BIOLOGY

Paper 9184/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

The majority of weaker candidates answered incorrectly.

Question 3

Many weaker candidates believed incorrectly that all companion cells contain chloroplasts.

Question 4

The majority of candidates answered incorrectly.

Question 6

Some candidates found standard form difficult.

Question 10

The majority of weaker candidates found this challenging.

Question 11

The majority of stronger candidates answered correctly but weaker candidates found it difficult to relate the diagram to the correct description.

Question 13

A minority of candidates were able to evaluate the information correctly.

Question 16

The majority of stronger candidates processed the information correctly.

Question 21

Almost half of the weaker candidates didn't appreciate that base T (thymine) is replaced by base U (uracil) and so selected incorrectly option **A** or **B**.

Question 25

Weaker candidates found this very difficult.

Question 27

The majority of strong candidates had a good understanding of the transport of carbon dioxide by blood.

Question 34

The majority of weaker candidates thought incorrectly that both measles and tuberculosis are bacterial in nature.

Question 35

The majority of candidates were able to process the information correctly.

Question 36

The majority of candidates answered correctly.

BIOLOGY (US)

Paper 9184/23
As Structured Questions

Key Messages

- Candidates should have a clear understanding of the different bond types associated with protein structure and protein level of organisation. Knowledge of this was required in **Question 1(d)**. Some candidates incorrectly refer to peptide bonds when describing secondary and tertiary structure. In addition, some candidates named both the strong covalent disulfide bridges and peptide bonds as those that break during denaturation, which would not be the case.

- Memory cells should not be described as cells that 'remember' the foreign antigens of pathogens, as a number of candidates did in **Question 3(d)**. Memory cells can be described as long-lived cells of the immune system that are produced from both specific B-lymphocytes and T-lymphocytes as a result of a primary immune response to the presence of non-self antigens (for example, from an infection or in a vaccine). Candidates should understand that they are present in higher numbers than the original specific lymphocytes from which they originate. Memory cell production is a feature of active immunity.

- Candidates need to be clear about the different requirements for the command words 'explain' and 'describe' as in, for example, **Question 4(a)(i)**.

General comments

The performance of a number of candidates in this examination was outstanding. For these, a very good knowledge of the syllabus learning outcomes was evident and candidates were able to confidently apply knowledge and understanding to new situations. Many others gave clear unambiguous answers for many questions. In some cases performance could have been improved by giving further supporting detail for some answers.

In **Question 1(a)**, the strongest candidates understood that they needed to describe the term 'fluid mosaic' rather than describe the fluid mosaic model of membrane structure. In **Question 1(d)** many wrote about denaturation of enzymes in general, rather than about denaturation of proteins of cell membranes. In **Question 2(c)(ii)**, many described tumour formation rather than compare the cell cycle of cancer cell with a normal dividing cell. In **Question 4**, many candidates gave biologically correct explanations of the changes occurring in **Fig. 4.1** which could not be credited as the question asked them to describe the changes in the graph. **Question 5** proved to be the most challenging question overall for the majority of candidates. Although **Question 6** presented few problems to many candidates, this question proved to be the most challenging for weaker candidates, who tended to do well only on **(b)(iii)**.

Candidates had sufficient time to complete the paper. The majority attempted to answer all questions and handwriting was usually legible. Most candidates showed their working in **Question 3(b)** and many wrote out the formula they used to obtain the magnification of the image in **Fig. 3.1**.

Comments on specific questions

Question 1

This question assessed knowledge of the fluid mosaic model of membrane structure and transport across membranes from ***Section D*** and also gave candidates the opportunity to make links between protein structure (***Section B***) and the role of proteins in membranes.

(a) The clearest responses for the term 'fluid' described how phospholipid molecules move within the bilayer, with some indicating that mainly the molecules move freely within their own monolayer. It was also noted by a number that some of the membrane proteins also move within the bilayer. Other responses were less precise, stating that the bilayer moved or that the structures or components within the membrane moved, without naming these components. Some wrote about cholesterol and its role in fluidity, which was not required, while others wrote about how substances were able to move across the membrane. A greater proportion was able to successfully explain the scattered proteins forming the 'mosaic'. Explanations that were not creditworthy included the idea that there were many different components in the membrane or that there were many different ways to transport substances across the membrane.

(b) A high proportion of candidates gained full credit, with a smaller number providing clear, concise answers that made it obvious to which model of membrane structure they were referring. Some candidates gave a number of points rather than only one similarity and one difference.

(c) Almost all candidates could give one or more correct features of active transport and there were many who gave excellent accounts of the mechanism to gain full credit. Partial credit was awarded where candidates forgot to write about the membrane protein involved or described it as a channel protein, which is used in facilitated diffusion. Weaker responses incorrectly described movement from a low concentration gradient to a high concentration gradient. The best responses included detail of the conformational shape change of the membrane protein and stated that the mechanism was specific for the substance being transported. There were a number who incorrectly included detail of endocytosis and exocytosis.

