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Report on the Examination

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General Introduction to the November Series

This has been an unusual exam series in many ways. Entry patterns have been very different from those normally seen in the summer, and students had a very different experience in preparation for these exams. It is therefore more difficult to make meaningful comparisons between the range of student responses seen in this series and those seen in a normal summer series. The smaller entry also means that there is less evidence available for examiners to comment on.

In this report, senior examiners summarise the performance of students in this series in a way that is as helpful as possible to teachers preparing future cohorts while taking into account the unusual circumstances and limited evidence available.

Overview of Entry

Considering the exceptional circumstances preceding this series of exams, there were some very impressive responses on this paper with students displaying an excellent understanding of the assessed content. However, as in previous years, scripts at the lower end on the mark range showed little evidence of progression beyond GCSE. There was no evidence of students having insufficient time to complete the exam paper.

Apart perhaps from question 10.2, which proved to be a very effective discriminator, there was little evidence of any general misinterpretation of questions. The majority of questions were effective discriminators enabling the best students to fully display their skills across the full range of assessment objectives. This year, more students displayed the ability to successfully complete a dihybrid cross than on previous papers. Conversely, the responses to question 02.4, which assessed an understanding of probability, were extremely disappointing. Most students displayed a complete lack of understanding of probability and very few could use the probability values provided to arrive at a valid conclusion.

Apart from describing how to produce a calibration curve, the overall performance on questions related to the assessment of practical skills was disappointing. This was particularly evident in relation to the use of the calorimeter in questions 03.1 and 03.2 and when asked about the design of an investigation in 09.4. Many students also had difficulty describing how to determine the dry mass of a sample in question 07.3. As in previous years, the mathematical skills displayed by students were very varied.

The imprecise use of scientific terminology and limited powers of expression prevented some students from accessing specific marking points. This was particularly evident in questions 01.2, 01.4, 05 and 10.2 where reference to ‘messages’ and ‘signals’ were frequent as was the omission of key terms, particularly in question 05. The standard of handwriting indicated some improvement from last year but on some scripts it proved difficult to distinguish between key words such as colorimeter and calorimeter. There were fewer examples of answers being submitted in the form of bullet points compared with last year.

Comments on Individual Questions

Question 1

01.1 It was disappointing to find that only one in four students obtained both marks for this question by correctly referring to the contraction of circular muscles and the relaxation of radial muscles. Almost 40% of students scored zero, often by writing the converse or by not naming the muscles involved. Other incorrect responses used terms such as constrict, expand, widen, lengthen, and shorten rather than contract or relax to describe muscle action. A number of students gained one mark by suggesting that both circular and radial muscles were contracting or relaxing. Weaker responses suggested that the iris contains rods or cones to trigger the response.

01.2 This question proved to be a very effective discriminator. Most students, 74%, gained at least one mark, usually for stating that each cone is connected to a single neurone. Many of these students also realised that cones provide high visual acuity. Far fewer students, 14%, gained maximum marks as most students did not refer to cone cells sending separate (sets of) impulses to the brain. In some instances, the use of poor terminology, e.g. 'messages' or 'signals', prevented students accessing this mark. Despite being advised not to do so, some students provided details of colour vision.

01.3 It was pleasing to find that approximately 45% of students obtained both marks in this calculation and that 37% gained one mark. Students in this latter group were able to calculate the area of the fovea, but not as a percentage of the area of the retina. Errors relating to the conversion of μm to mm were common. Students who used the value of π from their calculator rather than using 3.14 (as stated in the question) were not penalised.

01.4 As with part 01.2, this question assessed an understanding of photoreceptors and similarly proved to be a very effective discriminator. However, only 65% of students gained at least one mark and only 10% gained maximum marks. One mark was most often gained for the knowledge that several rods are connected to a single bipolar neurone. A good proportion of these students then referred to rods providing high visual sensitivity for a second mark point. However, once more, the use of poor or incorrect terminology hindered many students. References to 'weak impulses' and 'stimuli combining' were common when students tried to explain how a threshold could be reached in a neurone. Better responses often referred to, or explained, spatial summation.

