BIOLOGY

Paper 9790/01
Structured Questions

Key messages

- Candidates are advised to use a ruler when reading off values from graphs, in order to obtain accurate values. There were considerable differences in the accuracy with which candidates extracted data from Fig. 21.2 and Fig. 21.3 when responding to **Questions 21(c)** and **(d)**.

- Questions containing two command terms require candidates to address both aspects. For example, in **Question 22(a)(ii)** some candidates gave excellent accounts of how cholesterol was arranged within the membrane but did not go on to relate this to its role. Others focused only on its role. Similarly, only the best responses for **Question 24(d)** described the direct effect of tetanospasmin and went on to explain how this results in muscular spasms.

- In questions involving an element of comparison, candidates would benefit from checking their responses to ensure that comparisons are correct and clear. For example, in **Question 25(c)**, candidates needed to make it clear whether they were referring to *in vitro* or *in vivo* fertilisation. In **Question 26(c)**, candidates needed to link their points to either type 1 or to type 2 diabetes.

General comments

A number of candidates gave strong performances in both **Section A** and **Section B**. Some may have benefited from more practice at **Section A** questions.

Question 21 included a number of parts where candidates needed to read through the information given and understand the situation before attempting a response. It would have helped some candidates to revisit this information to consider whether their responses could be further refined.

In **Question 23 (d)(iii)**, there were some excellent extended accounts of DNA replication. Many candidates were very knowledgeable and supported their answers with relevant details. Some candidates focused on higher level details without covering the basic features of the process and so omitted significant aspects of the process, such as explaining that both strands act as templates and that DNA nucleotides are added according to complementary base pairing rules.

It is important that candidates take careful note of the requirements of each question. In **Question 24**, some candidates only wrote about Gram negative or Gram positive bacteria in part **(b)**. Similarly, in **Question 25 (b)**, a number of candidates outlined the qualities of a mass flow system in animals, rather than explaining the need for the system, as was required by the question.

Practically all candidates attempted all parts of each question. Candidates were adept at using scientific terminology and many were skilled at drawing together pieces of knowledge from different parts of the syllabus to compose a full and balanced response to the appropriate part question.

Comments on specific questions

Section A

Overall, candidates found **Questions 2**, **12** and **14** to be the most challenging, followed by **Questions 4**, **8**, **13** and **11**.

Questions 1, **5**, **6**, **7** and **10** were the most accessible questions for candidates.

In **Question 2**, answer **C** was a common incorrect response. Candidates were told at the beginning of the question that gibberellin was a terpenoid and that it only contained the elements carbon, hydrogen and oxygen. This eliminates answer **C** since such a compound cannot be a protein.

Questions 3, **4** and **5** were based on the oxygen dissociation curve for haemoglobin. **Questions 3** and **4** required candidates to visualise the curve that included the plotted point **P** and the curve including the plotted point **Q** before choosing the correct statements to match the curves. Some had no problems with this skill and arrived at the correct answers, but others were less successful.

Questions 12, **13** and **14** were based on the kidney and were amongst those questions found most challenging by candidates. An understanding of membrane transport proteins and transport mechanisms across membranes was required. In **Question 12**, weaker candidates tended to only consider answers **A** and **B**, possibly because these both mentioned glucose. Candidates who knew that cotransport occurred were able to evaluate all of the possible options.

Section B

Question 21

(a) Practically all candidates made the link between a lack of chlorophyll and an inability to photosynthesise. Weaker responses only stated that photosynthesis could not occur and did not go on to consider why this did not matter for holoparasitic plants. Simple repetition of the information in the stem that the plant could gain carbon, water, mineral ions and other nutrients from the host was too vague.

(b) (i) The most effective responses were precise in their descriptions and related the properties of water to the extraction of water and mineral ions, as required by the question. For example, better accounts stated that water *molecules* are polar, rather than just stating that water is polar. Many candidates recognised that there would be high transpiration rates but fewer considered the transport of water and mineral ions in the xylem of the host plant. A number of candidates confused adhesion and cohesion; others only referred to them vaguely and did not distinguish between them. Few candidates considered the solvent properties of water and the transport of mineral ions.

