Skeletal Muscles

These practice questions can be used by students and teachers and is

Suitable for AQA A Level 7402 Biology Topic Question

Level: AQA A LEVEL 7402

Subject: Biology

Exam Board: AQA A Level 7402

Topic: Skeletal Muscles

1

(Extra space) _____

(5)

(b) ATP is an energy source used in many cell processes. Give **two** ways in which ATP is a suitable energy source for cells to use.

1. _____

2. _____

(2)

(Total 7 marks)

Read the following passage carefully.

2

A large and growing number of disorders are now known to be due to types of mitochondrial disease (MD). MD often affects skeletal muscles, causing muscle weakness.

We get our mitochondria from our mothers, via the fertilised egg cell. Fathers do not pass on mitochondria via their sperm. Some mitochondrial diseases are caused by mutations of mitochondrial genes inside the mitochondria. Most mitochondrial diseases are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria. These mutations of nuclear DNA produce recessive alleles.

One form of mitochondrial disease is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the tRNA. This results in the formation of a non-functional protein in the mitochondrion.

There are a number of ways to try to diagnose whether someone has a mitochondrial disease. One test involves measuring the concentration of lactate in a person's blood after exercise. In someone with MD, the concentration is usually much higher than normal. If the lactate test suggests MD, a small amount of DNA can be extracted from mitochondria and DNA sequencing used to try to find a mutation.

Use information in the passage and your own knowledge to answer the following questions.

(a) Mitochondrial disease (MD) often causes muscle weakness (lines 1–3). Use your knowledge of respiration and muscle contraction to suggest explanations for this effect of

MD.

(Extra space) _____

(3)

Two couples, couple **A** and couple **B**, had one or more children affected by a mitochondrial disease. The type of mitochondrial disease was different for each couple.

None of the parents showed signs or symptoms of MD.

- Couple **A** had four children who were all affected by an MD.
- Couple **B** had four children and only one was affected by an MD.

(b) Use the information in lines 5–9 and your knowledge of inheritance to suggest why:

- all of couple **A**'s children had an MD
- only one of couple **B**'s children had an MD.

Couple **A** _____

Couple **B** _____

(Extra space) _____

(4)

(c) Suggest how the change in the anticodon of a tRNA leads to MD (lines 10–13).

(Extra space) _____

(3)

(d) If someone has MD, the concentration of lactate in their blood after exercise is usuallymuch higher than normal (lines 15–17). Suggest why.

(Extra space) _____

_____

_____

(3)

(e) A small amount of DNA can be extracted from mitochondria and DNA sequencing used totry to find a mutation (lines 18–19).

From this sample:

- how would enough DNA be obtained for sequencing?
- how would sequencing allow the identification of a mutation?

_____

_____

_____

_____

(2)

(Total 15 marks)

3 (a) What is the role of ATP in myofibril contraction?

_____

_____

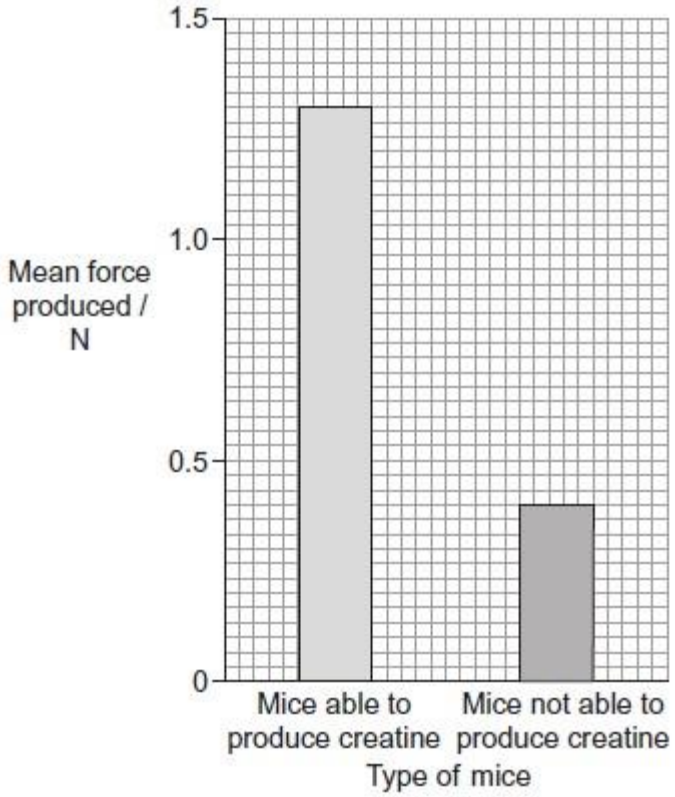
_____

_____

(2)

(b) Scientists investigated the effect of not being able to produce creatine on the forceproduced by muscle. They used mice with a mutation that made them not able to produce creatine.
The force produced when these mice gripped with their paws was compared with the force produced by normal mice that were able to produce creatine.

The graph shows the scientists' results.



(i) What was the percentage fall in the mean force produced by mice not able toproduce creatine, compared with the normal mice? Show your working.

Answer _____ %

(2)

(ii) Suggest an explanation for these results.

_____

_____

_____

(2)

(c) The mice that were not able to produce creatine were homozygous for a recessive allele of a gene. Mice that are heterozygous for this allele are able to produce forces similar to those of normal mice that are homozygous for the dominant allele of the same gene.

Explain why the heterozygous mice can produce forces similar to those of normal mice.

(2)

(Total 8 marks)

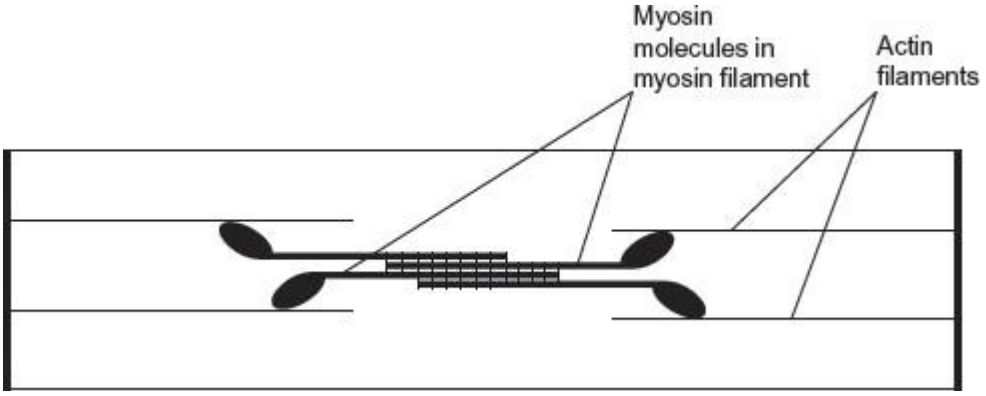
4 (a) A sarcomere is made up of different molecules.

Complete the table by naming the molecule that carries out the function described.

Function	Name
Attaches to Z line at the end of the sarcomere	
Breaks down ATP	
Covers binding site on actin in relaxed myofibril	

(3)

(b) The diagram shows the arrangement of actin and myosin in a sarcomere.



One form of muscle disease is caused by a mutated allele of a gene. This leads to production of myosin molecules that are unable to bind to other myosin molecules.

If myosin molecules are unable to bind to other myosin molecules, this prevents muscle contraction.
Use the diagram and your knowledge of how muscles contract to suggest why.

_____

_____

_____

_____

_____

_____

[Extra space] _____

_____

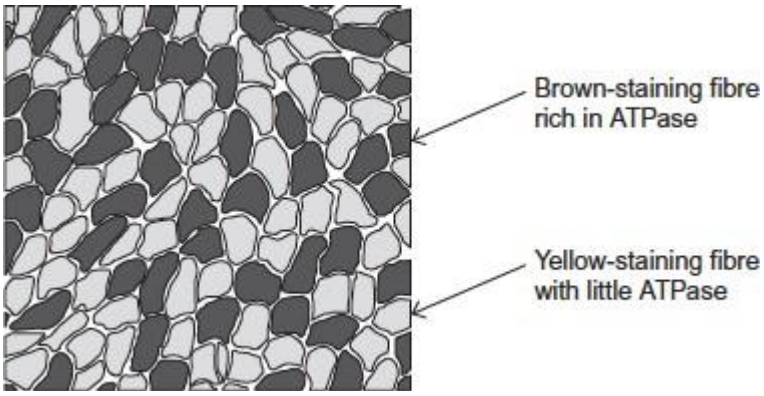
_____

(3)

(Total 6 marks)

5 Slow and fast skeletal muscles both contain slow and fast muscle fibres but in different proportions. The proportion can be determined by observing stained sections of muscle under a microscope. The stain used reacts with an ATPase enzyme. Muscle fibres containing a lot of this ATPase stain brown. Fibres containing little ATPase stain yellow.

The diagram shows stained muscle fibres in a section taken from a muscle.



(a) Both slow and fast muscle fibres contain ATPase.

Explain why.

_____

_____

_____

_____

(2)

(b) The tissue in the diagram came from muscle with a high proportion of brown-staining fibres.Was the tissue removed from slow or fast skeletal muscle?

Explain your answer.

_____

_____

_____

(1)

(c) The muscle tissue in the diagram had been stained for viewing with a microscope.

What is the evidence that it had been stained for viewing with an optical (light) microscope? Explain your answer.

_____

_____

_____

_____

(2)

(Total 5 marks)

6 Researchers investigated whether the blood supply to slow and fast muscle fibres in a muscle changes with age. They used diaphragms taken from hamsters (*Mesocricetus auratus*). The diaphragm is in constant use for breathing. They took diaphragms from groups of young, adult and old hamsters.

They removed the diaphragm from each animal and took a sample of muscle tissue.They examined it under an optical (light) microscope. For each sample they selected several fields of view at random. In each field of view, they then counted the number of capillaries associated with each type of muscle fibre.

This allowed the researchers to calculate the mean number of capillaries for each type of muscle fibre, for each age group.

The table below shows the researchers' results which include standard deviation (SD).

Hamster age group	**Number of hamsters in group**	**Mean number of capillaries associated with each type of muscle fibre**	
		Slow fibres (± SD)	**Fast fibres (± SD)**
Young	9	3.4 (±0.8)	4.0 (±0.8)
Adult	10	4.7 (±0.2)	6.3 (±0.4)
Old	8	4.6 (±0.9)	6.8 (±0.6)

(a) Give **four** precautions that the researchers took to make their calculations of mean number of capillaries per fibre reliable.

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

_____

(4)

(b) The researchers examined the muscle of an animal in the **old** age group. They found one field of view containing only slow muscle fibres. They counted 69 capillaries in this field of view.

(i) Use a calculation to estimate how many slow muscle fibres were visible in this field ofview. Show your working.

Number of slow muscle fibres = _____

(2)

(ii) The actual number of slow muscle fibres in the field of view was **not** the same as the number you calculated in question (i).

Give **one** reason why.

_____

_____

_____

(1)

(c) A student read the report of the researchers' investigation. She thought that theinvestigation was unethical but that a conclusion could still be made.

(i) Suggest why she thought the investigation was unethical.

(1)

(ii) She concluded that age had a significant effect on the mean number of capillaries perfibre.

Evaluate this conclusion.

(4)

(Total 12 marks)

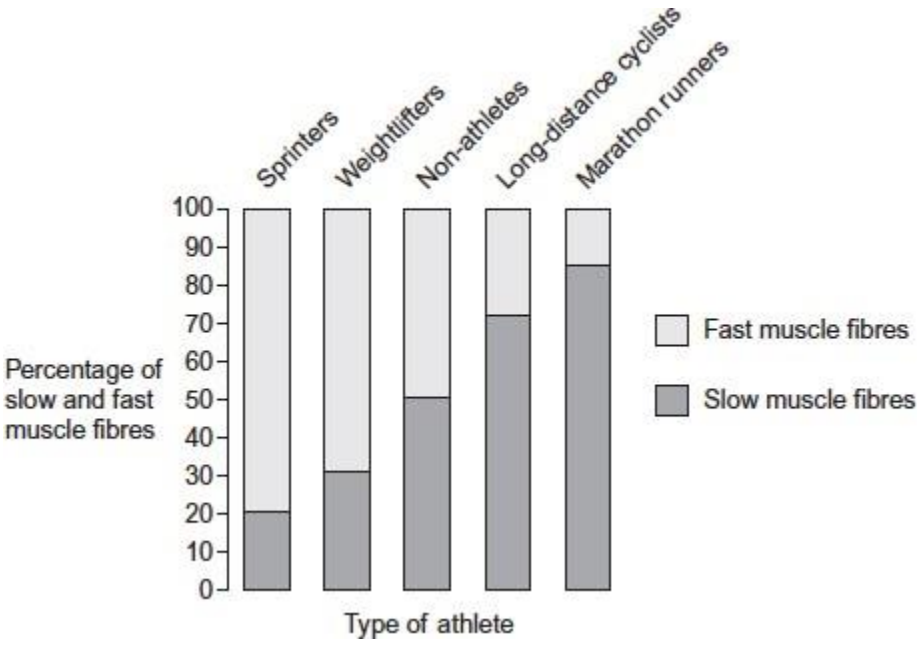
7 It is believed that each person is born with a certain percentage of slow and fast muscle fibres in their skeletal muscles. Most people have about 50% slow fibres and 50% fast fibres.

