SL Paper 3

a. Draw a labelled diagram to show the structure of a sarcomere. [2]

b. Explain the roles of actin and myosin in muscle contraction. [4]

Markscheme

a. *Award **[1]** for each structure clearly drawn and correctly labelled.*

   a. Z lines;

   b. thin actin filaments shown attached to Z lines;

   c. thick myosin filaments with heads;

   d. light and dark bands;

b. a. calcium/Ca^{2+} frees myosin binding sites on actin/thin filament;

   b. ATP (linked to myosin head) hydrolysed to ADP + P(i);

   c. myosin head cocked/assumes high energy configuration;

   d. myosin head binds to actin / forms a cross-bridge;

   e. actin filament slides towards center of sarcomere / dark band;

   f. combined sliding of actin filaments shortens muscle fiber / muscle;

   g. ATP binds to myosin head and breaks cross-bridge;

   Accept answers with properly annotated diagrams.

Examiners report

a. A relatively small number of candidates answered this option, but those who did generally achieved well.

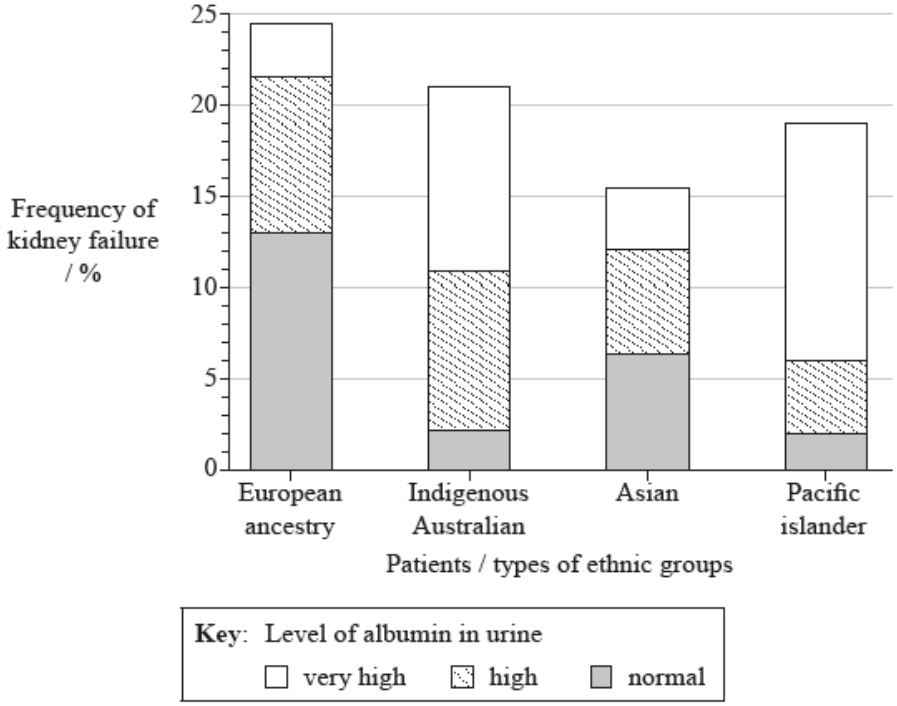
   The diagram of the structure of a sarcomere was well answered on the whole.

b. A relatively small number of candidates answered this option, but those who did generally achieved well.

   Most candidates had difficulty explaining the roles of actin and myosin in muscle contraction.

Inadequate filtering of waste products from the blood is known as kidney failure. If this condition is found in a patient, or albumin is present in their urine, it shows that the patient has chronic kidney disease. Type II diabetes is the leading cause of chronic kidney disease in Australia. The bar graph shows the frequency of kidney failure in patients with type II diabetes in different Australian ethnic groups. It also shows the level of albumin in the

urine of patients with both type II diabetes and kidney failure.



