BIOLOGY

Paper 9700/11
Multiple Choice

Question Number	*Key*	*Question Number*	*Key*
1	**C**	21	**A**
2	**D**	22	**C**
3	**B**	23	**C**
4	**A**	24	**D**
5	**D**	25	**B**
6	**B**	26	**A**
7	**B**	27	**B**
8	**D**	28	**B**
9	**B**	29	**A**
10	**B**	30	**B**
11	**A**	31	**A**
12	**A**	32	**C**
13	**D**	33	**A**
14	**B**	34	**B**
15	**C**	35	**A**
16	**A**	36	**D**
17	**C**	37	**B**
18	**C**	38	**D**
19	**B**	39	**A**
20	**B**	40	**D**

General comments

The paper differentiated well.

Comments on specific questions

Question 3

Many candidates found this difficult and could not manipulate the information correctly.

Question 4

The majority of candidates did not know what a typical eukaryotic cell contains.

Question 10

Weaker candidates did not understand the structures of amylose and cellulose. A common misconception was that cellulose contains α-glucose.

Question 11

Stronger candidates answered correctly but weaker candidates were confused about the distribution of peptide bonds and often selected answer **D**.

Question 14

Just over half of the candidates were able to evaluate which graphs correspond to high and low concentrations of a competitive inhibitor.

Question 16

Many stronger candidates processed the information correctly. Weaker candidates found this difficult both in terms of the direction of diffusion and respective directions of active transport.

Question 21

Just over a half of candidates knew that tRNA contains single stranded RNA which folds such that hydrogen bonding occurs between regions of complimentary bases.

Question 26

Weaker candidates did not know the functions of the labelled cells.

Question 27

Those candidates with a good understanding of oxygen dissociation curves and Bohr effect were able to process the information correctly.

Question 28

Nearly half of the candidates incorrectly selected option **D**. Carboxyhaemoglobin is formed when carbon monoxide binds to haemoglobin, not when carbon dioxide binds.

Question 29

Stronger candidates showed understanding of the concepts involved in the reactions involving carbonic anhydrase.

Question 32

Some stronger candidates and few weaker candidates answered this correctly.

Question 33

Stronger candidates answered well but weaker candidates found this challenging with all answers seen equally.

Question 37

Many weaker candidates believed incorrectly that only B-lymphocytes produce memory cells.

BIOLOGY

Paper 9700/22
AS Level Structured Questions

Key messages

- Having a good overall view of the stages involved in protein synthesis and a good understanding of the flow of information from DNA to proteins is highly beneficial when approaching questions involving transcription and/or translation, such as **Question 6(b)(ii)**. Candidates must know what is meant by the terms transcription and translation so that they can avoid using the term 'transcription' and describing translation and vice versa.

- The movement of water and water vapour should be explained in terms of water potential and not in terms of concentration. This was required in **Question 2(a)(ii)**. A gradient created by one area that has a higher water potential and another that has a lower water potential should be described as a water potential gradient and not as a diffusion gradient or a concentration gradient. When describing two adjacent areas with different water potentials, it is not correct for candidates to incorporate the term 'gradient'. For example, 'water moves from a higher water potential to a lower water potential' should be used rather than 'water moves form a higher water potential gradient to a lower water potential gradient'.

- When asked to describe graphical data, candidates should check to see if a pattern or trend can be described before giving more details. It is common for some credit to be given for data that is correctly extracted, with units if appropriate. Here, it is good practice for candidates to give both axis labels. If more than one curve is shown on a graph, as in **Question 3(b)**, candidates should check carefully the key or label assigned to the curve and then in the response be clear which curve is being described.

General comments

There were many candidates who gave very sound performances, displaying very good knowledge of learning outcomes of the syllabus and showing an ability to apply knowledge with understanding to new contexts. Some questions, such as **Questions 4** and **6**, required candidates to be able to draw from different areas of the syllabus. Well prepared candidates were able to do this with ease. Almost all candidates completed all part-questions.

Candidates often find it more difficult to associate a definition or description with a correct term than providing a definition or explanation of a term. This was shown in **Question 1** where, although many did gain full credit, others found it difficult to recall the correct term to match the statements given.

Stronger candidates were able to handle and assimilate all the information provided in the table and graph of **Question 3** to produce some excellent responses. Others found it more challenging to bring together information to help them respond to questions. For example, information in **(a)(i)** was used to help answer **(a)(ii)** and information in the two different formats of a graph and table were analysed to answer **(b)**. Some candidates needed to pay closer attention to the wording of questions, such as in **(c)** suggestions of how to eradicate measles were given while in **(e)** examples of costs in the smallpox vaccination programme or costs to individuals were given.

Candidates who were skilled at applying knowledge to answer questions set in an unfamiliar context were able to perform well in **Question 6**.

Comments on specific questions

Question 1

This question assessed candidate knowledge and understanding of learning outcomes from syllabus Topic 3.

A was generally very well known. Some candidates only gave the term 'activation', which was not strictly correct.

B was stated correctly by most. Some gave an amalgam of terminology used in the Enzymes topic of the syllabus: 'induced key', 'induced fit key', 'induced lock and key', 'induced substrate', 'lock and key fit' were seen. These could not be credited. Some weak responses stated 'catalysis'.

C was also well known by many, but there were some who gave named proteins as their response. Of these, 'haemoglobin' was most commonly seen.

D was less well known. A number left this blank, while others gave terms such as 'extrinsic', 'external cellular', 'exocellular', 'exocytosis' and 'catalysts'. Candidates were required to link back to a specific syllabus learning outcome that requires learners to state that enzymes function inside cells (intracellular enzymes) and outside cells (extracellular enzymes).

