A-LEVEL
BIOLOGY

7402/3: Paper 3
Report on the Examination

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General Comments

The paper produced a range of marks from 0 to 71 (out of 78), the highest mark being a few marks higher than in 2018. Correct responses were seen in all parts of all questions.

Almost all the marks for factual recall with understanding (AO1) in this paper are in the essay. The remaining questions test AO2 and AO3 skills using contexts given in the questions. These proved challenging for many students. This was most evident in questions testing evaluation, in answer to which most students argued one side, rather than giving balanced arguments. Students also struggled to make links between their own knowledge and some of the contexts set. The essay does require application of knowledge; about half of the 25 marks assess AO2. More successful essays demonstrated this, primarily in discussing the 'importance' at A-level standard. The vast majority of students' essays were confined to factual recall (AO1), which limited the mark they could be awarded to 15 (being the modal score).

There were several questions in which many students failed to obey the command word, for example describing data when asked to give an explanation for, or evaluation of the data. Students also seemed to ignore certain parts of the stem of questions such as the use of 'apart from' in 06.7. Some did not use the information or data provided in questions, even when told to do so.

Rote-learnt responses were evident, with students attempting to give them with no consideration of whether the response actually answered the question. Students often seemed to notice a key word in a question and focused on that, rather than considering the whole question. By doing this, they often missed the point of what was being asked.

Maths skills were tested in a range of ways, and whilst some algebraic skill was evidenced, the understanding and application of logarithmic scales was poor.

Several questions discriminated well. In this report, references to how well a given question discriminated are based on numerical discrimination indices calculated from marking data, not the opinions of the examiners. The discrimination index is a measure of correlation and indicates the extent to which an item discriminates between high-attaining and low-attaining students.

There were not as many issues with handwriting as in previous years, with most scripts being legible once scanned into the system. The inclusion of additional lines for student responses again yielded fewer additional pages, but there were several students who still felt they had to fill every line on the paper. This is not necessarily the case. Students must still select the appropriate piece of knowledge to answer the question, and not write everything they know from that part of the specification.

Question 1

01.1 tested AO1 skills and was aimed to be a simple start to the exam. However, it proved rather difficult for students, with only about 10% scoring three marks, and nearly a third scoring zero marks. It did discriminate well. Most students set the context of the blood arriving in the afferent arteriole and leaving via the efferent arteriole; a pity, as neither forms part of the glomerulus. Many used this to justify an increase in pressure, but failed to state that the pressure was high, and also failed to mention that it was blood or hydrostatic pressure. Those who omitted the arterioles often

went straight for high blood/hydrostatic pressure (thus avoiding the pitfalls of a comparative answer).
Most students made reference to the 'small molecules'; the less successful students left it at that while the more able students included lists, most of which were correct; the most common were water and glucose. These two marking points were the most commonly awarded. A small number of students mentioned the epithelium or endothelium, but omitted to make reference to the gaps, and had molecules crossing the cells. Occasionally answers suggested there were holes in the actual cells. The basement membrane was noted on occasion, but not frequently, and it was sometimes endowed with holes. Some students moved from the glomerulus/Bowman's capsule to various parts of the loop of Henle. A small number of students listed blood proteins as not forming part of the filtrate.

01.2 was generally well answered, with over three-quarters scoring the mark.

01.3 was generally well answered, with around 80% scoring the mark. Those who failed to score did so by either incorrect rounding or not obeying the rules for rearranging equations (i.e. divided first, then subtracted and arrived at an answer of 19).

01.4 also discriminated well, but the majority of students failed to make the necessary link of understanding that the loop of Henle is in the medulla of the kidney for MP1. Only about 2% of students scored all three marks. There were many descriptions of the data in **Figure 1**, but few explanations. Many students saw the term 'thickness' on the graph, ignored the rest of the question and based their response on a long diffusion pathway. For MP2, the mark scheme was made very accessible by accepting 'increase in sodium ion concentration'; however, many students only mentioned ions, and not sodium ions specifically. There was also a fundamental lack of understanding that the filtrate in the loop of Henle will eventually form urine, and so answers seemed to discuss water moving into the loop rather than out of the loop for MP3. Again, the mark scheme for MP3 was made more accessible by allowing 'more water is absorbed from the loop / collecting duct by osmosis'; however, most failed to give the mechanism, i.e. did not write *by osmosis*.