A sports scientist wondered if these percentages could change over time depending on the type of sport in which a person was involved. He knew from previous investigations that:

- the number of mitochondria within a fibre can change
- the diameter of a fibre can change
- the number of muscle fibres in a skeletal muscle remains constant over time.

He determined the mean percentages of slow and fast fibres in skeletal muscles of different types of athletes.

His results are shown in the graph below in the form in which he presented them.



(a) (i) In which type of athlete would the sports scientist expect to find muscle fibres with thehighest number of mitochondria?

_____

(1)

(ii) Explain the reason for your choice of athlete.

_____

_____

_____

_____

(2)

(b) The leg muscles of long-distance cyclists are usually larger than the leg muscles ofnon-athletes.

Suggest why.

_____

[Extra space]

(3)

(c) A reader of the sports scientist's results stated that 'the results show that regular weightlifting changes your proportion of slow and fast skeletal muscle fibres.'

Do you agree with this statement? Explain your answer.

(2)

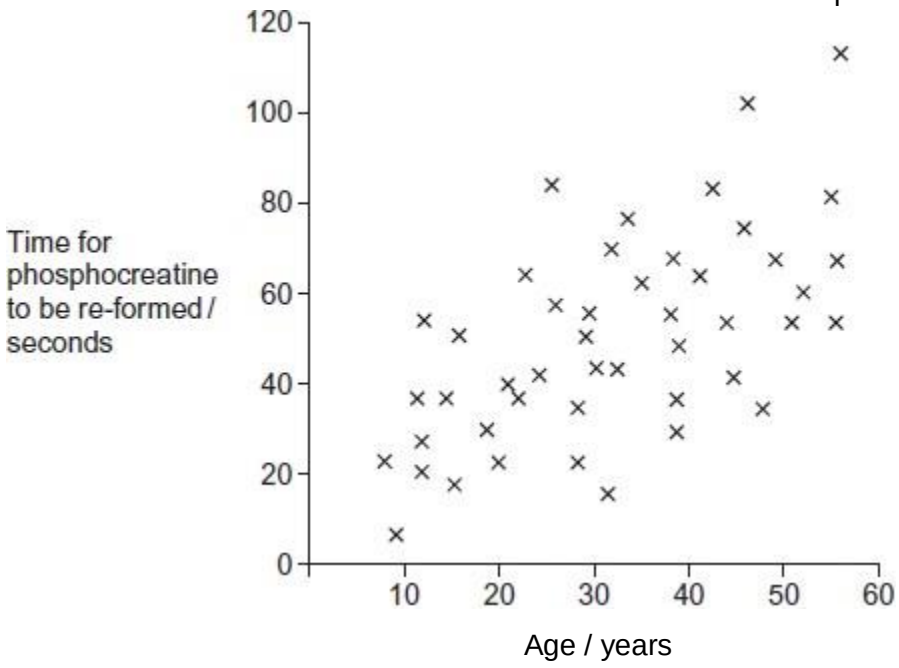
(Total 8 marks)

8 (a) What is the role of phosphocreatine (PC) in providing energy during muscle contraction?

(2)

Scientists investigated the time for phosphocreatine (PC) to be re-formed in arm muscles after the same exercise in healthy people of different ages. The exercise involved brief, rapid contractions of arm muscles.

The figure below shows the scientists' results. Each cross is the result for one person.



(b) There is a lot of variation in the time taken for PC to be re-formed in people of a very similarage.

Suggest **one** reason for this variation.

_____

(1)

(c) Use your knowledge of fast muscle fibres to explain the data in the figure.

_____

_____

_____

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_____

_____

_____

(Extra space) _____

_____

_____

_____

(4)

(Total 7 marks)

9 (a) Describe the part played by each of the following in myofibril contraction.

(i) Tropomyosin

_____

_____

_____

_____

_____

(2)

(ii) Myosin

_____

_____

_____

_____

_____

(2)

(b) The table shows features of fast and slow muscle fibres.

Feature	Fast muscle fibre	Slow muscle fibre

Type of respiration	Mainly anaerobic	Mainly aerobic
Glycogen	High concentration	Low concentration
Capillaries	Few	Many

Use information from the table to suggest and explain **one** advantage of:

(i) the high glycogen content of fast muscle fibres

_____

_____

_____

_____

(2)

(ii) the number of capillaries supplying slow muscle fibres.

_____

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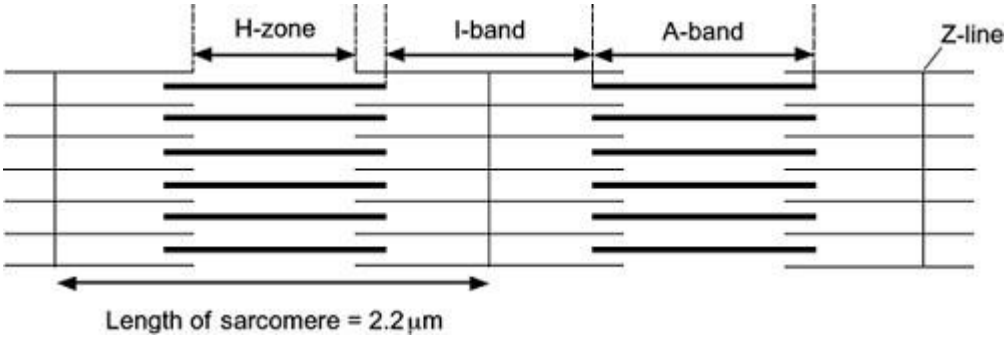
(2)

(Total 8 marks)

10 The diagram shows two relaxed sarcomeres from skeletal muscle.



(a) When the sarcomeres contract, what happens to the length of

(i) the I-band

_____

(1)

(ii) the A-band?

_____

(1)

(b) The length of each sarcomere in the diagram is 2.2 μm. Use this information to calculatethe magnification of the diagram. Show your working.

Magnification _____

(2)

(c) People who have McArdle's disease produce less ATP than healthy people. As a result,they are not able to maintain strong muscle contraction during exercise. Use your knowledge of the sliding filament theory to suggest why.

_____

_____

_____

_____

_____

_____

*(Extra space)*_____

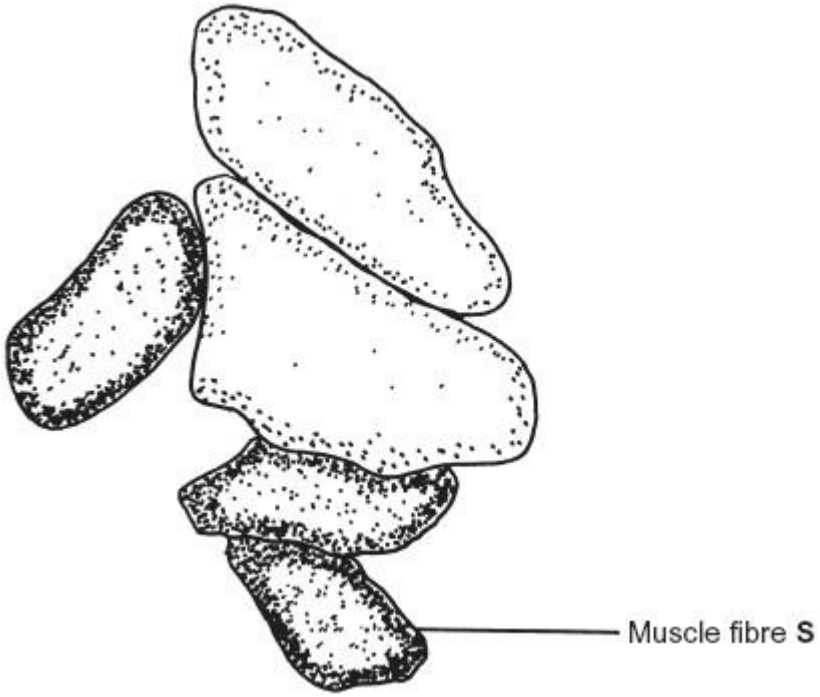
_____

_____

(3)

(Total 7 marks)

11 The drawing is a tracing of a cross-section through skeletal muscle tissue. This muscle contains fast muscle fibres and slow muscle fibres. The section has been stained to show the distribution of the enzyme succinate dehydrogenase. This enzyme is found in mitochondria.



(a) (i) Succinate dehydrogenase catalyses one of the reactions in the Krebs cycle. What isthe evidence from the drawing that muscle fibre **S** is a slow muscle fibre? Explain your answer.

_____

_____

_____

_____

(2)

(ii) Use evidence from the diagram to describe the distribution of mitochondria inside theslow muscle fibres. Explain the importance of this distribution.

_____

_____

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_____

_____

_____

(3)

(b) (i) You could use an optical microscope and a slide of stained muscle tissue to find thediameter of one of the muscle fibres. Explain how.

_____

_____

_____

_____

(2)

(ii) A student found the mean diameter for the slow muscle fibres in a section. Give **two** precautions that she should have taken when sampling the fibres. Give a reason for each precaution.

1. _____

_____

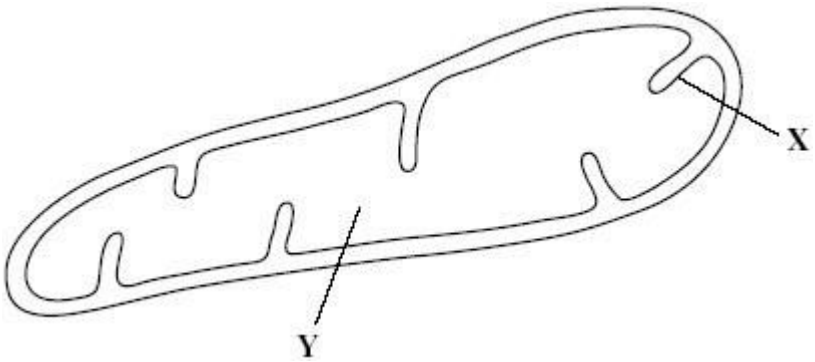
2. _____

_____

(2)

(Total 9 marks)

12 The diagram shows a mitochondrion.



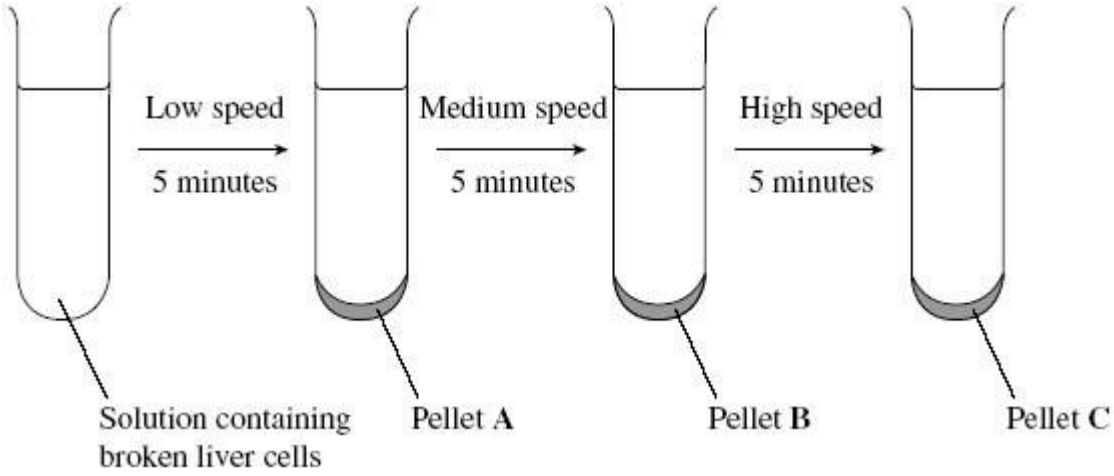
(a) Name the parts labelled **X** and **Y**.