[Source: Thomas M. C. *et al*. The burden of chronic kidney disease in Australian patients with type 2 diabetes (the NEFRON study). *Med. J. Aust*. 2006; **185** (3): 140–144. © Copyright 2006. *The Medical Journal of Australia* – adapted and translated with permission. *The Medical Journal of Australia* does not accept responsibility for any errors in translation.]

a.i. State the ethnic group with the lowest frequency of kidney failure. [1]

a.ii. State the frequency of both kidney failure and greater than normal albumin levels in patients of European ancestry with type II diabetes. [1]

. . . . . %

b. Compare the levels of albumin in urine of patients with kidney failure in the different ethnic groups. [3]

c. The usual method of screening for chronic kidney disease is to test for kidney failure. Using the data in the bar chart, suggest why this method leads to more cases being missed in patients of indigenous Australian ancestry than in patients with European ancestry. [2]

Markscheme

a.i. Asian

a.ii. 11.5(%) *(allow answers in the range of 11(%) to 12(%))*

(NOTE: question is worded awkwardly but if students give both 24.5% and 11.5% do not give credit)

b. all ethnic groups show range (very high, high and normal) of albumin levels;

greatest frequency of very <u>high</u> levels of albumin found in Pacific Islander patients/ European ancestry patients have lowest frequency of <u>very</u> high levels of albumin;

greatest frequency of high levels of albumin in Indigenous Australian/European ancestry patients / lowest frequency of high levels of albumin in Pacific Islander patients;

European ancestry patients have highest frequency of normal levels of albumin / Indigenous Australian/Pacific Islander patients have lowest frequency of normal levels of albumin;

c. European ancestry patients have highest/higher frequency of kidney failure but more than half/a large percentage have a normal level of albumin;

Indigenous Australian patients have lower frequency of kidney failure but higher levels of albumin;

it would be better to test for both kidney failure and albumin levels;

Examiners report

a.i. Candidates had no problem with the use of the bar chart to state which group had the lowest frequency of kidney failure, with most getting this mark.

a.ii. Most also used the bar chart to find the correct value of 11.5% although some seemed to misunderstand the question, giving two answers. This ambiguity seemed to be caused by the use of the word 'both' in the question. This led some candidates to give both 24.5% (for percentage with kidney failure) as well as 11.5% (for greater than normal albumin levels). As long as the 11.5% was clearly in the answer, the mark was awarded.

b. The responses to this question were often awkward and it seemed that some did not understand the data in this stacked bar chart so they did not make valid comparisons between the levels of albumin in the ethnic groups. Few were able to get the full 3 marks.

c. Almost all candidates found this question difficult and very few correct replies were seen. Many related their responses to perceived social inequities, not the data provided.

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a. Draw a labelled diagram to show the structure of a skeletal muscle sarcomere. [3]

b. Outline the role of myoglobin in muscle fibres. [2]

Markscheme

a. *Award [1] for each structure clearly drawn and correctly labelled.*

light and dark bands;

Z line;

(thin) actin filaments shown with no gap between these and Z line;

(thick) myosin filaments shown with heads;

b. binds oxygen when level is high;

releases oxygen when level is low;

acts as an oxygen store;

allows muscles to continue with aerobic respiration for longer;

Examiners report

a. Some very poor diagrams were seen. The structure of a skeletal muscle was drawn by many of the candidates, without showing the sarcomere.

b. Many candidates knew that myoglobin is used as an oxygen store.

a. Outline the function of myosin and actin in muscle contraction. [3]

b (i) State the function of the following structures in the human elbow. [1]

Synovial fluid

b (ii) State the function of the following structures in the human elbow. [1]

Biceps

Markscheme

a. a. formation of cross-bridges/myosin binds to the thin filament/actin;

b. Z-bands pulled towards each other;

c. sliding of actin and myosin filaments/shortening the sarcomere/I-band;

d. use of ATP to break cross-bridges / myosin releases actin when binding to ATP;

e. myosin heads re-set;

f. contraction ceases when myosin head detaches from the thin filament;

b (i) synovial fluid: avoids friction/lubricates / absorbs shock (at the elbow joint)

b (ii) biceps: flexes arm/raises lower arm

Examiners report

a. Only the better students could outline the function of myosin and actin in muscle contraction.

b (i) N/A

b (ii) N/A

Draw a labelled diagram to show the structure of a sarcomere in striated muscle.

