke	<b>B</b>
Ion that diffuses across the sarcolemma	<b>C</b>

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**(3 marks)**

(b) Outline how the filaments within muscle fibres slide past each other in the sliding filament mechanism of muscle contraction.

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**(2 marks)**

(c) A recent discovery has shown that a third protein filament, known as titin, is also present in muscle fibres. The role played by titin is still being investigated, but one study looked at the effects of removing titin from the muscles of mice.

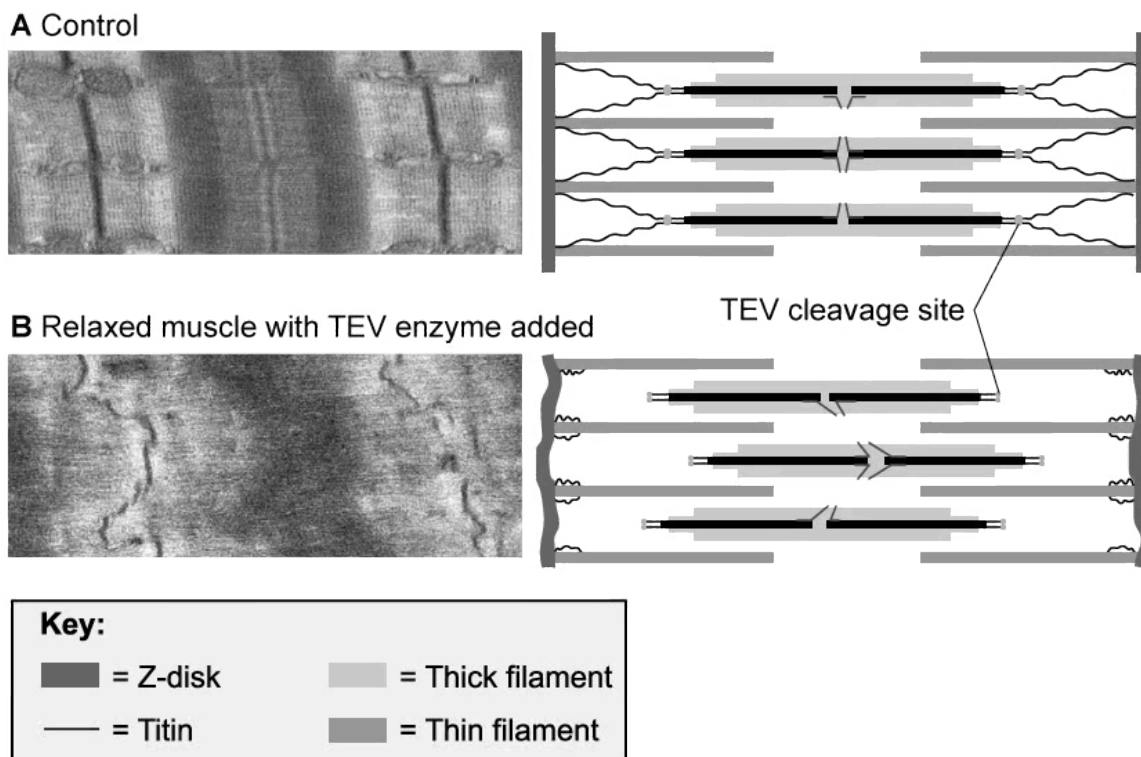
To remove the titin protein the mice had their muscles modified so that their titin filaments contained a cutting site for a plant enzyme called TEV protease. This meant that the scientists could use TEV protease to cut the titin proteins.

Suggest why the plant enzyme TEV protease was used rather than an animal protease.

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(2 marks)

(d) The image below shows the location of titin within the sarcomere, as well as some of the results gained from the study described in part c) above.



Use the image and your existing knowledge to suggest a possible function of titin filaments.

(1 mark)



# Hard Questions

**1 (a)** Malignant hyperthermia (MH) is a dangerous condition during which a patient's skeletal muscles become contracted and rigid. It is caused by a mutation in the gene that codes for intracellular calcium channels. MH is difficult to diagnose until it is triggered by the administration of an anaesthetic.

Suggest how the anaesthetic combined with the MH mutation could lead to contracted skeletal muscles in a patient.

