A-LEVEL
BIOLOGY

7402/2
Report on the Examination

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General Comments

Overall, this paper produced a good spread of marks with a higher mean mark than in 2017. There was no evidence of any general misinterpretation of questions or of students not having enough time to complete the exam paper. As reported last year, the responses of students to questions assessing well-established topics were generally superior to those assessing topics new to this specification. This was particularly evident with the new topic in question 6.3, gene linkage, and in question 10.4, the trichromatic theory. However, there were a couple of noteworthy exceptions to this; question 4.2 on succession and question 9.1 on natural selection. Although these questions were effective discriminators, relatively few students obtained half of the marks available. Many students simply provided rote-learnt answers without applying their knowledge as required in the questions.

Overall, the performance of students on questions assessing mathematical skills was good. Certainly, compared with the first exam in 2017, more students understood how to use logarithms. However, there was a wide range of performance on questions related to the assessment of practical skills. Some students had difficulty describing or understanding relatively simple practical procedures. Questions that required the application of practical skills in novel contexts proved challenging for all students.

There was evidence of students performing better than in 2017 on questions assessing the same topic area, e.g. synaptic transmission. The comprehension question also proved more accessible to students, despite the low marks achieved on part 10.4. This was partly due to an improvement in students' examination technique in terms of using information from the passage. Far more students completed this year's exam paper, suggesting students were more effective in time management.

One disappointing feature was the poor use of scientific terminology and the limited powers of expression students displayed. This was certainly a factor in preventing some students from accessing specific marking points. Contributing to this was the poor standard of handwriting which often made it difficult to distinguish between key words such as lactose and lactase. However, there were also some very impressive answers with students displaying an excellent understanding of the assessed content on the paper.

Question 1

01.1 Approximately 41% of students obtained both marks by referring to the reduction in ATP and reduced NADP. Students who gained a single mark usually did so by stating that there was less ATP rather than less reduced NADP. Many of these students incorrectly stated that less NADP or less reduced NAD was produced. Some students suggested that heat stress caused stomata to close and this limited carbon dioxide uptake and photosynthesis. Many students used additional pages for this question due to initially describing denaturation of rubisco or ATP synthase before realising that they needed to name specific products of the light-dependent reaction. It was disappointing to note that nearly a third of students scored zero.

01.2 Again, approximately 41% of students obtained both marks by explaining the role of rubisco in photosynthesis. Students gaining a single mark often failed to mention both RuBP and carbon dioxide, or simply referred to a six-carbon product with no mention of GP being formed. A minority of students incorrectly referred to GP as glucose phosphate. One in

four students scored zero. Most of these responses were limited to describing how denaturation of rubisco would occur. Some students confused the Calvin cycle with the Krebs cycle.

01.3 Almost two-thirds of students correctly named the stroma as the location of rubisco. The thylakoids, crista and matrix were common incorrect responses.

01.4 The majority of students (56%) obtained two marks, invariably for describing the effects of an increase in temperature on the activity of rubisco and rubisco activase. However, many students then failed to use all the information successfully to evaluate the scientists' conclusion. Only 25% of students obtained more than two of the four marks available. Relatively few students clearly stated that the results indicate that rubisco activase does not activate rubisco. Similarly, very few students stated that these results were only for cotton plants and were for isolated enzymes. Equally surprising was the scarcity of responses which referred to the lack of a statistical test. Consequently, this question did not discriminate as effectively as had been expected.

Question 2

02.1 The vast majority of students (94%) realised that an inversion would not result in a change in the number of DNA bases. .

02.2 This question proved to be a very effective discriminator with one in three students gaining maximum marks. Nearly all students (91%) gained at least one mark, often for referring to mutation or methylation of tumour suppressor genes. Mutation was the most frequently credited marking point, although a significant number of students mentioned both alterations for two marks. Weaker students who provided further details on mutations often limited their descriptions to a non-functional protein being produced. Better answers included changes in primary or tertiary structure. Many students describing methylation did appreciate that this could prevent transcription of tumour suppressor genes. A significant minority of students referred to uncontrollable cell growth rather than uncontrollable or rapid cell division. There were also irrelevant, and often incorrect, references to oncogenes.

02.3 Over 83% of students gained at least one mark, almost invariably for showing 84 cell divisions. Slightly more than half of these students provided further calculations leading to a correct answer for two marks. Common errors included 84^2 and 2^{83}.