Markscheme

Award [1] for each structure clearly drawn and correctly labelled.

Z lines;

thin actin filaments shown attached to Z lines;

thick myosin filaments with heads;

(two) light bands and dark bands;

*Award **[2 max]** for a poorly drawn or inaccurate diagram.*

Examiners report

Many candidates were able to get 3 marks for the diagram of the sarcomere in (b), although some poor diagrams were seen; very good diagrams were rare.

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b (i) State the role of ligaments in human movement. [1]

d. Explain the changes in ventilation rate during exercise. [2]

Markscheme

b (i) connect bones to bones / enable joint movement/flexibility/articulation/ prevent dislocation

d. a. increased (muscle) cell respiration releases more CO_2/decreases pH (in blood);

b. detected by (respiration centre in) brain/medulla;

c. signal sent to respiratory muscles to contract at a faster rate;

d. more oxygen carried by the blood / needed for aerobic (cell) respiration;

Examiners report

b (i) A relatively small number of candidates answered this option, but those who did generally achieved well.

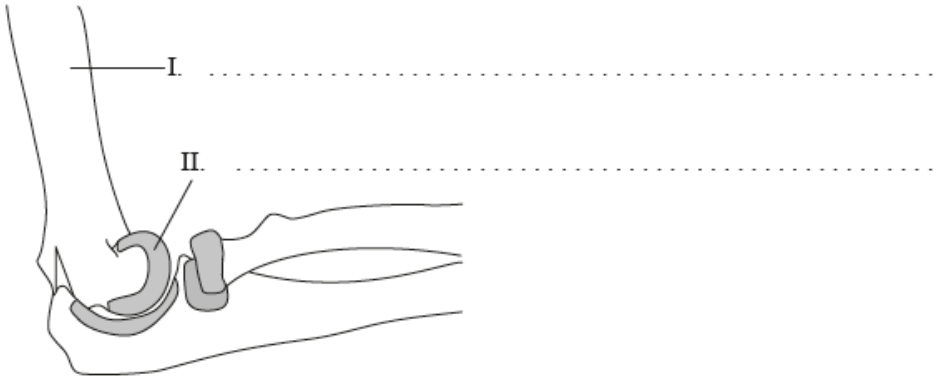
Most candidates could state the role of ligaments.

d. A relatively small number of candidates answered this option, but those who did generally achieved well.

B2 (c) was well answered but B2 (d) was not, with students failing to explain the changes in ventilation during exercise.

---

a. Label the following diagram of the side view of the human elbow joint. [1]



b. State the function of structures I and II. [2]

I:

II:

Markscheme

a. $\left.\begin{matrix}\text{I: humerus;}\\ \text{II: cartilage;}\end{matrix}\right\}$ (need both)

b. I: insertion/anchorage for attachment of muscle / acts as lever;

II: decrease friction / acts as a cushion/shock absorber;

Examiners report

a. It was surprising the large number of candidates who could not correctly identify the humerus and cartilage in the diagram of the elbow joint.

b. Many candidates also did not get marks for this section as they could not clearly state the function of the bone or of cartilage. Insertion/anchorage for attachment of muscle / acts as lever; seldom give marks for I; often vague such as ‘gives structure to arm’.