E was the least well known term. Use of K_m or close or phonetic spellings for 'Michaelis-Menten' were accepted. Many left this blank while others stated 'V_{max}'. Some gave '$^1/_2$Vmax' as their response, presumably remembering this as one stage in deriving K_m, but not realising that this is a rate of reaction rather than a concentration of substrate. Weaker responses confused the description with inhibition, so competitive inhibition and non-competitive inhibition were also seen.

Question 2

In this short question based on marram grass, candidates applied knowledge and understanding of transpiration, water potential gradients and adaptations of the leaves of xerophytic plants from syllabus Topic 7.

(a) (i) Knowledge of the xerophytic leaf features of marram grass was not required to answer this question. Many used a correct term for the adaptations seen. The presence of hairs or hair-like structures was also credited but other terms such as root hairs, needles, spikes and cilia were not as these indicate totally different structures not present. Candidates were told that the leaf had a thick cuticle, no stomata on the outer surface and stomata in pits and were asked for another adaptation visible in **Fig. 2.1**. Greater attention needed to be paid to this wording to gain credit.

(ii) The very best responses used correct terminology and gave precise explanations. These candidates understood: that it is water vapour rather than water that diffuses out through the stomata; that the rolled leaf/trichomes enable this water vapour to collect to create a humid area; and this reduces the water potential gradient between the substomatal air space and the enclosed area to lower the rate of transpiration. Many did gain partial credit with knowledge that a humid area is created in the enclosed area. Here, care needed to be taken to make the location of the humid area clear. For example 'area outside the cells' could refer to the intercellular air spaces. Candidates should describe movement of water and water vapour in terms of water potential and to use the term water potential gradient with care. Responses gaining higher credit used the terminology adeptly and explained that there would be a decreased rate of diffusion of water vapour out. These candidates were also clear that the less steep water potential gradient was created between the substomatal air spaces within the leaf and the enclosed area created by the rolled leaf adaptation, where the trichomes were located. A few also correctly explained that the enclosed area meant that there was no exposure to external air currents. Quite a number incorrectly thought that the rolling of the leaf would have created an enclosed area with a reduced leaf surface area.

(b) This was generally well known. Some gave examples of xerophytes, such as cacti, which was not required. Others knew that the term 'xero' was involved but responses such as 'xerotype', 'xerocyte' and 'xerophyllic' were not credited. 'Xenophyte' was also not credited.

Question 3

This was a longer question based on the infectious disease measles and assessing syllabus Topics 10 and 11. As noted in General comments, candidates needed to use the skill of gathering information from more than one source to produce a high quality response in **(a)(ii)** and **(b)**.

(a) (i) The calculation required proved to be fairly straightforward for most candidates. The actual number of cases that were stated for Chad and Eritrea were given to the nearest whole case, so this should have been the prompt to candidates to do the same. Common errors were with factors of ten and rounding to 1180 rather than giving 1179 as the answer.

(ii) The most complete responses stated the advantages of showing data as number of cases per 100 000 and then backed up these ideas with numerical data taken from **Table 3.5**. The most common example of supporting evidence was to state the values for the number of cases per 100 000 and to show how the use of actual cases for Chad, Eritrea and Ethiopia gave an incorrect actual ranking for the severity of the disease between the three countries. Many described how the problem of differing population size was overcome by using standardised values; fewer considered how the severity of disease between countries, or the spread of disease within one country, could be gauged. A common error was to state that the standardised values were 'averages'. Weaker responses stated that it was easier or quicker to use estimates rather than count all the people with the disease, which did not show an understanding that the standardised values were derived from the actual number of cases reported. Others stated that the standardised values were easier to handle or to plot on a graph, not noticing that the actual values given were straightforward for handling. A few interpreted 'number of cases' as 'number of deaths'; this was not penalised if the correct ideas were given. As the raw values seemed higher than the standardised values, some suggested that using the raw figures would be 'bad for tourism', or would 'give the country a bad name', which is not the case.

(b) This was a challenging question requiring a number of skills and candidates were expected to take time to plan their response before writing their ideas down. Some candidates did produce excellent responses: well organised, thought processes clearly stated and correct values extracted from the table and graph. A good approach was to study the graph in **Fig. 3.1** and get a good idea of the main trends shown. These trends should then have been considered in conjunction with candidate knowledge and understanding of vaccinations. Not all candidates showed awareness of the fact that for a population to avoid a high number of cases of measles: a high percentage of the population needs to be effectively immunised against the disease; full immunity against measles takes time to develop in an individual; and for the population to remain protected a high percentage cover needs to be maintained. As candidates were told that the data in **Fig. 3.1** was for children under 1 year, some realised that each year there would be a continued need to vaccinate infants in order to increase or maintain percentage cover for the population. The importance of considering percentage vaccination over the years rather than for just one year was missed by some. This was the concept of how a high proportion of vaccinated one-year olds would mean that the following year there would be a high proportion of two-year olds with immunity, and so on, so that eventually a high proportion of young people (most susceptible to measles) should have immunity to help to avoid an epidemic. Finally, the standardised values of cases per 100 000 for each country could be checked to see if the statement was supported or not. When checking **Table 3.1**, two high values should have stood out: 15.31 for 2011 in Central African Republic and 71.60 in 2011 for Chad. Some candidates realised that these represented an epidemic and for Central African Republic, with a decreasing percentage vaccinated there would be little chance of controlling this. Although Chad had a trend of increasing percentage vaccination, some noted that over the years there was still not a sufficient proportion of the population protected. It was not sufficient to say that these were outbreaks. The best responses realised that, for example, values such as 1.48, 0.89 and 0.81 for Eritrea could all be considered low and representative of the success of a vaccination programme. Some interpreted a difference between 1.48 and 0.89 as significant and suggestive of a failure of a vaccination programme. It was not sufficient to state number of cases (per 100 000) without giving the years. Also, many points required candidates to match cases per 100 000 with the trend of percentage vaccinations increasing or decreasing, rather than to give a single year's percentage vaccination and match that to the same year's standardised case value. Most realised that there was little value in making comparisons for any one year between countries as this did not address the issue of vaccination programmes within a country. Some candidates did not pay attention to **(a)(ii)**, where they were told it was advantageous to use cases per 100 000 and gave the actual number of cases, which could not be credited. There were also some who only gave cases per 100 000 for the countries and did not give percentage vaccination values to show

increasing or decreasing trends or make the statements of this. Others gave values correctly extracted from the graph and table but did not state which country this was.