Question 2

In 02.1, students either failed to include the necessary detail, or failed to select the correct part of the nitrogen cycle, with some describing the whole thing, seemingly expecting the examiner to choose the correct part. For MP1, very few actually named a nitrogen-containing compound, or confused ammonification with nitrogen fixation. MP2 was more commonly awarded. Two-thirds of students scored at least one mark, and this question discriminated well.

Students found 02.2 to be more accessible, with only about 15% failing to score any marks. Students generally had the right idea, but there were an alarming number of calorimeters in use. For MP2, those who failed to score generally gave answers such as 'read the colorimeter' and did not state what to measure. There were many references to the production of calibration curves, which would not be necessary in this case, i.e. students did not consider the context, and gave a role-learnt response. This was evidenced even further by several responses adding Benedict's solution to each sample.

Question 3

Roughly 50% of students scored the mark on 03.1. Those who failed to do so mostly thought the valve was a semi-lunar valve. Looking at where the tendons are in the photo should have helped students here. Bicuspid valve was accepted, but this is not a specification term, and so does not need to be taught.

03.2 should have been easy for students, however only around 40% scored the mark. There were many answers giving general laboratory rules and procedures, such as 'wear goggles/lab coat', again showing that students were not considering the actual practical in this question. There were also many vague answers stating 'be careful' or 'take care'.

03.3 explicitly stated 'Explain how valve **A** in **Figure 2** maintains a unidirectional flow of blood', however responses were often rote-learnt ones. By guiding students back to the diagram, it was also hoped that they would notice where the tendons are, and therefore realise which of the valves would open and close. There were, however, many responses in the context of semi-lunar valves. More than two-thirds scored zero marks. There were several descriptions, rather than explanations, i.e. students outlined when they would open or close, but not the cause. Those who scored one mark generally only told half of the story, i.e. explaining why valve **A** would open or close, but not both.

In 03.4 around half of students scored at least one mark, showing clear understanding of the control of heart rate, and could apply it to the response to caffeine. This question discriminated well. In general, some who did not score marks described the data, or did not look at the data at 60 minutes as asked. Some also ignored caffeine in the question and gave answers relating to sugar providing more energy, or explained why heart rate increases during exercise. Some thought caffeine would increase the speed of an action potential travelling down a neurone. More specifically, those who failed to gain MP1 did not give the idea of more impulses, often just stating 'an impulse' would be sent. There were also many instances of 'signals' being sent. For MP2, those who failed either had MP1 and the increase in heart rate, but didn't mention the SAN, or got as far as increasing impulses to the SAN but then stopped short of increasing heart rate, so did not link back to **Figure 3**.

Around 40% of students scored the mark on 03.5. Those who failed to score the mark often did not use **Figure 3**, and just divided 4700 by 88, giving an answer of 69. There were also many who gave answers in the thousands, and who therefore had not considered the question at all, or they would have realised that it would be impossible for this volume to leave the heart in each beat. Again, there was incorrect rounding evident.

Over 70% of students scored two marks on 03.6, it was well considered and answered. Those who failed to score MP1 mostly just said 'give sugar'. Those who failed to score MP2 on the whole did not include enough detail, for example by stating 'as a control' or 'for comparison'.

Question 4

Nearly all students scored the mark on 04.1. The most common answers given for those who did not score were 'deletion,' 'silent mutation,' 'missense mutation' or 'crossing over'.

04.2 discriminated well, although only about 5% scored three marks. This is the first evaluation question on the paper. The majority of students failed to evaluate, only giving reasons in support for, or against the conclusion. Students also attempted to answer 04.4 here; this question was not looking for the differences between the two groups, only the effect of training. As a result, there were explanations of the increase, which were not needed. For MP2, most students mentioned not knowing if 'the results' were significant, which has never been accepted on AQA's GCE papers. Several students also mentioned 'no standard error bars on the graph'. Standard error is not in the specification. There were also many rote-learnt evaluative statements, which do not apply in this case. They included 'correlation does not mean causation', 'we do not know the sample size/age of people', 'it might be due to other factors/diet/type of exercise'. The general assumption by students should be that if an investigation has been carried out by 'scientists' then it has been carried out correctly. For example, if not stated, the sample size will be sufficient.