Question 2

02.1 Approximately two-thirds of students obtained at least one mark in this question, usually for mentioning that the cell-surface membrane has a phospholipid bilayer. Approximately one in four students also correctly interpreted that steroid hormones would be 'lipid soluble', enabling them to pass rapidly through the cell-surface membrane. A significant number of students simply referred to steroid hormones as being 'fat soluble', 'non-polar' or not being 'water soluble', responses which were not credited. Some students suggested that steroid hormones would pass through protein channels and/or carriers, or that active transport or water potential gradients were involved.

02.2 This question was generally well answered with almost 80% of students obtaining at least one of the two marks available. Most of these students referred to the complementary nature of the structures involved. Unfortunately, some students disqualified this point by referring to an active site or enzyme-substrate complex. Surprisingly, fewer students

mentioned tertiary structure/shape, often simply indicating that the molecules were specific. Consequently, only 40% of students obtained both marks.

02.3 This was another question with a high discrimination index. The best responses included all information on the mark scheme which provided alternatives to access maximum marks. Nevertheless, only 54% obtained a mark and only half of these students obtained both marks, by showing a clear understanding of how AR could stimulate gene expression. Students obtaining a single mark often did so by describing that AR attaches to the promotor (region). Incorrect responses included references to DNA polymerase (rather than RNA polymerase), methylation, acetylation and histones.

02.4 This question was not well answered with less than 30% of students obtaining any of the three marks available. The main reason for this was that most students incorrectly concluded that the higher the number of CAG repeats, the greater the risk of developing prostate cancer. The probability value at ≤17 CAG repeats was often thought to be an anomaly or to show the highest risk of developing prostate cancer. There was considerable confusion and misuse of the terms 'probability', 'chance' and 'risk'. The P values were frequently thought to show the probability of developing prostate cancer or to show the probability of having that number of CAG repeats. Very few students mentioned accepting or rejecting the null hypothesis and those who did sometimes had it the wrong way round. Some students thought that no statistical test had been carried out. Only 6% of students provided a suitably detailed conclusion to gain all three marks.

Question 3

03.1 Responses to this question were disappointing with almost 60% of students failing to gain a mark. Most students identified the stirrer and air space as important features in enabling a valid measurement of the total heat energy released. However, the explanations provided were often either incorrect or lacked detail. Common errors were to refer to the air space as a vacuum or to omit any reference to heat. A significant minority of students incorrectly referred to the oxygen concentration inside the calorimeter as a feature. Water was mentioned in a variety of contexts, but only infrequently in terms of high (specific) heat capacity.

03.2 Over a third of students failed to gain at least one mark for this calculation. Students who failed to realise that the sample of biomass was 2g rather than 1g were able to gain one of the two marks available. Similarly students who were able to perform the calculation but did not provide their answer in kilojoules gained a mark. 42% of students successfully completed the calculation to obtain both marks.

03.3 It was surprising to find that almost 40% of students failed to gain a mark on what was considered to be a relatively accessible question. Again, lack of sufficient detail prevented a significant number of students from obtaining a mark. These students often limited their responses to 'light not being absorbed' or to 'chlorophyll not using all the light'. Despite the question being in the context of 'light falling on producers', a considerable number of answers stated that light 'misses the producers'. Students who obtained one mark frequently stated that light missed the chloroplasts/chlorophyll. The 31% of students who gained a second mark often referred to light being reflected or that it was the wrong wavelength. A minority of students gained credit for stating temperature could be a limiting factor. Students who mentioned carbon dioxide rarely specified its concentration and so failed to gain credit.

03.4 Almost 91% of students gained at least one mark, often by naming ATP as a product of the light-dependent reaction required for the light-independent reaction. Almost 30% of students failed to name reduced NADP as the second product. The most frequent incorrect responses were reduced NAD, NAD and NADP. Water, carbon dioxide, oxygen, RuBP and triose phosphate were also incorrectly suggested by a minority of students.