(i) **X** _____

(ii) **Y** _____

(2)

Scientists isolated mitochondria from liver cells. They broke the cells open in an ice-cold, isotonic solution. They then used a centrifuge to separate the cell organelles. The diagram shows some of the steps in the process of centrifugation.



(b) Suggest which pellet, **A**, **B** or **C** contained the mitochondria.

(1)

(c) Explain why the solution used was

(i) ice-cold

_____

_____

(1)

(ii) isotonic.

_____

_____

_____

_____

(2)

(d) People with mitochondrial disease have mitochondria that do not function properly.

Some people with mitochondrial disease can only exercise for a short time. Explain why a person with mitochondrial disease can only exercise for a short time.

_____

_____

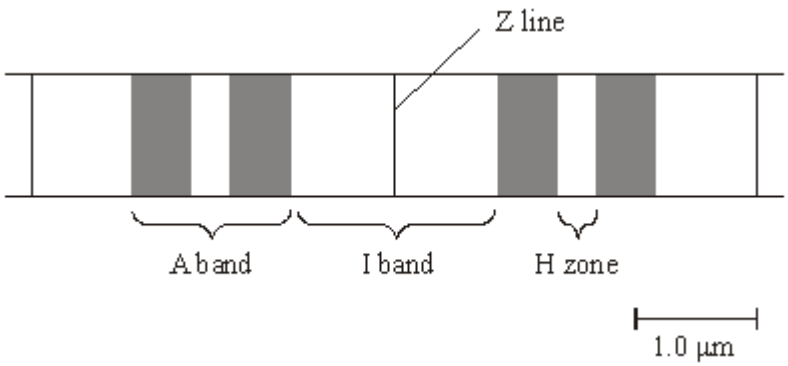
_____

_____

(2)

(Total 8 marks)

13 The diagram shows part of a myofibril from a relaxed muscle fibre.



(a) When the muscle fibre contracts, which of the A band, I band and H zone

(i) remain unchanged in length,

_____

(1)

(ii) decrease in length?

_____

(1)

(b) Explain what caused the decrease in length in part (a)(ii).

_____

_____

_____

_____

(2)

(c) The whole muscle fibre is 30 mm long when relaxed. Each sarcomere is 2.25 µm longwhen contracted. Use the scale given on the diagram to calculate the length of the contracted muscle fibre in millimetres.

Length of contracted fibre = _____ mm

(2)

(d) The table gives some properties of the two different types of muscle fibre found in skeletal muscle.

(i) Complete the table by writing the words 'high' or 'low' for the remaining threeproperties of each type of muscle fibre.

	Type of muscle fibre	
	Type 1	**Type 2**
Speed of contraction	high	low
Force generated	high	low
Activity of the enzymes of glycolysis	high	low
Number of mitochondria		
Activity of Krebs cycle enzymes		
Rate of fatigue		

(3)

(ii) The myosin-ATPase of **type 1** muscle fibres has a faster rate of reaction than that in **type 2** fibres. Use your knowledge of the mechanism of muscle contraction to explain how this will help **type 1** muscle fibres to contract faster than **type 2**.

(4)

S(iii) The blood leaving an active muscle with a high percentage of **type 1** muscle fibres contained a higher concentration of lactate than that leaving a muscle with a high percentage of **type 2** muscle fibres. Explain why.

(2)

(Total 15 marks)

14 The flow chart outlines an investigation to determine from where the calcium ions involved in muscle contraction are released.

Calcium ion transport proteins were isolated from human tissue.

↓

These proteins were injected into a rabbit.

↓

The rabbit formed antibodies to the proteins. These antibodies were collected and labelled with gold particles.

↓

Muscle tissue was treated with the labelled antibodies and examined with an electron microscope. High concentrations of gold particles were observed attached to the sarcoplasmic reticulum.

S (a) Labelled antibodies and an electron microscope can be used to produce images locating proteins on the surface of organelles, but cannot be used to observe cross bridge cycling in muscle cells. Explain why.

(5)

(b) Describe the role of calcium ions and ATP in muscle contraction.

(5)

(Total 10 marks)

15 **Figure 1** shows part of a single myofibril from a skeletal muscle fibre as it appears under an optical microscope.

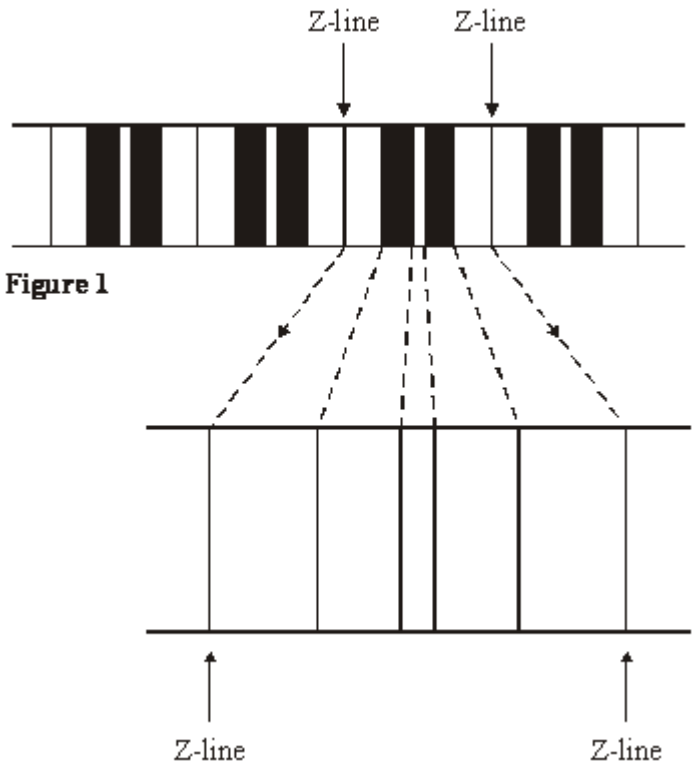


Figure 1

Figure 2

(a) (i) Complete **Figure 2** to show the arrangement of actin and myosin filaments in this part of the myofibril as they would appear under an electron microscope. Label the actin and myosin filaments.

(2)

(ii) Why are the details you have drawn in **Figure 2** visible under the electron microscope but not under the optical microscope?

_____

_____

(1)

(b) The myofibril in **Figure 1** is magnified × 8000. A muscle fibre is 40 µm in diameter. Calculate the number of myofibrils which would fit side by side across the diameter of the muscle fibre. Show your working.

Answer _____ myofibrils.

(2)

(Total 5 marks)

(a) **Figure 1** shows part of a myofibril from skeletal muscle.

16

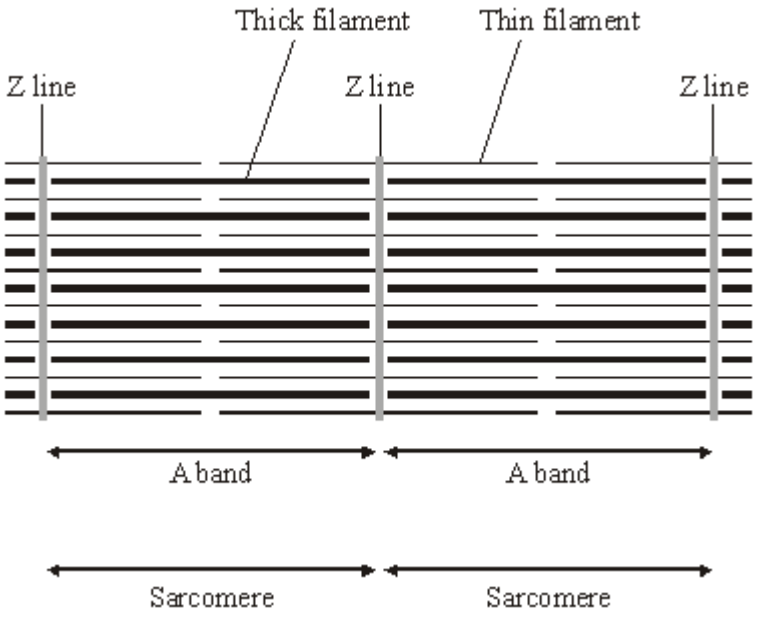


Figure 1

(i) Describe **two** features, visible in the diagram, which show that the myofibril is contracted.

1. _____

_____

2. _____

_____

(2)

(ii) Explain the role of calcium ions and ATP in bringing about contraction of a musclefibre.

Calcium ions _____

_____

_____

ATP _____

_____

(3)

(b) **Figure 2** shows the structure of a neuromuscular junction. The vesicles contain acetylcholine.

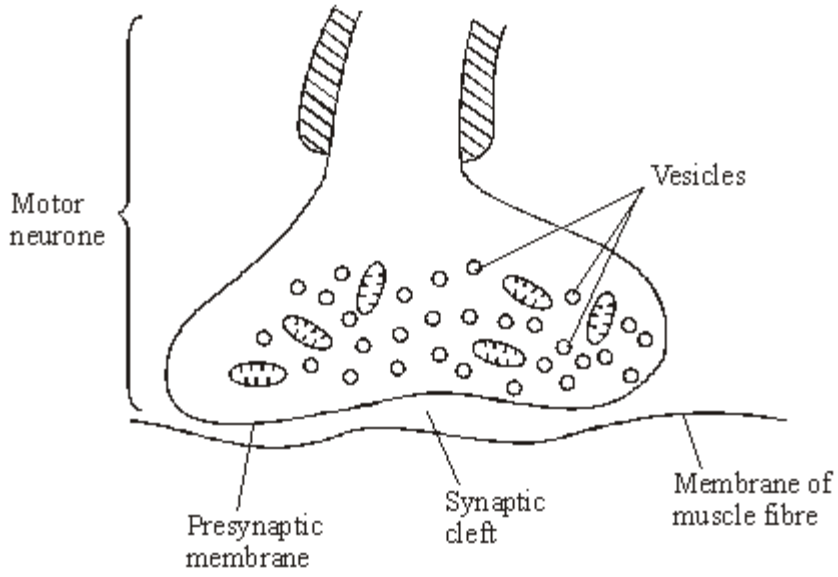


Figure 2

(i) An action potential is generated at the cell body of the motor neurone.Explain how this action potential passes along the motor neurone to the neuromuscular junction.

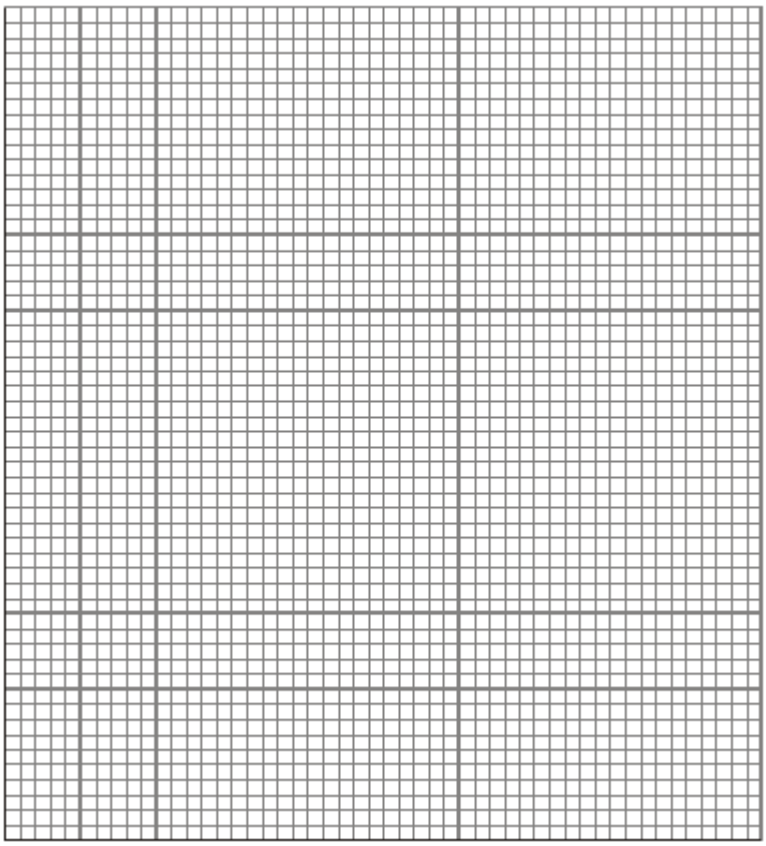
(3)

(ii) When the action potential arrives at the neuromuscular junction, it results in thesecretion of acetylcholine into the synaptic cleft. Explain how.