(c) This was very well answered by candidates and all the points were seen. The most common of these was the fact that the smallpox vaccine was freeze-dried and so thermostable. It was not correct to say that the vaccine was frozen. Although many may have understood that the same vaccine could be used throughout, a proportion of these could not be credited as their response only went as far as stating that the smallpox virus did not mutate and they did not continue to mention the vaccine. Ease of administering the vaccine needed to be qualified further to gain credit: some correctly mentioned the use of the bifurcated needle, others mentioned that it was easy to train individuals to give the vaccine. Weaker responses appeared to have misread the question and explained what needed to be done to improve the measles vaccination programme, without making any reference to the smallpox eradication programme.

(d) To gain credit, answers needed to state both active and artificial immunity.

(e) This was generally very well done, although the quality of expression varied considerably. The best responses were clear that cost was involved: for example 'large quantities of vaccine need to be bought' is a response of a far higher standard than 'they need lots of vaccine'. Weak responses answered from the point of view of an individual rather than a complete vaccination programme, so were not worthy of credit. Others were too vague to be credited.

Question 4

As a general introduction to **Question 4**, which was based on Topics 1, 4, 8 and 9, candidates were presented with an unfamiliar diagram of a simplified circulatory system of a mammal, **Fig. 4.1**. This was required for **(b)** and **(c)** and was useful stimulus material for part **(a)**.

(a) The most complete responses addressed both parts of this question and explained clearly what was meant by 'closed' and what was meant by 'double circulation'. For 'closed', 'blood contained in blood vessels' was sufficient to gain credit as this included the capillaries, arteries and veins. These three types of blood vessel are the minimum that should be known for the blood vessels, so if candidates did choose to name the vessel types then these three were required. For 'double circulation', there were many who expressed knowledge of the pulmonary and systemic circulatory systems in a fluent manner. Many chose instead to describe double circulation in terms of passage of blood twice through the heart for each complete circuit round the body, which was equally acceptable. This would separate the idea of double circulation from the cardiac cycle, which is one heart beat. Some who chose to describe double circulation named the blood vessels of the heart and explained blood entering and leaving, without stating where the blood was going to or coming from.

(b) Most candidates appeared to take care when studying **Fig. 4.1** and correctly named the relevant blood vessels, valve and heart chamber. The most common error was to omit 'right' or 'left' where appropriate.

(c) Knowledge of the composition of blood compared to lymph was required for this question. The most common correct response was that red blood cells were not present in lymph; plasma proteins were also given correctly by a number of candidates. Proteins were not accepted, as this would include molecules such as antibodies that are found in lymph. Common incorrect responses included white blood cells, carbon dioxide and glucose. Only stating a content of a red blood cell, such as haemoglobin or carbonic anhydrase, was not sufficient; where these appeared with red blood cells as an answer, the response was given credit.

(d) The majority of responses were able to gain partial credit for realising that gas exchange involved diffusion of the respiratory gases and for stating the direction of movement of oxygen and of carbon dioxide. A number did not mention carbon dioxide. Many of the candidates who gained full credit gave more detail of the pathway involved, including the squamous epithelium of the alveolar wall and the endothelium of the capillary wall and noted the importance of the red blood cell in the process. 'Epithelium' alone was not sufficient as it was not clear what type of epithelium was being referenced. Some gave features of gas exchange surfaces, such as a large surface area or short diffusion distance, rather than describing the process of gas exchange, which was not required. A few confused 'epithelium' and 'endothelium,' and, for example, wrote about gases crossing the endothelium of the alveolus.

(e) (i) The label line to cell structure **F** pointed directly to the nucleolus, and this was given by many candidates. There were fewer that knew that structure **G** was the cell surface membrane even though it separated one intestinal epithelial cell from the next. Less precise answers that were accepted for **F** and **G** were 'nucleus' and 'cell membrane'. **G** was left blank by some and there were very many incorrect cell structures stated.

(ii) The best responses were precise and to the point when outlining the features of facilitated diffusion. A number of outstanding responses gave all the points required. There was good knowledge here that carrier proteins were used to transport glucose and that these proteins were specific to the molecule. Specificity and protein conformational change were less frequently seen than the other features of facilitated diffusion. Other responses additionally explained why facilitated diffusion of glucose was necessary, which was not part of the question. Some wrote that both carrier and channel proteins were used, with some describing the movement of ions. The most common error was to state that facilitated diffusion required ATP or energy; some of these responses also explained that glucose went against the concentration gradient, while others stated that glucose moved down the gradient.

Question 5

Candidate knowledge and understanding of syllabus Topic 5 was assessed in **(a)** and **(b)**, where **Fig. 5.1** served as a visual prompt to help candidates. **(c)** required application of knowledge. Here, a link was made between the cell cycle from Topic 5 and cell signalling from Topic 4.

(a) (i) This was a straightforward question that was well answered by many. Most correct answers went down one of two routes: either stating that coiling and/or supercoiling were taking place or stating that condensation occurred. Of the responses that did not gain credit, most gave descriptions of spindle formation and nuclear envelope disassembly, neither of which answered the question about chromosomes becoming visible. A few candidates described coiling as 'recoiling', which was not the correct term to use, and others incorrectly thought that 'uncoiling' or 'decondensing' occurred.