(ii) This question was very well attempted by the majority of candidates, although not all used the correct terminology. The most effective responses noted the role of osmosis, the involvement of guard cells (rather than plant cells in general) and correctly referenced turgidity.

(c) Effective responses concentrated only on describing the distribution, rather than the abundance, of the three plant species, as required by the question. Such responses also included accurate extraction of data from Fig. 21.2, with the correct units, and a clear indication of whether distributions were related to horizontal distances or height above mean high water mark.

Some candidates did not extract data with sufficient accuracy and many referred to abundance rather than distribution, e.g. 'there were many *A. subterminale* plants' rather than '*A. subterminale* plants were present'. Not all candidates recognised that there was overlap in the distribution of the three species, especially in the area where *C. salina* was described as common.

When describing the ranges within which particular species occurred, some descriptions only gave the upper or lower limit; both are required to completely describe the range. A number of candidates incorrectly considered the halfway point between 0.0 and 0.1 m above mean high water mark to be 0.5 m, rather than 0.05 m.

Candidates who attempted to explain the distribution had not noted the requirements of the question.

(d) Most candidates were able to identify and describe the trends in the data shown in Fig. 21.3, although a few incorrectly considered the mean percentage cover to refer to the percentage of quadrats in which particular species were found. The most effective responses included accurate supporting data, rather than vague references to approximate values, or described differences in the increases or decreases over the three years.

Some candidates suggested explanations for the trends, which were not required by the question.

(e) Many candidates included information in their responses about the differences seen with and without *C. salina*, to show the effect of the presence of the parasite. Some went on to develop good suggestions to explain these differences in terms of competition between the two salt marsh plants. Candidates suggesting that the presence of *C. salina* was beneficial to *A. subterminale* had not appreciated its role as a parasite.

(f) Good knowledge of the features of a keystone species was displayed by many candidates, and the best accounts applied this knowledge to parasitic plants. Weaker responses did not consider the disproportionately large influence of keystone species.

Question 22

(a) (i) Many candidates carefully drew a box around the hydroxyl portion of the cholesterol molecule in Fig. 22.1. Some extended their boxes too far into the hydrocarbon rings. A number of candidates did not know the correct answer and either selected regions within the hydrocarbon part of the structure or left this answer blank.

(ii) Effective responses described both the arrangement of cholesterol and its role within cell membranes. Attention to detail was important in describing how a cholesterol molecule orientates itself with respect to the hydrophilic areas (phosphate heads) and the hydrophobic core (fatty acid tails) of the phospholipid bilayer. Some responses went on to give excellent descriptions of how cholesterol regulates fluidity when temperatures increase or decrease. More limited responses simply stated that cholesterol regulates fluidity or maintains the stability of membranes. A number of responses speculated about what occurs when the temperature is increased or decreased, and described the addition or removal of cholesterol from membranes.

It was essential to address both the arrangement and role of cholesterol in cell membranes in order to fully address the question.

(b) This was a straightforward question that produced some complete and fluent responses. Most candidates were able to describe a number of correct features. The most common error was to describe villi as folds of the small intestine.

Some candidates included accounts of digestion, which were not required.

(c) Candidates achieving most highly used the information in Fig. 22.2 to identify the cell structures involved and combined this with additional knowledge to produce a sequential account.

Others did not suggest how the micelles gained entry to the cell or thought that the micelles were covered by a membrane. Some candidates missed out the smooth endoplasmic reticulum and stated that cholesterol went straight to the Golgi apparatus. A number of candidates mentioned the Golgi apparatus, but did not give an example of what occurred there. The smooth endoplasmic reticulum was frequently described as the rough endoplasmic reticulum. Most candidates understood that the Golgi vesicles moved to the cell surface membrane for exocytosis to occur and some mentioned the involvement of the cytoskeleton in vesicle movement within the cell.

(d) The most effective responses considered both environmental and genetic factors. Few candidates stated that the graph showed continuous variation. Some made it clear that many genes were involved and went on to give sensible suggestions, such as variation in the genes coding for transport proteins. Reference to variation in genes for absorption was too vague. A number of candidates thought that the graph showed stabilising selection and gave accounts that did not address the question.