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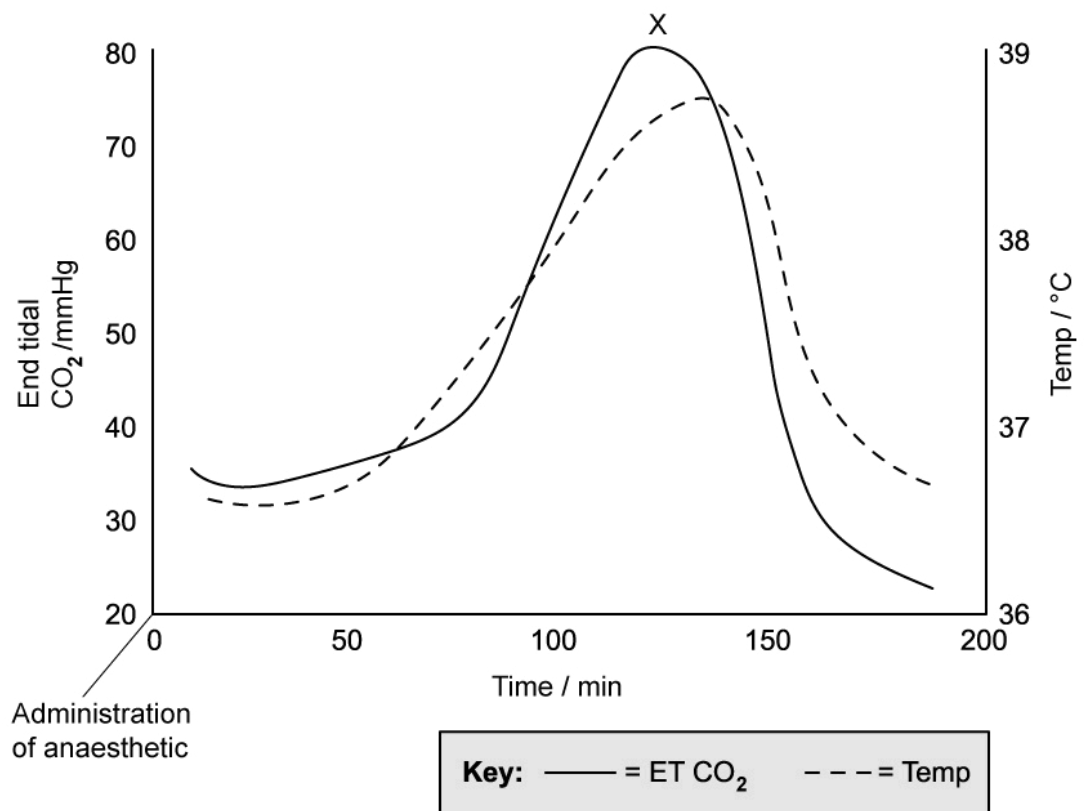
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**(5 marks)**

**(b)** The graph shows some of the physiological effects that take place after the administration of an anaesthetic to a patient who is MH susceptible. End Tidal Carbon Dioxide refers to the amount of carbon dioxide released during an exhaled breath.



Use your knowledge of the events taking place inside a contracting skeletal muscle to explain the effects on the graph between 0 and 150 minutes after the administration of an anaesthetic.

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**(3 marks)**

(c) MH is a very dangerous condition that can be fatal if not treated quickly.

Use the information provided and your own knowledge to explain why MH can be fatal.

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**(2 marks)**

(d) At point **X** on the graph in part a), a life-saving drug called dantrolene was administered.