03.5 This proved to be a difficult calculation for the 50% of students who scored zero. Although many students appreciated that 16 cell divisions had taken place, a common error was to calculate 2000^{16} rather than 2000×2^{16}. Some students arrived at the correct number of 131072000 but then failed to give their answer in standard form. Almost 37% of students provided the correct answer, however.

Question 4

04.1 Despite 26% of students obtaining maximum marks and only 53% obtaining one mark, this question and the other parts of question 4 were very effective discriminators. Better students provided a clear explanation of the banding pattern and obtained maximum marks with little difficulty. However, even some of these students benefited from the decision to ignore references to the A band. Confusion over the A band was displayed by students of all abilities. Students obtaining a single mark frequently identified the I or light band as containing only actin. The position of actin and myosin was sometimes reversed, resulting in only a single mark for explaining that both filament types were in the overlap region. Some answers described the different regions of the sarcomere and gave correct letters for bands and lines, but omitted to mention actin or myosin. The banding was occasionally incorrectly related to whether the fibres were slow-twitch or fast-twitch. Varying amounts of detail of the sliding filament theory were included in some answers.

04.2 There were some excellent answers to this question with 31% of students obtaining maximum marks and over 53% gaining at least three marks. It was pleasing to note that the majority of students displayed some understanding of the procedure required to produce a calibration curve. Students who failed to gain any credit, 14%, often provided very vague descriptions and omitted important details. For example, (distilled) water was not included in producing dilutions of the creatinine solution (mark point 1) and then the addition of the creatinine-detecting solution (mark point 2) was omitted. Students gaining one or two marks often included at least one of these mark points but then failed to refer to measuring the absorbance or transmission of the tested solutions. These responses were frequently limited to 'reading values/results' on a colorimeter. A few students referred to calorimeter rather than colorimeter. One common theme across the majority of responses was the use of the term 'amount' rather than 'volume' when referring to solutions. This use of poor terminology prevented students from accessing mark point 3.

04.3 Approximately one in four students obtained both marks on this question. These marks were usually awarded for adding the creatinine-detecting solution to the urine and reading off the concentration of creatinine using its absorbance value on the graph. Only a minority of answers included using the same volumes of solution as used to produce the calibration. These responses almost invariably included the alternative marking point of adding the creatinine-detecting solution. When only one mark was awarded, it was usually for using the calibration curve. However, some of the descriptions of how to find the concentration from the calibration curve were too vague to be credited. A common incorrect idea was to draw a tangent to the line on the calibration curve and then calculate the gradient. There were many references to extrapolation and lines of best fit, which were ignored.

Question 5

05.1 This question, in which all the mark points assessed knowledge and understanding, proved to be the most effective discriminator on the exam paper. Approximately 17% of students gained maximum marks and 21% scored zero. The two mark points most frequently credited were the fusion/movement of synaptic vesicles to the presynaptic membrane with the release of acetylcholine, and the diffusion of the acetylcholine across the synaptic gap. Some weaker responses stated that vesicles were released and that these diffused across to the postsynaptic neurone. Other frequent errors in these weaker responses included: calcium ions diffusing out of the synaptic knob rather than in, referring to the binding site on receptors as an active site and using the term 'signals' for depolarisation. Failure to use precise terminology was also evident even in better responses. A number of students provided relatively good descriptions but failed to achieve more than three marks due to the omission of key terms such as 'receptors', (presynaptic and/or postsynaptic) 'membrane' and (calcium/sodium) ions. Consequently, 54% of students gained three or more marks whereas 38% of students obtained at least four marks.

Question 6

06.1 Although 50% of students obtained both marks, this question was a good discriminator. Crossing over and independent segregation/assortment (of homologous chromosomes) were frequent correct responses. Slightly fewer students referred to random fusion of gametes. Almost 27% of students failed to obtain a mark. There were numerous incorrect responses, including allopatric/sympatric speciation, natural/directional/stabilising selection, epistasis, mutation, epigenetics, linkage, genetic bottleneck, genetic drift, gene flow, founder effect, and geographical isolation.