(ii) This was well known and most candidates gave a well-expressed response, with a few describing telomeres and histone proteins. Some only noted the presence of a centromere and could have improved their answer by stating that the sister chromatids were held together by the centromere. Weaker responses did not include the term 'chromatid' and so descriptions of a chromosome composed of two chromosomes, two threads or two chromatins were seen. A few described late prophase which is not required.

(b) Candidates who did well in this question produced a response that was clear, used scientific terminology and was unambiguous. In these responses candidates clearly understood that the chromosome at metaphase consisted of the two sister chromatids connected by the centromere, compared to the anaphase chromosome that was now only one of the chromatids. Also, the position of the chromosomes at metaphase was described as being at the metaphase plate or spindle equator, instead of at the 'centre of the cell' or 'in the middle of the cell'. Similarly, for anaphase, good responses stated 'poles' rather than 'ends'. Other responses could have improved their phraseology, for example, 'chromosomes split' does not give a clear indication that the centromeres divide to separate the sister chromatids. Some were confused or not careful in distinguishing between a chromosome composed of sister chromatids and a bivalent, so descriptions of chromosome pairs, sometimes stated as homologous pairs, lining up at the equator in metaphase were seen. Some could have improved their answer by making it clearer whether they were describing metaphase or late anaphase when stating differences between the two.

(c) The quality of response for **(c)** was very varied. Some candidates gave answers that contained far more information than was required at AS Level, which was not necessary. Many responses were well-expressed, with a sequential account of cytokinin as the signalling molecule, binding to the receptor of the target cell and hence triggering the responses within the cell that would bring about cytokinesis. Some were less clear in their answer and could have stated the location of the receptor as being in the cell surface membrane, as well as showing an understanding that cytokinin-receptor binding was specific in nature. A few concentrated on the response within the cell and forgot to provide details of ligand binding to receptor or the location of the receptor. The most common error was to state that the receptor was part of the cytokinin molecule. A number misread cytokinin as cytokine and gave the sequence of events occurring in the immune response that involved cytokine, while others wrote about nerve impulse conduction.

Question 6

Topics 1, 2 and 6 were assessed in this question. Candidates applied knowledge and understanding to answer questions on an unfamiliar theme, glycogen synthase.

(a) (i) Many candidates were able to gain full credit here with some excellent drawings of the ring form of α-glucose. For others, knowing that glucose is $C_6H_{12}O_6$, may have helped them carry out a quick review and re-think their drawing. One error was to draw out the ring form correctly but to make a mistake on CH_2OH, for example by giving C_2H_5OH, or to forget to add the oxygen into the ring form. A number drew the ring structure and only inserted the hydrogen and hydroxyl group for carbon 1, which meant that credit could not be given. The inversion of the hydroxyl and hydrogen groups on carbons 2 and 3 was also fairly common. Some candidates drew β-glucose, which was not credited.

(ii) Most knew glycosidic bond as the type of bond formed between the two α-glucose molecules and only the weakest responses gave peptide or hydrogen bond.

(iii) Candidates were not expected to know of glycogen synthase or glycogen branching enzyme. The clue was in the term 'branching'. The most common way to gain credit was for candidates to show knowledge that the enzyme catalysed bond formation and to give details that this bond was between carbon 1 and carbon 6. A few candidates went down another correct route, and explained that different active sites were required for the formation of the different bonds involved. Weaker responses simply stated that glycogen branching enzyme was for forming branches. Others wrote about the suitability of amylopectin as a storage molecule, which was not required.

(b) (i) The best responses were concise and gave a similar explanation to that from the relevant syllabus learning outcome. Where this was not known, there were a large range of responses, only some of which were credited. There were three ideas that were being assessed: knowledge that a gene was a physical part of DNA, more detailed knowledge that this was a sequence of nucleotides, and an understanding that the gene contained coded information for the production of a polypeptide. Vague responses, that could have been improved by including these points, included reference to producing characteristics or gave examples such as eye colour, or described how genes produced the overall individual's make-up. The best responses did not confuse the term 'genetic code' with the phrases 'code for' or 'coding for' and so avoided incorrect statements such as 'a gene is a genetic code'. Other common errors were to state that a gene was a triplet of bases or to say that a gene coded for an amino acid.

(ii) Candidates who did well in this question knew the definition of a gene mutation and were also able to think through the chain of events occurring in protein synthesis. For these candidates, the roles of mRNA and tRNA, and the way they interacted to lead to the replacement of one amino acid for another, was fluently expressed. It was made clear that only one codon would be changed. Good responses explained that this was a base (or nucleotide) substitution, rather than stating 'substitution mutation', which was not credited without further detail as many only used the term for the idea of one amino acid being replaced by another. More confused responses were unclear that mRNA was formed as a result of transcription, stating that mRNA copied the information or did not mention tRNA as the molecule that brought the incorrect amino acid to the ribosome. Others misread the question and only focused on how the replacement of the amino acid would lead to a non-functioning protein, giving descriptions of levels of protein structure.

(c) Most gained some credit for **(c)**, with a large number displaying correct knowledge of the cell structures responsible for synthesising ATP and for protein modification. The description for the first cell structure needed to be read carefully, and the strongest responses noticed that this was about the assembly of the ribosomes, so correctly stated nucleolus. Many others saw the term ribosomes and incorrectly gave rough endoplasmic reticulum.

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Paper 9700/33
Advanced Practical Skills 1

Key Messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills that can be applied to the requirements of the examination.

Candidates should be able to assess the risk of different procedures. A risk assessment would include judging that heating chemicals might be harmful or that some chemicals are irritants. For example, heating Benedict's solution or hydrochloric acid, would be assessed as medium risk. A high risk would be the use of high concentrations of acids or alkalis.

Candidates should be familiar with recording quantitative results and qualitative observations in a table. Tables should have ruled headings with no units in the body of the table. The heading for the independent variable should be in the left column or top row with the appropriate units.