Question 3

03.1 Less than 17% of students realised that the apparatus was left for an hour so that the oxygen was absorbed or respired. Frequent responses which were not credited included "to reach equilibrium", "to reach a constant/stable/maximum rate of respiration", "to activate enzymes" and "to allow pressure to stabilise".

03.2 Approximately 70% of students obtained at least one mark, usually for stating that an increase in the volume/pressure of gas in the flask caused the coloured liquid to move to the right. Although many students did appreciate that the gas evolved in this investigation was carbon dioxide, most referred only to respiration rather than anaerobic respiration. A

minority mentioned both aerobic and anaerobic respiration. Some students suggested that ethanol produced by anaerobic respiration increased the pressure in the flask

03.3 This question clearly demonstrated the benefit of following the instruction to 'show your working', with over 52% of students obtaining one mark for an incorrect answer with some valid working. Often this was awarded for showing division by 24. Less than a third of students gained both marks. A common incorrect answer was 0.049; this was awarded one mark as this was indicative of some correct methodology.

03.4 Approximately 31% of students gained this mark, often by referring to the large range in numbers, the rapid increase in numbers or to an exponential increase. Common responses not credited included "to fit on the scale", "numbers are large", "is more accurate" and "is more comparable".

03.5 Surprisingly, only 53% of students obtained this mark. Many failed to do so due to vague terminology such as 'lack of food' or 'lack of resources'. Others showed lack of knowledge, for example "killed by lactate". The most common correct responses mentioned a decrease in glucose or oxygen, or an increase in ethanol.

03.6 This proved relatively straightforward for most students with over 75% obtaining both marks. Very few students (3%) failed to gain any credit, as the majority could provide at least one of the steps required in the calculation. This was often for 2000 x *e*/2.72 or *e*/2.72 raised to the correct power.

Question 4

04.1 This question proved to be more demanding than expected, with less than 7% of students obtaining maximum marks. Most of the students did not appreciate that a large number of quadrats should be used. Reference to a method of randomly determining the position of quadrats was the most frequently credited marking point. However, a significant number mentioned randomly positioning quadrats without suggesting a method for this. There were some responses which suggested randomly throwing quadrats! Students often spent time describing how the percentage cover in a single quadrat could be determined without explaining how the mean percentage could be calculated. A significant number referred to counting numbers rather than determining percentages.

04.2 This question proved to be an effective discriminator in terms of students using the information provided in **Figure 5**. Just over 20% of students scored zero as they often provided a description of succession with little, if any, reference to the information provided on the exam paper. Only 7% of students gained maximum marks. Students who did gain credit usually identified beach grass as the pioneer species. Students varied considerably on how they progressed from this point. The idea of the pioneer (or named) species changing the abiotic environment in some way was often understood, though not always stated clearly enough to gain the mark. The idea of a 'less hostile' environment was not often stated and, if it was, it was not often linked to a named species. There were extensive descriptions of competition between species without linking this to the changes in the biotic environment. There were also descriptions of secondary succession which is not on the specification. Surprisingly, relatively few students suggested that the hardwood and confer trees represented the climax community. In fact, a significant minority of students suggested the conifers and hardwood trees were the pioneer species and seemed to be reading the x-axis of the graph from right to left.

04.3 Two-thirds of students were able to explain that the conifer and hardwood trees reduced the percentage of light reaching the ground. Incorrect answers either omitted to mention trees or just referred to plants or larger species reducing the light.

04.4 Approximately 72% of students stated that the NPP would decrease or remain constant to gain one mark. Less than a third of these students could explain why. The most common response to gain two marks linked the low/decreased NPP with reduced light for photosynthesis. Students who suggested that NPP would remain constant usually did not gain a second mark for explaining that photosynthesis/GPP would equal respiration. A significant number of students thought the NPP would increase, either because there were more plants photosynthesising or because there was more light absorbed by the trees for photosynthesis, with the same respiratory losses.

Question 5

05.1 Approximately 50% of students scored zero for this question. Many of these responses related to "making the investigation a fair test", to "controlling variables" or "to allow a comparison of the results". The variation in water, salt and glucose content of different foods was mentioned by many students, but only the best answers stated that this would affect the water potential of the blood/body. Consequently, only 7% of students gained both marks. The idea that the volume of urine could be affected by consuming different foods was a more accessible marking point but the use of poor terminology, such as 'amount of urine', meant that students failed to gain a mark. There were several references to 'volume of urine' in the stem of the question to guide students to the use of correct terminology.

