BIOLOGY

Paper 9790/01
Structured

Key Messages

- In questions that require a comparison between two or more factors, candidates must use comparative language in their responses. Absolute terms such as large or small are not credit worthy when the emphasis on a difference is required (larger or smaller).
- It is important for candidates to read through all questions before they begin and take note of any structured answer space. If answer space has been structured, it is to assist candidates in organising their response. Better responses make use of such structure.
- Questions containing two command terms require candidates to address both aspects to achieve full credit. Often, only one of the two aspects was covered and this limited the credit which could be awarded.

General comments

There were a large number of candidates who had clearly prepared extremely thoroughly for this examination and who showed ability in both **Sections A** and **B**. Frequently there was evidence that a good number of these candidates had gained knowledge beyond the requirements of the learning outcomes of the syllabus.

Some candidates demonstrated quite a disparity in their performance between **Sections A** and **B**, which require different skills. Identifying early the style of question that is easy to approach and the style of question in which it is harder to do well, could help the final overall performance of some candidates when preparing for the examination and when practising questions.

Question 21 was a short introductory question that assessed a range of skills: straightforward recall of knowledge, use of a photomicrograph to identify structures, application of knowledge of ultrafiltration in the kidney. Many candidates could have improved their response in **Question 21(b)(iii)** by giving information about the blood entering as well as the blood leaving the glomerulus using comparative terminology.

In **Question 22**, candidates were presented with information about the manuka plant, which was unfamiliar material. The introduction to this question was lengthy and covered a range of ideas. Some candidates appeared to cope very well with this and in addition to making full use of the information given about the investigations for **Question 22(a)**, they used the text in the first and second paragraphs to help them plan their response for **Question 22(b)**.

There were some who performed very well on **Question 23**, which contained a considerable quantity of unfamiliar material and which assessed material taken from a number of different areas of the syllabus. Many candidates would have benefited in the gene therapy section of this question from re-reading the information provided at the various stages within the question and, together with using their syllabus knowledge and understanding, becoming completely clear about the difference between a virus, a viral vector and a packaging cell.

In **Question 24**, two of the questions requiring extended responses, **Question 24(e)(ii)** and **Question 24 (g)(iii)** were answered very effectively by candidates who organised their points in sequential fashion. In **Question 24(e)(ii)** candidates could begin with a stimulus and end with a response. In **Question 24(g)(iii)**, candidates could note the source of the energy to drive the process of chemiosmosis and then work through the process step by step to highlight differences between the mitochondrion and the experiment. Some

candidates could have improved their performance in these questions by planning before they wrote their response.

In **Question 26(b)**, many candidates could have produced diagrams of a better quality, with labelling and annotations added. A high proportion, although asked to draw a guard cell, drew the complete stomatal pore with two guard cells. Candidates must ensure that they answer the actual question asked.

Practically all candidates attempted every question of **Section A** and every part-question of **Section B**. Most tended to use the correct scientific terminology to help improve their responses and wrote responses that were legible.

Comments on specific questions

SECTION A

Overall, candidates found **Question 16**, followed in order by **Questions 19**, **6** and **15**, to be the most challenging.

Questions 15 and **16** required practice at interpreting curves showing blood pressure changes in the heart. Many stated tropomyosin for **Question 19** instead of troponin. The most common incorrect response for **Question 6** was answer **D**. Those that gained credit realised that maltase is produced in the intestinal epithelial cells and not the pancreas.

Question 9, followed in order by **Questions 8, 12** and **17**, were also quite challenging for many candidates.

In **Question 9**, many incorrectly thought that the role of the AVN was to act as non-conducting tissue, a role that is performed by the fibrous ring.

Practically all candidates knew the correct answer for **Question 3**, closely followed by **Question 2**.

Other questions that were the most accessible to candidates were **Questions 1, 4, 7, 10** and **13**.

SECTION B

Question 21

(a) A proportion of candidates knew a good working definition of homeostasis and, in giving their definition, covered all of the points expected. Many also included the idea of negative feedback mechanisms being involved, with fewer referring to a dynamic equilibrium. Quite a number of candidates would have benefited from learning a definition of homeostasis as these candidates attempted to bring together ideas to make up an answer. This was achieved with varying success. Giving examples such as thermoregulation and the regulation of blood glucose concentration were not required.

(b) (i) Most knew that **Fig. 21.1** was the cortex area of the kidney. The most common incorrect response was the medulla.

(ii) This was very well answered by the majority of candidates, although the spelling of glomerulus was variable.

(iii) Some candidates were confident as to what this question was asking and remained focused on describing the differences between the blood entering the glomerulus and the blood leaving the glomerulus and giving explanations for these differences. They were able to successfully apply their knowledge and understanding of ultrafiltration. The strongest responses used comparative terms and, if the blood vessels were named (which was not essential), they were named correctly as afferent arteriole and efferent arteriole. In order to gain credit for ultrafiltration or a description of ultrafiltration, this needed to be in the context of explaining why there was less glucose, amino acids etc. in the blood in the efferent arteriole and not as a consequence of high blood pressure. Many candidates knew that the diameter of the efferent arteriole was narrower than that of the afferent arteriole. Generally, the most able candidates used this fact to explain why blood was at a higher pressure in the afferent than in the efferent arteriole. A much greater number incorrectly thought that the high pressure generated by the narrower diameter for ultrafiltration meant that the

blood leaving the glomerulus was also at a high pressure. Very few noted that there would be a decreased volume of blood leaving the glomerulus than entering it. Some candidates could have improved their response by using comparative terminology. It was fairly common for some candidates to become distracted from the question and give some very detailed descriptions of ultrafiltration, rather than answer the question and compare blood entering with blood leaving the glomerulus. Descriptions stating that red blood cells and plasma proteins remained in the blood entering were not relevant to the question, which asked for differences. However, it was pertinent to state that there was a higher proportion of these in the blood exiting.