(3)

(c) Between the ages of 20 and 50, 10% of total muscle mass is lost. Between the ages of 50 and 80, a further 40% of the original total muscle mass is lost. Most of the muscle lost consists of fast fibres.

(i) Plot a graph on the grid below to show the percentage of muscle mass remainingbetween the ages of 20 and 80. Assume that the rate of muscle loss in each age range is constant.



(3)

(ii) Explain why explosive exercises, such as sprinting and weightlifting, will be moreaffected by this muscle loss than aerobic exercises, such as jogging.

_____

_____

(1)

(Total 15 marks)

17 **Figure 1** shows part of a sarcomere.

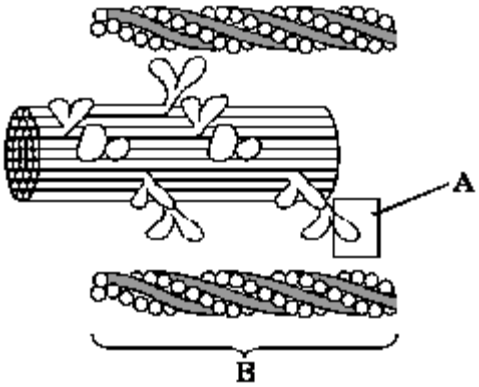


Figure 1

(a) (i) Name the main protein in structure **B**.

_____

(1)

(ii) Name the structure in box **A**.

_____

(1)

(b) (i) Describe how calcium ions cause the myofibril to start contracting.

_____

_____

_____

_____

(2)

(ii) Describe the events that occur within a myofibril which enable it to contract.

(3)

Slow and fast skeletal muscle fibres differ in a number of ways. Slow fibres get their ATP from aerobic respiration while anaerobic respiration provides fast fibres with their ATP. **Figure 2** shows a bundle of fast and slow fibres seen through an optical microscope. The fibres have been stained with a stain that binds to the enzymes which operate in the electron transport chain.

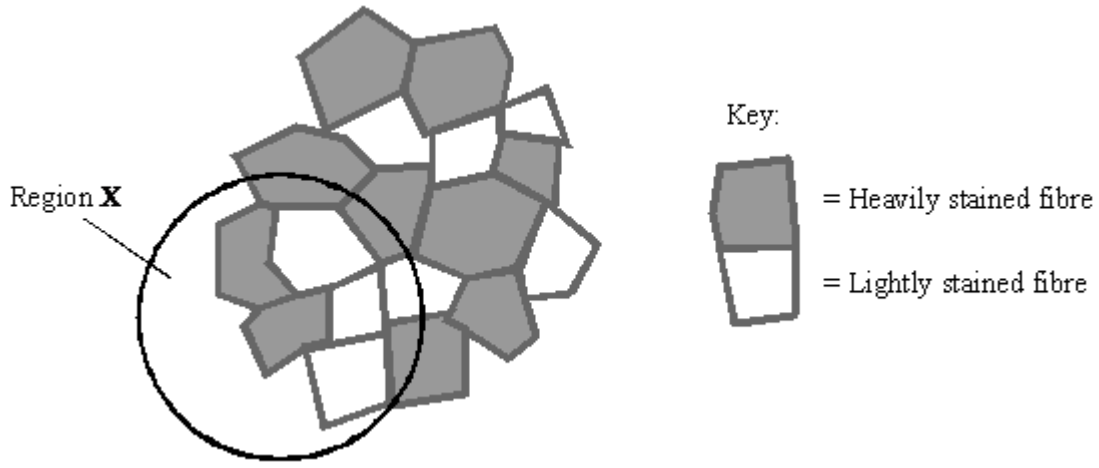


Figure 2

S (c) (i) Describe how you could calculate the percentage of fast fibres in this bundle.

(1)

(ii) The figure calculated by the method in part (c)(i) may not be true for the muscle as a whole. Explain why.

_____

(1)

(d) The fibres in **Figure 3** correspond to those in region **X** of **Figure 2**. They were stained with a substance that binds to enzymes involved in glycolysis. Shade **Figure 3** to show the appearance of the fibres. Use the shading shown in the key.

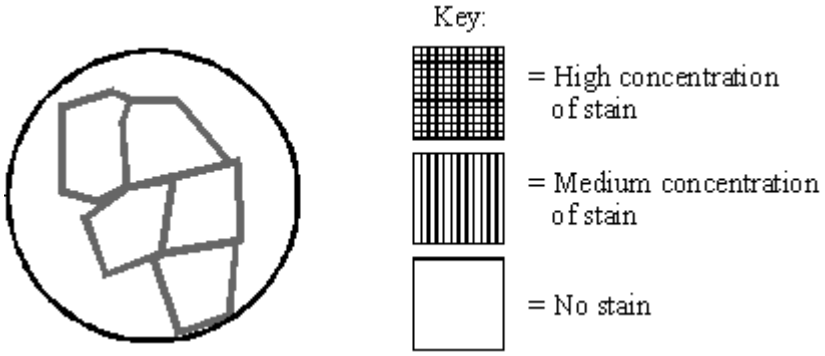


Figure 3

(2)

S (e) Recent research has shown that the difference in fibre types is due in part to the presence of different forms of the protein myosin with different molecular shapes.

Explain how a new form of myosin with different properties could have been produced as a result of mutation.

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_____

_____

(4)

(Total 15 marks)

18 (a) (i) What is meant by homeostasis?

_____

_____

(1)

(ii) Giving **one** example, explain why homeostasis is important in mammals.

_____

_____

_____

_____

(2)

(b) Cross-channel swimmers may suffer from muscle fatigue during which the contraction mechanism is disrupted. One factor thought to contribute to muscle fatigue is a decrease in the availability of calcium ions within muscle fibres. Explain how a decrease in the availability of calcium ions could disrupt the contraction mechanism in muscles.

_____

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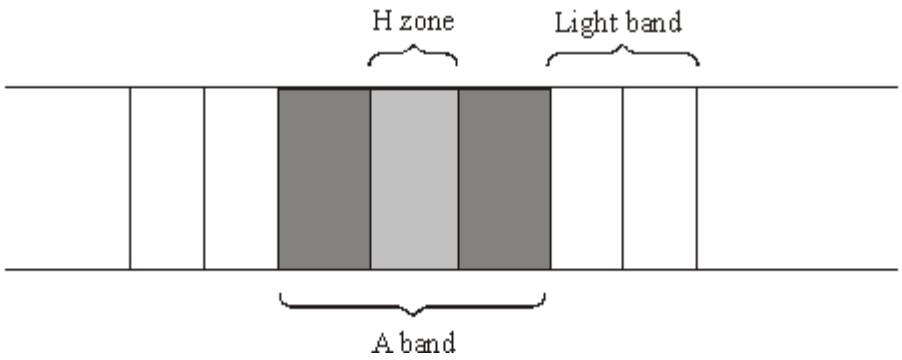
(3)

(Total 6 marks)

19 (a) The diagram shows the banding pattern observed in part of a relaxed muscle fibril.



(i) Describe what causes the different bands seen in the muscle fibril.

_____

_____

_____

_____

(2)

(ii) Describe how the banding pattern will be different when the muscle fibril iscontracted.

_____

_____

_____

_____

(2)

(b) There is an increase in the activity of the enzyme ATPase during muscle contraction. An investigation into muscle contraction involved measuring the activity of ATPase in solutions containing ATP, myosin and different muscle components. The table shows the results.

Solution	Contents	ATPase activity / arbitrary units
A	ATP, myosin and actin	1.97
B	ATP, myosin, actin and tropomyosin	0.54
C	ATP, myosin, actin, tropomyosin and calcium ions	3.85

(i) Explain the importance of ATPase during muscle contraction.

_____

_____

_____

_____

(2)

(ii) Using your knowledge of muscle contraction, explain the difference in the results between

A and **B**;

_____

_____

_____

_____

(2)

B and **C**.

_____

_____

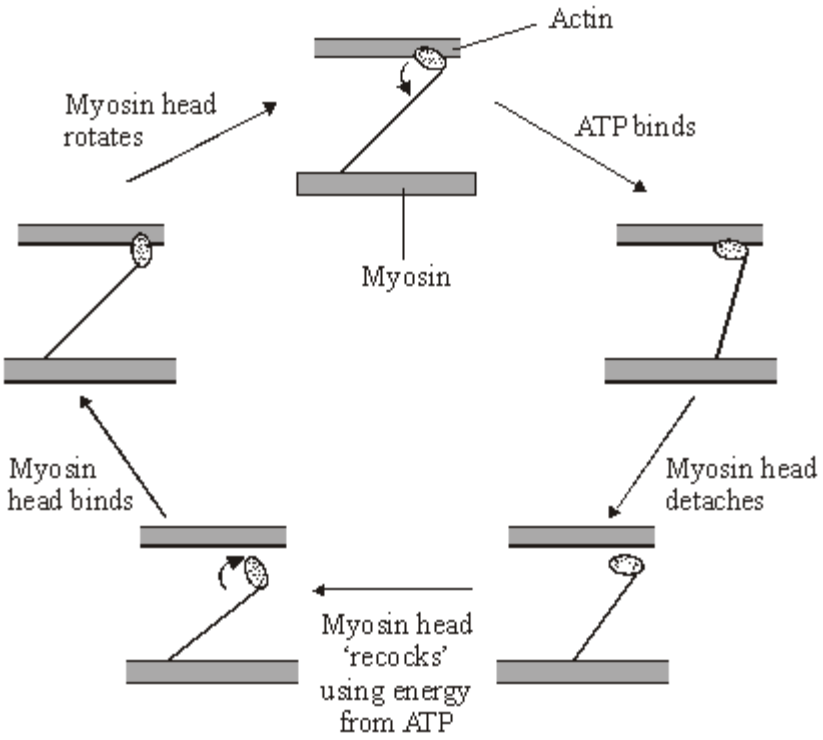
_____

_____

(2)

(Total 10 marks)

20 The diagram shows the stages in one cycle that results in movement of an actin filament in a muscle sarcomere.



(a) Describe how stimulation of a muscle by a nerve impulse starts the cycle shown in thediagram.

(3)

(b) Each cycle requires hydrolysis of one molecule of ATP and moves one actin filament 40 nm. During contraction of a muscle sarcomere, a single actin filament moves 0.6 µm. Calculate how many molecules of ATP are required to produce this movement.

Answer _____

(2)

(c) After death, cross bridges between actin and myosin remain firmly bound resulting in rigormortis. Using information in the diagram, explain what causes the cross bridges to remain firmly bound.

_____

_____

_____

_____

(2)

(Total 7 marks)

21 **Figure 1** shows a diagram of part of a muscle myofibril.

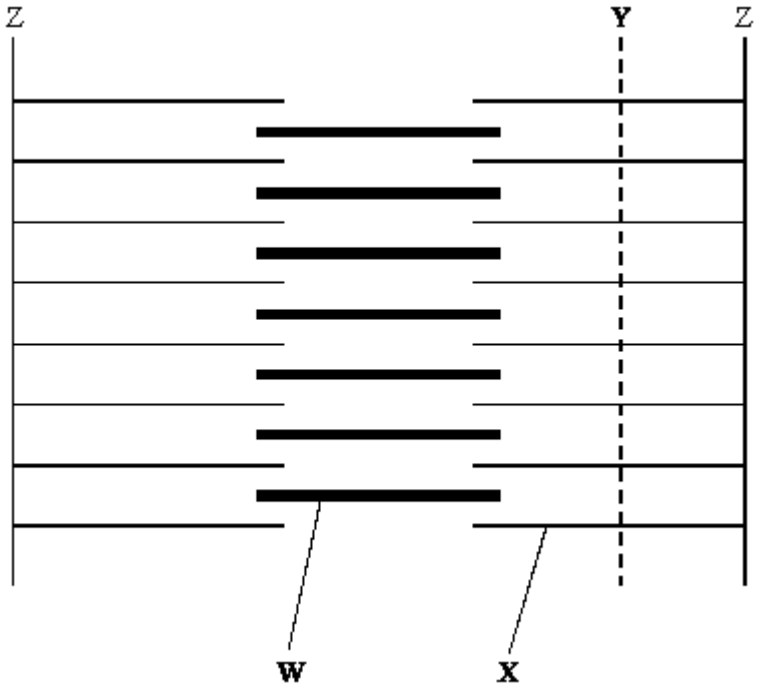


Figure 1

(a) Name the protein present in the filaments labelled **W** and **X**.

