AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.6.3 SKELETAL MUSCLES

SCORE	PERCENTAGE
/223	%

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Q1.

(a) Increase in aerobic respiration
OR
Increase in / more mitochondria
OR
Increase in / more slow muscle fibres;

Ignore: reference to Krebs cycle as this in the stem of the question.

1 max

(b) 1. (More aerobic respiration) produces more ATP;
2. Anaerobic respiration delayed;
3. Less or no lactate;

1. Accept: produces ATP faster.

2. Accept: aerobic respiration can continue.

2. Accept : no anaerobic respiration.

3. Accept: lactic acid.

3

(c) 1. Correct answer in range 84 to 84.2 = 2 marks;
2. For one mark accept incorrect answer but shows r (radius) = 0.63 (mm)
OR
d (diameter) = 1.26 (mm);

2. Ignore: numbers after 0.63 and 1.26.

2

(d) 1. A numerical comparison of range = **2 marks** i.e.
Young (fibres) range 14/15 – 47/48 (μm) **and** adult (fibres) 17/18 – 86/87/88 (μm)
OR
Young (fibres) range 32/33/34 **and** adult (fibres) range 68/69/70/71;
2. Comparison of range without numbers = one mark i.e.
Adult (fibres) greater range / spread / variation (of diameters)
OR
Young (fibres) smaller range / spread (of diameters);
3. Comparison of mode = one mark i.e.
Adult (fibres) peak/most common/frequent/mode at 50 (μm) and young (fibres) peak/most common/frequent/mode at 30 (μm);

*1. Accept: **one** mark for comparison of minimum values i.e.*

14/15 compared to 17/18

*Allow **one** mark for comparison of maximum values i.e.*

47/48 compared to 86/87/88.

*1. Note: comparison of both maximum and minimum values = **2 marks**.*

3. Accept: adult (fibres) peaks at higher diameter or young (fibres) peak / most frequent at lower diameter.

3. Reject: reference to mean / average.

2 max

[8]

Q2.

(a) C = M line / M disc / myosin filament

D = mitochondrion

E = myofibril

3

(b) Sarcomere

1

(c) Answer in range 1.14–1.18

1

(d) 1. As a store of glucose

Ignore provide energy

OR

To be hydrolysed to glucose;

2. For respiration / to provide ATP;

2

(e) 1. Low pH changes shape of calcium ion receptors

Do not accept tropomyosin does not move

2. Fewer calcium ions bind to tropomyosin;

Accept troponin

3. Fewer tropomyosin molecules move away;

4. Fewer binding sites on actin revealed;

5. Fewer cross-bridges can form

OR

Fewer myosin heads can bind

Must include idea of fewer at least once

3 max

[10]

Q3.

(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 heads to 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]

Q4.

(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 / no ATP 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]

Q5.

(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' (because cyclical)

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 phosphate available to make/recycle ATP;
2. So less energy/so less ATP available for contraction/fast muscle 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 creatine production);
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]

Q6.

(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 / fixed to 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]

Q7.

(a) 1. Splitting / breakdown / hydrolysis of ATP;
2. (Muscle) contraction 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 myosin.

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

2 max

(b) Fast because (lots of) ATPase allows rapid **hydrolysis** of ATP
OR
Slow 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]

Q8.

(a) 1. Fields of view randomly chosen;
2. Several fields of view;
3. All same species (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]

Q9.

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

Must only include this group and no other.

1

(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 avoid fatigue.

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 (than fast);

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 started weightlifting / 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]

Q10.

(a) 1. (Phosphocreatine) provides phosphate / phosphorylates;

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 / slower respiration;

4. ATP used to reform phosphocreatine;

4

[7]

Q11.

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

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 per glucose;

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 / long periods of exercise

2

[8]

Q12.

(a) (i) Decreases;

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]

Q13.

(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]

Q14.

(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]

Q15.

(a) (i) A band;

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 = $\frac{48}{16}$ / = 3 μm ; = 1 mark

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]

Q16.

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

Q17.

(a) (i) Myosin filaments drawn longitudinally in A-band region;
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 ÷ $\frac{16}{8000}$

2

[5]

Q18.