Question 22

(a) A good starting point for the first section of this question was to recall understanding that total biological variation is equal to the sum of environmental variation and genetic variation. Some candidates realised that **Investigations 2** and **3** artificially controlled the situation by reducing the contribution of environmental variation to zero, by growing plants in uniform conditions. This enabled them to look for evidence of genetic variation. Many knew that the results of **Investigation 1** supported environmental variation: fewer discussed how genetic variation could also be evident as a result of selection pressures acting. Some were able to gain credit by using comparative data from **Table 22.1**. It was important for candidates to refer to the particular investigation when discussing a point. In the second section of this question, it was made clear to candidates that the phenotype being considered was leaf colour and candidates were asked whether this phenotype is an example of continuous variation. The best responses gave features of continuous variation and related this specifically to leaf colour. Some explained why it was not discontinuous variation, which was not the question asked.

(b) Responses of a high standard gave a range of different advantages of maintaining the genetic diversity shown in the manuka plant. This contrasted with answers that stated one advantage that was just further elaborated. Some attempted to explain how genetic diversity had come about, which was not the focus of the question.

(c) The kingdom Prokaryotae was stated by a proportion of candidates. Most of the rest stated Bacteria or Protoctista so could not be credited.

(d) This was well answered by candidates and most gained full credit. The most common misconception was that penicillin affects the synthesis of peptidoglycan.

(e) Most gave an acceptable definition of diffusion. A general definition or one in the context of the honey solution diffusing through the agar was acceptable. Weaker responses introduced a cell membrane into their definition and these were not credited.

(f) This question asked candidates to describe and interpret the results for the two strains of *Clostridium difficile*, which many candidates did to very good effect. Biological explanations of the results were not required and some candidates could have saved themselves time in this respect. All the expected points were seen, with candidates generally concentrating more on descriptive rather than interpretive points. Some extracted data from **Table 22.2** to support their ideas and at times this helped them to secure credit.

(g) Some candidates gave very good answers here. Others needed to think more carefully about the consequences of bacteriostatic versus bactericidal effects of an antibacterial substance. It was not enough only to suggest that the bactericidal effect was seen because the zone of inhibition was the same or a similar size. A zone of inhibition produced as a result of a bactericidal substance will decrease in diameter, given sufficient nutrients in the agar and degradation of the substance. This is due to the inward growth of the population of the bacteria outside the edge of the zone. No colonies of bacteria and/or no 'hazy' growth of bacteria (characteristic of bacterial lawns where colonies merge) would be seen in the zone. This would contrast with a bacteriostatic substance, where the cells from the original spread that have been prevented from growing will begin to grow and divide and form colonies within the zone.

(h) Those candidates who produced a high-quality account began with a consideration of one or more mutations as the cause of antibiotic resistance. Some even thought to give examples of how the protein produced as a result of the mutation would impart resistance to the bacteria. The responses continued with a concise explanation of the involvement of natural selection and then gave details of how the gene coding for antibiotic resistance could be passed on. In this way, they

had approached the question from all angles and assured themselves of full credit. Some of the less comprehensive responses concentrated on the overprescription of antibiotics or on people not completing the course of antibiotics, often forgetting to think about how the resistance was spread.

Question 23

(a) (i) Most candidates gained credit here. Candidates could approach this question by showing an understanding that viruses can infect stem cells: this would mean that a therapeutic allele within a viral vector could be introduced into defective cells. Alternatively, credit was gained by considering the features of stem cells desirable for this type of treatment. Most candidates wrote about the ability for continued mitotic division of stem cells or the ability to divide and form cells that can differentiate into a specific cell type. 'Can form any cell' was not enough to be accepted for this point.

(ii) The most popular method of delivery suggested by candidates was injection, with the use of liposomes or inhalers being suggested by some candidates. The question asked for only one method and candidates who produced a list from which to choose did not gain credit.

(b) Most candidates knew that RNA polymerase, rather than DNA polymerase would be the enzyme for the synthesis of RNA. Some made up an enzyme name, such as RNA transcriptase, RNA synthesase or RNA synthase.

(c) Candidates who understood the role of the viral vector knew that the intention of adding env proteins to the vector was not to trigger an immune response in the human host, which many others suggested. There were some well-expressed responses explaining that the env proteins were able to bind to receptors on host cells. Some qualified further and suggested that this would trigger endocytosis while others explained that fusion would occur to allow in the modified viral genome. Some gained partial credit and could have improved their response by explaining that the env proteins may be specific to the target host cells. Weaker responses thought that the env proteins were on the packaging cell and that this cell was introduced into the host.

(d) (i) The information leading to the correct response for this well-answered question could have come from the information provided in the introduction before **Question 23(b)**, which stated that the viral vectors were RNA viruses, or from syllabus knowledge of the enzymes used in genetic engineering.

(ii) Many candidates had a good idea of the role of integrase and most were able to express themselves well enough to gain credit. Weak responses thought that integrase would allow viral components to be assembled, which would defeat the purpose of a viral vector.

(e) Most candidates who gained some or full credit based their answer on the safety aspect of constructing a viral vector without the *gag*, *pol* and *env* genes. It was important for candidates to show understanding that these genes produce viral proteins that would enable viral replication to take place so a response that stated 'so viral proteins aren't made' would not be enough to gain credit. Some introduced the idea of not wanting an immune response to occur if the virus replicated and could infect other cells, without realising that if unwanted viral infection did occur, then an immune response would be a desired effect. There were some candidates who suggested that the viral proteins may end up in the target cell membrane and that this would trigger an immune response against the host cell: this was an acceptable point. A few sensibly pointed out that there may not be enough room for the therapeutic gene within the viral vector if the other genes were left intact.

(f) The majority of candidates were able to give at least two or three relevant limitations of using viral vectors in gene therapy for SCID. The most popular limitation cited was the short-lived nature of the treatment and hence the requirement for further treatment. There were some concise but informative accounts of the potential for tumour formation or the development of leukaemia as a result of imprecise integration into the host cell genome.