W _____

X _____

(1)

(b) **Figure 2** shows the cut ends of the protein filaments when the myofibril was cut at position **Y**. **Figure 3** shows the protein filaments when the myofibril was cut at the same distance from a Z line at a different stage of contraction.

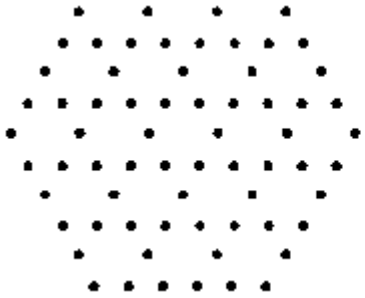


Figure 2

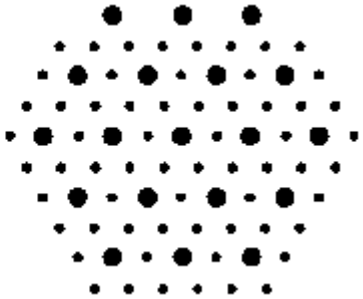


Figure 3

Explain why the pattern of protein filaments differs in **Figure 2** and **Figure 3**.

_____

_____

_____

_____

(2)

(c) Describe the role of calcium ions in the contraction of a sarcomere.

_____

_____

_____

_____

_____

(4)

(Total 7 marks)

This question should be written in continuous prose, where appropriate.

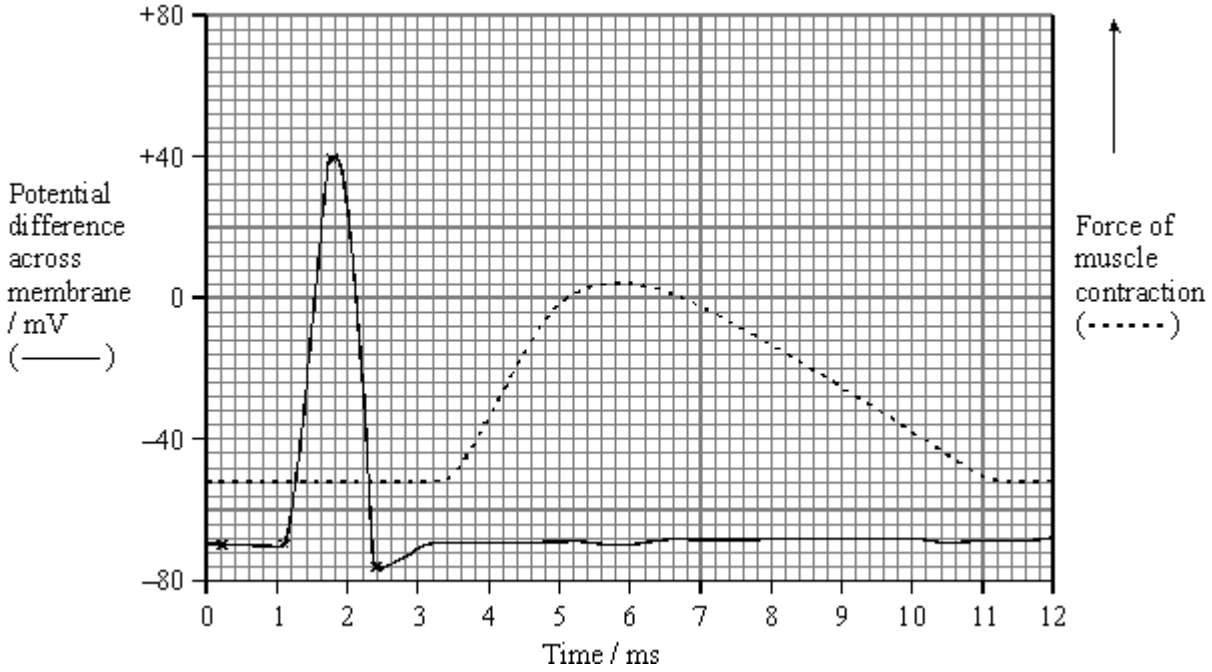
22

(a) Explain how a resting potential is maintained in a neurone.

(4)

(b) In an investigation, an impulse was generated in a neurone using electrodes. Duringtransmission along the neurone, an action potential was recorded at one point on the neurone. When the impulse reached the neuromuscular junction, it stimulated a muscle cell to contract. The force generated by the contraction was measured. The results are shown in the graph.

The distance between the point on the neurone where the action potential was measured and the neuromuscular junction was exactly 18 mm.



(i) Use the graph to estimate the time between the maximum depolarisation and thestart of contraction by the muscle cell.

Time _____ ms

(1)

(ii) Use your answer to part (i) to calculate the speed of transmission along this neuroneto the muscle cell. Give your answer in mm per second.

Show your working.

Speed _____ mm s^{-1}

(2)

(iii) Give **one** reason why the value calculated in part (ii) would be an underestimate of the speed of transmission of an impulse along a neurone.

_____

_____

(1)

Acetylcholine is the neurotransmitter at neuromuscular junctions.

(c) Describe how the release of acetylcholine into a neuromuscular junction causes the cellmembrane of a muscle fibre to depolarise.

_____

_____

_____

_____

_____

_____

(3)

(d) Use your knowledge of the processes occurring at a neuromuscular junction to explaineach of the following.

(i) The cobra is a very poisonous snake. The molecular structure of cobra toxin is similarto the molecular structure of acetylcholine. The toxin permanently prevents muscle contraction.

_____

_____

_____

_____

(2)

(ii) The insecticide DFP combines with the active site of the enzymeacetylcholinesterase. The muscles stay contracted until the insecticide is lost from the neuromuscular junction.

(2)

(Total 15 marks)

23 Surgeons sometimes use a drug called pancuronium to stop muscles contracting during an operation.

Pancuronium binds to acetylcholine receptors on muscle fibres.

(a) Suggest why pancuronium is able to bind to acetylcholine receptors.

(2)

(b) Pancuronium causes muscle paralysis. Explain how.

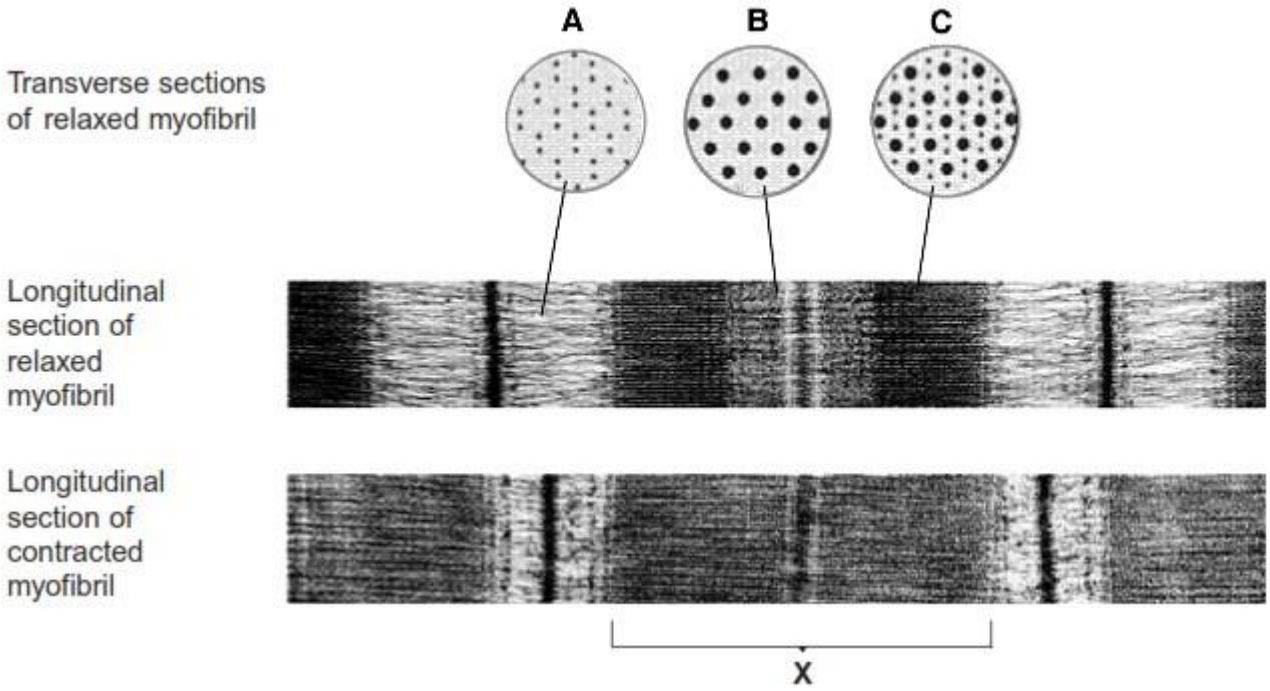
(Extra space)

(3)

(Total 5 marks)

24 **Figure 1** shows sections through relaxed and contracted myofibrils of a skeletal muscle. The transverse sections are diagrams. The longitudinal sections are electron micrographs.

Figure 1



(a) (i) The electron micrographs are magnified 40 000 times.
Calculate the length of band **X** in micrometres.
Show your working.

Length of band **X** = _____ µm

(2)

(ii) Explain the difference in appearance between transverse sections **A** and **C** in **Figure 1**.

_____

(1)

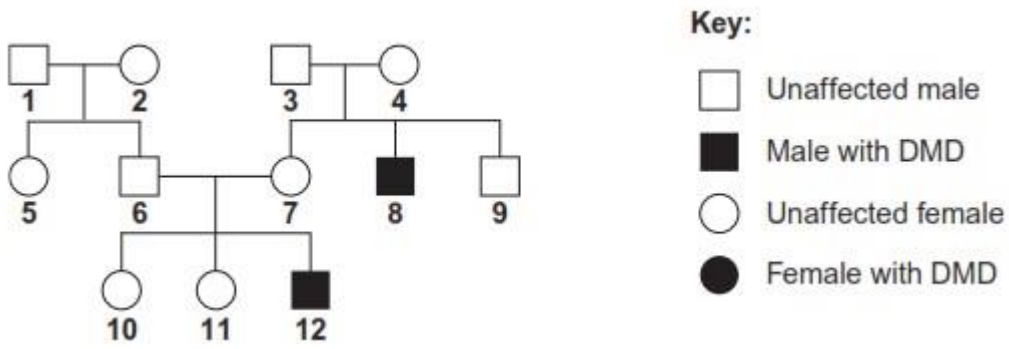
(b) Explain what leads to the differences in appearance between the relaxed myofibril and thecontracted myofibril.

(*Extra space*)

(4)

(c) Duchenne muscular dystrophy (DMD) is a condition caused by the recessive allele of a sex-linked gene. A couple have a son with DMD. They want to know the probability that they could produce another child with DMD. They consulted a genetic counsellor who produced a diagram showing the inheritance of DMD in this family. This is shown in **Figure 2**.

Figure 2



The couple who sought genetic counselling are persons **6** and **7**.

(i) Give the evidence to show that DMD is caused by a recessive allele.

_____

_____

(1)

(ii) Give the numbers of **two** people in **Figure 2** who are definitely carriers of muscular dystrophy.