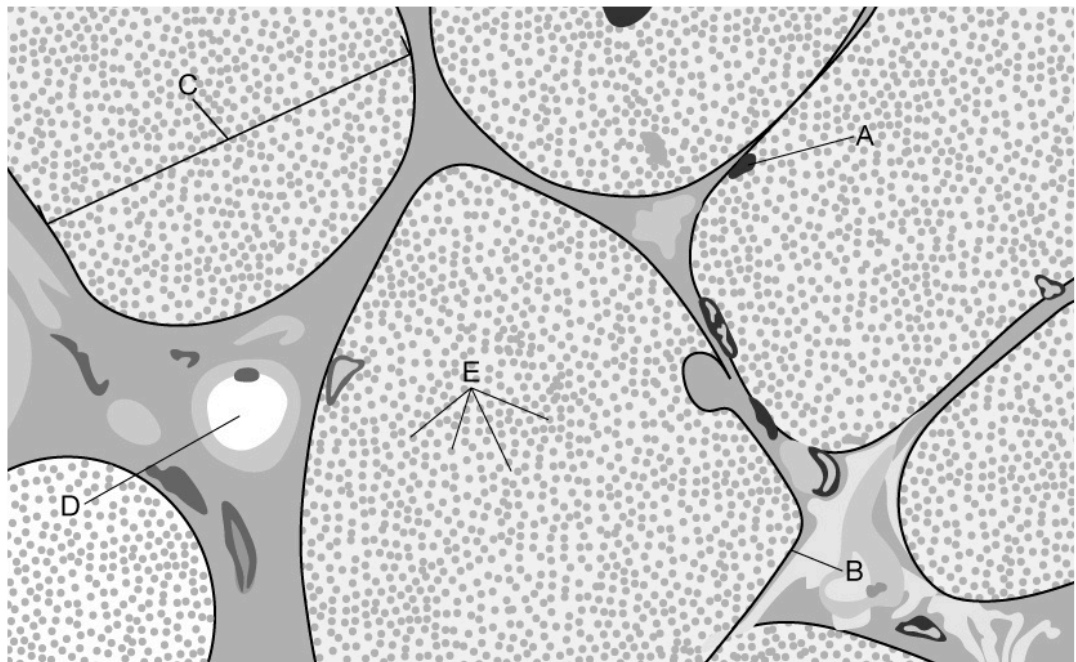
Suggest how dantrolene might counteract the effects of the anaesthetic.

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**(2 marks)**

2 (a) The diagram shows a cross section through a skeletal muscle.



Identify the structures labelled **A - D** in this diagram.

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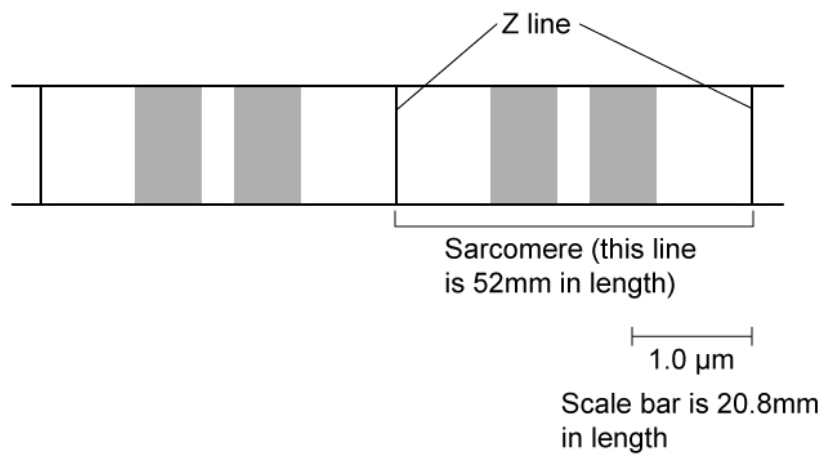
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**(4 marks)**

**(b)** The structures labelled E in the diagram in part a) above are called myofibrils. When myofibrils are viewed in longitudinal section they have a striped, or striated, appearance and are made up of many sarcomeres. Two sarcomeres are shown in the diagram below.



The myofibril is 4.5cm in length when it is relaxed, while a contracted sarcomere measures 1.9μm.

Use the scale on the diagram above to calculate the length of a contracted myofibril (the image measurements are provided for you).

State your answer in mm.

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**(3 marks)**

- (c)** The striated pattern visible on the sarcomeres is due to the presence of two types of filament within the myofibril. These filaments are known to be involved with muscle contraction, but a relatively recent discovery has shown that a third protein filament known as titin, is also present. The role played by titin is still being investigated, but one study was carried out in mice that looked at the effects of removing titin from their muscles.

To remove the titin protein, the mice had their muscles modified so that their titin filaments contained a cutting site for a plant enzyme called TEV protease.

Suggest why the plant enzyme TEV was used rather than an animal protease.