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a. Draw a labelled diagram of a sarcomere. [3]

b. Explain the role of calcium ions in muscle contraction. [2]

Markscheme

a. *Award **[1]** for each structure clearly drawn and correctly labelled.*

Z lines;

actin filaments;

myosin filaments with heads;

light bands and dark bands;

b. Ca^{2+} ions released when a nerve impulse arrives at the muscle;

Ca^{2+} ions are released from the sarcoplasmic reticulum;

binding sites for myosin heads are exposed;

this allows cross-bridges between myosin and actin to form;

Examiners report

a. The diagram of a sarcomere was very poorly done on the whole, with many bearing little resemblance to what was required. Those who did attempt a diagram often managed to gain a mark for showing Z lines, but little else. Quite a large number of candidates left this part of the option blank.

b. This was also not well done. It is a challenging topic, and proved to be a good discriminator for the more able candidates. It is obviously an area which students find difficult to understand.

Draw a labelled diagram showing the arrangement of proteins in a sarcomere.

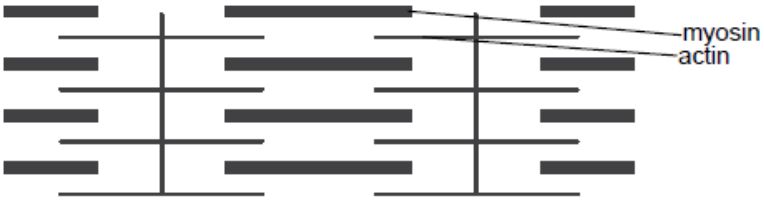
Markscheme

a. actin filaments – drawn as thin lines;

b. myosin filaments (with heads) – drawn as thick lines;

c. regions of overlap between fibres should follow diagram of sarcomere;

d. correct labelling of the A or H band/Z line;



Examiners report

There were some good diagrams and some poor diagrams of a sarcomere. Many candidates got all 3 marks.

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a. State the names and functions of the antagonistic muscles of the human elbow joint. [2]

c. Explain the role of ATP in muscle contraction. [2]

Markscheme

a. a. biceps flexes/bends the arm;

b. triceps extends/straightens the arm;

c. a. ATP binds to myosin heads;

b. ATP used to break cross bridges;

c. energy released when ATP forms ADP and phosphate;

d. myosin head reset;

e. actin slides over myosin;

Examiners report

a. Most candidates knew the functions of the biceps and triceps muscles.

c. There was much confusion over the exact role of ATP in muscle contraction.

List **two** structural features of a joint that reduce friction between bones.

1. .....
2. .....

Markscheme

a. cartilage;

b. synovial fluid;

c. joint capsule (prevents fluid from leaking);

Examiners report

In 3a, a disappointing number could list cartilage and synovial fluid as the answers.

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a. Draw a labelled diagram to show the structure of a sarcomere. [3]

b. Describe how skeletal muscle contracts. [3]

Markscheme

a. *Award **[1]** for each structure clearly drawn and correctly labeled.*

   Z lines;

   thin actin filaments shown attached to Z lines;

   thick myosin filaments with heads;

   light and dark bands;

   *Award **[2 max]** for poorly drawn/inaccurate diagram*

b. action potential arrives at the neuromuscular junction/depolarizes muscle cells;

   release of calcium ions from the sarcoplasmic reticulum;

   (calcium binding to troponin exposes actin) to form cross-bridges;

   heads push actin filament towards centre of sarcomere (so sarcomere becomes shorter);