_____

(1)

(iii) Complete the genetic diagram to find the probability that the next child of couple **6** and **7** will be a son with muscular dystrophy. Use the following symbols:

$\mathbf{X}^{D}$ = normal X chromosome

$\mathbf{X}^{d}$ = X chromosome carrying the allele for muscular dystrophy

Y = normal Y chromosome

	6	**7**
Parental phenotypes	Unaffected	Unaffected
Parental genotypes	_____	_____
Gametes	_____	_____

Offspring genotypes _____

Offspring phenotypes _____

Probability of having a son with DMD _____

(4)

(d) DMD is caused by a deletion mutation in the gene for a muscle protein called dystrophin. A deletion is where part of the DNA sequence of a gene is lost. People in different families may inherit mutations in different regions of this gene.

Scientists isolated the dystrophin gene from DNA samples taken from children **10**, **11** and **12**. They cut the gene into fragments using an enzyme. The scientists then used two DNA probes to identify the presence or absence of two of these fragments, called **F** and **G**. This allowed them to find the number of copies of each fragment in the DNA of a single cell from each child.

The table shows their results.

Child	**Number of copies of gene fragment per cell**	
	F	**G**
10 (unaffected girl)	2	1
11 (unaffected girl)	2	2
12 (boy with DMD)	1	0

(i) The number of copies of gene fragments **F** and **G** shows that person **12** has DMD. Explain how.

_____

_____

(1)

(ii) The number of copies of gene fragments **F** and **G** shows that person **12** is male. Explain how.

_____

_____

_____

_____

(2)

(iii) The genetic counsellor examined the scientists' results. He concluded that person **10** is a carrier of DMD but her sister, **11**, is not.

Describe and explain the evidence for this in the table.

_____

_____

_____

_____

_____

_____

(*Extra space*) _____

_____

_____

(3)

(e) Person **12** took part in a trial of a new technique to help people with DMD.

Doctors took muscle cells from person **12**'s father and grew them in tissue culture.

They suspended samples of the cultured cells in salt solution and injected them into a muscle in person **12**'s left leg. They injected an equal volume of salt solution into the corresponding muscle in his right leg. Person **12** was given drugs to suppress his immune system throughout the trial.

Four weeks later, the doctors removed a muscle sample from near the injection site in each leg. They treated these samples with fluorescent antibodies. These antibodies were specific for the polypeptide coded for by gene fragment **G** of the dystrophin gene.

The results are shown in the table.

Location and treatment	Percentage of muscle fibres labelled with antibody
Left leg - injected with cultured cells suspended in salt solution	6.8
Right leg - injected with salt solution	0.0

(i) Why was it necessary to treat person **12** with drugs to suppress his immune system?

_____

_____

(1)

(ii) Explain why salt solution was injected into one leg and cultured cells suspended insalt solution into the other.

_____

_____

_____

(1)

(iii) This technique is at an early stage in its development. The doctors suggested thatfurther investigations need to be carried out to assess its usefulness for treating people with DMD.

Explain why they made this suggestion.

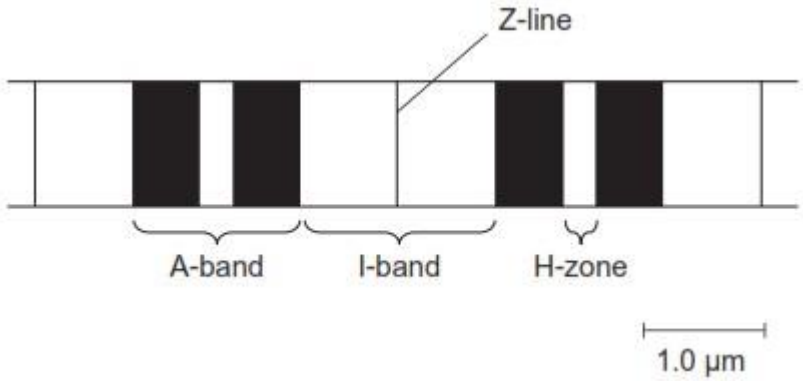
_____

(*Extra space*) _____

(4)

(Total 25 marks)

25 The diagram shows part of a relaxed myofibril.



(a) When the myofibril contracts, which of the A-band, I-band and H-zone will

(i) remain unchanged in length _____

(ii) decrease in length? _____

(2)

(b) The whole myofibril is 21 mm long when relaxed. Use information from the diagram, andthe scale provided, to calculate the number of sarcomeres in the myofibril.

Show your working.

Number of sarcomeres = _____

(2)

(c) Calcium ions are involved in myofibril contraction.Describe how.

_____

_____

_____

_____

_____

_____

(Extra space) _____

_____

_____

(3)

(Total 7 marks)

26

(a) Describe the role of each of the following in muscle contraction.

(i) Tropomyosin

_____

_____

(2)

(ii) ATP

(2)

(b) Explain how muscles maintain posture.

(Extra space)

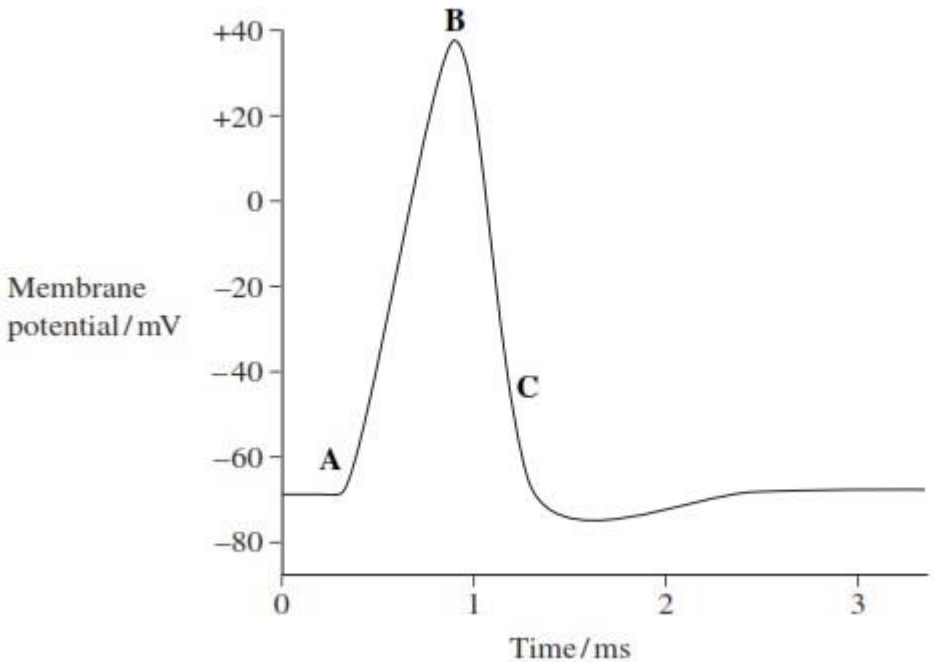
(3)

(Total 7 marks)

Figure 1 shows changes in the membrane potential of a neurone during one action potential.

27

Figure 1



(a) What happens in the membrane to cause the change in membrane potential at time **B**?

_____

_____

_____

_____

(2)

(b) No further action potential can be produced between times **A** and **C**.

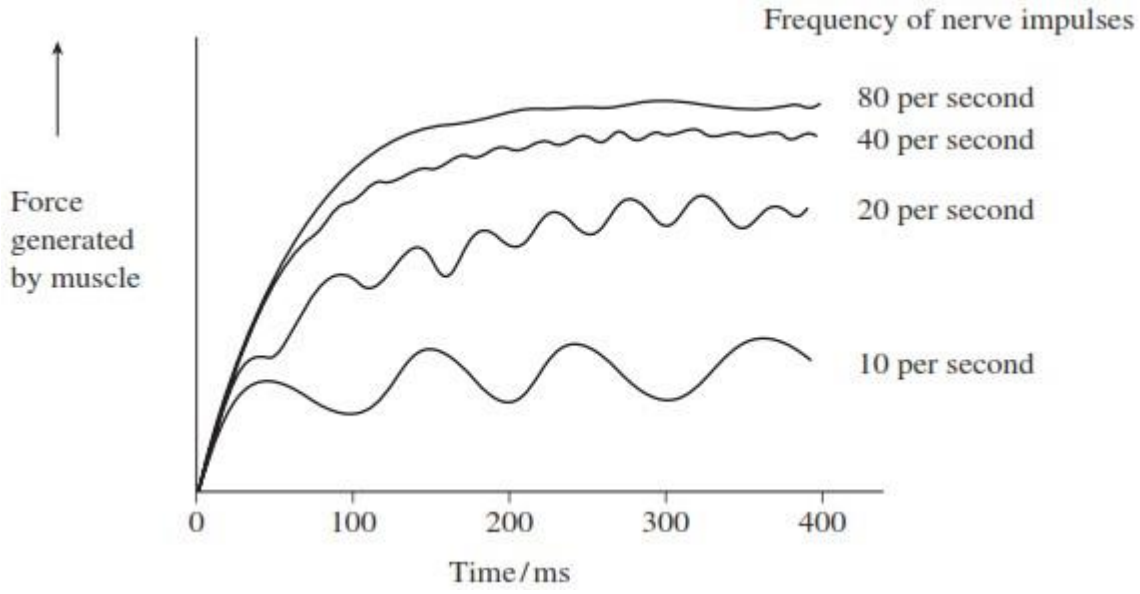
What is the name given to the period between times **A** and **C**?

_____

(1)

(c) **Figure 2** shows the force generated by a muscle when it was stimulated by different frequencies of nerve impulse.

Figure 2



A taser is a device used by the police to arrest violent suspects. It fires electrical impulses very similar to action potentials into a suspect. The frequency of the impulses is between 15 and 20 per second.

(i) Suggest the effect a taser has on a suspect's muscles.

_____

_____

_____

_____

(2)

(ii) Tasers with frequencies of between 40 and 80 per second are not used, because theyare considered too dangerous. Suggest how they might be dangerous to a suspect.

_____

_____

_____

_____

(2)

(Total 7 marks)

Mark schemes

1

(a) 1. Calcium ions diffuse into myofibrils from (sarcoplasmic) reticulum;

2. (Calcium ions) cause movement of tropomyosin (on actin);
3. (This movement causes) exposure of the binding sites on the actin;
4. Myosin heads attach to binding sites on actin;
5. Hydrolysis of ATP (on myosin heads) causes myosin heads to bend;
6. (Bending) pulling actin molecules;
7. Attachment of a new ATP molecule to each myosin head causes myosin headsto detach (from actin sites).

5 max

(b) 1. Releases relatively small amount of energy / little energy lost as heat;*Key concept is that little danger of thermal death of cells*

2. Releases energy instantaneously;

Key concept is that energy is readily available

3. Phosphorylates other compounds, making them more reactive;
4. Can be rapidly re-synthesised;5. Is not lost from / does not leave cells.

2 max

[7]

2

(a) 1. Reduction in ATP production by aerobic respiration;

2. Less force generated because fewer actin and myosin interactions in muscle;
3. Fatigue caused by lactate from anaerobic respiration.

3

(b) Couple **A**,

1. Mutation in mitochondrial DNA / DNA of mitochondrion affected;
2. All children got affected mitochondria from mother;
3. (Probably mutation) during formation of mother's ovary / eggs;

Couple **B**,

4. Mutation in nuclear gene / DNA in nucleus affected;
5. Parents heterozygous;
6. Expect 1 in 4 homozygous affected.

4 max

(c) 1. Change to tRNA leads to wrong amino acid being incorporated into protein;
2. Tertiary structure (of protein) changed;

3. Protein required for oxidative phosphorylation / the Krebs cycle, so less / noATP made.

3

(d) 1. Mitochondria / aerobic respiration not producing much / any ATP;
2. (With MD) increased use of ATP supplied by increase in anaerobic respiration;3. More lactate produced and leaves muscle by (facilitated) diffusion.

3

(e) 1. Enough DNA using PCR;
2. Compare DNA sequence with 'normal' DNA.