(g) Some of the responses to this question were of a very high standard. A good approach was to suggest the detrimental effect Wiskott-Aldrich syndrome would have on the health of a person who is not receiving treatment for the disease and then to explain why this would occur. For full credit, candidates needed to address both parts of the question. When explaining, the strongest answers took each of the named defects and addressed them separately. Others gave a response that was

too general, for example saying that there would be a weak immune response did not show understanding that B lymphocytes that are defective may not mature into plasma cells and antibodies may not be produced (or may be defective and over-produce antibodies), for example. Practically all candidates understood that there would be problems with blood clotting owing to the low platelet count and small cell structure.

(h) This was one of the most demanding part-questions of the paper. The best answers showed a very good understanding of the features of sex-linked inheritance and the patterns that would be observed if a recessive allele is located on the X chromosome. The focus should have been on the male members of the family and many candidates missed this point and wrote about the females in the family. Others misunderstood what was required of them and did not answer the question as asked. Instead they drew out or described the various different crosses that could occur. Of these, it was usually not possible to award credit as very few were accompanied by a key for symbols that might help link to an acceptable point.

Question 24

(a) Candidates who gained credit named both of the required domains. Eukaryotes was well known by the other candidates, who usually then wrote 'prokaryotes' and were unable to gain any credit. Candidates should use the term Bacteria and not Eubacteria (and Archaea, not Archaebacteria).

(b) Almost all candidates gained credit, with most suggesting that *Halobacterium salinarum* has a flagellum for motility.

(c) Good answers made it clear whether the points that were being made were about the non-halophile or *H. salinarum*. The terms water potential and water potential gradient should be used and the strongest responses did this. A 'high concentration of water' is not an acceptable alternative to a high water potential. Explanations for the movement of water in terms of solute potential rather than water potential are not valid unless there is a reference to the pressure potential, which was not known in the case of the bacterial cell walls concerned in this question. Candidates also need to understand that a numerical value of solute potential becomes more negative when there is a higher solute concentration so that this has the effect of decreasing the overall water potential (more negative). Many candidates could avoid confusion by consistently referring to water potential in their response rather than solute concentration or solute potential. Some could have benefited from re-reading their response: for example, a statement that water would leave the halophile by osmosis was sometimes accompanied by the conclusion that the cell would burst. The terms hypotonic, hypertonic and isotonic are more relevant to animal cells than plant or bacterial cells. This is because of the contribution made by the cell wall to the overall water potential of the cell, and only a comparison of water potentials inside and outside of a cell will determine the direction of osmosis. For bacterial, plant or animal cells, if candidates compare external and internal solutions in terms of water potential, then this reduces any potential confusion.

(d) Most candidates gained credit here. Where credit was given, approximately half suggested potential damage to DNA structure and the other half suggested a mutation.

(e) (i) Many knew that the behaviour described was an example of phototaxis. There were quite a number who incorrectly stated phototropism.

(ii) This question was based on cell signalling but expected candidates to refer to the behaviour shown by *H. salinarum*. Some candidates showed a very good ability to highlight an aspect of cell signalling and link this to one of the various pieces of information provided in the text. A number of candidates gave good sequential accounts. Some realised that red-orange light was the stimulus and sensory rhodopsin I the receptor and began their response with confidence. Some thought that other factors were involved and that sensory rhodopsin I would cause the production of a chemical that would then bind to a receptor. Weaker responses wrote about nerve impulse conduction.

(f) Many gained full credit, usually for describing an alpha helix and stating that this was part of secondary structure. **X** in **Fig 24.1** was clearly demarcated by a square bracket and this area showed an alpha helix only. Some candidates attempted to describe the complete protein shown.

(g) (i) Most could name the enzyme described in the introduction as ATP synthase or ATP synthetase. Candidates who stated ATPase were not credited as this is a different enzyme.

(ii) This part was set out as two bullet points so that candidates would be more likely to complete **Fig. 24.2** as instructed, which many did correctly. Others did not add the arrow heads or add the hydrogen ions and did not gain credit.

(iii) Some responses were very thorough and included most of the expected points. There was considerable variation in the clarity of organisation of the response and the strongest answers followed a sequential route through the process of chemiosmosis and made it clear when they were referring to the mitochondrion or the experiment.

Question 25

(a) The strongest responses covered both parts of this question. Generally, candidates knew the type of habitats best suited to each crop plant type and that C4 plants had evolved adaptations to cope with higher temperatures and the effect of photorespiration. It was not necessary to give lengthy details about C4 leaf anatomy and physiology, which many well-revised candidates did. When discussing the potential impact of climate change on future patterns of agriculture, some candidates could have broadened their response and focused less on carbon dioxide concentrations. It was important to consider the effect of global warming and changing rainfall patterns. Many gained credit for showing understanding that the balance would change to cope with the changing climate. Fewer gave examples of specific consequences to agriculture in their discussion.

(b) Most candidates could adequately describe features characteristic of insect pollinated plants and many gained full credit for this extended answer. Some wrote ‘they’, which would be a reference to the entire plant instead of referring to the flowers, for example, ‘they are brightly coloured’.

Question 26

(a) Due to an issue with this question, careful consideration was given to its treatment in marking in order to ensure no candidates were disadvantaged. Answers in the top row of the table were discounted and the marking adjusted. The published question paper and mark scheme are corrected versions.
For the second statement, some candidates gave a precise answer: ‘chlorophyll a’ or ‘primary pigment’, and gained credit. It was not enough to state ‘chlorophyll’ as chlorophyll b is not a primary pigment. ‘Reaction centre’ was also accepted: a better answer would have been ‘chlorophyll a reaction centre’ as some consider the entire photosystem to be a reaction centre. One clue to the correct answer in the third statement was ‘initially’. Another was the fact that the energy absorbed was passed on. This led some candidates to surmise that the missing term was referring to the accessory pigments (or other acceptable terms for these). ‘Carotenoids’ and ‘xanthophylls’ and ‘chlorophyll b’ were also acceptable answers. Many candidates did not answer this third statement in enough detail and wrote ‘photosystem’. Most candidates knew that water was the source of the electrons used to replace those lost from photosystem II. ‘Photolysis’ was also another acceptable alternative to complete the final sentence.