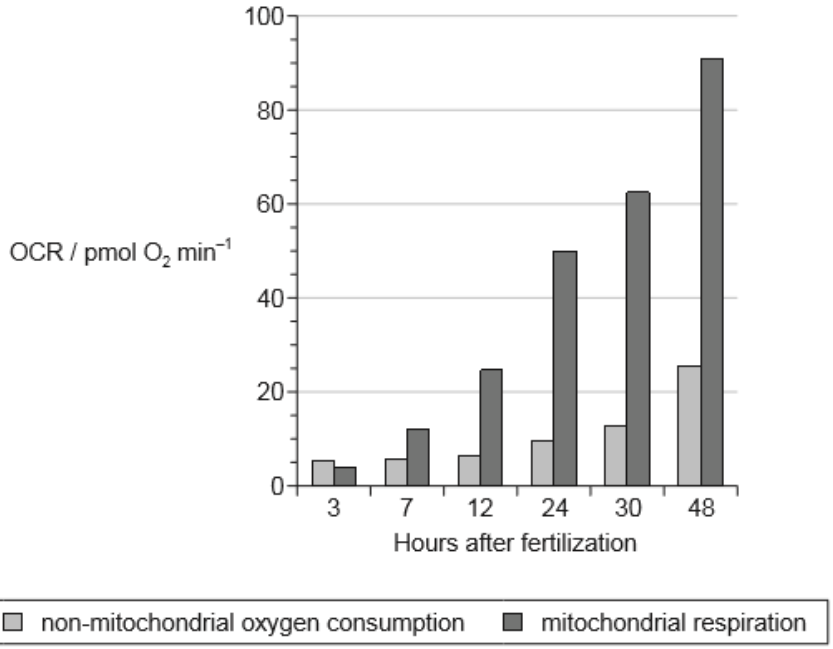
   use of ATP to break cross-bridges/re-set myosin heads;

Examiners report

a. The diagram of a sarcomere was very poorly drawn on the whole, with many bearing little resemblance to what was required. Those who did attempt a diagram often managed to gain a mark for showing Z lines, but little else. Quite a large number of candidates left this part of the option blank.

b. This was also not well answered. It is a challenging topic, and proved to be a good discriminator for the more able candidates. It is obviously an area which students find difficult to understand. Very few could accurately describe the sequence of events in skeletal muscle contraction.

Oxygen consumption by a tissue or organism arises from mitochondrial respiration and non-mitochondrial oxygen consumption. High oxygen levels in the cell can damage DNA, proteins and lipids. In early embryo development, elevated non-mitochondrial oxygen consumption acts as an essential mechanism for protection. The bar chart shows the oxygen consumption rates per embryo (OCR) measured in Zebrafish (Danio rerio) during embryo development in the hours after fertilization.



[Source: Adapted from: Stackley, K.D., Beeson, C.C., Rahn, J.J. and Chan, S.S.L. (2011) Bioenergetic Profiling of Zebrafish Embryonic Development. *PLoS ONE* **6**(9): e25652. doi:10.1371/journal.pone.0025652. Figure 3.]

a. State the OCR in mitochondrial respiration 24 hours after fertilization. [1]

. . . . . pmol O_2 min^{-1}

b. Compare OCR due to non-mitochondrial oxygen consumption and mitochondrial respiration after fertilization. [2]

c. Suggest reasons for the rise in mitochondrial respiration in the 48 hours after fertilization. [2]

d. Non-mitochondrial oxygen consumption does not produce ATP and decreases in relation to mitochondrial respiration 48 hours after fertilization. Discuss the importance of non-mitochondrial oxygen consumption in a developing embryo. [1]

Markscheme

a. 50 (pmol O2 min^{-1}) (allow answers in the range of 49 to 51)

b. a. both increase with time after fertilization;

b. mitochondrial OCR increases (a lot) more than non-mitochondrial;

c. after 48 hours there is approximately three times more mitochondrial than non-mitochondrial OCR;

d. at 3 hours non mitochondrial OCR is higher than mitochondrial;

c. a. mitosis requires a large amount of energy;

b. more cells implies higher metabolic rate/DNA synthesis/other cell processes;

c. more mitochondria present with time;

d. mitochondria work more efficiently/faster;

d. protect DNA/protein/lipids/embryo (until mitochondrial respiration removes oxygen efficiently)

Examiners report

a. The data for Option C was a bar chart showing oxygen consumption in zebrafish embryos in the first 48 hours after fertilization. The data was fairly well answered with part (c) where the candidates were asked to suggest reasons for the changes in the graph causing most difficulty

b. The data for Option C was a bar chart showing oxygen consumption in zebrafish embryos in the first 48 hours after fertilization. The data was fairly well answered with part (c) where the candidates were asked to suggest reasons for the changes in the graph causing most difficulty.