(e) Most responses described the benefits of a reduced risk of atheroma formation and a reduced risk of heart attack. The best answers also commented on the benefits of reducing concentrations of LDL cholesterol and increased uptake of LDL by liver cells.

Question 23

(a) This was usually well known.

(b) Most candidates addressed the question effectively, but comments were sometimes too vague. Some candidates described the production of daughter cells without noting that the daughter cells would be genetically identical. Others only stated that there would be 'the same amount' of DNA, or 'same number of chromosomes'.

(c) Many candidates showed a detailed understanding of the concepts involved and provided full responses. Some explanations were too vague, not always making it clear that the newly synthesised DNA molecules contained two polynucleotide chains or that the strands would only contain ^{14}N. Others did not relate the products of replication in the second generation to the bands obtained.

(d) (i) Most candidates provided valid suggestions. Some suggested that if a problem occurred in one area, replication could still continue in the other sections, not realising that this would still prevent the complete molecule from being replicated.

(ii) Many candidates made a correct suggestion based on the different number of hydrogen bonds between A-T base-pairs and C-G base pairs. Some responses were too vague, noting the number of hydrogen bonds between A and T but making no comparison with C-G base pairs. Some responses only restated the information provided in the question.

(iii) There were some outstanding sequential accounts of DNA replication that included the names of the enzymes involved together with their roles. Many included details additional to the main ideas expected.

Most responses noted differences in the replication of the leading and lagging strands but not all recognised the role of DNA ligase.

Some responses lacked key details such as the breaking of hydrogen bonds between complementary strands, the role of DNA polymerase and details of complementary base pairing.

A small number of candidates misunderstood the question and described transcription.

Question 24

(a) Nearly all candidates identified at least one of the features characteristic of prokaryotic cells in Fig. 24.1.

(b) The most effective responses included a concise description of differences in the cell wall between Gram-positive and Gram-negative bacteria, and related these differences to the action of penicillin. Some responses only considered one of the two types of bacteria.

Most candidates understood that penicillin acts on the peptidoglycan area of the cell wall, but fewer gave details of the inhibition of transpeptidase or the prevention of cross-link formation.

Some candidates omitted to explain that penicillin would have a greater effect on Gram-positive bacteria.

(c) This was well known by nearly all of the candidates.

(d) Only candidates who understood that GABA was an inhibitory neurotransmitter were able to engage fully with this question. Most realised that vesicle fusion with the presynaptic membrane would not occur in the presence of tetanospasmin and that exocytosis and diffusion across the synaptic cleft would therefore not occur. The most effective responses included a step-by-step explanation.

Question 25

(a) Nearly all candidates were able to state a benefit of being multicellular, with most citing cell specialisation or division of labour. Fewer candidates were able to state a disadvantage. Some noted that there would be greater complexity but without further qualification this could not be considered to be a disadvantage.

(b) The best responses provided a logical account that focused on explaining the need for mass flow, rather than explaining what mass flow means. Many candidates stated that mass flow was needed as diffusion would be too slow to satisfy the demand for resources over the longer distances involved. Fewer considered the decrease in surface area to volume ratio.

(c) Nearly all candidates understood the two terms *in vitro* and *in vivo*, although descriptions were not always accurate. For example, a number stated that *in vitro* fertilisation occurs in the uterus. A small number of candidates thought that both types of fertilisation occurred within the body and that differences were in the number of sperm present or the number of eggs fertilised.

(d) The names of the pathways were generally well known and many candidates arranged the biochemicals to represent the pathways in a suitable way. Arrow heads were clear and in the right direction. The Krebs cycle was better known than the link reaction. The most common error was to produce a two-stage arrangement for the link reaction, with pyruvate being converted to co-enzyme A, which was then converted to acetyl co-enzyme A. Some candidates drew straight lines for CO_2 or co-enzyme A, but forgot to add arrow heads to show whether each was a reactant or a product.

Question 26

(a) Most candidates were able to explain how glucose oxidase was specific only to glucose. Fewer mentioned the role of the membrane in the biosensor. Some went on to describe how the product formed gave a digital readout, which was not required.