(b) Candidates were asked to draw a guard cell, which some did. Depending on the quality of the diagram, credit for a correct shape could be awarded here and, if labelled, for the difference in thickness of the cell wall. Many drew the complete stomatal pore, comprising the pair of guard cells surrounding the stoma. Unless a single guard cell was labelled, the mark for shape could not be awarded unless correctly described in the textual response. It was very common for ‘stomata’ to be seen, which was not credited, instead of the singular ‘stoma’, which was correctly given by some candidates. The quality of the diagram produced by a number of candidates could have been much improved.

BIOLOGY

Paper 9790/02
Data Analysis and Planning

Key messages

- When attempting the data analysis section of the examination, candidates should underline key points within the stem of the question to ensure full understanding of the context of question. This is also true of tables of data or graphs, where annotation may help candidates understand the key points.
- On a data analysis paper it is expected that candidates use the data supplied in order to help them answer the questions. This also means that candidates are expected to manipulate any figures in support of their arguments. This is a key element of this paper.
- The paper requires a good understanding of the principles of biology in order to explain the results presented in the questions. Candidates must ensure that the scientific knowledge that they use is both appropriate to answer the question and is in sufficient depth for a Pre-U qualification.
- When planning an experiment or procedure, a clear logical structure would ensure that key points such as the underlying hypothesis or suitable controls are not missed. Time should also be given to complete the plan, with an introduction (including identification of variables), a method, and a description of analysis (including statistical tests).

General comments

The Data Analysis and Planning examination tests candidates' abilities in two distinct areas. ***Section A*** presents the candidates with a series of results of scientific work carried out in a variety of contexts. It requires description, analysis, explanation and evaluation of the data, which may be presented in a variety of ways. ***Section B*** is a planning exercise in which candidates are required to plan an investigation that could be used to generate the type of data suitable for statistical testing of a particular hypothesis.

In ***Section A***, **Question 1** presented candidates with results from an investigation into contraction of isolated muscle tissue. Candidates were expected to analyse the results and draw a graph of the manipulated data. **Question 2** introduced candidates to an unusual species of grass that has both C3 and C4 varieties. Data from an investigation on these two varieties were presented and candidates asked to compare and explain the differences, including taking a wider look at the ecological and evolutionary aspects of the two forms.

Section B asked candidates to consider a well-known aspect of enzyme theory: the idea of competitive and non-competitive inhibition. Candidates should have been familiar with the use of changing substrate concentration to determine inhibitor type, and this planning exercise asked them to give details of how this could be done using the enzyme succinate dehydrogenase. Many candidates found this a challenging task.

Comments on specific questions

Section A: Data analysis

Question 1

Candidates were given data relating to the addition of ATP to isolated muscle strips. This included different ATP concentrations as well as boiled ATP and glucose alone. Candidates were asked to carry out a simple calculation of percentage change in length and then to plot the data on a graph. Candidates were expected to use the table and their graph to describe and explain each of the experimental treatments.

(a) Most candidates gained full credit here with correct answers that included the correct number of decimal places.

(b) The graph consisted of some unusual plotting points, with boiled ATP and glucose not fitting into a conventional line graph. Many candidates dealt with this easily by plotting a line graph beside a bar chart using the same *y*-axis. Alternatively, a bar chart for all data points was acceptable. Common mistakes included the plotting of a histogram instead of a bar chart and having bars touching, or incorrect plotting of points due to a complicated scale being chosen for the *y*-axis.

(c) (i) Most candidates gained credit for describing the results, but many were unable to explain them. A few wrote about boiled ATP and glucose suggesting that they may not have read the question carefully. There was confusion about the role of ATP in muscle contraction, with a significant number of candidates wrongly referring to ATP helping myosin to bind to the actin filament.

(ii) Again, most candidates could provide an adequate description of the effects of boiled ATP and glucose, but fewer were able to offer an explanation. Candidates referred to ATP being unaffected by boiling or some ATP being broken down by boiling. Some developed this further by stating that ATP was not a protein so would not be denatured by boiling. Few candidates were able to provide a clear explanation of the effect of glucose. Candidates must ensure that the answers they give are unambiguous. In this case, saying that boiled ATP had 'no effect on shortening' could mean two things – that it did not cause shortening, or that it did not reduce the shortening that took place with unboiled ATP.

(d) This question asked candidates to describe two limitations of the experiment and was well answered. Many gained credit for identifying that there were no replicates. Other common correct responses were temperature not being controlled and possible differences in the volumes of the test solutions. Several candidates referred to the range being inadequate which was too vague to be awarded credit. The actual range was suitable, but the intervals within that range were a possible limitation of the experiment.

Question 2

Candidates were presented with data from an experiment on a species of grass that has two distinct varieties: a C3 and a C4 form. The investigation changed carbon dioxide concentration in a high temperature and high light intensity environment. Candidates were asked to compare and explain the results. Data was then given for water loss from the two varieties and candidates asked to consider this in relation to the plants evolutionary advantage.

(a) The majority of candidates were able to compare the results for the C3 and the C4 plants and many achieved maximum credit. Candidates must be careful when using the term 'rate' to describe the gradient of a line on a graph. This should be limited to graphs which have time along the *x*-axis. Candidates need to remember to use units when quoting comparative data. It was not unusual for candidates to read the wrong key for the C3 and C4 plants. They would benefit from annotating trends and patterns shown by the data on the graph before attempting the question.

(b) Some excellent answers were seen, with a significant number of responses giving good details of C4 biochemical mechanisms and anatomy. However, other candidates did not link the competition between oxygen and carbon dioxide for the enzyme rubisco, leading to increased photorespiration at low levels of carbon dioxide.