2

[15]

3

(a) 1. (Reaction with ATP) breaks/allows binding of myosin to actin/ actinomyosin bridge;

2. Provides energy to move myosin head;

1. Credit 'breaks' or 'allows' binding to actin (because cyclical)

2. Allow in context of 'power stroke' or 're-cocking' (becausecyclical)

2. Ignore contraction on its own

2

(b) (i) Any value between 68.5 and 69.49 (%);;

If get difference of 0.9 but calculation of percentage incorrect, then award 1 mark;

2

(ii) (Mutant mice)

1. Unable to make phosphocreatine/ less phosphateavailable to make/recycle ATP;
2. So less energy/so less ATP available for contraction/fastmuscle fibres;

1 and 2. Reject production/creation of energy once

2 Accept less energy for grip

2. Accept no energy/no ATP for contraction/fast muscle fibres

2

(c) 1. (Heterozygous) have one dominant/normal allele (for creatineproduction);
2. (This) leads to production of enough/normal amount of creatine;

1. Accept has one allele/one copy of the gene for/that is making creatine

2

[8]

4 (a)

Function	Name
Attaches to Z line at the end of the sarcomere	**1. Actin;**
Breaks down ATP	**2. ATPase / myosin (head);**
Covers binding site on actin in relaxed myofibril	**3. Tropomyosin;**

Accept water

Accept troponin

3

(b) 1. Can't form myosin / thick filaments;

Neutral: prevents actin and myosin sliding filament action

2. Can't pull / can't move actin / slide actin past / (myosin) have to be joined / fixedto pull actin;

Accept: myosin can't pull on each other

3. Myosin moves / if attached doesn't move;

4. Can't move actin towards each other / middle of sarcomere / between myosin /can't shorten sarcomere / can't pull Z lines together.

Accept: contract for shorten

3

[6]

5 (a) 1. Splitting / breakdown / hydrolysis of <u>ATP</u>;

2. (Muscle) <u>contraction</u> requires energy / ATP;

Accept 'uses energy'. Reject idea of 'movement' of muscles requiring energy.

Reject suggestion that 'energy is produced'.

3. Use of ATP by <u>myosin</u>.

Accept a reference to any use of ATP by myosin. No credit for any further detail.

2 max

(b) <u>Fast</u> because (lots of) ATPase allows rapid **hydrolysis** of ATP
OR
<u>Slow</u> because (lots of) ATPase allows rapid **synthesis** of ATP.

Accept either approach as some texts refer to ATPase as the enzyme at the end of the ETC in mitochondria.

1

(c) 1. Need light to see colour / brown / yellow;*Requires reference to light.*

2. Cannot see colour / brown / yellow with electrons / an electron microscope;

Requires reference to electrons / electron microscope.

Accept 'see black and white with electrons / electron microscope'.

3. No organelles are visible.

Accept appropriate named examples of organelles.

2 max

[5]

6 (a) 1. Fields of view randomly chosen;

2. Several fields of view;
3. All same <u>species</u> (of animal / hamster);

Reject general statements related to sample size. All mark points relate directly to information provided in Resource A.

Accept 'all (Mesocricetus) auratus'.

4. Same muscle / organ used / only diaphragm used;5. Used at least 8 (animals) in each (age) group.

4 max

(b) (i) 15

Correct answer = 2 marks.

Allow 1 mark for showing

69 ÷ 4.6

OR

answer of 10 / 10.1 (correct calculation using fast in error.)

2

(ii) 1. (Calculation) used mean (number of capillaries);
2. Variation in number of capillaries per fibre.

*Note: maximum of **1** mark for this question.*

Ignore reference to an anomaly or calculation errors.

1 max

(c) (i) (Removing diaphragm means) animals / hamsters are killed.

1

(ii) 1. (Suggests) significant (difference) between young and adult;

MP1, MP2, MP4 and MP5 can include use of figures but check figures are used correctly.

2. (Suggests) not significant (difference) between adult and old;

Statements related to 'results being significant / not significant' do not meet the marking points. It is the difference that is significant or not. However, only penalise this error once.

3. For slow **and** fast fibres;

This MP can be given in the context of either MP1 or MP2 but only allow once. As well as this context there must be a reference to 'both' types of fibre.

4. (Suggests) significant (difference) between young and old for <u>fast</u> (fibres)
OR
(Suggests) not significant (difference) between young and old for <u>slow</u> (fibres);

All aspects of either approach required to gain credit.

5. (Suggests) significant (difference) where means ± SD do not overlap
OR
(Suggests) not significant (difference) where means ± SD overlap;

All aspects of either approach required to gain credit.

6. Stats test is required (to establish whether significant or not).

4 max

[12]

7 (a) (i) (Group) 5 / marathon runners.

Must only include this group and no other.

(ii) 1. (5 / marathon runners) have highest percentage of slow fibres;

*Maximum of **1** mark if the wrong fibres have been identified.*

2. (Slow fibres) use aerobic respiration / aerobic respiration occurs in mitochondria;

Either approach requires identification of aerobic respiration.

3. (Slow fibres) best for endurance / long periods of exercise / to avoidfatigue.

2 max

(b) 1. No (overall) change in number of fibres;

Reject any suggestion of an increase in number of fibres.

2. Increase in diameter of fibres;

'Size' without qualification is insufficient.

3. (Due to) training / exercise;
4. (Long-distance) cyclists have more / higher percentage of slow fibres (thanfast);

A comparison is required to meet this MP.

5. Slow fibres of wider diameter than fast fibres;
6. (Long-distance) cyclists have more mitochondria;
7. (Long-distance) cyclists have more capillaries (in muscles).

Idea of 'more' (than non-athletes) is required to gain credit.

Accept converse (for non-athletes) in MP4, MP6 and MP7.

3 max

(c) 1. Weightlifting favoured by / weightlifters have a high proportion of fast / low proportion of slow fibres

OR

Weightlifters have more fast / fewer slow fibres than non-athletes;

But (cannot tell because):

Reward for general statement or comparison with non-athletes.

For 'proportion', accept percentage (or idea of a ratio).

2. Do not know what 'weightlifters' (tested) were born with / had before startedweightlifting / training

OR

Don't know if there has been a change (in proportion due to weightlifting / training);

3. No information about age / gender / number of weightlifters (in sample).

For this MP, accept another relevant factor that might affect 'weightlifter' e.g. weights lifted, sex, diet, ethnicity, country of birth.

Ignore general statements about 'other factors'.

2 max

[8] (a) 1. (Phosphocreatine) provides phosphate / phosphorylates;

8

Accept P_i or P in circle Reject phosphorus

2. To make ATP;

Accept:

ADP + CP → ATP + C

Neutral – provides ATP

2

(b) One suitable suggestion;

eg

1. Genetic differences;
2. Level of fitness / amount of regular exercise done / mass of muscle;
3. Sex;
4. Ethnicity
5. Metabolic rate;
6. Number of fast / slow muscle fibres*Neutral lifestyle / diet / illness*

1 max

(c) 1. Fast muscle fibres used for rapid / brief / powerful / strong contractions;

2. Phosphocreatine used up rapidly during contraction / to make ATP;

3. (As people get older) slower metabolic rate / slower ATP production / slowerrespiration;

4. ATP used to reform phosphocreatine;

4

[7] (a) (i) 1. Moves out of the way when calcium ions bind;

9

1. Accept shape change with Ca^{2+}

1. *Don't accept just "calcium"*

2. Allowing myosin to bind (to actin) / crossbridge formation;

1. Accept presence of calcium ions leads to movement instead of binds

Accept references to troponin

2

(ii) 1. Head (of myosin) binds to actin and moves / pulls / slides actin past;

Q

2. (Myosin) detaches from actin and re-sets / moves further along (actin)

1. Accept myosin power stroke (to move actin)

1. Accept push

1. Accept crossbridges form instead of myosin head binds to actin

1. Must refer to myosin head or crossbridges

3. This uses ATP;

2 max

(b) (i) 1. (Glycogen broken down) gives (lots of) glucose for glycolysis / anaerobic respiration;

1. *Give if context of anaerobic respiration clear*

2. Glycolysis / anaerobic respiration not very efficient / only yields 2 ATP perglucose;

2. Accept anaerobic respiration is a quick source of ATP for exercise

2. Accept very little ATP

2

(ii) 1. (Many capillaries) give high concentration / lots of oxygen / shorter diffusion pathway for oxygen / large surface area for oxygen exchange / diffusion / good glucose supply with little glycogen present;

2. Allows high rate of / more aerobic respiration ***OR*** prevents build-up of lactic acid / (muscle) fatigue;

3. *Accept idea of aerobic respiration during endurance events / longperiods of exercise*

2

[8] (a) (i) Decreases;

10

Accept any word that means a decrease e.g. shorter / narrower / smaller etc

1

(ii) Nothing / stays the same length / does not change;

1

(b) 1. Two marks for correct answer of 29545-30455;

Correct answer = 2 marks outright. Range allows for a 1mm error in measuring

2. One mark for incorrect answers in which candidate clearly divides measured width by actual width;

Ignore rounding up

2

(c) (Idea ATP is needed for:)

1. Attachment / cross bridges between actin and myosin;*Accept the role of ADP in attachment*

2. 'Power stroke' / movement of myosin heads / pulling of actin;*Not just 'filaments slide' as given in the question stem*

3. Detachment of myosin heads;

4. Myosin heads move back / to original position / 'recovery stroke'

3 max

[7]

11

(a) (i) Contains more / large amount of succinic dehydrogenase;

Accept "the enzyme" since only one being discussed

(Slow fibres) have lots of mitochondria / (slow fibres) respire aerobically;

2

(ii) Near edge / outside;

Short distance for diffusion of oxygen / Allows rapid diffusion / more diffusion of oxygen;

Ignore glucose
Accept carbon dioxide

Oxygen used by mitochondria / electron transfer system in mitochondria;

Accept effect of carbon dioxide on cell e.g. carbon dioxide changes pH / carbon dioxide affects enzymes

3

(b) (i) Measure with graticule / eyepiece scale;

Calibrate against something of known size:

OR

Estimate / measure field diameter with a scale;
Estimate number of fibres to cover diameter;

Q *Last point could be a calibrated slide / haemocytometer / red blood cell or reasonable alternative*

Accept
Mount on ruler / haemocytometer / graph paper; use this to measure size;
Note position of ruler must be specified and correct

2

(ii) Equivalent measurements taken;

At random to avoid bias / avoid choice of particular fibres;

Large number to be representative / minimise effect of extremes / of anomalies;

As a stained slide is provided reject references to safety. Ignore reliable

2 max

[9]

12 (a) (i) Crista / inner membrane;

1

(ii) Matrix;

1

(b) B;

1

(c) (i) Reduce / prevent enzyme activity;

1

(ii) Prevents osmosis / no (net) movement of water;

So organelle / named organelle does not burst / shrivel;

Q *Allow reference to cell rather than organelle for first mark point only.*
Regard damage as neutral

2

(d) (Mitochondria) use aerobic respiration;

Mitochondria produce ATP / release energy required for muscles (to contract);

Q *Do not accept reference to making / producing energy.*

2

[8] (a) (i) A band;

13

1

(ii) H zone and *I* band;

1

(b) filaments in *I* / thin filaments / actin filaments slide in between myosin / thick filament; thin filaments enter H zone / meet in middle of A band / pull Z lines closer;

2

(c) correct answer: 22.5 mm ;; = 2 marks

OR relaxed sarcomere length $\frac{48}{16}$ = mm ; = 1 mark

/ = 3

2 max

(d) (i) In table:

low	high
low	high
high	low

(1 mark per row;;;)

3

(ii) 1 overall rate of contraction limited by rate of ATP-splitting;

2 ATPase splits ATP / hydrolyses ATP / converts ATP to ADP(+ phosphate);

3 ATP-splitting provides energy for *any TWO from* myosin-actin interaction; myosin head movement / actin to move relative to myosin; to 'cock' myosin head;

4 **max**

(iii) lactate = product of anaerobic respiration;

type 1 has higher activity of glycolytic enzymes / has lower activity of Krebs cycle enzymes / has fewer mitochondria;

2

[15] (a) 1. e.m. gives high resolution due to short wavelength of electrons;

14

2. antibodies attach specifically to target proteins;
3. gold particles are electron dense;
4. electrons must pass through a vacuum so material must be dead / fixed for e.m.;5. cross-bridge cycling requires living cells / metabolism / named aspect-e.g. ATP synthesis;

5

(b) 1. Ca^{2+} removes blocking molecules / uncovers binding site on actin;
2. correct references to Ca^{2+} binding to troponin / moving tropomyosin;
3. allows myosin heads to attach to actin filaments;
4. allows sliding of the actin and myosin filaments;
5. binding of ATP causes myosin (head) to detach (from actin);
6. (hydrolysis of) ATP releases energy;
7. which changes the configuration / cocking of the myosin head;

5 max

[10] (a) (i) Myosin filaments drawn longitudinally in A-band region;