(d) Generally the stronger candidates considered both the idea of denaturation of proteins as well as their involvement in cell membranes. Some saw the term 'denaturation' and gave an account of enzyme denaturation, with only some of these explaining how this would lead to membrane damage. Descriptions of protein denaturation were varied, with some giving much detail about increase in kinetic energy and vibration of molecules but not going on to give the precise details of which bond types would break and how this would affect secondary and tertiary protein structure. A common error was to state that peptide bonds would break, rather than to explain that the weaker hydrogen and ionic bonds between R-groups would break. There were many who were too general in their description. Most correct ideas about how the membrane would be damaged focused on the inability of the membrane to transport substances across, although a few realised that cell signalling and cell recognition would be affected. Weaker responses suggested that the proteins would disappear from the membrane or wrote about the fluidity of the phospholipid bilayer.

Question 2

Candidates used knowledge and understanding from ***Sections E*** *and* ***F*** in this question.

(a) It was generally well known that DNA replication occurs during interphase, although there was a proportion who thought that DNA replication occurred during mitosis or in specific stages of mitosis, and a few thought that DNA replication would occur at the same time as transcription. More able candidates were precise in their response and correctly gave the S phase of interphase.

(b) (i) As with part **(a)** a high proportion of candidates recognised that the pairing between bases was due to hydrogen bonding. Weaker responses stated covalent bond or glycosidic bond.

(ii) Although many correctly identified base **Y** as the pyrimidine, there were fewer who went on to state how **Y** had only one ring as part of its structure compared to the two rings of purines. Of these, not all gained credit as they went on to give an incorrect explanation of the ring as being a pentose sugar. Candidates are not expected to know details of the structure of the bases, but should be able to recognise that purines have a double ring structure and pyrimidines have a single ring structure. A stated difference in size of between **Y** and **X** was also credited.

(c) (i) Candidates were expected to be able to give a concise definition of a gene mutation and then further qualify this definition. There were some very full responses that went beyond the question requirements. Some wrote about changes to the DNA sequence or gene sequence rather than the sequence of nucleotides or sequence of bases in the DNA. Many did not explain exactly what was meant by a gene mutation. Weaker responses stated that a gene mutation is an altered sequence of amino acids or that a gene mutation was a change in the number of chromosomes. Some weak responses used incorrect terminology or phrases, such as 'changed DNA code', 'mutated protein',

'gene codes for a different amino acid', 'wrong amino acid is made', change in DNA base sequence of an amino acid' and 'change in the coding of a gene'. A few incorrectly described tumour formation.

(ii) Some candidates realised that their response should be based on the cell cycle and they answered accordingly to gain full credit. Others did not give comparative information or described tumour formation.

Question 3

This question, on immune system cells and vaccination, from ***Section J***, contained links to ***Sections A*** and ***I***, and included a magnification calculation.

(a) This presented few problems to most candidates. Some gained full credit by giving detail of RER structure and noting the presence of ribosomes as the site of protein synthesis. Far fewer suggested that RER may be required for modification or for protein transport (to the Golgi body). Some did not use the information provided, so did not highlight the link between plasma cells and antibodies. However, these still gained credit for knowing the function of RER and making the link with ribosomes.

(b) Most candidates measured the length of **A**-**B** correctly and knew the formula to use to determine the magnification of **Fig. 3.1**. Loss of credit was commonly because the candidate was not able to convert the measurement correctly to μm and so obtained a calculated value that was frequently a factor of 10 out. Measuring in cm often proves to be a mistake for some candidates as they forget to multiply by 10 to convert to mm before multiplying by 1000 to get to μm.

(c) The majority of candidates who performed well knew the name of the causative organism of smallpox. Incorrect responses seen were virus, bacteria, *Vibrio*, *Morbillivirus* and *Plasmodium*.

(d) There were some comprehensive and well-expressed responses given for this question. The best showed an understanding that memory cells for both B- lymphocytes and T-lymphocytes would be present for a secondary response and gave good explanations as to how this would provide immunity. Not all remembered to state that these would remain in the circulation and there were many who mistakenly thought that plasma cells turned into memory cells. Common errors were to suggest that there would be a continually high level of antibodies or that plasma cells were still remaining. A few thought that the vaccine contained plasma cells or antibodies.