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

Q19.

(a) (i) actin (*Accept* tropomyosin);

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 fibres different 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 DNA of 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]

Q20.

(a) (i) maintaining a constant internal environment;

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]

Q21.

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

Q22.

(a) calcium ions;
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 moved using 1 ATP;
15 ATP;

2

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

2

[7]

Q23.

(a) **W** = myosin
X = actin;

1

(b) myofibril is contracting in **Figure 3** / relaxing 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]

Q24.

(a) membrane relatively impermeable / less permeable to sodium ions / gated channels are closed / fewer channels;
sodium ions pumped / actively transported out;
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]

Q1.

(a) Approximately two-thirds of students did not obtain this mark. Often these students referred to an increase in the Krebs cycle or succinic acid activity, both of which were given in the stem of the question. The most common valid response referred to an increase in aerobic respiration.

(b) This question proved more difficult than expected with less than 10% of students obtaining all three marks. Many students appreciated that the trained mice could produce more ATP, and some stated they could carry out aerobic respiration for longer. However, when mentioned, anaerobic respiration and lactic acid production were usually described in terms of the control mice rather than the trained mice. Many of the responses included general changes due to training such as more mitochondria, more 'slow twitch' muscle fibres, and an increase in the supply of oxygen to muscles.

(c) Although three out of ten students gained both marks for this calculation, over 50% scored zero. The most common incorrect answer was 83.3 where the students converted the area of the field of view into micrometres and then divided by fifteen.

(d) Most students gained one mark for describing differences between the samples of muscle fibres from young mice and adult mice. The most common correct response referred to the greater range of diameters of muscle fibres in adult mice. Better answers often provided a numerical comparison of the ranges, to score two marks. However, these values were not always read accurately from the graph, limiting this type of response to one mark. A common error was to refer to the modal values in each group as mean values.

Q5.

(a) This question discriminated more than expected, with 34% obtaining two marks and 50% one mark. Most students wrote about ATP being used to make/break the binding with actin. A few failed to make any reference to actin and failed to score. Those who obtained the second mark went on to refer to ATP providing the <u>energy</u> to move the myosin head.

(b) (i) 63% of the students could calculate the correct percentage fall.

(ii) 63% of students obtained both marks and 30% obtained zero. Those who failed to score often wrote an account of what phosphocreatine is used for. 'These results' they were asked to explain included the mice being unable to produce creatine.

(c) 74% obtained one mark for the observation that the heterozygous mice have one dominant allele (of the gene for creatine production). Only 11% went on to say that this one allele allowed the mice to produce enough, or the normal amount of, creatine. Some said that the dominant allele masks the recessive allele, which is true but doesn't explain why the heterozygous mice can produce a similar force to normal mice.

Q6.

(a) This required factual recall of components of the sarcomere. Just over 50 percent obtained all three marks. Students who failed to score often had the correct names

but associated with the wrong function.

(b) This proved very challenging to many and almost 40 percent failed to score. Some excellent answers were seen. These students understood that myosin molecules are bound tail to tail so that their heads can pull actin filaments towards the centre of the sarcomere and thus shorten the sarcomere. Obviously, if the tails fail to bind to each other, this will not happen; in fact, the myosin molecules would move rather than the actin. Many students simple wrote about the sliding filament theory but without relating this to the question.

Q7.

(a) Most students achieved mark point 1 but better answers were required to score both marks. Some students went on to state that muscles used ATP but 'contraction' was stipulated in the marking point. Some very good answers were seen with all three marking points given, together with extra detail about use of ATP by myosin.

(b) A lot of information was required in the answer to award this mark point: the muscle type; the hydrolysis / synthesis of ATP; and the fact that a high concentration of ATPase allows this to be rapid. Not many students managed to include all these requirements.

(c) The majority of students scored one mark here but a full explanation was required to gain two marks. Mark point 1 was commonly seen but the explanation in mark point 2 was less often seen. Some students noticed the lack of visible organelles.

Q8.