05.2 The vast majority of students (94%) obtained at least one mark for this question. Most correct responses referred to furosemide being the most effective drug. Many also provided the alternative response for the same marking point, i.e. that both drugs were more effective than the placebo. Far fewer students referred to standard deviations, leading to approximately only 35% of students gaining a second mark. Even when students mentioned SDs overlapping they often did not refer to significance. The converse was also evident. Some students compared the spread of SDs and related this to the reliability of the results. Occasionally, ranges were mentioned rather than SDs.

05.3 Less than a third of students obtained this mark. Although many students appreciated that furosemide removed excess fluid from the body by removing it in the urine, they did not all mention the reduction in the volume of blood. Again, poor use of scientific terminology was evident. A minority of students answered this in terms of baroreceptors and heart rate.

05.4 Although approximately 27% of students scored zero, this question proved to be a good discriminator, with almost 50% of students obtaining at least two of the three marks available. There were some detailed, concise responses which showed an excellent understanding of the effect of furosemide on nephrons. Many students appreciated that an increase in concentration of sodium and chloride ions in the filtrate would decrease its water potential. This marking point was often credited for the converse idea, i.e. that the water potential would be higher in the blood/medulla. Similarly, many students were credited for stating that more water would be absorbed by osmosis into the filtrate, i.e. the converse of less water being removed. However, a significant minority of students referred to the osmotic movement of fluid rather than water, or incorrectly suggested that more

water was reabsorbed from the collecting duct. Many students could name a part of the nephron where osmosis occurs, although a minority did refer to water movement between the medulla and the ascending loop of Henle.

05.5 Surprisingly, only 20% of students obtained this mark. A common error was not to factor in that the mean rate of flow of blood plasma is 60% of the mean rate of blood flow into the kidneys. A common incorrect answer was 20400 cm^3.

Question 6

06.1 Approximately 72% of students gained at least one mark for this question. The most common correct responses related to linkage and the random fusion of gametes. A significant number of students mentioned small sample size. Epistasis was infrequently suggested. The most common incorrect response was 'mutation', followed by environmental factors and epigenetics.

06.2 The great majority of students (83%) provided the correct genotype of ttmm. Variations such as mtmt were also credited, but students should be encouraged to use the standard format. The most common incorrect response was tm.

06.3 This question tested a new topic on the specification and proved challenging for many students. Despite the stem of the question and **Figure 7** providing evidence of linkage, this was not mentioned by many students in their explanations of the results of the genetic cross. This resulted in 45% of students scoring zero. Students who did refer to linked genes did not always mention crossing over or the low number of phenotypes produced because of this. Consequently, only 31% of students obtained at least two of the three marks available. The best answers explained that if the linked genes were inherited together, the offspring would be in a 3:1 ratio, but that crossing over produced small number of Tm and tM gametes that resulted in the low numbers of recombinant tall and mottled, and dwarf and normal plants. Many students who scored zero suggested that the ratio should be 9:3:3:1 and explained why the plants with the dominant phenotypes were most frequent. A few students suggested that mutations had caused the phenotypes which occurred in low numbers. Some students suggested that crossing over occurs in mitosis.

06.4 Almost 50% of students obtained both marks for this question. Students gaining a single mark (30%) usually correctly completed the phenotypes of the offspring in **Table 4.** Incorrect responses for the ratio of offspring in **Table 4** varied considerably, however a ratio of 1:1:1:1 was seen relatively frequently.

Question 7

07.1 This question proved to be an effective discriminator. Approximately 48% of students gained at least two out of the three marks available, however 21% scored zero. The most frequently awarded marking point related to the diffusion of dopamine across the synaptic gap. Many students also linked the entry of sodium ions to depolarisation. A significant number of students referred to the opening of sodium ion channels but failed to mention the entry of sodium ions into the neurone. Similarly, many students stated that dopamine attaches to receptors but did not state that the receptors were located on the postsynaptic membrane. Consequently, only one in six students provided a sufficiently detailed explanation for maximum marks.

07.2 This question was answered well, with 88% of students obtaining at least one of the two marks available. This mark was usually awarded for stating that morphine stimulates the release of dopamine. Many students (63%) also gained credit for stating that morphine attaches to opioid receptors. Failure to gain this second mark was often due to omitting the term opioid or for suggesting that morphine attaches to an active site on the receptor.