Even with a very simple mark scheme, question 04.3 was poorly answered by students, with nearly 70% scoring zero marks. Given the clear information in the stem of the question that this was a non-coding region, and that this region stimulates the synthesis of both mtDNA and mitochondrial mRNA, students simply ignored this information. This was either because they did not understand the idea of a promoter region or they just leapt on the idea of mutation, and therefore there were many responses with change to protein shape/active site shape/inactive enzymes. They also did not seem to realise that the mutation was in group C, and so discussed the mutation increasing CS activity. Some also ignored looking for differences between groups, and explained why both groups increased. For MP1, the direct understanding that less expression of mtDNA would lead to fewer mitochondria produced was also not commonly seen. There was also some poor expression, with students stating that overall there would be fewer mitochondria, not less replication. Only the more effective responses seemed to make this link. Of those who scored MP2, some could make the link with reduced transcription or translation, but most gave the lower quality response of just less CS/enzyme produced.

04.4 was generally well answered, with the majority of students scoring some marks. Again, however, there was a lack of evaluative skill on display. Most commonly, students were able to score MP3. Many students mentioned increased CS and/or $VO_{2\ max}$ activity, but failed to then link this to the effect, e.g. more Krebs cycle activity or oxygen available. The more able students gave a thorough link between the increase of CS and $VO_{2\ max}$ and the effect on respiration.

Question 5

05.1 was well answered, with about 70% scoring the mark. Those who failed to score mostly either gave a hypothesis rather than a null hypothesis, or gave a generalised null hypothesis, such as 'there is no significant difference between observed and expected'.

05.2 was correctly answered by just over half of students. It required students to identify two factors that **can be controlled** in a choice chamber used by scientists during an investigation in a laboratory. Many failed to read the stem of the question and recognise this context; the scientists were not attempting to recreate or mimic the dynamic environment of the reef itself. Those students who correctly identified two factors selected accepted abiotic factors, usually pH, temperature and the salinity of the water that could reasonably influence the behaviour of the COTS. Unfortunately, some students made references to biotic factors in the natural marine environment, such as the need for 'a reef' to be present or the 'type of coral' or to 'maintain the natural environment of the ocean', that are impossible to control. Those students who were only

able to identify one factor did not gain credit. Very few gave more than two answers so were not in jeopardy of having marks cancelled through the list principle.

05.3 saw students failing to evaluate once more, with only about 6% scoring all three marks; there was also a lack of understanding of how to analyse the statistical data in **Table 1**, and confusion with p values and critical values, with comments such as 'no critical values are given, so no conclusion can be drawn'. Many students could identify that both light regimes caused movement away, showing evidence of reading and interpreting the question accurately. Invalid comments such as 'results are significant' were once again evident.

05.4 is a relatively straightforward calculation, however only just over a third of students scored two marks. Successful students appreciated that the COTS were moving towards constant light, were able to calculate the distance travelled as 48000 mm, divide this figure by the speed of 259 mm min^{-1} and convert 185 minutes into hours, to achieve two marks. Answers that scored one mark were a mix of the distance travelled correctly shown as 48000 mm, or the answer not being rounded to the nearest hour as requested. A large number of students who scored zero could not convert metres into millimetres, calculating the distance to be 4800 mm.

Question 6

In 06.1 and 06.2, roughly a third of students scored the marks. Those who failed to score either read incorrectly from the graph or, more commonly, did not know how to convert between normal and logarithmic scales, despite being told which button to use on their calculator. There may have been students who did not have a scientific calculator. This is one of the required materials, as indicated on the front of the paper.

06.3 was well attempted by most students and, aside from the essay, had the highest discrimination index. MP1 was very commonly awarded, especially the first alternative of 'competitive inhibitor'. Students confidently discussed Trexall having a similar shape and being a competitive inhibitor. Rarely did students think of it as a non-competitive inhibitor. MP2 was also well answered, with students giving both alternatives. Many students did spend time suggesting both aspects of MP1, and similarly both aspects of MP2, assuming this would be worth all the marks. The most able students, however, went onto MP3 and made the link between a lack of nucleotides for DNA replication.

06.4 also discriminated well, as it tested relatively simple practical skills in a novel context. Only about 9% of students scored both marks, with around a further 30% of students scoring one mark. More students attained a mark for the first part of this question relating to percentage change than for the part relating to measuring tumour volume. Many students realised that it is necessary to calculate a percentage change in order to be able to compare results. However, fewer students explained why this was necessary, i.e. because the tumours might have had different initial masses. Fewer students answered the second part of the question correctly; not many seemed to understand the point of the question. They gave the same or a similar answer to both parts of the question, saying that it was necessary to calculate percentage change and to measure tumour volume in order to see if the tumour changed sized, or to calculate rate of growth, or to see if the Trexall is effective. There was also a significant number of students who simply stated it would be 'easier to measure' for both parts of the question.