(b) Although many knew either the missing reactant or the missing product in the reaction catalysed by glucose oxidase, only a few were able to give the complete word equation to gain credit. The most common error was to think that water, rather than oxygen, was the missing reactant.

(c) Most candidates answered this question well, although some responses would have benefited from clearer referencing to type 1 or type 2 diabetes. Rereading the answer could have helped candidates to pick up on errors. Some candidates described type 2 diabetes but referred to it as type 1 diabetes, limiting the credit that could be awarded for this question.

BIOLOGY

Paper 9790/02
Data Analysis and Planning

Key messages

- In this paper it is expected that candidates will make use of the data supplied to help them answer the questions. Many candidates would have improved their responses through reference to the data given, including manipulation of figures in support of their arguments. These skills are key elements of this paper.

- The paper also 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 questions and reflects the depth of study expected at this level.

- The planning exercise provides opportunities for candidates to plan an investigation using techniques that should be familiar to them in a context that may be unfamiliar. This requires a good understanding of the syllabus to allow candidates to select information and procedures that are relevant. Key to developing such an understanding is the experience of all of the practical learning outcomes in the syllabus. It was clear that many candidates were unaware of the methodology required to carry out an investigation on animal populations set in an unfamiliar context.

- In **Question 3**, candidates who organised their responses carefully into a clear structure were able to develop the most effective responses. Examples of such structures included the use of sub-headings and numbered points. In addition, it is essential that candidates consider all of the information provided in the question and follow the guidance on what to include in their plans. Many candidates find that annotation and underlining of key points in the Question Paper helps them to do this.

General comments

The paper tests candidates' abilities in two distinct areas. **Section A** presents the candidates with a series of results from 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 this paper, **Question 1** presented candidates with a range of physiological data from five species. Candidates required a good understanding of cardiovascular physiology and needed to link the figures given with fundamental differences in the biology of the different species. Not all were able to apply their knowledge of the underlying biology to understand differences in the data between the species. Most candidates were more confident with **Question 2**, in which they had to analyse data relating to island biogeography.

Section B gave a scenario in which scientists were attempting to look for population changes in weevils threatened by parasitic wasps. Although not an investigation likely ever to have been carried out by candidates, the principles of sampling and estimation of population size should have been familiar. Some candidates would have benefited from greater familiarity with these techniques.

Comments on specific questions

Section A: Data analysis

Question 1

(a) (i) This question involved rearranging a simple equation in order to calculate the stroke volume of an amphibian. Almost all candidates could do this, though a few misread the data or left the answer lines blank.

(ii) Physiological data is often stated as units per kilogram body mass or per gram body mass. This question asked candidates why this was done. Nearly all candidates realised that physiological measurements would often be in proportion to body mass, but not all appreciated that this manipulation would allow figures to be more comparable.

(b) Several ways to address this question were possible. Most candidates considered the fact that rats have a double circulatory system, but many described the differences between the rat and the other animals in Table 1.1 without providing an explanation for the higher blood pressure of the rat. Good responses used correct biological terminology and linked relevant biological knowledge to explanations.

(c) Some candidates showed sound understanding of the comparative physiology of open, closed, single and double circulatory systems and were able to address the question in detail, referring to the mixing of blood from the systemic and pulmonary systems. Few contrasted the gas exchange and circulatory systems of insects with those of vertebrates. A number of candidates, who were unsure of the meaning of partial pressure of oxygen, described differences in blood pressure and so duplicated the responses already given in part **(b)**.

(d) (i) Some candidates gave excellent responses to this part of the question. Many candidates identified the effect of low temperature on metabolic activity and the requirement for oxygen. There were also some well-expressed answers that considered the higher solubility of oxygen in colder waters linked to decreased cardiac outputs. Some candidates had misinterpreted the question and stated that the fish has a low metabolic rate since it needs to minimise heat loss in order to conserve energy.

(ii) Most candidates gave the correct answer.

(iii) Many candidates gave good answers and described the consequences of increased activity, including increased muscle contraction, increased aerobic respiration and the need for more respiratory substrates. Not all expressed these consequences in terms of an increase, appearing to overlook the fact that the fish still respires when at rest.