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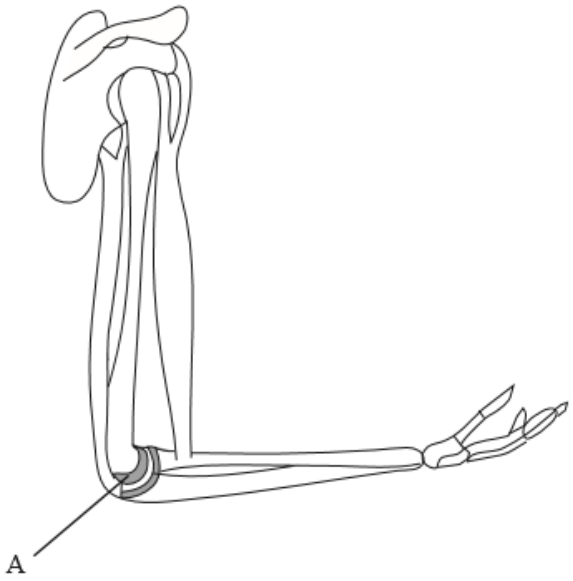
d. The data for Option C was a bar chart showing oxygen consumption in zebrafish embryos in the first 48 hours after fertilization. The data was fairly well answered with part (c) where the candidates were asked to suggest reasons for the changes in the graph causing most difficulty.

The diagram below shows an elbow joint.



a (i) On the diagram, label a pair of antagonistic muscles. [1]

a (ii) State the function of the structure labelled A. [1]

b. Explain the role of ATP in the contraction of skeletal muscle. [3]

Markscheme

a (i) biceps and triceps correctly labelled; (biceps = muscle on right, triceps = muscle on left)

Both needed for mark.

a (ii) cartilage is hard but flexible) able to absorb mechanical shocks / allows bones to pivot or move smoothly

b. ATP binds to myosin heads;

ATP binding causes cross bridges to break/heads detach from binding site;

ATP broken down/hydrolysed to ADP + Pi, causing myosin heads to change angle/become “cocked”;

myosin heads attach to binding sites on actin filament further along sarcomere;

ADP + Pi released and myosin heads push actin filament along/power stroke occurs;

Allow ONE mark if there is a general understanding of the role of ATP in the sliding of filaments but without specific details.

Examiners report

a (i) Most candidates could label “antagonistic muscles” on the diagram, but very few could name them.

a (ii) Many thought that structure A was simply the joint, and gave superficial responses such as “helps the arm to bend”, which did not gain any marks.

Others said incorrectly that A was synovial fluid.

b. This challenging question proved to be a good differentiator for the more able candidates, as a lot of understanding and detail were required in order to gain the marks.

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a. Analyse the electron micrograph for the state of contraction of the muscle fibre. [2]

[Source: http://click4biology.info/c4b/11/hum11.2.htm
Used with permission.]

b. Outline ATP production in muscle fibres during intense exercise. [2]

c. Explain the role of ATP in muscle contraction. [2]

Markscheme

a. a. muscle fibre is (partially) contracted;

b. thick and thin filaments show considerable overlapping;

c. narrow/reduced light bands between Z lines / *OWTTE*;

b. a. for 8–10 seconds creatine phosphate regenerates ATP;

b. anaerobic respiration produces ATP until lactate too high/for about 2 minutes/ 800 m of running;

c. a. ATP breaks cross-bridges (between myosin and actin);

b. ATP resets/activates/changes position of/cocks myosin heads;

c. ATP provides energy to move actin/causes sliding of filaments;