(a) It was vital that students used the information that was provided in the resource accurately rather than giving generalised methods of making data reliable. Mark points 1 and 2 could be awarded when given in a single statement such as, 'several fields of view were selected at random'. In mark point 3 'species' was essential, 'same breed' is not equivalent. Mark point 5 needed to be specific to the resource, i.e. that at least 8 animals were used in each group. General statements about each group having lots / large number of hamsters were insufficient.

(b) (i) Most students successfully carried out this calculation.

(ii) Mark point 1 was most commonly seen. In this instance, 'The calculation used an average' was acceptable as equivalent to mean, as it demonstrates the correct understanding.

(c) (i) The occasional student suggested that this investigation was unethical as the hamsters would be in pain or stressed but the vast majority realised hamsters would be killed.

(ii) Students encountered many problems with this question. Many only discussed changes 'as the hamsters got older / younger', rather than using the specific age groups. Some only discussed whether there was a change, or what the change was, rather than discussing the significance of this difference. Many students seemed unaware that it is not the 'results' that are deemed significant or not but the 'differences between the results'. It was surprising at A2 that not more students achieved mark points 5 and 6. It was expected that students who had calculated standard error and 95% confidence limits in Stage 2 of this ISA would realise that standard deviation is insufficient to determine significance.

Q9.

(a) (i) Nearly all students scored this mark; the wording in the resource should have been used, 'long distance runners' is not the name of the group.

(ii) This was generally well answered and 2 marks were common. Mark point 3 was the least often awarded.

(b) This was well answered, although mark point 2 was not always awarded, even though it was attempted, due to lack of reference to 'diameter'; students often referred to 'thickness' instead.

(c) Most students scored mark point 1 and many went on to give mark point 2 or 3.

Q10.

(a) About 50% of students obtained both marks in this part. Some got confused between ADP and ATP and others failed to score one of the marks because of references to phosphorus being transferred.

(b) Nearly 70% of students obtained the mark in this part. The examiners ignored vague references to things such as lifestyle, diet and illness.

(c) This part produced an almost perfect distribution of marks between 0 and 4. The best answers identified that it takes longer to re-form phosphocreatine (PC) as people get older. Students then linked this to slower metabolism, respiration or ATP production as people get older. They also identified that the type of exercise identified would involve fast muscle fibres that contain a lot of PC and that this requires ATP to be re-formed. The mark a student obtained depended on how far they got with this story. A common error appeared to relate to misinterpretation of the graph, with students suggesting older people had more PC, so it took longer to re-form.

Q11.

(a) (i) About a third of students explained at length how tropomyosin *prevents* contraction,rather than explaining its role *in contraction*. Some of these students obtained one or both marks by going on to describe what happens during contraction.

(ii) About forty percent obtained one mark for describing how the myosin head pulls actin past itself. A similar percentage went on to obtain a second mark for either describing the ratchet mechanism, or the role of ATP. The remainder tended to get confused between the roles of actin, myosin, troponin and tropomyosin.

The specification requires students to know the general properties of slow and fast muscle fibres. In general, fast fibres are used for movements that involve brief, intensive contraction (eg sprinting) and slow fibres are used for more protracted contraction (eg long-distance running). The intention was for students to bring this knowledge to bear in (b), when using the information in the table.

(b) (i) About half of students obtained one mark for this question, for stating that glycogen is a source of glucose for anaerobic respiration (glycolysis). Only a few went on to note that a high concentration of glycogen provides a lot of glucose, or very rapidly supplies glucose, for a rapid rate of anaerobic respiration. The mark could also be gained for noting the advantage of this

rate being high, ie it overcomes the fact that anaerobic respiration provides little ATP.

(ii) Many students obtained one mark for noting that many capillaries would provide a *good* supply, or a *lot* of oxygen. As in (i), few went on to link this to maintaining a high rate of aerobic respiration.

Q12.

(a) Almost all students correctly stated that the I-band would shorten and that the A-band would not change in width.

(b) Most students gained one mark for the principle of dividing the measured width by the actual width. However, only better students were able to convert the measured width to micrometres. Students who failed to score often divided the actual width by the measured width.

(c) Most students were aware that ATP is needed for the attachment between actin and myosin. However, the ability to tell the rest of the story in terms of the 'power stroke', detachment of the myosin heads and the return to their original position proved to be a good discriminator.