(c) (i) Nearly all candidates gained credit for the idea of allowing comparison between plants with different leaf areas.

(ii) Generally, candidates answered this question well with a number identifying that C4 plants might have fewer stomata so reduced loss of water vapour. Structural adaptations that reduce rates of transpiration were also cited e.g. stomata in pits and presence of hairs. Several candidates gave more general answers rather than referring to the data from this experiment. This included explanations about where the C3 and C4 plants may live and so leading to differences in water loss.

(d) Very many general answers were seen here, with 'adaptation' cited but no indication of what the adaptation was or how it would be useful. Despite this, most candidates were able to give two

specific examples of climate such as higher temperatures or dry conditions. Few developed this to explain why a C4 photosynthetic pathway would be an evolutionary advantage to the plant.

Section B: Planning

This section required candidates to plan an investigation which could be carried out to determine if an inhibitor was competitive or non-competitive.

Overall candidates found this very challenging, despite clearly knowing the theory behind competitive and non-competitive inhibitors. Many found it very difficult to work out how they would carry out the experiment that would lead to the classic graph of substrate concentration and initial rate of reaction.

Generally, the hypothesis stated was reasonable with some candidates including a null hypothesis, although this was not always correct. The theory to back up the hypothesis was often limited or missing, although some candidates were able to explain effectively when they made conclusions that relied on theory of enzyme action.

The dependent variable was usually correctly identified as the time taken for the indicator to change colour. The independent variable on the other hand was nearly always wrong. Most candidates identified the inhibitor concentration rather than the substrate concentration as the independent variable and stated a range of values that should be tested. A few candidates chose a range of temperatures as the independent variable.

Nearly all candidates were able to list at least two controlled variables.

The risk assessment was generally poorly attempted and tended to be rather simplistic, referring to basic laboratory protocol such as avoiding Bunsen burner flames or avoiding broken glass. The risk assessment should include identification of the specific hazards and how to avoid injury. In this exercise, enzymes were being used (possible irritants) and methylene blue.

Working on an assumption that it was substrate concentration being changed rather than inhibitor, the methods described by most candidates were workable, although disorganised in places. Candidates must attempt to write a method based on a framework of areas that need to be covered. Many candidates did not include any enzyme, while others missed out basic but important steps such as equilibration of solutions, mixing solutions thoroughly or production of replicates. Any investigation that involves dilutions should include a description of the dilution method (such as a dilution table).

Analysis and evaluation was attempted by most candidates with reference to a suitable statistical test and its possible interpretation. However, quite a few candidates described the method in detail but then produced little to address these areas. The most able candidates drew a sketch of their expected results with K_m and V_{max} indicated for both types of inhibition. A suitable statistical test was mentioned in most cases although was not always correctly justified. Some candidates confidently referred to standard deviation or the production of error bars in order to judge variability in data.

BIOLOGY

Paper 9790/03
Case Study and Synoptic Essay

Key Messages

- It is essential that candidates take some time reading the questions carefully and underlining or annotating key points before they attempt to answer.
- The case study may consist of material taken from a research article, but the questions asked will all have a basis in content from the syllabus and the appropriate learning outcomes. Candidates must always bear this in mind and attempt to include the appropriate scientific knowledge and understanding when answering the questions.
- Mathematical skills are essential in all of the biological examination papers, including Paper 3. Candidates should check all of their calculations carefully and consider whether the answer given is a realistic and appropriate one.
- It is essential that candidates produce a plan before attempting to answer the essay question. The plan does not need to be extensive or in great depth, but it does need to cover all of the major topic areas that could form part of the discursive essay. The nature of the plan depends on the candidate's personal preference, perhaps a list or mind-map, and should act as a prompt for the production of a well-balanced and coherent piece of writing.
- It is also important that candidates consider all essay titles carefully before making a final choice. Sometimes, after careful consideration, an apparently difficult essay can be broken down into some straightforward topics.

General Comments

Paper 3 is the Case Study and Synoptic Essay paper divided into two sections, **A** and **B**.

Section A presented material from a research article on the control of malaria, the reasons why this is challenging and possible solutions. On the whole candidates did well on all areas of **Section A**, but some careful reading was required for some questions and candidates needed to think carefully before jumping to conclusions.

Section B provided a choice of essay titles aimed at testing knowledge of the syllabus and also eliciting responses that show greater depth of reading around the subject. Responses were of a reasonable standard with some well-planned and logical essays, with all three titles being attempted by candidates.

Comments on Specific Questions

Section A: Case study

Question 1

This reminded candidates of some details about the malarial parasite, and described a trial of a new vaccine that was being used in an effort to reduce cases of malaria worldwide. Candidates were asked to describe how malaria spreads, why it is difficult to fight infection in the body, and the mechanism of the vaccination trial that was undertaken.

(a) Few candidates could correctly identify the genus of the malarial parasite, with common responses including 'mosquito' and 'protoctista', or no answer given at all. The method of transmission was reasonably well answered but many candidates left out either the infected person or the uninfected person and described the movement of parasite either to or from the anopheles mosquito only. Many candidates showed good knowledge of vectors and anticlotting agents in the mosquito saliva.

(b) In this question candidates were asked how the parasite had developed the ability to evade the human immune system. Some very good answers were given but some were vague and lacked detail of possible mechanisms. Few candidates recognised that the response required details of variation, mutation, survival of individuals and passing on of their advantageous alleles (natural selection). However, many gained credit for describing how the parasite enters host cells and is able to change its surface antigens.

(c) Some candidates answered this question very well with good detailed knowledge of the immune response. A significant number, however, misinterpreted what was required, giving detailed answers of the whole immune response rather than focusing on exposure to the *Plasmodium* antigens stimulating B or T lymphocytes to produce memory B or T cells.