Question 2

(a) This question was generally very well answered with most candidates describing the positive correlation between island area and species number. The best answers were supported with the use of comparative data or appropriate data manipulations. Explanations usually referred to larger islands having more habitats and niches, less competition and greater availability of resources.

(b) (i) Almost all candidates correctly plotted the data points on the grid, although not all selected appropriate scales for the space available.

(ii) Most candidates realised that they needed to draw a line of best fit on Fig. 2.1 and then use the second graph to read off the extinction rate.

(iii) Most candidates correctly described the negative correlation between the number of species and the rate of extinction. A significant number then made a link between island size and extinction rate.

(c) Candidates were expected to describe how isolation of one population from another could result in allopatric speciation and change over time. Most candidates gave a reasonable answer to this question although a logical sequence of events was often missing or confused. Candidates were

not as familiar with ideas of geographical isolation, allopatric speciation and selection pressures as expected.

(d) Most candidates recognised the difficulties in identifying species and ensuring that no species have been overlooked. Many also considered difficulties in defining what a species is and recognised that the species richness of an island may be of a transient nature. Fewer considered difficulties in assessing extinction rates, such as having incomplete data and uncertainties over lines of best fit.

Section B: Planning

Question 3

Candidates were required to plan an investigation into the effect of releasing parasitic wasps used for biological control of a pest weevil species on other species of weevil living in grassland adjacent to farmland.

Most candidates had a sound level of understanding of the problem and were able to devise a plan that would work in practice. Some candidates gave the required level of detail in the methods that they described for carrying out the investigation. Others omitted details of sampling and how population sizes could be determined.

A suitable hypothesis was formulated by most candidates, but not all provided relevant supporting biological knowledge. Some candidates went on to state a null hypothesis, which is an important prerequisite to carrying out a statistical test.

The majority of candidates, but not all, identified dependent and independent variables. Similarly, controlled variables were also identified by most candidates.

Most of the risk assessments were limited. Specific risks (if present) should be identified together with relevant precautions to reduce the risk. Vague statements about ‘taking care’ are insufficient.

Some candidates formulated a suitable method for collecting valid data and described it in sufficient detail to allow a clear understanding of the intended method. Suitable methods included making estimates of population sizes of weevils both before and after release of the parasitic wasp, using a mark-release-recapture technique and the calculation of the Lincoln index.

Many candidates did not consider suitable sampling techniques with many suggesting throwing a quadrat into a field, rather than determining placement through the use of random number tables. Appropriate sampling methods such as pit-fall traps and sweep nets were described infrequently. Most candidates understood that captured weevils had to be marked, but many candidates suggested releasing the wasps after the first sample of weevils had been marked and before any had been recaptured. Some candidates marked the wasps with paint before release, which was unnecessary since it was the size of the weevil population that was being estimated.

Analysis and evaluation were described by most candidates with reference to a suitable statistical test and its possible interpretation. Although some candidates appreciated the complex nature of doing a field study in terms of uncontrolled variables, others had gaps in both their knowledge and their understanding of fieldwork methodology appropriate to this investigation.

BIOLOGY

Paper 9790/03
Case Study and Synoptic Essay

Key messages

- The Case Study may consist of material taken from one or more research articles or other sources, but the questions asked will all have a basis in syllabus learning outcomes. Candidates must always bear this in mind and attempt to include appropriate scientific knowledge and understanding when answering the questions. Some responses could have been improved by more factual content, so that conclusions made from observations were supported by biological knowledge.

- Mathematical skills are essential in all of the Biology examination papers, including Paper 3. Candidates should check all of their calculations carefully. It is sometimes wise to take a step back from the calculation and consider whether the answer given is a realistic and appropriate one. This also gives an opportunity to check that the correct unit, if required, has been used.

- 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 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 candidates personal preference, be it a bulleted list or spider diagram, but it can act as a prompt for the production of a well-balanced and coherent piece of writing.

- It is important that candidates consider all essay titles carefully before making a final choice. Sometimes, after careful consideration, an essay that at first sight appears difficult can be broken down into some straightforward topics.

General comments

On the whole, candidates did reasonably well on all areas of **Section A**. Some responses could have been improved with greater clarity and by inclusion of more detail.