When carrying out practical work candidates should be encouraged to consider how they could improve their investigations to increase the confidence in their results, e.g. by repeating the procedure.

General Comments

The majority of Centres returned the Supervisor's report with the results obtained and seating plan with the candidate papers. The information included in the Supervisor's report is essential, as any problems encountered by the candidates, or factors such as the temperature in the laboratory can be taken into account when marking the candidates' scripts.

Candidates who have used materials and apparatus during practical work as part of the course are likely to perform better in the examination. Whilst the activities in the examination may not be familiar, candidates who have had the opportunity to follow instructions carefully in a variety of practical work are likely to find it easier to organise and complete unfamiliar activities.

Preparing the correct materials and providing the specified apparatus are essential for the success of the examination. The majority of Centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

In general, many candidates demonstrated that they had a good understanding of the skills required. There was good discrimination between the weaker and more able candidates and the majority of candidates showed that they were familiar with the use of the microscope.

Candidates who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

Candidates and Supervisors should not be concerned if the results obtained are very variable, as consistency of results within a Centre is not being assessed.

Comments on Specific Questions

Question 1

(a) (i) The majority of candidates were able to describe the test for starch using iodine solution.

(ii) Many candidates were able to describe the test for reducing sugars using Benedict's solution. The most common error was not stating that the temperature of the water-bath needed to be between the temperatures of 80 °C and 100 °C.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The better candidates included headings for the solutions (**S1**, **S2** and **S3**), the starch test and the reducing sugar test. Acceptable headings for the dependent variable included observation and colour. The majority of candidates gained credit for recording the correct colour changes for both tests for **S1**, **S2** and **S3**.

(iv) The majority of candidates correctly identified **S1**, **S2** and **S3**.

(v) Many candidates correctly stated a hazard with the greatest level of risk and rated it as medium or high.

(b) (i) The majority of candidates were able to complete the sentence correctly.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The better candidates included an appropriately detailed heading for the independent variable (solutions or samples) and the dependent variable (number of plasmolysed cells). The majority of candidates gained credit for recording the number of plasmolysed cells. The better candidates included repeats in their table.

(iii) The majority of candidates correctly identified the difficulty of judging the degree of plasmolysis of the cells as the significant source of error when measuring the dependent variable.

(iv) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly and used most of the space provided. Many candidates were able to draw a cell from the epidermis in **W** and **S1** with double lines representing the cell walls. The most common errors were to draw lines that did not meet up precisely or were too thick. Many candidates correctly showed the cell membrane in **S1** coming away from the cell wall.

Most candidates used a label line to identify the cytoplasm in **W** and **S1**.

(v) Many candidates correctly explained that **S1** had a lower water potential and that water, moved, by osmosis, from the cells to the solution outside. Many candidates correctly stated that there was no net movement of water for cells in **S3**.

Question 2

(a) (i) The majority of candidates gained credit for correctly describing how to measure the volumes $\mathbf{V_0}$ and $\mathbf{V_9}$.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The better candidates included an appropriately detailed heading for the independent variable (tube) and the dependent variable (volume / cm^3). The majority of candidates gained credit for recording the volumes for $\mathbf{V_0}$ and $\mathbf{V_9}$, for each of the four tubes and including the processed results by stating the volume of water lost by evaporation in each tube. The most common errors were stating the incorrect heading for the dependent variable and for including units in the body of the table.

(iii) The majority of candidates gained credit for correctly completing the table.

(iv) The majority of candidates gained credit for correctly describing a suitable control for the investigation.

(v) Most candidates correctly described using a thermostatically-controlled water-bath to increase the temperature as a way to increase the rate of evaporation from the tubes. Credit was also given to the use of fans to increase wind speed and to lower humidity. The most common error was describing the use of lamps without any reference to temperature.

(b) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (total circumference of holes / mm) and the *y*-axis (rate of evaporation of water / $cm^3\ day^{-1}$). Some

candidates, however, labelled the incorrect axis or gave incomplete headings. The *x*-axis must be the dependant variable.

Most candidates used scales of 5.0 to 2 cm for total circumference of holes and 0.2 to 2 cm for the rate of evaporation of water. Many candidates plotted the points exactly with a small cross or dot in a circle, and some drew a sharp, clear, ruled line, as a line of best fit or accurately connecting the points. The most common error was drawing lines which were too thick or not ruled to the centre of the point. Candidates should be reminded of the need to use a sharp pencil.

(c) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The better candidates gained credit for carefully following the instructions, drawing the quarter of the stem as shown in **Fig. 2.4** and for showing at least three layers of tissue. Many candidates gained credit for drawing a well-proportioned diagram.

(d) (i) The majority of candidates stated that the micrometre is the most appropriate unit for use with the light microscope and showed 0.024 multiplied by 1000.

(ii) Many candidates stated the correct number of eyepiece graticule units for line **Y** within a range and showed this number multiplied by the answer for **(d) (i)**. The most common errors were to measure line **Y** with a ruler or not showing all the steps in the calculation.

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Paper 9700/41
A2 Structured Questions

Key messages

- Candidates need to read questions carefully, interpret related stimulus material and focus on what the question is asking before composing their answer. Data questions such as **4(e)(i)** and **5(b)** provide examples of questions where candidates often wrote in general terms without fully analysing the question and its context.
- Some questions require candidates to make a reasoned judgement about a hypothesis or a recommendation for action, e.g. **4(e)(ii)** and **5(c)**. Candidates should state their decision clearly and explain whether each line of reasoning supports or opposes the hypothesis or decision.
- Candidates should use A Level biology terminology in their answers in order to access maximum credit.

General comments

Candidates who scored highly were able to combine a breadth and depth of knowledge with an ability to interpret the question and to understand and use new information from the question context.