(d) This was an interesting question asking why a rabies vaccine was given to the control group (instead of the traditional placebo of an inert substance). The majority of candidates correctly described the rabies vaccine as a control to compare against the effects of using the *Plasmodium* vaccine but only a few candidates further developed their response, explaining the need to use a control that also stimulated the immune system. Some candidates correctly identified the ethical issue of giving a 'control' that would not protect from malaria but that would at least protect the group from rabies.

(e) Here candidates gave some excellent answers explaining how irradiation changes the malarial parasite so that it is no longer able to divide. There was clear reference to mutation and damage to DNA or genes and the impact on altering proteins such as enzymes. However, some candidates stated that irradiation would change the genetic code, which is incorrect.

(f) The arguments for and against a vaccination programme were addressed well by the majority of candidates. In arguments for the use of the vaccine, most candidates recognised that the vaccine meant that lives were saved. Some correctly referred to the statistically significant difference between the effectiveness of the two vaccines. Very few further developed their answers to include aspects such as reduced healthcare costs, economic implications or prevention of epidemics. When discussing the arguments against, common answers included possible side effects, limited sample size and age range, cheaper alternatives and only 56% effectiveness of the vaccine in preventing malaria.

Question 2

This question continued the theme of the prevention of malaria, but focused on education as a means of control.

(a) (i) Most candidates recognised that fever could have multiple causes and that misdiagnosis was a problem with home diagnosis. They also compared this with the professional judgement of trained hospital staff.

(ii) This was well answered on the whole with lots of excellent responses that discussed the description of the symptoms, how to get support, and use of anti-malarial drugs, insecticides or nets. If credit was lost it was because of vague statements such as 'prevent bites from mosquitoes' rather than giving specific details of how this could be achieved. Several did not mention mosquitoes at all.

(b) This question focused on the possible impact of removing a species from a food chain, in this case asking about those at the tops of food chains. Many candidates correctly referred to 'keystone species' although it should be emphasised that not all keystone species are predators. A large number also described the impact on the trophic levels below this, followed by the decrease in the next trophic level. Candidates need to make sure that they are clear which trophic level is being discussed, and actual examples would have clarified their answers considerably. Very few candidates noted any potential effect on abiotic aspects and loss of habitats.

Section B: Essay

The most popular choice of essay was **Question 5** followed by **Question 3** and then **Question 4**. It was clear that those candidates who produced a structured plan for their essay also produced an essay that was clear, uncluttered and relevant to the title. Candidates should attempt to lay out the main points of discussion of their essay before they begin.

Question 3

Describe applications of cloning technology and discuss the need for controlling its use.

This was reasonably well answered on the whole with some good detail and evidence of significant and relevant background reading, including clear definitions of cloning and cloning technologies. A large number of candidates, however, produced superficial essays that lacked much of the content from the syllabus, and provided no evidence of further reading. In many cases only animal cloning was considered, and this often focused mainly on Dolly the sheep, ignoring techniques such as embryo twinning. Few candidates made any serious attempt at discussing the need to control cloning, leading to essays that tended to lack balance and argumentation. Those that did address this issue made some interesting and valid points.

All candidates who chose this essay scored reasonably well on communication and on spelling, punctuation and grammar (SPG).

Question 4

Microscopes have transformed the study of biology. Discuss the extent to which this is true.

This was the least popular of the essay titles and many candidates appeared to find it difficult to plan a well-structured and coherent argument. Many of the essays seen tended to be rambling accounts of microscopes in a limited number of contexts. It was expected that a well-produced essay would cover the history and types of microscopes and their uses. It was also essential to reflect on areas of biology where they have had less impact. This was seen in few cases.

Although some candidates included a range of examples with depth of detail, many were superficial lists of facts. There was some evidence of extensive background reading in a few essays but most extended little beyond textbook material.

Question 6

How do different types of animal behaviour promote survival?

This was by far the most popular essay with over 50% of candidates choosing it. It was expected that a well-balanced and structured essay would include a definition of behaviour followed by the different types of behaviour, appropriate examples and how these behaviours promote survival. This was seen in many cases with some marvellous arguments and good descriptions of a wide range of behaviour types. This essay showed an extensive amount of background reading with some excellent examples of behaviour which then went on to explain how the behaviour type was linked to survival strategies. Those candidates who achieved less well tended to give vague details of behaviour types, few examples and often with scientific errors. Others tended to limit their argument to very few types of behaviour, missing out for example innate or social behaviour altogether and focusing almost entirely on operant and classical conditioning. These essays obviously lacked balance. There was little evidence of practical work in this field.

As with all of the essay choices, it was clear that candidates who had read extensively around the topic were far more able to produce a balanced and well-argued account of the topic compared to candidates who made little reference to any biological material not on the syllabus.

BIOLOGY

Paper 9790/04
Practical

Key messages

- Candidates should assimilate all the information provided in each question before they start to give answers. It was clear that some candidates had not followed the instruction at the beginning of **Question 1** to read the whole of the question before starting the practical work. There were very few annotations written on the scripts and little evidence of any rough planning.
- Few answers incorporated the theoretical knowledge underpinning **Question 1** on this paper.
- Some candidates used the terms 'qualitative' and 'quantitative' in their answers to **Question 1(k)**, **(l)** and **(m)**, although they were often used incorrectly.
- Drawings should always be planned out so that enough space is left around the edge for labels and any annotations if required. Many of the answers to **Question 2(a)** did not have enough space for labels and they were often poorly positioned so that labels were too close together and label lines crossed each other.

General comments

Many candidates did not show full understanding of the two essential problems that they were investigating in **Question 1**, as described in the information given on page 2 of the paper about glucose, reducing sugars and non-reducing sugars. Diastix® test strips are used solely for the detection of glucose. Benedict's solution gives a positive result with all types of reducing sugar and will indicate the presence of non-reducing sugars if they are first hydrolysed by acid or by an enzyme. These two tests were used to assess the sugar content of diluted coconut water.