07.3 Interestingly, as with 07.1 also based on synaptic transmission, this question was a very effective discriminator. The percentage distribution of marks was also closely related to that on 07.1, even though slightly more students gained marks on this question. Most students appreciated that the entry of chloride ions would cause a more negative charge in the postsynaptic neurone. This was described in a variety of ways and the mark scheme was applied with a certain degree of leniency. Fewer students successfully explained that more sodium ions would be required to reach threshold. Again, there were frequent references to the opening of sodium ion channels with no indication of the direction of movement of sodium ions. There were some bizarre explanations of how depolarisation is prevented, which included reference to a wide range of different ions. The idea that sodium and chloride ions combine to form salt occurred on more than one occasion. Nevertheless, there were also some excellent explanations and most students obtained a mark for explaining that depolarisation was less likely to occur.

Question 8

08.1 The mark scheme for this question reflected the considerable variation in acceptable definitions for the term genome. Despite this, nearly 40% of students did not obtain the mark. There some very detailed definitions which often included the DNA in mitochondria and chloroplasts. The most common incorrect responses referred to “all the genes in a chromosome” or “all the genes in a species”.

08.2 Almost 80% of students obtained at least one mark for this question, often for referring to complementary structures. Almost half of these students gained a second mark by referring to a specific tertiary structure, shape or binding site. Weaker responses suggested that the term complementary is equivalent to ‘similar’ or referred to ‘active site’ rather than binding site.

08.3 This proved more difficult than expected with only 26% of students obtaining the mark. Incorrect responses included (unbound) DNA fragments, nucleotides, exons, introns, DNA without an antibody or transcription factor bound to it, and any combination of two of the three parts required to gain the mark. The constituent parts of a DNA molecule were also listed.

08.4 Again, relatively few students (30%) obtained the mark for this question. The most frequent correct responses referred to cDNA binding to the *P34* gene, preventing its transcription, or binding to mRNA, preventing its translation. The binding of the cDNA to mRNA, resulting in the destruction of mRNA, was also described. Binding to the promoter region was less frequently awarded. A significant minority of students mentioned that cDNA prevented RNA polymerase binding to the *P34* gene or just prevented its transcription, but with no suggestion of how. Incorrect responses often referred to cDNA increasing/decreasing methylation of the *P34* gene or simply that cDNA could not be transcribed into mRNA and translated to form the P34 protein.

08.5 Considering that this question was relatively straightforward, it proved to be a very effective discriminator. Surprisingly, many students could not name both enzymes correctly. Consequently, only 35% of students obtained both marks for this question and 28% obtained a single mark. DNA helicase, reverse transcriptase and DNA polymerase were frequent incorrect responses. Even when the correct enzymes were named, students did not always describe the precise roles of the enzymes in the formation of recombinant plasmids. These descriptions were often too vague, e.g. "produces sticky ends" or "joins DNA together", without any mention of the plasmid/vector. A significant minority referred to incorrect types of bonds when outlining the role of correctly named enzymes.

08.6 A significant number of students had difficulty applying their knowledge of electrophoresis to separating proteins. Only 14% of students gained both marks for this question, however 50% did at least obtain a single mark. Many students simply reverted to discussing DNA, especially VNTRs, or referred to DNA and protein, often suggesting that proteins consist of bases. Common responses which were not credited often referred to 'size' and 'mass', with no reference to the structure of proteins. However, better answers did obtain a mark when mass/size was linked to the number of amino acids or polypeptides. Difference in charge was the most frequently awarded marking point. Far fewer students mentioned different 'R groups' or 'variable groups'.

Question 9

09.1 Despite less than 13% of students obtaining more than two marks, this question proved to be an excellent discriminator. The most frequently awarded marking point was that the frequency of the *LP* allele would increase in the offspring generation. Many students who gained this mark often gained credit for stating that individuals with the advantageous allele would survive and reproduce. However, poor terminology, particularly referring to 'gene' rather than 'allele', prevented a significant number of students from gaining this mark. There were also many references to 'alleles surviving and reproducing'. Although many students realised that drinking milk gave a nutritional advantage, a named nutrient was not always included to gain a mark. Similarly, mutation was mentioned by some students but this was often not credited as many of these responses suggested that drinking milk had caused the mutation. Directional selection was only included in a minority of responses. A significant minority of students thought that *LP* occurred in cattle and suggested that cattle were selectively bred to continue lactase production. Some students also suggested that the allele for LP was obtained from cow's milk.

09.2 Approximately 50% of students gained a mark on this question, invariably for referring to *LP* as a dominant allele. Half of these students obtained the second mark by explaining that dominant alleles were expressed (in the phenotype). Many students who scored zero simply suggested that selection for the *LP* allele caused its rapid rise, indicating they had not carefully read the question. Perhaps of greater concern was the number of students who suggested that the recessive allele of the *LP* gene had reverted to its dominant form either via mutation, methylation or acetylation.