Q13.

(a) Many candidates produced sound answers to part (i), successfully linking succinate dehydrogenase concentration to aerobic respiration and hence to slow twitch fibres. Although most responses to part (ii) referred to the peripheral distribution of the enzyme, they often failed to provide a satisfactory explanation of the importance of this distribution. Comments about the diffusion of ATP into and out of cells were frequent.

(b) There were many poor answers to part (i) in spite of the fact that estimating the size of objects viewed with a microscope is a specification requirement. Candidates who had the necessary practical experience tended to offer appropriate responses, illustrating the importance of practical work in this specification. Others persisted in quoting impracticable approaches based on the equation relating magnification to observed and actual size. Although, in part (ii), many candidates suggested that random sampling would avoid bias, few offered the suggestion that the sample should be large enough to be representative. There were many instances of candidates failing to appreciate that they had been provided with a prepared slide and therefore that answers such as taking muscle from different areas of the body were inappropriate. Many weaker candidates opted for an approach based on safety. The numerous comments about "not cutting yourself" were judged inappropriate.

Q14.

(a) (i) Rather disappointingly only approximately half the candidates correctly named part **X** as a crista or as an inner membrane. Common incorrect responses included 'fold' 'villi' and 'microvilli'.

(ii) Even fewer candidates correctly named part **Y** as the matrix. A common incorrect response was 'cytoplasm'.

(b) The majority of candidates correctly suggested that pellet **B** would contain mitochondria.

(c) (i) Most candidates realised that using an ice-cold solution would reduce or prevent enzyme activity. However, a significant minority of candidates suggested that this denatured enzymes.

(ii) Many candidates started by providing a definition of the term isotonic and then explained that using an isotonic solution prevents net movement of water. However, most of these candidates referred to water movement into or out of 'cells' and did not obtain the second mark for explaining that organelles would not burst or shrivel.

(d) Very few candidates obtained both marks for this question. Although many candidates gained a mark for stating that mitochondria produce ATP or release energy, a significant number referred to 'energy being produced'. Few candidates referred to aerobic respiration or linked exercise to muscles. There were a number misconceptions concerning respiration particularly in relation to 'energy being used' in respiration and to mitochondria providing oxygen during respiration.

Q15.

(a) Most candidates correctly selected the A band in part (i) although several also added the H zone, whereas few scored for part (ii) because they only selected the I band.

(b) The sliding filament theory appeared to be understood well although many candidates included superfluous material about calcium ions, tropomyosin and troponin.

(c) The omission of responses here by several candidates, or inappropriate calculations by many others once again highlighted a lack of confidence and competence in the application of mathematical skills. A few were able to calculate the relaxed length of a sarcomere but it was the only better candidates who could use this to calculate the length of a contracted fibre.

(d) Nearly all the candidates could recall the correct information required for part (i). Equally, they demonstrated a thorough knowledge of muscle contraction so many scored marks for appropriate descriptions of myosin-actin interaction and myosin head movement in part (ii). However, fewer actually applied their knowledge to the specific questions asked. Thus, some responses contained no reference to the role of myosin-ATPase. Of those that did, many believed that the enzyme had a direct effect on the myosin rather than through the hydrolysis of ATP. There were several references to the enzyme causing the production of ATP. As in part (b), many included explanations about calcium ions, tropomyosin and troponin.

In part (iii), the majority of the candidates understood that lactate was a product of anaerobic respiration but examiners found few responses that included reasons why type 1 muscle fibres should have a higher rate. There were many references to lactate being broken down to release energy.

Q16.

(a) A full answer to this section required reference to several different aspects – the resolving power of the electron microscope, the need for tissue to be alive to demonstrate a physiological process but to be dead to be viewed in the electron microscope, and the specificity of antibodies (with gold particles attached) to label only certain structures. It was rare to find such an holistic view.

Some candidates appeared to have forgotten about the existence of the

transmission electron microscope, explaining that only the outer surfaces of muscle fibres could be observed rather than any cross-bridge cycling that occurred within them. Others erroneously felt that, although the resolving power of the electron microscope was good, it was not good enough to observe crossbridges between muscle protein filaments.