06.5 tested relatively simple maths involving reading from a graph and applying numbers to a given equation. However, only about 15% scored two marks. In general, students achieved one mark

for calculating the correct volume of the tumour after treatment, but then were not able to scale it correctly to its original size. Various incorrect methods were used to scale to 100% such as multiplying the reduced volume size by 25%, 125%, or 225% (because the graph starts at 200 for 0 mg of Trexall, some students thought that was the original size so thought it had actually reduced by 225%). Some misread the graph and thought the reduction was 15% or 35%. It was also clear that some students thought 75% was the same as $\frac{4}{5}$ and then tried to convert to 100% by multiplying by $\frac{5}{4}$. Some also achieved one mark if they completed the calculation correctly but then rounded incorrectly.

In 06.6 most students only scored one mark, and mostly for MP1. They were able to link the greater significant reduction using 30 mg with the overlap in the standard deviations. Where students failed to score marks, they either acknowledged the lack of overlap but did not link this to significance or compared the data point for 25 mg instead of 20 mg and incorrectly suggested that there was an overlap. Many students spotted that, in some cases, there will have been a 100% reduction in tumour size, and gained MP2. A number of students identified the increased cost which could be incurred using 30 mg. Some students wrote blanket statements about side effects, and failed to score MP5, since they had not acknowledged the context of higher doses, though many students identified this context correctly. Very few students linked the larger standard deviation at 30 mg to a wide variation in effectiveness of the treatment. The most common explanation referred to 'results being inaccurate because of the larger standard deviation'. There were also several students who clearly did not understand what standard deviation shows as they stated '20 mg would be more effective as the standard deviation is lower'.

06.7 clearly states 'Apart from age and general health' in the stem of the question. Despite this, they were the most commonly given answers, along with gender/sex, which is also in the stem of the question ('All of the patients were female'). Many did not seem to consider this study, and gave general, vague ideas such as diet, activity and lifestyle. About a fifth of students scored the mark, with the most commonly given answers being ethnicity, other medication taken or duration of arthritis.

06.8 showed far better attempts at evaluation, with about a quarter of students scoring all three marks, and nearly two-thirds scoring at least two marks. Students identified that pain decreased with Trexall, and also in the control group. However, some did not mention that pain decreases **more** with the Trexall compared with the control group. Many students had identified small sample size, and some also mentioned only females studied. A number of students identified that there was no statistical test, but once more used the word 'results' rather than 'difference' being significant. A number of students simply quoted the data stating the mean score for pain at the start and then at the end; this did not score a mark. Only a few students calculated by how much the pain had decreased in both groups. Some students did mention about pain being subjective or that patients might lie about pain. General, rote-learnt responses were again evident, such as 'not repeated', 'due to other factors', 'do not know long-term effects' and 'there may be side-effects'.

Question 7

The mean mark for the essay was comparable with last year, being 13.6 compared with 13.3. The modal mark was 15. This shows that the vast majority of essays were solely based around factual recall, with little attempt to address the theme, i.e. 'the importance of', either at all, or at A-level depth. Roughly half of the essay marks are dedicated to this theme, and reward AO2. Therefore, comments such as 'without respiration/photosynthesis/oxygen organisms would die', 'muscle contraction enables movement away from predators' or 'without DNA replication we could not grow or repair' do not qualify as addressing the theme at A-level depth.

The level of response mark scheme makes references to 'several topics' being covered in order to qualify for the top two levels. The 'commentary' on the scheme defines 'several' as at least four topic areas. It was pleasing to see that there were few essays in which students wrote at length about only one or two topic areas, which would have limited them to a maximum of 10 marks. Students would be well advised to write about five (or even six) topic areas, as a form of insurance. However, there were a limited number of essays written in vague detail about ten or more topic areas, with little or no A-level content, and no addressing of the theme.

Attempts to include material beyond the specification were very rare, only being seen in about 0.5% of essays at the correct depth. Just knowing the name of an enzyme or bacterium not in the specification does not qualify as material beyond the specification. It needs to be a paragraph.

To achieve 24 or 25 marks, the contents of an essay must meet all the criteria for the 21 to 25 (extended abstract) level *and* contain material that is beyond the specification content and at (at least) A-level standard, i.e. not anecdotal. Where relevant material was included, it often consisted of examples that were required knowledge in previous specifications; for example, gene therapy for cystic fibrosis. Many textbooks contain these previously required examples and their use constitutes a perfectly valid approach to novel contexts for the essay.

07.1 The importance of DNA as an information-carrying molecule and its use in gene technologies

This essay was the more rarely chosen title, and generally was either answered really well, or quite poorly.