15

Actin filaments drawn longitudinally from Z-line to edge of H-zone;

[Max. 1 mark if Actin and Myosin are not correctly labelled]

2

(ii) Electron microscope has greater resolution / able to tell two close objects apart better / electrons have shorter wavelength / higher frequency;

1 (b) Correct answer = 20;

Allow 1 mark for: $\frac{16 \times 1000}{8000}$;

OR

$40 \div \frac{16}{8000}$

2

[5

] (a) (i) H band not visible / reduced / little / no thick filament / myosin only region / ends of

16

thin filaments / actin close together;

I band not visible / reduced / little / no thin filament / actin only region;
A band occupies nearly all sarcomere / thick filament / myosin close to Z line;
Large zone of thick-thin overlap;

max 2

(ii) *Calcium ions:*
Bind to troponin;
Remove blocking action of tropomyosin /
expose myosin binding sites;

ATP:
Allows myosin to detach from actin / to break cross bridge;
[allow attach and detach]
Releases energy to recock / swivel / activate myosin head / drive power stroke;

max 3

(b) (i) Depolarisation of axon membrane / influx of Na^+ <u>establishes local currents;</u>
Change permeability to Na^+ / open Na^+ gates of <u>adjoining region;</u>
<u>Adjoining region</u> depolarises / influx of Na^+;

3

(ii) Depolarisation of (presynaptic) membrane;
Ca^{2+} channels open / increased permeability to Ca^{2+} causing influx of Ca^{2+} ;
Vesicles move towards / fuse with presynaptic membrane;
[If ions mentioned once assume candidate is referring to ions throughout; if no mention of ions penalise once only]

3

(c) (i) 1. Correct axes labelled, correct orientation, linear scale;
2. Key points (100%, 90% and 50%) plotted correctly;
3. Plots joined by straight lines;
[allow reasonable hand-drawn straight lines]

3

(ii) <u>Fast fibres used</u> (in explosive exercise);
[allow reverse for slow fibres]

1

[15] (a) (i) actin (*Accept* tropomyosin);

17 **1**

(ii) myosin head;

1

(b) (i) Ca^{2+} binds to [part of] the actin / troponin;
this causes tropomyosin to be displaced;
uncovers [myosin] binding sites [on actin] / allows actin to bind;

max 2

(ii) myosin heads bind to actin / cross bridge formation /actomyosin formed; myosin heads / crossbridges swivel / ratchet mechanism; causing actin to slide relative to myosin; energy provided by hydrolysis of ATP;

max 3

(c) (i) (number lightly stained fibres / total number of fibres) × 100;
(actual numbers are 10 / 18 × 100)

1

(ii) sample not representative / large enough / individual muscle fibresdifferent sizes / contain different number of myofibrils;

1

(d) all some stain = 1 fast dark and slow lighter = 2

2

(e) change in base sequence in DNA / addition / deletion / substitution of a base in DNAof the gene which codes for myosin; change in amino acid sequence / primary structure; causes a different tertiary structure; which alters the binding properties of myosin;

4

[15] (a) (i) maintaining a constant internal environment;

18 **1**

(ii) *one mark for example of factor kept constant; one mark for explaining its importance;*

e.g.
temperature / pH; optimum for enzymes / effect of pH / temperature on enzyme activity;

OR

water potential / blood glucose;

effect of osmotic / blood glucose imbalance on cells;

2 max

(b) cannot interact with / move tropomyosin from binding sites on actin;
(reject active sites) myosin(heads) do not bind /
actinomyosin not formed; does not activate ATPase /
energy not released from ATP;

3

[6] (a) (i) A / dark band is mainly due to myosin filaments;

19

H zone only myosin filaments; darker
band has both types of filament; light
band has only actin filaments;

2 max

(ii) H zone narrows;
light band narrows;
outer darker regions of A / dark band widen;

2 max

(b) (i) breaks down ATP yielding energy; used
to form / break actomyosin bridges;

2

(ii) **A** and **B** tropomyosin covers binding site
on actin; no cross bridges formed /
ATPase activity on myosin head reduced;

2

B and **C** calcium ions remove
tropomyosin;
binding / calcium ions increase ATPase activity;

2

[10] (a) calcium ions;

20

bind to / displace tropomysin; *(allow troponin)* reveal binding
site on actin; myosin binds to exposed sites on actin /
actomyosin formed / cross bridges form between actin and
myosin; activates ATPase;

3 max

(b) distance single actin filament moves divided by distance movedusing 1 ATP;
15 ATP;

2

(c) respiration stops / no ATP produced;
ATP required for separation of actin and myosin / cross bridges;

2

[7]

21 (a) **W** = myosin

X = actin;

1

(b) myofibril is <u>contracting</u> in **Figure 3** / <u>relaxing</u> in **Figure 2**; movement of actin fibres between myosin fibres;

2

(c) interact with / move / touch tropomyosin;
(allow troponin as alternative)

to reveal binding sites on actin;
(not active sites)

allowing myosin (heads) to bind / touch actin / actinomyosin formed;
activate ATPase / energy released from ATP;

4

[7]

22 (a) membrane relatively impermeable / less permeable to sodium ions / gated channels are closed / fewer channels; sodium ions pumped / actively transported <u>out</u>; by sodium ion carrier / intrinsic proteins; inside negative compared to outside / 3 sodium ions out for two potassium ions in;
(if sodium mentioned but not in context of ions, negate 1 mark)

4

(b) (i) 1.6;

1

(ii) 18 ÷ 1.6 = 11.25;multiply by 1000 to convert from ms to s / 11 250;

(correct method = 1 mark, i.e. $\frac{distance}{time}$ *or × 1000)*
(correct answer based on (b)(i) = 2 marks)

2

(iii) time for transmission / diffusion across the neuromuscular junction / synapse;time for muscle (fibrils) to contract;

1 max

(c) movement by diffusion;binding to receptors on (post-synaptic) membrane; causing sodium channels to open / sodium ions to move in to muscle (cell);

3

(d) (i) toxin binds to / competes for / blocks the acetylcholine receptors;acetylcholine can not depolarise the membrane / the toxin does not cause depolarisation;

(allow references to generating action potentials instead of depolarisation, do not allow references to impulses in muscles)

2

(ii) acetylcholinesterase is unable to breakdown acetylcholine;acetylcholine still available to depolarise the membrane / generate action potentials in the membrane;

2

[15] (a) Pancuronium has <u>similar</u> structure / shape to acetylcholine;

23

Reject <u>same</u> 're. Acetylcholine / re.receptor'

Complementary to / fits receptor;

Ignore 'active site'

2

(b) (Pancuronium) not removed from receptor by ACh-esterase / not broken down by ACh-esterase;
(Pancuronium) prevents ACh from binding / blocks receptor site;
ACh (normally) causes opening of Na^+ channels / causes action potential in muscle fibre;

Accept converse re. pancuronium

(Pancuronium) prevents <u>influx</u> of Ca^{2+} ions (to start contraction);
(Pancuronium) prevents unblocking of binding sites on actin;

3 max

[5] (a) Correct answer: 1.25;

24

Ignore working

OR (if wrong answer)

$$\frac{\text{measurement in µm}}{40000} \; / \; \frac{\text{measurement in mm}}{40} = 1 \text{ mark}$$

125 but wrong order of magnitude = 1 mark

2 (ii) **C** has myosin / thick (and actin / thin) filaments;

OR

A has only actin / thin (/ no myosin / no thick) filaments;

1 max

(b) When contracted:

Thick & thin filaments/myosin & actin overlap more;

Interaction between myosin heads & actin / cross-links form;

Movement of myosin head;

Thin filaments / actin moved along thick filaments / myosin;

Movement of thin filaments / actin pulls Z-lines closer together;

Displacement of tropomyosin to allow interaction;

Role of Ca^{2+};

Role of ATP;

Allow ref. to 'sliding filament mechanism' / described if no other marks awarded

4 max

(c) (i) 8 has DMD but 3 and 4 do not / 12 has DMD but 6 and 7 do not / neither parent has the condition but their child has;

Allow parents 3 and 4 give 8, parents 6 and 7 give 12

1

(ii) 4 ***AND*** 7;

1 (iii) Parental genotypes: 6 = $\mathbf{X^DY}$ AND 7 = $\mathbf{X^DX^d}$

AND

Gametes correct for candidate's P genotypes – e.g.

$\mathbf{X}^{D}$ and $\mathbf{Y}$ + $\mathbf{X}^{D}$ and $\mathbf{X}^{d}$;

Offspring genotypes <u>correctly derived</u> from gametes e.g.

$\mathbf{X}^{D}\mathbf{X}^{D}$ + $\mathbf{X}^{D}\mathbf{X}^{d}$ + $\mathbf{X}^{D}\mathbf{Y}$ + $\mathbf{X}^{d}\mathbf{Y}$;

Male offspring with MD correctly identified: $\mathbf{X}^{d}\mathbf{Y}$;

Probability = 0.25 / correct for candidates offsprings genotypes;

Accept ¼ / 1 in 4 / 1:3 / 25%

NOT '3:1' / '1:4'

4

(d) (i) No gene fragment **G**;

1

(ii) Only one copy of gene fragment **F**;

Male has only one X-chromosome / is XY
(c.f. female has two / is XX);

2

(iii) 10 has only one copy of gene fragment **G**;

10 has only one normal X-chromosome / has one abnormal /
normal allele / has one X / is $X^{d}X^{D}$ / is X^{d} has only one heterozygous;

11 has two normal X-chromosomes / has 2 normal alleles /
is $X^{D}X^{D}$ / has not got X^{d} / has 2 copies of (F and) G;

3

(e) (i) To prevent rejection / prevent antibody production vs. injected cells /
injected cells have (foreign) antigen (on surface);

1

(ii) Shows effect of <u>cells</u> / not just effect of injection / not just effect of salt solution;

1

(iii) Only one person tested so far – need more to see if similar results /need more to see if reliable;

Need to assess if new (dystrophin positive) muscle fibres are functional / if muscle becomes functional;

Can't tell how widespread effect is in the muscle / sample taken near injection site;

Need to test for harmful side effects;

Need to test if successful for other mutations of dystrophin gene;

Need to assess permanence / longevity of result/insufficient time allowed in investigation;

(In this patient) only small response / %;

Further sensible suggestion;

4 max

[25]

25

(a) (i) A; **1**

(ii) H + I; **1**

(b) Correct answer: 7000;

Accept 6422 to 7608 Ignore working

OR

1 sarcomere = $\frac{48}{16}$ (µm) and use of 21 (000) µm / use of $\frac{21(000)}{3}$;

Allow 1 mark

OR

Allow for error re. interconversion of mm / µm: e.g. $\frac{21}{3}$ / $\frac{2100}{3}$

Allow 1 mark

2

(c) Rise in Ca^{2+} (in muscle cells) / Ca^{2+} enters (muscle cells) / Ca^{2+} from SR;

Leading to movement of blocking/inhibiting molecules/troponin/ tropomyosin;

Expose binding sites on actin/on thin filament;

Allow actin-myosin interaction / cross-bridge formation/allow myosin to bind/allow filaments to slide past each other;

Activate ATP-ase (on myosin);

3 max

[7] (a) (i) Blocks myosin binding (site) on actin;

26

Accept converse statements

Moves from binding site on actin due to Ca^{2+};
Allowing myosin to bind (to actin) / crossbridge formation;

2 max

(ii) Releases myosin from actin;

Accept coming / moving away from actin

Causes myosin head to move / cock;
Used in active transport of Ca^{2+};

2 max

(b) Antagonistic muscles / opposing pairs of muscles;
Working across/at joints;
Both contract to keep joint/the body at certain angle / upright;
Isometric contraction;
Only a few fibres contract to avoid fatigue/slow muscle fibres used;

3 max

[7] (a) Potassium channels open (and K^+ ions diffuse out);

27

Accept references to sodium channels opening;

Sodium channels close (and stops Na^+ ions diffusion in);

Leading to depolarisation;

Accept sodium pump (starts) to pump out sodium ions

2

(b) (Absolute) refractory (period);

1

(c) (i) Causes them to contract;

And relax;

Rapidly/twitch;

2 max

(ii) Cause continuous muscle contraction;

Accept a reasonable suggestion of harm – linked to muscle contraction

At high force;

Causing failure to breathe/heart stops pumping/ damage to bones or joints;

2 max

[7]