(e) The best responses focused on the features of the vaccination programme for eradicating smallpox, rather than on features of the disease, and also used correct scientific terminology to gain credit. The term 'strand' was fairly frequently seen, presumably intended to mean 'strain'. Others referred to the unchanging virus but then went on to state that it meant that it was non-resistant to the vaccine or that it meant the pathogen could not adapt to the vaccine. In the best answers, reference to the ease of identifying people with smallpox was carefully related to the fact that individuals who had been in contact with those with smallpox could then be vaccinated, or the term 'ring vaccination' was used. Others incorrectly stated that these individuals could be treated with the smallpox vaccine and the vaccine was sometimes described as 'frozen' rather than 'freeze-dried'.

(f) The precise type of immunity provided by the smallpox vaccine was required, hence only those noting that if was both artificial and active gained credit. Weaker responses stated that the immunity was temporary or gave descriptions explaining that antibodies and white blood cells were present.

Question 4

Question 4 was on a theme of blood pressure, with knowledge and understanding from ***Section G*** and ***Section C*** assessed.

(a) (i) Many candidates gave precise descriptions and accompanied these with numerical data extracted from the graph. Some responses could have been improved by stating exactly where the changes were occurring. Partial credit was awarded for a statement that included a description of the decrease in blood pressure with distance.

(ii) Many realised that, because the blood in the veins is at such a low hydrostatic pressure, the valves are the main structural feature of veins in returning blood back to the heart. These candidates gained full credit. Some responses gave detail of the lower quantity, compared to arteries, of smooth muscle and elastic fibre in the tunica media. As this is a consequence of not having to cope with the high pressure blood leaving the heart, it was not relevant for this question.

(b) Some candidates found this a straightforward question and gained full credit. Many responses gave a detailed description of enzyme action which was not required and so gained no credit. There were a number of weaker responses that gave long descriptions of translation.

(c) This question was generally well answered and the details of competitive inhibition were well known. Some candidates gave confused descriptions of ACE as the substrate and competing with the drug for the active site on the enzyme. Weak responses did not refer to enzyme inhibition and wrote about the possible effect in the body of a decrease in angiotensin.

Question 5

Parts **(c)** and **(d)** of this question required extended responses. There was considerable variety in the quality of these responses and some candidates appeared to have little knowledge of the main ideas. ***Sections A***, ***B*** and ***G*** were assessed in **Question 5**.

(a) Many candidates understood the main advantage of using the light microscope to view movement in *Chlamydomonas* was the ability to view living, and hence moving, organisms. Not all differences between the light and electron microscope, such as details about magnification and resolution, were relevant in answering this question.

(b) (i) The most common correct answer was the link to chlorophyll. Stating that magnesium was needed for chloroplasts or for photosynthesis was not adequate to gain credit.

(ii) Good answers to this question used the information supplied about *Chlamydomonas* and applied knowledge and understanding of the properties of water to the organism. Hence, they realised that the property of hydrogen bonding to provide high surface tension for organisms to 'walk' on water was not appropriate to *Chlamydomonas* as an organism that moves through water. Noting that the organism was photosynthetic enabled some candidates to explain that the transparent nature of water would allow light through for photosynthesis. Other good answers related properties of water to *Chlamydomonas* (and other such organisms).

(c) Some candidates realised that this was a question related to the decreasing surface area to volume ratio that occurs when organisms get larger. Those who gained full credit explained the benefits of the transport system in reducing the time taken to supply cells or in being involved in mass flow. Some responses gave examples of substances that are transported and of these, many of the best responses were careful to only refer to the transport of respiratory gases by animals rather than by plants. Although there were some very well-expressed responses that considered both multicellular and unicellular organisms, there were a number that were vague and only concentrated on unicellular organisms. Some of those who did not gain credit stated that transport systems were not required when there was only one cell, while many stated that unicellular organisms were less active but did not go on to explain the idea of bulk transport for multicellular organisms.

(d) Generally only the candidates who did well overall were confident enough to begin their response with the presence of sucrose in the phloem sieve tube. The majority decided to give the whole account of movement of sucrose from the photosynthesising mesophyll cells adjacent to the companion cell. This means that there were often long accounts of the events occurring in the companion cells leading up to the arrival of sucrose in the phloem sieve tubethat were not relevant for this question. Some candidates were still able to gain credit for describing the events leading to mass flow. There were a few answers that were too general. Common misconceptions included stating that the hydrostatic pressure would increase as a result of water entering the sieve tube from the companion cells rather than from the xylem and that the flow was as a result of a water potential gradient rather than a hydrostatic pressure gradient. Some contradicted themselves by stating that the influx of sucrose decreased water potential and increased solute potential. Some candidates knew that a pressure gradient existed but were not clear that it was at the source where the hydrostatic pressure was higher. A number wrote about a hydrostatic pressure being created at the source rather than an increase in hydrostatic pressure resulting from an inflow of water.

Question 6

This question assessed learning outcomes in ***Section K***. In part **(b)**, only some candidates were able to gain full credit on the ecology definitions.