Though there were students who were cognisant of the importance aspect of the essay, they were just as likely to answer it with regard to gene technology, as they were with regard to DNA as an information-carrying molecule. Their focus tended to be on the structure and replication of DNA, with only more effective answers including aspects of inheritance or natural selection. Rarely was DNA actually discussed as an information-carrying molecule and, if so, it was mostly inferred rather than directly stated. Attempts were made to link the importance of mutations to the structure and/or function of proteins, particularly enzymes.

There was some confusion with epigenetic control of gene expression, and how acetylation and methylation work, and vague attempts were made to link gene expression and cancer to the title.

A variety of aspects of gene technology from the specification were commonly seen, such as *in vivo* and *in vitro* cloning, genetic fingerprinting and DNA probing. Many of the techniques discussed in essays were somewhat outdated, with some discussing manual Sanger sequencing as a current way to sequence the DNA of humans. Students seemed to view *in vivo* and *in vitro* cloning as separate parts of the specification, whereas they are both part of 3.8.4.1. Students who

scored fewer marks tended to mix up, or amalgamate PCR, *in vivo* cloning, gel electrophoresis, DNA probing and genetic fingerprinting.

Most of the material students selected was relevant to the title. The title is 'The importance of DNA' and not RNA, and so the area most commonly penalised as irrelevant was very long descriptions of translation of mRNA using tRNA and amino acids, with no mention of DNA.

07.2 The importance of bonds and bonding in organisms

This essay was more commonly selected but showed several surprising features. Firstly, students themselves had selected the topics to write about, but seemingly knew little about them. Secondly, there was a lot of very poor and questionable knowledge of chemistry on display, for example 'hydrogen bonds are the strongest bonds', 'covalent bonds are weak and easily broken' and 'hydrogen bonds are hydrolysed'. Thirdly, in general, the level of scientific language used was poor; answers lacked correct terms, or the correct level of detail.

As mentioned, the theme of 'the importance of' was rarely addressed at A-level standard, if at all. Students seemed to think one sentence at the end of a lengthy section of recall would suffice. For example, after going into great detail about the cohesion-tension theory, students would write 'without water plants cannot photosynthesise'.

Recalled knowledge of carbohydrates, lipids and proteins was generally good, particularly with the structure of cellulose and the phospholipid bilayer of plasma membranes. A number of students believe every molecule is joined by hydrogen bonds. There were also answers that mixed up the terms hydrophobic and hydrophilic. Students discussed enzymes, and binding creating specific active sites, but rarely did they discuss the induced-fit model, most recall being GCSE level. Higher level responses discussed the importance of the bonding in terms of denaturation, or enzyme inhibition. There were some students for whom active sites were on everything, not just enzymes, including antibodies, hormone receptors, actin, and promotor regions of DNA.

The structure of DNA and the process of DNA replication were well understood, but the common error of DNA polymerase forming hydrogen bonds between complementary bases was evident in many cases, along with hydrogen bonds being hydrolysed. Answers discussing bonding in ATP were generally poor. Students appeared not to know the structure of ATP, commonly stating it was just adenine and three phosphates, omitting the ribose, or calling it deoxyribose. Students suggested that when each ATP molecule is hydrolysed a huge amount of energy is released, when in fact 7.6×10^{-23} kJ per ATP molecule is not a lot of energy. They also suggested that ATP is easily hydrolysed, stating the covalent bond between phosphates is weak. Many students also mentioned 'ATPase' but with no context. The specification states ATP hydrolase and ATP synthase, and students should use these terms. Other errors within the topic of DNA included students stating bases are 'highly reactive', that DNA is 'easily translated' and mixing up DNA polymerase and RNA polymerase.

Many students chose to discuss hydrogen bonding in water, and the properties this gives water, and also linked this to water transport in plants. The theory on display was generally of A-level standard, and there were some decent links to the importance of this bonding. There was a large number of students who thought that hydrogen bonds hold the hydrogen and oxygen together in a molecule of water; the understanding that this is covalent bonding is actually basic GCSE knowledge. There were students who incorrectly stated that water is hydrolysed during photolysis.

Within the topic of skeletal muscles, many students discussed the role of troponin. The specification states the role of troponin is not required, and just mentioning the word does not constitute material beyond the specification on the essay.

The essay title is the importance of bonds and bonding **in** organisms, so bonding between organisms, or outside of an organism, would be irrelevant to this essay. The most commonly irrelevant topics written about by students were pair bonding/courtship behaviour and PCR.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.