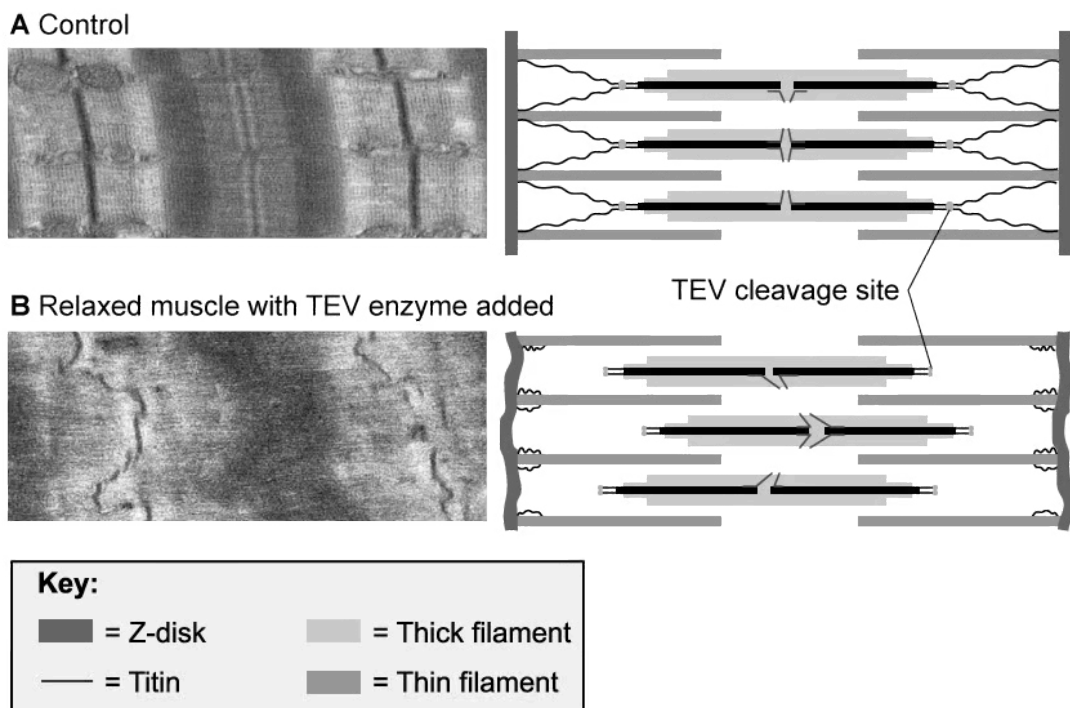
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(2 marks)

(d) The diagram below shows the location of titin within the sarcomere, as well as some of the results gained from the study described in part c) above.



Use information from the diagram and your existing knowledge to suggest 3 possible functions of titin filaments.

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(3 marks)

**3 (a)** Flexion of the elbow involves contraction of the biceps to bring the hand upwards when performing a manual action, for example when scratching the nose.

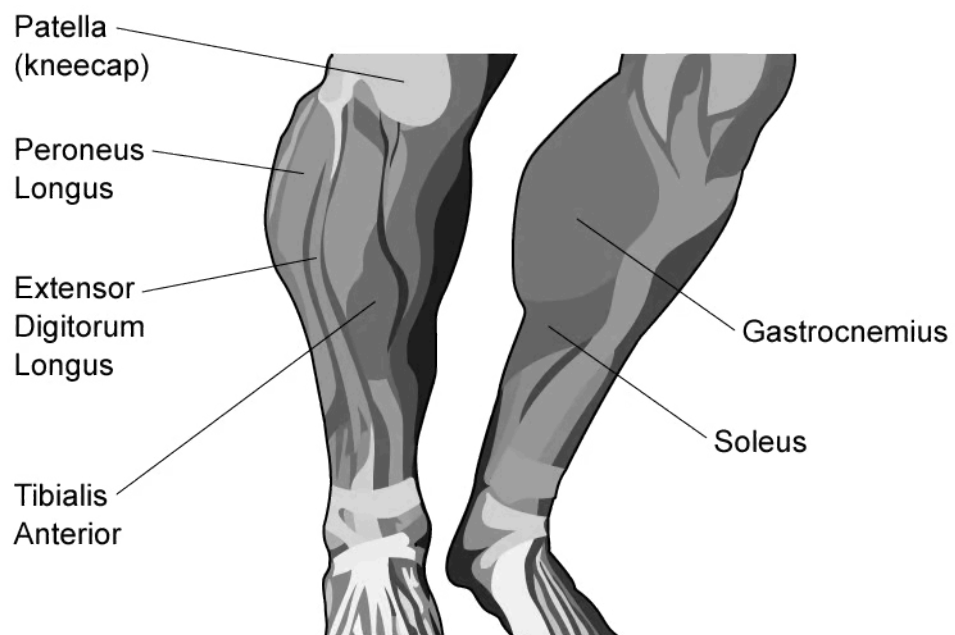
Aside from the role played by the triceps in extending the arm afterwards, suggest **two** advantages to having the system of an antagonistic pair of muscles in arm movement.