The investigation in **Question 1** is a good way to demonstrate the difference between the specificity of tests for sugars and their sensitivity to low concentrations of sugars. Many candidates inappropriately tried to fit ideas from previous papers, such as those taken over the past three years, to this new and different scenario.

The drawings of the cross-section of the thorax of the embryo mammal in **Question 2(a)** were often impressive. The organisation of the question helped candidates find, draw and label the structures required. In most cases, the outlines were drawn accurately and the organs correctly situated in those drawings. Presentation was not always very good, but lines were clear and mostly unbroken. Considering that candidates were working under a time pressure the results were commendable.

Question 3(a) tested candidates' knowledge of the ultrastructure of muscle. Although the transmission electron micrograph shows cardiac muscle, the structure visible is identical to striated muscle. Some candidates showed impressive knowledge of both structure and function of muscle, but many were very unsure of the structures that were visible and terminology was often weak.

Comments on specific questions

Section A

Question 1

Candidates were instructed to investigate the sugar content of a 10% solution of coconut water. They were provided with test strips that test for glucose, Benedict's solution and reagents necessary to conduct a non-reducing sugar test. Some candidates either ran out of time or did not know how to carry out the non-reducing sugar test as they left **Question 1(j)** blank. Some answers to this question suggested that the test

had not been conducted correctly and that the reaction mixture had not been neutralised properly with the sodium hydroxide solution provided. Other answers for **Question 1(h)** and **(j)** were identical so it was assumed that these candidates had not carried out the acid hydrolysis.

(a) Most candidates stated that the colour of the test strip was dark brown and the concentration of glucose was ≥ 20 g dm^{-3}. Some stated that it was only 10 g dm^{-3} which suggests that they compared the colour on the pad with the colour chart too quickly without waiting for the full 30 seconds.

(b) There were some excellent descriptions of the action of glucose oxidase and peroxidase in the test strips that bring about the colour change. However, there were also many very vague answers and some that stated that the pads contain immobilised enzymes, but showed no knowledge of the reactions that occur when glucose is detected. The use of immobilised enzymes did not answer this question.

(c) Almost all candidates gave an appropriate time for this trial. Any time within 60 seconds was considered appropriate for the conditions provided. However, answers that were expressed to the nearest 0.1 or 0.01 of a second were not accepted. It is impossible to record the time to this degree of resolution with the apparatus available.

(d) It was clear that many candidates had not read the whole question before starting otherwise they would have noticed that on page 10 it states that a 10% solution of coconut water is reported as having a sugar concentration of 5 g dm^{-3}. Also, many candidates ignored the fact that they were provided with two stock solutions of glucose. It was expected that they would use a wide range extending beyond 10 g dm^{-3} so that they would also use the 100 g dm^{-3} stock solution to make some dilutions. Some candidates used a range from 0 to 100 g dm^{-3} with the lowest concentration being 20 g dm^{-3}. Others only used the 10 g dm^{-3} solution to prepare their dilutions. Only the minority used both solutions and of those only a few used more than four or five intermediate concentrations across the range. There was really no need to extend the range as far as 100 g dm^{-3}. All candidates used proportional dilution and many stated that they only made up 5 cm^3 of each dilution, although there was evidence that some changed this when they realised later how much they would need.

There was some confusion over the use of percentage solutions. Some candidates made it very clear that their solutions were percentages of whichever stock solution they used. For example, a 20% solution of the 10 g dm^{-3} solution would be a 2 g dm^{-3} solution. Others referred to the solution that they had prepared from the 100 g dm^{-3} stock solution simply as percentage solutions, e.g. 20%, 40%, etc. They seemed unaware of the convention that a percentage solution is prepared using a solution of mass per 100 cm^3 water, not 1 dm^3 water.

(e) Almost all candidates used a single table for their results. Some used a split table – one for each of the two methods. Most candidates took care over the construction and completion of their tables. Some did not have fully informative column headings but most had replicate results for the Benedict's test. Presentation was not always very clear. Some candidates unnecessarily calculated rates of reaction and found that there was little space to include a final column for the data. Some candidates identified one or more results in their table as anomalous even though they had not carried out any replicates and these results did not look out of line with other concentrations.

(f) Most of the candidates drew appropriate graphs of their data. Some used scales that proved difficult to extract data for **Question 1(h)** and **(j)**. For example, it is not a good idea to use a scale of 30 mm to represent 10 s or 20 g dm^{-3}. Some candidates had to extrapolate their lines in order to draw intercepts which is generally unacceptable in this type of exercise and showed poor planning in the choice of dilutions.

(g) Candidates described the pattern of results using suitable vocabulary. The graph should show an exponential decrease in time taken to reach the end point as glucose concentration increases. Candidates who calculated rates often had straight line relationships and of course had the benefit that they could start their lines at the origin. Few candidates manipulated the data to illustrate their answers.

(h) Very few candidates used the spaces provided to clearly show the results that they obtained, including colours of the test strips and the final concentration of glucose and reducing sugar.

Stronger answers presented results in small tables, often indicating replicates and mean concentrations.

(i) This question simply required candidates to describe how they used an intercept on their graph to determine the reducing sugar concentration. A few candidates gave approximate answers by stating that the concentration was 'around' a particular value. In some cases this was because they had not chosen a suitable range of dilutions.

(j) Some candidates did not complete this question, suggesting that they did not know how to carry out the non-reducing sugar test. It was expected that the results for both methods would be higher as any sucrose (or other non-reducing disaccharide that might be present in coconut water) would be hydrolysed to form glucose and fructose. The extra glucose would be detected by the test strips and the extra reducing sugars would be detected by the Benedict's test. A few astute candidates used the space provided to explain that the concentration of non-reducing sugar is the difference between the result for Benedict's solution in **Question 1(h)** and **(j)**. The difference between the results for the test strips is the extra glucose produced by hydrolysis of the non-reducing sugars.