06.2 Approximately 77% of students correctly named the relationship between the alleles as codominance. Incorrect responses included epistasis, heterozygous, dihybrid, dominant, recessive and linkage.

06.3 Despite almost 59% of students obtaining all 3 marks, this question proved to be a very good discriminator. When the parental genotypes were correctly given, the correct offspring genotypes, phenotypes and ratios usually followed to gain maximum marks. There was almost an equal split of students who achieved, two, one or zero marks. A frequent error was to show the parental tall genotype as homozygous rather than heterozygous. The mark scheme enabled these students to achieve two marks if they then successfully completed the resulting dihybrid cross with the corresponding phenotypes and ratio. Most students achieving two marks did so via this pathway. However, some students provided the correct parental phenotypes and dihybrid cross but then made an error when showing the phenotypes of the offspring produced. A significant minority of students showed a 9:3:3:1 ratio despite completing all other parts correctly! Students achieving one mark often provided the correct parental genotypes but could not produce a correct dihybrid cross. The mark scheme also allowed one mark for correct dihybrid genotypes of offspring from incorrect parental genotypes.

06.4 This question was an excellent discriminator, especially for a two-mark question. Approximately 38% of students were able to correctly calculate the percentage of pink-flowered plants in the population. Approximately 23% obtained one mark, often for showing that 2pq represented the percentage of heterozygous/pink-flowered plants. A frequent error was to use 0.09 = q and 0.91 = p, giving 2pq = 16.38, which gained one mark. Some students either correctly or incorrectly calculated 2pq but then divided by 2 to give pq as the final answer which resulted in zero marks.

Question 7

07.1 Approximately 38% correctly performed this calculation. Many students, however, correctly read off the values from the graph but then failed to subtract the initial mass of 0.5 g per pot to find the growth over the 20 days. The correct calculation of 1.375 was sometimes divided by 20 to provide a final incorrect answer.

07.2 Considering this was a five-mark question and assessed evaluation skills, it was not a very effective discriminator. Approximately 92% of students gained at least one mark, often for stating that potassium nitrate was the most effective fertiliser and chicken manure the least effective. Almost three out of four students gained at least two marks, frequently by noting that there was no increase in growth after applying 30 g of potassium nitrate. Poor use of terminology was again apparent with marks not being gained for using 'at' rather than 'above' or having 'no effect' rather than 'no increase'. Occasionally weaker answers included details on decomposition and a comparison of natural and artificial fertilisers. Almost 50% of students gained three or more marks. There was some variation in how these higher marks were achieved. The most frequent additional points related to the fertilisers being more effective than the control and that no statistical test had been carried out. Less frequent were responses which noted that the investigation was only carried out on spinach plants and that there was only a gradual increase in growth when more than 30 g of ammonium sulfate fertiliser was used. Only 6% of students achieved all 5 marks.

07.3 Approximately 36% of students obtained both marks and 59% at least one mark. Many students gained two marks for concisely stating that the sample would be heated until a constant mass was obtained. One mark was often awarded for the idea of reweighing to constant mass but without any mention of further heating. A significant number of students mentioned heating but with no reference to weighing and scored zero marks. Responses scoring zero also included a wide variety of methods to remove the water from the sample, including paper towels, silica gel, drying agents and reverse osmosis.

Question 8

08.1 Although only 8% of students obtained both marks and 30% obtained one mark, it was clear that there was a general lack of understanding of the structure of the glomerulus (and of the renal capsule). Invariably, students who mentioned the basement membrane obtained both marks. A common misconception in answers scoring zero was that proteinuria was caused by the proteins not being reabsorbed. This lack of understanding was often further emphasised by suggesting that reabsorption of protein would occur in areas such as the loop of Henle and the collecting duct. Students who obtained one mark did appreciate that proteinuria was caused by proteins passing into the filtrate at the glomerulus.