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**(2 marks)**

**(b)** The image below shows some of the muscles in the human lower leg.



Use the diagram and your knowledge of antagonistic pairs to identify the muscles involved in the following motions:

Dorsiflexion - moving the toes upwards towards the shin

Plantar flexion - moving the toes away from the shin eg. when standing on tiptoe

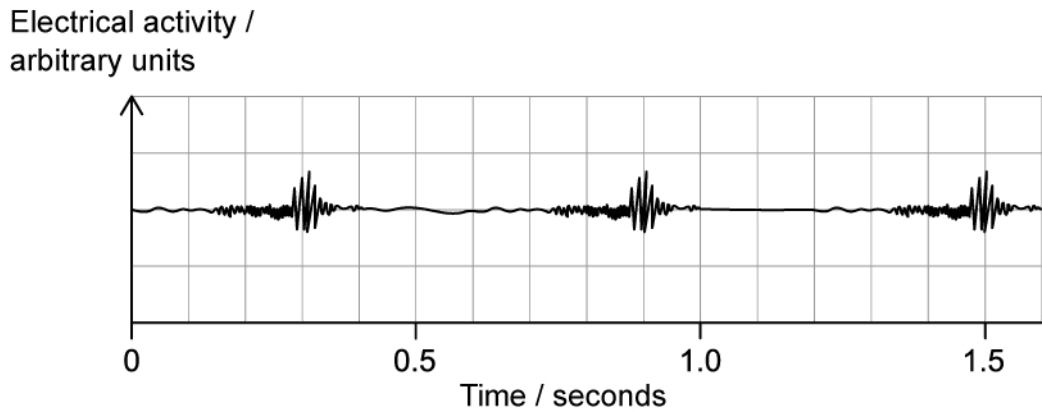
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**(2 marks)**

- (c) A technique called electromyography uses electrodes placed onto the skin close to major skeletal muscles. The electrodes measure electrical activity in those muscles and in their surrounding nervous connections.

The diagram below is an electromyograph trace combined from electrodes placed on a person's left and right gastrocnemius muscles (see diagram in part b for the location of that muscle) taken while the person was walking at an even pace.



Assuming a mean stride length of 75cm, calculate the person's walking speed.

State your answer in kilometres per hour /  $\text{kmh}^{-1}$ .

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**(4 marks)**

- (d) For the person walking in part c) above, state, with a reason, the stage of the respiratory pathway that would be supplying most of the ATP required for muscular contraction of the leg muscles.

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**(2 marks)**

4 (a) Explain why tendons need to be inelastic.

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(3 marks)

(b) Synovial fluid plays an important role in musculoskeletal movement.

One feature of synovial fluid is that it is classed as a non-Newtonian fluid. This means that it changes its viscosity according to the surrounding conditions.

Suggest and explain **one** function of a joint that is aided by synovial fluid being a non-Newtonian fluid.

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(2 marks)

(c) Osteoarthritis is a common condition of the joints in which cartilage becomes thinned and eventually wears away.

Suggest **two** symptoms of osteoarthritis and a possible remedy.

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(3 marks)

**5 (a)** *One mark is available for clarity of communication throughout this question.*

Describe the sequence of musculoskeletal events that lead to a grasshopper jumping to catch its prey.

Do not go into the molecular detail of the events; limit your answer to events at an organ-by-organ level.

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**(6 marks)**

**(b)** Describe the events that lead up to the formation of actin/myosin cross-bridges during muscle contraction.

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**(4 marks)**

- (c) Duchenne muscular dystrophy (DMD) is a severe genetic disorder that affects boys and young men. It is an inherited, X-linked condition that causes progressive loss of muscle tissue, and most often causes death by asphyxiation as important breathing muscles (eg. the diaphragm) lose their function.

A mutation in the gene for a protein called dystrophin. A lack of dystrophin causes excess calcium ions to leak from the sarcolemma.

Associated changes to the ion balance within the sarcoplasm also cause water to enter mitochondria by osmosis.

Suggest how these descriptions of events with DMD cause a loss of muscular function.

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**(5 marks)**