The essay titles in **Section B** test the synthesis of ideas from across the syllabus, supported by suitable examples that relate directly to the learning outcomes. The essays of some candidates demonstrated evidence of reading around the subject and further research; many of these were of a high quality. Features of the best essays included a high level of planning, a good balance of ideas, a thoughtful synthesis of ideas and an ability to debate or argue, rather than simple lists of facts.

Comments on specific questions

Section A: Case study

Question 1

(a) The majority of candidates described the effects of a mutation that leads to changes in water movement across membranes. Some candidates omitted information about protein synthesis and movement of proteins into membranes.

Before answering a question like this, candidates should take account of mark allocation and structure their answer appropriately.

(b) Most candidates gave very good answers that linked selective disadvantage, low allele frequency and recessive alleles with the occurrence of these diseases. The best responses were clearly expressed and included application of relevant knowledge about recessive alleles, genetic crosses and phenotypic ratios.

(c) This mathematical calculation of probability proved to be challenging for a large number of candidates. A few were unable to multiply fractions correctly. Many missed out the final stage of the calculation where a 1 in 4 ratio of offspring from a simple monohybrid cross needed to be considered.

Question 2

(a) Most candidates recognised that this question required an understanding of both cholera and cystic fibrosis and produced some good quality answers that covered most of the ideas expected. A well-constructed answer included a link between the number of CFTR proteins and the possibility of a protective effect of cystic fibrosis on the harmful effects of cholera. Other answers required more detail or omitted some important aspects of the process, such as changes in water potential as a result of the movement of chloride ions.

(b) (i) Some candidates gave good comparative descriptions that referred to data from the graph. Many candidates omitted to comment on the error bars.

(b) (ii) A range of relevant explanations were given for the choice of prostaglandin in the second study. The potentially harmful effects of cholera toxin and the action of prostaglandin in mimicking the effects of the toxin were the most common answers.

(b) (iii) Most candidates provided effective responses, with the majority identifying that one study found heterozygote advantage and the other did not. Many also noted other valid differences. Few candidates commented that in the first study the dependent variable was water loss, while in the second it was chloride ion secretion.

Question 3

(a) Candidates found this question particularly challenging. Many did not appreciate the need to explain why the allele frequency is *still* high.

(b) A number of candidates made the link between reduced sweat production in people with cystic fibrosis and in people who are heterozygous for the *ΔF508* allele and the low occurrence of this allele in hot countries. Some candidates were unable to suggest a likely explanation.

Section B: Synoptic essay

A number of candidates demonstrated evidence of reading around the subject and included concepts, ideas and examples that extended beyond the syllabus. Others were less confident or less well read, leading to more limited answers. Several of the essays revealed some originality in the organisation of subject matter and the style of the argument that was developed.

Question 4

Those candidates who appreciated the meaning of ‘proteome’ were able to engage effectively with this title and make links to a range of topic areas with which they were familiar. Stronger candidates used a clear line of explanation and argumentation to form the bulk of the essay content.

Relevant issues for consideration included the significance of mutation, the generation of variation during meiosis, various forms of genetic modification and a discussion of the possible consequences of these changes to the genome. For the proteome, candidates could have discussed the need for changing protein expression as cells grow and specialise. A small number of candidates discussed the need for constancy in the proteome for the proteins involved in fundamental life processes, such as respiration. A discussion of conserved proteins would have improved the quality of responses of some candidates.

Although a number of candidates described gene therapy, few broadened their discussion to consider other medical implications. Areas that could have been covered included the diagnostic implications of differences

in the genome and proteome and the possibility of creating different drugs designed to treat people with specific features to reflect the variation that exists in the genome and in the proteome. This introduces the idea of personalised medicine.

A few candidates misread the question and answered it in terms of 'the human genome and proteome' instead of 'a human's genome and proteome'. Although many relevant issues were still explored, it meant that the essay had an emphasis on evolutionary change in a population as opposed to the uniqueness of the individual.

Question 5

The quality of response to this essay was very varied. Relevant areas for consideration included discussion of the relative importance for plant growth of genetic factors and environmental factors, as well as the role of plant growth regulators.