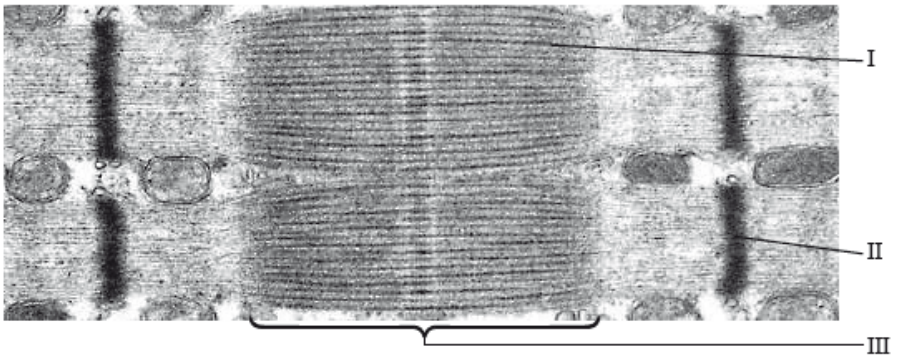
Examiners report

a. In a, the better candidates were able to state that the fibre was (partially) contracted as there was a narrow/reduced light band between the Z lines.

b. b was not well answered, with few considering the duration of ATP regeneration by creatine phosphate or the time taken to build up lactic acid.

c. Better candidates could explain the role of ATP in muscle contraction.

Label the parts of the following micrograph of the striated muscle.



[Coen A.C. Ottenheijm, Leo M.A. Heunks and Richard P.N. Dekhuijzen(2008) Diaphragm adaptations in patients with COPD. _Respiratory Research_, 9(12), doi:10.1186/1465-9921-9-12. © 2008 Ottenheijm _et al._; licensee BioMed Central Ltd.]

I .....

II .....

III .....

Markscheme

I. thick filament / myosin;

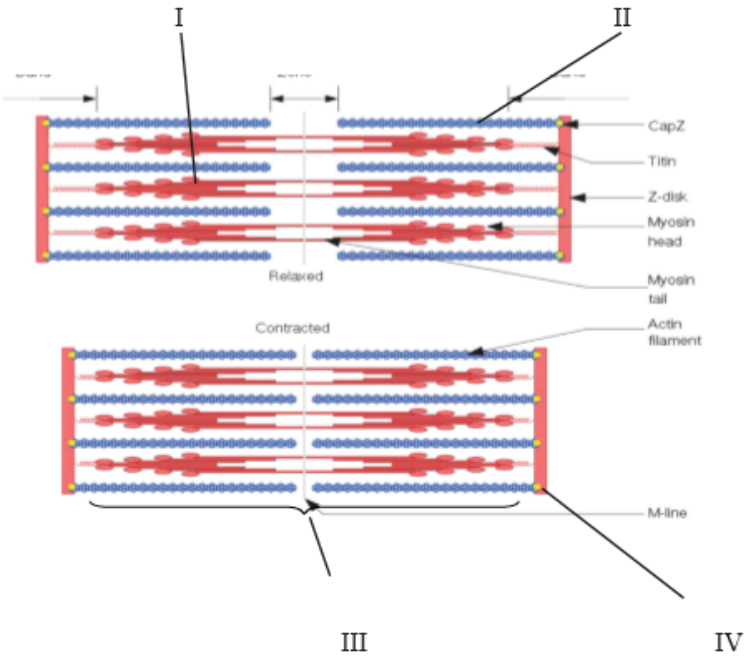
II. Z line;

III. A/dark band;

Examiners report

Surprisingly few candidates were able to correctly label the micrograph of striated muscle. They confused myosin with actin and the dark band/A line with the sarcomere.

The following is a diagram of a sarcomere.



[Acknowledgment: http://upload.wikimedia.org/wikipedia/commons/6/6e/Sarcomere.svg]

Label parts I, II, III and IV

I. .....

II. .....

III. .....

IV. .....

Markscheme

*Award **[1]** for any two of the following correctly identified.*

I. myosin head/filament;

II. actin filament;

III. dark band/A band;

IV. Z line;

Examiners report

Most answers were correct.