Generally candidates were most successful on **Questions 1** (photosynthesis recall), **4(a)** (conservation recall), **7(a)** and **7(b)** (respiration recall) and the two biotechnology essays. Questions that involved data handling, skills of analysis and the making and substantiating of judgements (**Questions 2**, **4 and 5**) tended to be lower-scoring. Genetic terminology in **Question 3** proved difficult for some candidates.

Comments on specific questions

Question 1

(a) The majority of candidates labelled the tissues correctly but often did not use the labels requested. Some candidates confused phloem with xylem.

(b) Generally candidates answered well, but incomplete answers were seen quite often, such as omitting the term diffusion or not naming the substanced that diffused. A common incorrect response related thinness to penetration of light. Some candidates described features of xylem and palisade mesophyll tissues.

(c) (i) Most correct responses made a comparative reference to the difference in the thickness of the cell wall. Some candidates thought incorrectly that chloroplasts are present in lower epidermal cells and not in guard cells. Non-technical descriptions of shape, such as ‘sausage-shaped’ and ‘bean-shaped’, were not creditworthy.

(ii) Many candidates gained full credit. Incorrect responses included those which focused on the cells outside rather on the events inside the guard cell or to misname the guard cell as a stoma.

Question 2

(a) The definition was well known but some candidates gave an answer specific to haemoglobin rather than a general definition. There was some confusion between the different polypeptides, α and β, described in the question and the secondary structural motifs α-helices and β-pleated sheets.

(b) Few candidates gained full credit. Partial credit was often gained by describing the manufacture of monoclonal antibodies or for adding appropriate monoclonal antibodies to urine and explaining that they would bind to u-FSH. Those answers which mentioned immobilisation usually focused incorrectly on dipsticks. Some candidates discussed hCG instead of u-FSH.

(c) Few candidates gained full credit. The need for the Golgi apparatus to glycosylate the protein was the most common creditworthy response. Candidates tended to think incorrectly that the mammalian cells will already have the 'right promoters'. Common incorrect responses included reference to an immune response to bacterial cells or bacterially-produced recombinant protein, the human patient being used as an incubator for monoclonal antibodies, and raising antibodies to remove, 'attack' or 'kill' all of the substances in urine.

(d) Some candidates gained full credit but generally the standard of drawing and recall was limited. Common incorrect responses included the zona pellucida being much too thick or outside of the corona radiata and terms such as theca were frequently misspelt.

(e) (i) Many candidates gained credit for the comparisons but the explanations proved to be very difficult. Some candidates did not appreciate that the figures were a mean and attempted to calculate a percentage.

(ii) Candidates found this very difficult. Many thought that the test compared using FSH with not using FSH rather than comparing the use of the two types of FSH. The term 'critical value' was used rarely.

Question 3

(a) Many candidates gained full or almost full credit. Common incorrect responses included self-pollination described as asexual and offspring of self-pollination showing no genetic variation.

(b) Whilst some candidates appreciated that the distance travelled by the pollen would be less, few named the anther and stigma or discussed the comparative distance between them.

(c) Many candidates gave a prehearsed answer with no reference to the new context of the question. A common misconception equated smaller flowers with shorter plants.

Question 4

(a) (i) Most candidates understood habitat loss due to urbanisation but then frequently incorrectly linked this to deforestation. Some candidates appreciated the human causes and some the lack of pollinating insects.

(ii) Most candidates gave a comprehensive list.

(b) Most candidates understood the role of gibberellins, although few knew that gibberellin moves to the aleurone layer. The role of amylase was less well known. Although references were seen to transcription and mRNA, this was rarely linked to the gene being switched on. Most candidates gained credit for the sugar produced being used for respiration or as an energy source.

(c) (i) Stronger candidates could distinguish between the two statements and describe the effect of each variable but many candidates could not distinguish between the two variables.
In the second part candidates often approximated the value rather than reading the value from the graph to the nearest grid line.

(ii) Whilst many candidates understood the principle of scraping many did not discuss the pros and cons of scraping and did not make a judgement on whether to recommend the procedure or not.

Question 5

(a) Many candidates gained partial credit but few gained full credit.

(b) Many candidates gave a summarised rewording of the question rather than grouping the data into categories showing a preference and not showing a preference to the calls of their own males.

(c) Whilst the criteria for determining whether organisms belong to the same species or not were well-known, some candidates found it difficult to apply them appropriately within the context of the question and data provided. Candidates who made and then clearly communicated their decision usually gained credit.

Question 6

(a) Candidates who gave several different modes of action for the toxin, or developed an idea in step-by-step detail with correct references to the key molecular players gained most credit. Common incorrect responses included misuse of the terms synapse and synaptic cleft, binding to the sodium ion channel without mentioning the specific receptor protein, referring to sodium or calcium rather than the relevant ions, using enzyme-substrate terminology inappropriately, receptor proteins having an active site and neurotoxin not being a 'competitive inhibitor' of acetylcholine or its receptor proteins. The terminal of a pre-synaptic neurone can be referred to as a synaptic knob, but there is no such structure as a 'post-synaptic knob'.

(b) Most candidates gained full credit. Common incorrect responses included that calcium ions enter the pre-synaptic membrane rather than the pre-synaptic neurone, and to describe exocytosis of whole vesicles leaving the neurone and entering the synaptic cleft.

(c) Common correct answers included a description of the role of synapses in learning and memory, and in unidirectional transmission of nerve impulses. Some candidates described an action potential incorrectly as being weak or under a threshold, whereas it is an all or nothing response.

Question 7

(a) The process of glycolysis was outlined well by most candidates, although some lost credit by not including the number of molecules of each substance produced. Some candidates confused photosynthesis and respiration and referred incorrectly to reduced NADP. Incorrect responses included incorrect use of 'substrate level phosphorylation', NAD being involved in reduction rather than oxidation of the glycolysis intermediate and that NAD causes the step to happen whereas it acts as a co-enzyme.