(a) (i) Although many correctly identified nitrification as the stage shown, many others thought that this was nitrogen fixation.

(ii) Candidates who did well overall gave a correct, concise answer to gain full credit. Others, who correctly wrote about denitrification, then went on to contradict themselves by describing decomposition. Weak responses only described decomposition.

(b) (i) There were only a few that began their definition of an ecosystem as 'a unit…..'. Most described an ecosystem in terms of a region or community. Where candidates realised that ecosystems involved both biotic and abiotic factors and that interactions occurred, credit was awarded. Some candidates gained credit for the idea of a self-sustaining unit. There were a number who wrote about abiotic organisms or non-living organisms. Generally, weaker responses gave the definition of a community or stated that organisms interacted.

(ii) There were some detailed definitions given. Many candidates vaguely described a producer as an organism that makes its own food and some incorrectly described a producer as an organism that makes its own energy.

(iii) Many knew the definition of a habitat, although quite a number did not actually state 'a place…' or equivalent, simply beginning their answer with 'where an organism lives', which did not gain credit.

BIOLOGY (US)

Paper 9184/35

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, such as 5% urea solution and enzyme solution. 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.

Candidates should be able to use a serial dilution to obtain required concentrations of solutions and specified volumes of solutions. In this case, candidates were required to dilute a 5% urea solution to start their serial dilution and to prepare 20 cm^3 to use for each successive dilution. Candidates were required to show a three step serial dilution of urea solution using a constant dilution factor at each step. The initial step combines 20 cm^3 of the 5.00% urea solution with 20 cm^3 of water to produce a 1:2 dilution. In the second step, 20 cm^3 of the 1:2 dilution is combined with 20 cm^3 of water producing a dilution of 1:4. Candidates were required to show how to make three concentrations of urea solution by this method e.g. 5.00%, 2.50%, 1.25% and 0.625%.

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

(b) (i) Many candidates were able to carry out a serial dilution, showing this correctly in **Fig. 1.1**.

(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 (percentage concentration of urea) and the dependent variable (time / seconds). The majority of candidates gained credit for recording times in whole seconds for the four concentrations of urea. The better candidates included repeats in their table.

(iii) The majority of candidates correctly identified the difficulty in judging the colour change of the whole piece of red litmus as the significant source of error when measuring the dependent variable. Many candidates also correctly identified the inconsistency of mixing the urea and the enzyme as a source of error. Credit was also given for the area of the piece of litmus paper not being an exact size.

(iv) Some candidates correctly identified that the use of a mechanical stirrer would make the mixing of urea and enzyme the same for each concentration of urea or that a ruler could be used to standardise the area of red litmus paper.

(v) Many candidates correctly stated that the syringe used in the investigation may have a systematic error.

(vi) Many candidates correctly described how to increase the time taken to reach the end-point by lowering the temperature with a thermostatically-controlled water-bath, or by decreasing the concentration of enzyme by serial dilution or by decreasing the volume of enzyme.

(c) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (time of sampling / minutes) and the *y*-axis ($^{13}CO_2$ in the breath / arbitrary units). Some candidates, however, labelled the incorrect axis or gave incorrect units for time. The *x*-axis must be the dependant variable.

Most candidates used scales of 20 to 2 cm for time of sampling with 30 at the origin and 2 to 2 cm for $^{13}CO_2$ in the breath with 10 at the origin. Many candidates plotted the points exactly with a small cross or dot in a circle, and some drew a sharp, clear, ruled line, 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.

(ii) Many candidates gained credit for the idea that for sampling times of 60 minutes, 75 minutes and 110 minutes there was a decrease in substrate concentration. Less urea resulted in fewer enzyme substrate complexes being formed. The most common error was not mentioning the formation of enzyme substrate complexes.

Question 2

(a) (i) 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, only drawing the half of the stem as shown in **Fig. 2.1** and for showing at least two layers of tissue. Many candidates gained credit for drawing the epidermis as double lines and for drawing a well-proportioned diagram. Most candidates used one label line to identify the pith.

(ii) 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. The better candidates produced drawings using a sharp pencil which did not include any shading and used most of the space provided. Many candidates were able to draw two adjacent cells from the epidermis and two adjacent cells from the cortex with double lines representing the cell walls. The most common error was to draw lines that did not meet up precisely or were too thick. Most candidates used one label line to show the position of one cell wall.

(b) (i) The majority of candidates stated that the micrometre is the most appropriate unit for use with the light microscope and showed 0.028 multiplied by 1000.

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

(iii) Some candidates correctly stated that the presence of air spaces helped the stem to float in the pond.

(c) Many candidates recorded observable differences appropriately, with the majority able to gain full credit.

BIOLOGY (US)

Paper 9184/43
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.

BIOLOGY (US)

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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.