08.2 45% of students correctly indicated that a sex-linked mutation would be located on the non-homologous region of an X chromosome.

08.3 This question was an effective discriminator. Approximately 90% of students obtained at least one mark and 8% obtained the maximum four marks. Many students noted that the wild type stem cell treatment was effective as group D mice had lower protein in their urine (than groups B and C). The other two mark points often credited were related to the short duration of the investigation and that it had been carried out on mice rather than on humans. Far less often did students refer to the possibility of rejection or an immune response. Even less frequently did students mention that the results for only 68% of the

group D mice are shown and that the others may have been cured or died. A very limited number of students did gain credit for indicating that the numerical quantity of protein in the urine was not shown in the data. Only the best answers considered in detail both the experimental design and the data provided.

08.4 Approximately 60% of students scored zero on this question. Most of these students displayed a poor understanding of the investigation taking place. They often focused their responses on the Y chromosome or, less frequently, on dominant and/or recessive alleles. A common error was to suggest the transplanted stem cells developed into a Y chromosome and that a gene/allele on this chromosome was expressed to reduce proteinuria. Only 10% of students gained both marks by suggesting that the stem cells differentiated into cells of the glomerulus and reduced/prevented the movement of protein into the filtrate. Students who obtained a single mark usually gained the mark point relating to the differentiation of stem cells.

Question 9

09.1 This was another example of a two-mark question which proved to be a very effective discriminator. Approximately 28% of students obtained both marks and a similar percentage obtained a single mark. Students who failed to gain a mark often named incorrect enzymes, with reverse transcriptase, DNA polymerase and DNA helicase being the most frequent. A significant number of students, who correctly named restriction endonuclease, incorrectly stated that the enzyme 'cuts the gene', thereby disqualifying the mark point. However, more students gained a mark for correctly describing the mode of action of restriction endonuclease than of ligase.

09.2 This question was not well answered and proved to be a poor discriminator. Only 2% of students gained both marks and 26% obtained a single mark. The idea that delayed insertion of the transferred gene into nuclear DNA would result in gametes that lacked this gene was not appreciated by the vast majority of students. However, approximately one in four students did realise that cell division would have occurred before this gene was inserted. There was a variety of incorrect suggestions to explain the lack of the desired characteristic in the offspring. These included: problems with inserting the gene into the plasmid, lack of transcription and translation of the gene, and the idea that differentiation of cells had already taken place before insertion.

09.3 40% of students obtained both marks by clearly explaining that the results showed a significant increase in growth of the transgenic zebrafish as the SDs do not overlap. The 27% of students who obtained a single mark often stated that the SDs do not overlap but did not correctly explain what this meant. Some used imprecise terminology such as 'the results are significant' or 'the results are not due to chance'. A number of students who did not gain a mark attempted to describe effectiveness in terms of the difference in SDs. Occasionally, students stated that the SDs did overlap and the differences were not significant. Few students referred to overlap of the means. Again, this was a two-mark question which proved to be a very effective discriminator.

09.4 Similarly to 09.2, this question was not well answered and was not an effective discriminator. Although 45% of students gained at least one mark, only 7% of students gained both marks. Many students were able to describe two of the required features but then struggled to explain how each feature helped to ensure the validity of any conclusions obtained. The most frequently credited mark point related to the large sample size so that the results would be representative. Although many students referred to the investigation

being carried out for 12 months, this was often linked to egg development rather than growth of fish. Other features mentioned by students which were not credited included using the same number of transgenic and non-transgenic fish, using fish of the same age/gender/species and using a statistical test.