(b) The processes producing ATP were generally well known. Most candidates used ticks and crosses in all the boxes as instructed, but a few candidates left some boxes blank and so could not gain credit for these.

(c) Some candidates showed good understanding and gained full credit. Weaker candidates usually described the relative amounts of oxygen and carbon dioxide involved in producing the RQ value and did not consider the underlying processes taking place in the seeds or seedlings to produce these values. Few candidates appreciated that anaerobic respiration results in a high RQ value in excess of 1.

Question 8

(a) Most candidates gave mutation rather than gene mutation as their answer. Responses not creditworthy included change to the DNA sequence and change to the genetic code, as these are too imprecise.

(b) Most candidates gained some credit and many candidates only missed full credit by not including the offspring phenotypes and not relating these to the genotypes in the Punnett square. Some candidates attempted to answer without using a Punnett square which made the the task much more difficult. A number of candidates misinterpreted their symbols such as c^h as chinchilla rather than Himalayan.

Question 9

(a) Most candidates showed good knowledge and answers mostly showed logical sequencing of events. However, a few went beyond the scope of the question to transforming bacteria which was required in part **(b).**

(b) Some candidates described only the first stage in the process but stronger candidates described both stages although most candidates found it challenging to include sufficient detail in their

descriptions. Common incorrect responses included omitting the nutrient medium in the petri dish, confusing antibiotic with antibody and the plasmid being given the antibiotic resistance genes along with the new insulin gene.

Question 10

(a) Most candidates showed good understanding and organised their responses well, keeping batch and continuous culture separate and in the question order. A common error was to discuss the production of a secondary metabolite in static low nutrient conditions or high stress conditions rather than as a dynamic process.

(b) Stronger candidates gained high credit by using the correct biological terms in the correct context and order. Incorrect responses included omitting the detail of extraction from the spleen, confusing lymphocyte cells or plasma cells with antibody proteins, mixing the plasma cells with myeloma cells rather than fusing them together, and trying to test the antibody product as opposed to the hybridoma cell in order to select the correct cell for large scale cloning.

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Planning, Analysis and Evaluation

Key Messages

It was essential for candidates to read and take note of the information provided in both **Question 1** and **2** in order to be able to answer the questions fully. Candidates also need experience of practical work in order to be familiar with techniques mentioned even when these techniques are in unfamiliar contexts. This was particularly applicable in **Question 1**. Candidates should be comfortable with the purpose of a control experiment and the techniques involved in dilution of standard solutions.

There will generally be data handling questions involving statistical methods. Some responses showed good understanding but many seemed unclear about what standard deviation is and the proper construction of a null hypothesis. These are areas that would benefit from careful practice as would drawing conclusions from sets of data.

General Comments

Candidates did not seem to be short of time and most candidates were able to confine their answers to the space provided.

Comments on Specific Questions

Question 1

This question introduced candidates to an enzyme practical and, based on the information provided, asked questions on the dilution of a stock solution, the planning of a similar experiment and the inference of the expected results. Although the exact investigation was a novel context, background practical experience in the general area was of great value here. Careful reading of the information provided was essential.

(a) The stem of the question provided information about how to answer this question. The majority of candidates conveyed the idea that the end point of the reaction would be difficult to pin-point exactly. Fewer candidates went on to explain why this would be, but most who did, realised that the cleaning solution would become cloudy or coloured during the digestion process. Others were aware that the process of gelatine removal would be gradual, thus making it difficult to decide when to stop the stopwatch. A few candidates suggested that it might be necessary to lift the lens out of the cleaning solution to observe if the gelatin or colour had gone and that this would add another potential difficulty to exact timing. A number of candidates suggested areas of candidate error with regard to use of the stopwatch which was not a valid response.

(b) (i) Candidates are be expected to have performed a dilution of a stock solution to prepare a range of known concentrations as part of their practical training. The vast majority were able to name either proportional or serial dilution as appropriate methods or give a valid description. Fewer candidates suggested an appropriate range and number of dilutions to be prepared, despite the information on range being provided in the stem of the question. Relatively few responses indicated that the candidates realised that a conversion is required from mg cm^{-3} to μg cm^{-3}. Even fewer candidates realised that it is good practice when performing a dilution to use the same diluting medium (in this case buffered saline) as present in the original solution you are trying to emulate (here the lens cleaning solution). Most merely described diluting with water to achieve 50 cm^3 of the new solution.

(ii) Candidates found this question difficult. The control for an enzyme-based practical should be familiar to candidates, but a majority put only water as their control solution. A few of the best responses conveyed the impression that the purpose of a control experiment is to prove that no factor other than the independent variable causes the dependent variable to change. This idea had

to be made specific to the context provided, which is that the other components of the cleaning solution do not break down the gelatin layer. Thus an appropriate control is either boiled cleaning solution or the buffered saline (plus EDT). This then allows the experimenter to show that it is the enzyme not the other constituents of the cleaning solution that is responsible for the breakdown of the protein (gelatin). Common incorrect answers stated that the control solution is just 'buffer', with the reason given as 'to control pH' or suggestions that the mid range of the enzyme concentrations was the control.

(c) (i) The majority of candidates were able to identify the variables which were provided in the stem of the question. Some responses were too general to gain credit. These included just 'time' or 'concentration of solution' rather than time to remove gelatin or concentration of subtilisin A. A few responses had the variables the wrong way round.