(b) The roles of calcium ions and of ATP in muscle contraction were generally well known by most candidates. Some over-emphasised the part played by calcium ions in transmission of the impulse to the muscle rather than in the contraction process itself. However, details of the removal of the blocking molecules from sites on the actin and the combination of the myosin head with these sites, followed by movement and release of the myosin head, were generally included.

A common omission was that ATP would need to be split into ADP and phosphate if its energy were to be made available.

Q17.

(a) Although in general part (i) was attempted, marks were not always obtained by candidates. A common error was to draw actin and myosin in roughly the correct places relative to each other but to pay little attention to the lines aligning the space for response and the drawing of the myofibril. Part (ii) was well understood and most candidates were able to recall the main advantages of electron microscopes.

(b) This calculation produced fewer correct responses than the calculation later in the question paper. From the responses given it was apparent that few candidates were able to comprehend what they were being asked to do and did not measure the width of the sarcomere at 16mm. Those candidates that did make this measurement mostly went on to calculate the correct answer of 20.

Q18.

(a) In part (i), rather too many candidates failed to refer to the diagram in their answers. “The sarcomere has shortened” was the most common example of a factually correct statement which failed to answer the question. The role of ATP continued to cause confusion. There were many answers describing the role of ATP as attracting the myosin to the actin, clearly beyond the bounds of any degree of uncertainty.

(b) Part (i) was the only question on the paper that was universally badly answered, with over 90% of candidates scoring one or zero. It was not easy to determine whether candidates were misinterpreting the question or simply did not understand how the impulse is propagated. Part (ii) produced better responses with many candidates gaining all three marks. Candidates who used incorrect charges on the ions, e.g. Ca^{+} or Ca^{2-}, failed to gain marks and would have been better off writing the words ‘calcium ions’. Another common error was to have the calcium ions being released as opposed to entering.

(c) Although well answered, the graph in part (i) brought up several issues. Candidates making errors in graphs should be encouraged to obtain an additional sheet of graph paper from the invigilators and attach it to their script. Several candidates failed to gain marks because their final offering was not discernable from several previous attempts. Candidates should also be encouraged to use sharp pencils and rulers in constructing graphs. A level biology follows IOB guidelines on the construction of graphs and in this case failure to join the plots with straight lines was not rewarded. In this question, straight lines were required by the data presented in the stem anyway. In (ii), most candidates gave a correct response.

Q19.

(a) (i) and (ii) A majority of candidates were able to identify A as the myosin head, although rather fewer were able to name actin as the main protein in the thin filament.

(b) In general, the responses to this section of the question revealed a pleasing level of knowledge and understanding.

(i) Many candidates, including otherwise weaker candidates, were able to describe the role of calcium ions in binding to troponin and removing tropomyosin from the myosin binding sites on the actin molecule.

(ii) Again, a good number were able to describe the role of ATP and the two proteins in bringing about contraction of the myofibril.

(c) (i) Only better candidates realised that to calculate the percentage of fast fibres, the number of fast fibres (lightly stained fibres) must be divided by the *total* number of fibres and this figure then multiplied by one hundred. Many weaker candidates multiplied the ratio of the two fibres by one hundred.

(ii) Most candidates could explain that the figure obtained might not be typical as different regions of a muscle may have different proportions of the two fibres, or because the sample used is such a small one as to be not necessarily reliable.

(d) Only really able candidates realised that *all* the fibres would undergo glycolysis, whether respiring aerobically or anaerobically. However, those respiring anaerobically would undergo glycolysis only (and not any further stages of the aerobic pathway) and so produce the enzymes used in glycolysis in greater concentrations.

(e) Many candidates interpreted this question as another concerning natural selection, despite the clear instruction to explain how a new form of myosin could be *formed as a result of mutation*. Good candidates were able to explain how alterations to the base sequence of DNA could result in a different mRNA and, as a result, a different primary structure of the protein. They then went on to explain how this would result in different folding of the molecule, tertiary structure and properties as a result.

Q20.

This question produced a wide range of marks. Nevertheless, it was generally well answered by the majority of candidates.

(a) (i) Although many candidates obtained this mark, there were a number of vague definitions which did not clearly link homeostasis to the internal environment.