Question 10

10.1 Although only 4% of students gained all three marks and 67% gained at least one mark, this question was an effective discriminator. The most frequently credited marking points were the use of (stored) fat in respiration/metabolism and less (stored) food being required due to reduced respiration/metabolism during hibernation. A significant number of students attempted to describe gluconeogenesis, but very few did this successfully. Most confused this process with glycogenolysis. Several other features of hibernating bears were mentioned including reduced movement, fat insulation and their reduced surface area to volume ratio, but the significance of these features were rarely explained. References to water were less frequent. However, reduced urination, reduced sweating and particularly the production of water from respiration were all credited at some point. Some students incorrectly suggested that water could be provided by hydrolysis.

10.2 This question was the second most effective discriminator on this exam paper. This was surprising considering that 36% of students scored zero. Approximately 25% of students obtained at least three marks and 14% obtained the maximum four marks. The best answers displayed a full understanding of the role of chemoreceptors and the autonomic nervous system in reducing the heart rate in response to a decrease in the metabolic rate. Some of the students who scored zero failed to mention the nervous system and based their response on the reduced heart rate reducing the supply of oxygen to tissues, this resulting in a reduced metabolic rate. Other students could not accurately recall any details of the nervous control of the heart rate or described how contraction of the heart is coordinated. Frequently, students who gained a single mark did so for stating that impulses were sent to the SAN. The role of chemoreceptors was appreciated in better responses. However, a significant minority of students suggested that they only respond to the concentration of oxygen in the blood. Rarely did students refer to the frequency of impulses in terms of more or fewer, but this did not prevent maximum marks being achieved. However, poor use of terminology was again a feature with ‘messages’ and ‘signals’ particularly apparent on low scoring responses.

10.3 Very few students could apply their knowledge and understanding of chemiosmosis to uncoupling proteins. Consequently, only 7% of students obtained both marks and 29% one mark. 10% of students did not attempt this question. Many students simply repeated the information on uncoupling proteins in the passage or completely ignored this and described the production of ATP via chemiosmosis. Some students suggested that these uncoupling proteins released another form of energy without being specific. A significant number of students incorrectly referred to the ‘production of energy’. Students who gained a single mark usually gained credit for mentioning the release of heat energy rather than the passage of protons through the uncoupling proteins. Despite the problems students encountered with this question, it proved to be an effective discriminator.

10.4 This question caused few problems for most students, with 79% obtaining at least one mark and 59% both marks. However, it proved to be a poor discriminator. Most students appreciated that the snow melting earlier, when the snowshoe hares still had their white coats, meant they were no longer camouflaged and therefore more easily spotted and killed by predators. Occasionally, the snow melting earlier was omitted from the answer. A more

frequent occurrence was to suggest that the snowshoe hares were camouflaged from their prey which was not credited. Some students confused the use of the terms predator and prey. A significant minority of students attempted to explain the reduced survival rate of the hares in terms of temperature control, failing to appreciate that new fur replaces old fur. Some responses were vague, only referring to mutations and a lack of beneficial alleles.

10.5 This question proved more difficult for students than 10.4 and was a far more effective discriminator. Only 11% of students gained the maximum four marks and 58% at least one mark. The best responses were often clear and concise explanations of how early moulting enabled the survival of snowshoe hares in their mountain habitats and included the use of appropriate scientific terminology. Weaker responses referred to genes rather than alleles and to 'more alleles' rather than to an increase in their frequency. Students who did not explain the survival of snowshoe hare populations in terms of 'earlier moulting' were unable to obtain more than two marks. Similarly to question 10.4, weaker answers attempted to explain survival in terms of maintaining a constant body temperature or confused the terms predator and prey.

Concluding remarks

Despite showing some understanding, students regularly fail to gain marks by using inappropriate terminology. As highlighted above, students should be encouraged to use the term 'active site' only when referring to an enzyme molecule, 'tertiary structure' only when referring to a protein, and 'impulse', not message or signal, when describing nervous coordination.

Questions that test understanding of kidney function seem to cause particular difficulty to students. Teachers might find the teaching notes and slide presentation provided on the AQA website helpful (https://www.aqa.org.uk/resources/science/as-and-a-level/biology-7401-7402/teach/teaching-notes).

Mark Ranges and Award of Grades

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