(ii) Many of the best responses provided a detailed method based on the information provided. Despite the instruction not to repeat the description of the dilution method used a number did so. Candidates should aim at producing a logical set of instructions such that someone else could follow them.
Although most candidates realised that the volume of each enzyme solution should be kept constant, fewer stated a valid volume at which it should be kept constant (10 cm^3) and which would fit the apparatus they were using. Volumes significantly more or less than this would require an alteration of the apparatus away from that provided. Only some candidates suggested an accurate piece of apparatus to allow the volumes to be measured. The vast majority of candidates suggested that a timer/stopwatch should be used to record the end-point of the reaction. Colourimetry is not an appropriate technique in this investigation. The key variables to keep constant were well covered by most candidates and made good use of the information provided, however a significant proportion missed that the temperature required by this investigation was 35^0C not the 60^0C optimum. Credit was awarded for mentioning the need to bring the enzyme solution to temperature before putting in the simulated lenses. This point was not seen very often, but the best responses gave a logical sequence of steps for carrying out the investigation and making clear at what point equilibration should occur. In others there was some mention of 'equilibrating to temperature' with no indication as to when this should occur - or even saying it was after the lens was put in, which would really invalidate the whole experiment. In some cases candidates put in a vast range of possible things to standardise. It is important to be selective about what variables are important factors in the particular investigation. Candidates should be aware that it is best practice to repeat each experiment at least twice (to give 3 results) and that it is the identification and removal of anomalous results from the mean that improves reliability.
Whilst as a practical experiment the investigation is low risk, it it does have some risk. Where hazards are mentioned the nature of the hazard needs to be clear and specific and the precaution linked to the particular hazard. General statements about 'danger' and 'care' are not sufficient.

(d) (i) Many candidates were able to orientate the axes correctly and write sufficiently detailed axes titles. Either time or rate was acceptable on the *y*-axis but the labelling did need to indicate full detail in terms of removal of gelatin. Some candidates provided appropriate units but there was some confusion over the correct units for a reaction rate. Many candidates were able to sketch an appropriate line for their axes. The commonest error was to sketch a rate graph when it was time on the *x*-axis and thus showed the plot rising, whereas the time for gelatin to be removed will drop with higher enzyme concentrations. Some candidates drew rate of enzyme activity against temperature graphs showing a decrease at the end.

(ii) Determining an unknown concentration from a graph of known concentration was a technique that was not familiar to all candidates. A significant number made reference to the peak of the graph or to the maximum/minimum plateau region or to the gradient of the graph. Others made a general statement about comparing to the graph or to the data, without explaining what they meant. Good responses either repeated the experiment with cleaning solution of unknown concentration (or took the mean value from Table 1.1) and then made it clear they would read across from this time to see where it hit the plot which indicating the actual concentration. Thumbnail sketches helped make this clear in a number of cases.

Question 2

This question was about the effect of pre-natal alcohol exposure on the rate of median nerve conduction. The tables of data and experimental design had to be carefully studied in order that the results were understood. Familiarity with the *t*-test was also examined. There were some good responses to the statistical sections, but also a lot of misconceptions.

(a) Many responses gained credit here. Weaker responses did not make reference to the pre-natal aspect of the alcohol exposure. Others incorrectly stated volume, concentration or amount of alcohol. There were some who thought the independent variable was the speed of conduction.

(b) (i) Candidates were able to suggest a number of key conclusions. There was some confusion when candidates did not appreciate that the values in the table were rates of nerve conduction and thus drew the incorrect conclusions on comparative velocity between pre-natal alcohol exposure and no pre-natal alcohol exposure. Some candidates were not specific enough in their choice of data to compare and did not refer to specific days at which they made their comparison. Some responses gave only raw speed figures. Some candidates correctly processed the data to compare the change in conduction speed over the time period for the two groups.

(b) (ii) Here the focus was on the whole median nerve. Many candidates continued to compare the non-alcohol exposed babies with the alcohol exposed babies. Some conclusions could be focused on comparison between motor and sensory neurones at a given time and with a given alcohol exposure. There were some responses in this category, but the majority of candidates who obtained credit here made reference to the fact that the conduction velocity increased as the baby got older.

(c) To identify any one particular result within the table of data, the group, type of neurone and number of days should be stated. Most candidates realised that the most reliable result could be identified by the smallest standard deviation. There was some confusion between standard error and standard deviation. No credit was given for references to standard error. Some candidates gave several results which they thought most reliable. These responses showed a lack of understanding of the descriptive side of statistics as they included statements like ‘those at 20 days because they had less time with or without alcohol’, with no reference to the actual data and standard deviation.

(d) (i) There were a lot of confused responses here. Many candidates incorrectly discussed significance in terms of how different speeds of nerve conduction might have an effect on the development of the baby. Only a few candidates correctly identified that there was no overlap in the standard deviations of the two numbers being compared. There seemed to be some confusion about what a standard deviation shows and some uncertainty about this type of descriptive statistics. Again standard error and error bars were quite often mentioned and were inappropriate responses.

(ii) Many candidates gained credit here for either saying that the data was continuous or that means were being compared. A few responses suggested that the test allowed you to find the mean or to find out if the data had normal distributions. It was also important to give a positive characteristic of the data that allows a *t*-test to be performed. Some candidates digressed into what the *t*-test might show about the data with comments on chance and probability.

(iii) There is a standard format in which a null hypothesis should be framed. Thus it should state that there is no significant difference between the conduction speed in the sensory neurone of babies from group 1 and babies from group 2. The most common omissions were to not make reference to the sensory neurone or to omit the word significant to qualify ‘different’.

(e) Candidates needed to read the stem of the question carefully in order to answer this question. The expected responses were not just critiques of the experiment in terms of things like ‘no repeats’. Certain faults in design were valid when trying to apply these results to all babies. These included small sample size, gender imbalance, differing sample size and restricted age range of the mothers. Suggestions that the alcohol consumed by the mothers was ‘not constant’ was not creditworthy. The two groups who are not represented are those mothers who drink some alcohol but less than 32 mg per day and those who drink occasionally rather than daily as in the sample. There were also rather general suggestions on the difference in alcohol transference across the placenta or in the way different mothers metabolised it in the liver which did not address the question.