(k) The candidates tended to give rather simplistic precautions. They also stated that they used a standardised method for some aspect of their procedure without stating what this method was. Credit was not given for methods that were stated in the question, but was given for those that were not. Some candidates stated that they used repeats but there was no evidence of this in the table in **Question 1(e)**. Many wrote about parallax error in syringes which was not credited. It was clear that some candidates tested one solution at a time, which was an extreme precaution, but the compromise meant it was not possible to do any replicates.

(l) Asked to comment on the reasons for any differences between the figure of $5\,g\,dm^{-3}$ and their results, candidates resorted in the main to discussion of the limitations of their procedure rather than consider the principles of the two methods and differences between samples of coconut water. Credit was not given for limitations that the candidates could easily have controlled. Only a few candidates stated that coconut water may contain reducing agents other than reducing sugars.

(m) This question was not the same type of evaluation question that candidates may have practised. This required them to consider advantages and disadvantages of the two methods and many gave rather simplistic answers. Some stated that using a colorimeter would give better results with Benedict's solution than watching for the cloudiness to appear. The question did not ask candidates to suggest any improvement and it is not possible to heat the test solutions to the required temperature in a colorimeter. Some stated that the test strips only identify the presence of glucose, but did not make any reference to fructose that could be in the coconut water and would most certainly be present after acid hydrolysis of sucrose in the non-reducing sugar test. One candidate wrote about fructose in some rough notes, but then crossed it out and did not write about it in the answer. Many repeated themselves here by referring to the same aspect as it applied to the two methods. Most candidates compared the two tests without stating the advantages and disadvantages of both tests as required. Few candidates discussed the problem of using Benedict's solution to test the sugar content of coloured fruit juices.

Section B

Question 2

In **Question 2(a)**, candidates presented a labelled drawing of a cross-section through the thorax of an embryo of a small mammal. The presentation of these drawings was often very poor with poor positioning of label lines and labels. However, the observations made on the drawings were often worthy of full credit. The comparisons of the lung tissue of the embryo with the lung tissue of an adult small mammal were often presented well with the occasional table used to make direct comparisons.

(a)(i) The drawings were usually large enough with an appropriate outline. The sections of the heart, lungs and spinal cord were drawn in the correct positions and were all labelled. Some drawings were too small and some so large that they could not be fitted onto page 13 of the paper. Candidates need to plan their drawings before starting to make certain that they will be able to show all of the required features.

(ii) Drawing the position and outlines of skeletal structures proved rather more challenging as the section through the vertebra was omitted by some and not drawn correctly. The sternum was occasionally positioned in the wrong place and not differentiated from the ribs on either side.

(iii) Almost all candidates drew the oesophagus in the correct place, if often rather small, below the spinal cord, and showed the lining of the lumen correctly.

(iv) Almost all candidates gave an appropriate magnification and showed how they had determined it. Many unnecessarily used the eyepiece graticule to calculate the magnification.

(b) It was expected that candidates would describe how the embryonic lung differs from the adult. Some made very clear the differences by referring to both tissues. Candidates often interpreted the structure of the embryonic lung correctly, stating that no gas exchange occurs and that the embryo receives oxygen from exchange at the placenta. Some were less secure in their answers and stated that less gas exchange occurs in the embryonic lungs. Most referred to alveoli and alveolar walls but there was a distinct lack of appropriate terminology. For example, candidates stated that the tissue was darkly stained without referring to specific cell types or nuclei or cytoplasm. Many referred to blood vessels without differentiating between capillaries, veins and arteries. There were also few references to squamous cells in the adult and cuboidal cells in the embryo. Some candidates thought that the adult lung was diseased in some way and wrote about emphysema and lung cancer.

Question 3

The transmission electron micrograph of cardiac muscle in **Fig. 3.1** shows very clearly several myofibrils within a cardiac muscle cell. The sarcomeres along the lengths of these myofibrils are also very clear as the Z lines are very pronounced. Some candidates gave very detailed answers to **Question 3(a)**, but many showed very limited knowledge of the ultrastructure. Some candidates showed impressive knowledge of the functions of the structures that they labelled. **Question 3(b)** concentrated on the receptors for cell signalling molecules on the surface of cardiac muscle cells.

(a) Some candidates labelled at least four of the structures visible in **Fig. 3.1** and gave appropriate functions for each. Some labelled many more than four so filled up all the white space around the TEM. Others struggled to identify structures correctly and often gave incorrect functions.

Relative size was the biggest problem in this question as candidates were often unsure of the scale of the structures visible. Incorrect examples include: the area at the top of the image labelled as connective tissue and the myofibrils as muscle fibres, mitochondria often labelled as red blood cells or capillaries and in one case as a coronary artery, and Z lines labelled as intercalated discs. The most difficult structures to label were the A band, the I band and the thick and thin filaments. The thick filaments are only clearly visible in the A band and the most appropriate place to label the thin filaments is in the I band either side of the Z line. The thick filaments are composed of myosin and other proteins so it is incorrect to label them simply as ‘myosin’. Similarly, the thin filaments are composed of actin, troponin and tropomyosin so they cannot be labelled simply as ‘actin’. The strongest candidates used brackets to label the different zones within the sarcomeres.

(b)(i) Candidates often gave suitable reasons for the presence of β receptors on the surface of the muscle cells. They either explained that adrenaline and noradrenaline are water soluble so cannot penetrate the phospholipid bilayer, or they referred to the secondary messenger system as being a much faster way to stimulate changes in the muscle cell than relying on movement through transport proteins to the interior of the cell.

(ii) There were many good answers to this question. These answers discussed the advantages of using antibodies in studying histology, compared with using chemical stains, drawing on knowledge of antibody structure. Many referred to the high degree of specificity and the wider range of antibodies that can be used compared with the much smaller numbers of chemical stains. They also drew on their knowledge of monoclonal antibodies to state that they can be used within living organisms, e.g. for diagnosis of infectious diseases and tumours.