(ii) Candidates had little difficulty giving one example of homeostasis, usually referring to thermoregulation or control of the blood glucose concentration. Most candidates who obtained a second mark referred to the effect of change of temperature on enzyme activity.

(b) There were many excellent descriptions of the role of calcium in muscle contraction. However, there were a few common errors and omissions. There were frequent references to ‘active site’ rather than ‘binding site’ and a significant number of candidates did not mention actin. A minority of candidates attempted to answer this question in terms of the role of calcium in synaptic transmission.

Q21.

This question proved to be a good discriminator enabling the very best candidates to score maximum marks.

(a) Most candidates obtained both marks in part (i) by correctly linking the banding pattern to the presence of myosin and actin filaments. Weaker candidates often failed to name the protein filaments present in muscles. In part (ii), slightly fewer candidates gained maximum marks. A common error was to suggest that the A band increased in length often negating one of the correct responses for decrease in length of the H zone or light band.

(b) This proved more troublesome, but most candidates were able to gain at least two marks out of the six available. In part (i), many candidates appreciated the role of ATPase in the breakdown of ATP to yield energy. Most candidates referred to the use of this energy in the formation or breakdown of actomyosin bridges. In part (ii), better candidates provided excellent details on the role of tropomyosin, calcium ions and ATPase activity in muscle contraction. Weaker candidates often gained a single mark for appreciating that tropomyosin covered the binding site on actin but provided rather confused descriptions of the role of calcium ions. A common error amongst these candidates was to refer to ‘an active site’ rather than a binding site.

Q22.

This question was well answered.

(a) Even the weakest candidates realised that calcium ions were involved, and the majority were able to explain fully the changes which occur before actin is able to bind with myosin.

(b) Many candidates gained full marks. The most common errors related to the inability to convert ìm to nm. A significant number did not attempt to answer the question.

(c) Many candidates scored full marks. A significant number did not read the question carefully enough and wrote about the role of ATP in the recocking of the myosin head.

Q23.

(a) Very few candidates did not achieve this mark.

(b) The majority of candidates correctly identified the figure showing a muscle myofibril in contraction and gave a valid reason for their choice, but some candidates did not make it absolutely clear which figure they were referring to. A common misconception was to describe the shortening of protein filaments rather than filaments sliding across one another to shorten a sarcomere.

(c) Most candidates obtained at least two marks, usually for stating that calcium ions touch tropomyosin, which allowed bridges to form between the protein filaments. Few candidates made it clear that exposed myosin binding sites were located on actin filaments, and a significant number incorrectly referred to binding sites as active sites. Only a small proportion of candidates went further and explained how the energy for contraction is provided from ATP.

Q24.

(a) Most candidates appreciated that the charge inside the neurone would be negative

compared with the charge outside and they often gave a clear explanation about the pumping movement of sodium ions being the cause of this difference. The impermeable nature of the neurone membrane to the movement of sodium ions was less well understood and very few candidates gave an adequate explanation which compared the relative amounts of sodium ions on both sides of the membrane.

(b) (i) Surprisingly few candidates used the graph accurately to give the correct time between depolarisation and the beginning of muscle contraction; 1. 5 ms was a common error, which suggested candidates used the scale on the x axis carelessly. Those candidates who constructed lines on the graph to identify the time period usually got the right answer.

(ii) Most candidates understood that speed was calculated as distance over time, but very few correctly converted ms to s.

(iii) This proved to discriminate well. Many candidates gave a valid suggestion about the role of a neuromuscular junction or the time it takes for muscle filaments to move. Unfortunately, a significant number missed the point of the question and discussed different types of neurone, the presence of a myelin sheath, the diameter of neurones, or the distance between nodes of Ranvier.

(c) A significant number of candidates began the description too early by including the detail about the movement of vesicles containing neurotransmitter towards the presynaptic membrane. Also, some failed to gain a mark by referring to the location of neurotransmitter receptors on the motor end plate rather than on a sarcolemma or a cell membrane. The depolarisation of a muscle fibre by the movement of calcium ions is a common misconception.

(d) Both parts of this question were answered well by a large proportion of candidates.