09.3 As expected, this proved difficult for many students with only 18% obtaining at least one mark and 5% gaining both marks. Many students had no idea how a mutation in DNA could cause lactase persistence. There was often confusion between lactase and lactose. Misconceptions included: mutations in proteins, mutations causing new genes to code for lactase and epigenetic changes/methylation/acetylation initiating lactase production. Some responses described deletion mutations in a different gene on the same chromosome, resulting in a frameshift which affected the lactase gene. Students who had some idea did

write about mutations in a gene that codes for the protein that switches off lactase. Others mentioned transcription factors, but the mutations were often in the transcription factor rather than in the gene coding for it.

Question 10

10.1 Despite only 8% of students obtaining maximum marks, this question proved to be an effective discriminator. 90% of students obtained at least one mark, often for stating that only rods or no (functional) cones are present. Slightly more than half of these students gained a second mark, usually for correctly describing the connections of rods and/or cones to a single neurone. However, poor terminology prevented some of these students from obtaining maximum marks. Some students used terms such as 'messages' and 'signals' rather than impulses. Even when students did refer to impulses, they often omitted reference to the optic nerve or brain, resulting in incomplete explanations.

10.2 The majority of students (70%) gained at least one mark for recognising that 2pq represented the heterozygous genotype. 39% of students successfully completed the calculation to obtain both marks. Many students scoring zero simply provided the Hardy-Weinberg equation with no annotation. Students obtaining one mark often thought that 0.1 was q rather than q^2, resulting in $2pq = 2 \times 0.9 \times 0.1$. This mark was not awarded when students (commonly) suggested that pq represented the heterozygous genotype.

10.3 Almost 70% of students obtained at least one mark for this question, with both of the marking points being awarded in similar numbers. Students who scored zero often correctly stated that red-green colour blindness is sex-linked but did not mention the X chromosome in their explanation. These students often realised that males only required one recessive allele to express the condition, but did not explain that females require two alleles. Some students did refer to males and females, but omitted the term allele. Sex-linked alleles were sometimes said to be on an unspecified sex chromosome, on both X and Y, or just on the Y chromosome preventing females being affected. Females were sometimes thought to be XY and males XX.

10.4 The answers to this question were extremely disappointing. Less than 1% of students gained maximum marks and only about a third of students obtained any of the three marks available. The trichromatic theory is a new topic on the specification and many students displayed a poor understanding of how different colours are distinguished. Many students incorrectly referred to green/red/blue cones/pigments rather than green-/red-/blue-'sensitive' cones/pigments. Consequently, fewer than 5% gained a second mark. Although better students did appreciate that 'other colours' were mixtures of different wavelengths of light, they failed to explain that 'other colours' resulted in the stimulation of more than one type of cone at the same time. Students who did gain a mark invariably referred to non-functional green-sensitive pigments or cones. However, this point was often negated as many students suggested that red-sensitive cones were also non-functional or absent, or that all cones were non-functional or absent. It was not uncommon to read answers that provided details on the breakdown of pigments which were not only beyond the requirements of the specification, but were also often inaccurate.

10.5 Only 3% of students gained both marks in this question as it was a rarity to see responses that mentioned that iPS cells would divide. Although most students did understand that iPS cells would differentiate, many suggested they formed the 'green-sensitive pigment' rather than cone cells. A significant proportion of students referred to the iPS cells developing into green/red/blue cones, again failing to gain the mark for omitting the term 'sensitive'. There

were also answers which referred to iPS 'growing' into cone cells with no indication of development or differentiation. Some students suggested that rod cells were produced or confused this method with gene therapy and referred to genes being injected into stem cells. Consequently, 48% of students scored zero on this question.

10.6 Most students (70%) obtained at least one mark for this question. Usually, this mark was awarded for stating that iPS is a long-term treatment or that gene therapy would only last two years. An additional mark was available if students realised that iPS would be a single treatment or that gene therapy would require regular treatments. However, this idea was rarely conveyed in students' answers. Far more students appreciated that one advantage of iPS was that rejection or an immune response was less likely. Although many students mentioned that gene therapy could cause 'harm' or 'side effects', this was often in the context of the 'injection' rather than due to using viruses. Consequently, only 8% of students obtained maximum marks and only 33% gained two or more marks. Many students also mentioned ethical issues, cost and/or the idea that results on monkeys were not necessarily transferable to humans. However, these constraints could also have applied to the use of iPS cells as a treatment.

Mark Ranges and Award of Grades

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