Discussion of genetic control could have included well-known examples such as the determination of flower structure, leaf shape and other anatomical and physiological characteristics of plant growth. Similarly, environmental factors could have included the influence of light and gravity on the growth of plants, with a discussion including tropisms and the variation seen in plants growing in a variety of habitats.

Both genetic and environmental factors act in part through the action of plant growth regulators. The plant growth regulators are coded for genetically and may in turn act on the expression of other proteins that determine growth. Similarly, the environment may affect the expression of plant growth regulators and have a huge impact on how they bring about growth changes in plants.

Many candidates focused almost exclusively on the role of plant growth regulators and omitted to consider the more fundamental genetic factors and environmental factors. Some candidates gave excellent accounts of the molecular basis behind the actions of IAA and gibberellins but their responses would have benefited from the inclusion of other ideas to give a more balanced and better argued essay.

Question 6

This essay was intended to be a discussion of the niche concept and its importance in environmental studies. The quality of essays varied considerably. Some accounts were particularly well balanced and well structured but others tended to be lists of facts about niches and the environment without further development.

The best essays often started by defining the niche, with examples, and then moved on to the importance of the niche concept in terms of conservation, the species concept and the changes in niches that occurs during succession, adaptive radiation and speciation. The importance of understanding an organism's niche in terms of the study, conservation and possible reintroduction of that species was well described in the better essays.

It was clear that candidates who had read extensively around the topic were better able to produce a balanced and well-argued account of the topic.

BIOLOGY

Paper 9790/04
Practical Biology

Key messages

- There was evidence that candidates had benefited from reports on previous examination series and from the experience of using past papers. While this is to be welcomed, some candidates tried to include marking points from previous examinations that were not appropriate to the practical exercises in this examination. For example, **Question 1** in this paper did not involve timing to an end-point and in **Question 2**, leaves do not have style scars.

- Candidates are expected to make some decisions about how they conduct the investigation in **Section A**. Sufficient practical details should be given to allow someone else to repeat their procedure. Unlike the planning question in Paper 2, there is no need for candidates to include details that do not relate directly to the procedure to be followed, e.g. by identifying independent and dependent variables. Nevertheless, candidates should state precisely how they intend to standardise variables or, if this is not possible, how they will take them into account.

- The three questions on this paper required candidates to apply their knowledge and understanding of the syllabus and to make decisions about the collection and presentation of results and observations. Some candidates did not show the depth of knowledge required to explain their results in **Question 1** or to analyse the result of their chi-squared calculation in **Question 3**.

- Candidates will always be expected to evaluate their procedures and the data that they collect. In general, credit will not be available for identification of errors and limitations that should have been avoided by candidates in their own procedures, given the materials, apparatus and time available. Candidates should also not assume that points of evaluation that applied to investigations from past papers can be applied universally.

- In **Question 2**, drawings often had lines drawn on them to show the measurements made in order to calculate magnification. Such lines should be placed with greater care to avoid obscuring relevant details.

- Candidates should appreciate when it is appropriate to round up figures in calculations and the appropriate number of significant figures to use. Several candidates made rounding errors in **Question 2(a)** when calculating magnifications.

General comments

Candidates need to have strategies to deal with anomalous results. Two types of anomalous results were apparent in the results collected for **Question 1**. The first type is where an individual result is not concordant with replicate measurements made under the same conditions. In these cases, candidates should consider reasons as to what caused the result to be anomalous. This can influence a decision as to whether a further repeat to replace the result should be carried out or whether the result can be validly excluded from any analysis.

The second type is apparent in processed data where a result for a particular set of conditions does not fit the apparent trend shown by results collected under different conditions. In deciding whether or not such results are anomalous, consideration should be given to the scatter in repeats under the same conditions, the confidence in the underlying trend against which the result is being judged and the extent to which the result deviates from the expected trend. There should also be awareness that it may be possible to fit more than one trend to the data, each time suggesting that a different result is the anomalous result.

Some candidates collected results that clearly conformed to the second type of anomaly and identified them as such. Others identified results as anomalous when the deviation from the perceived trend was relatively small and no replication had occurred to allow an assessment of variability. Such judgements could not be supported from the evidence.

In addition, although several candidates' results indicated that there was a threshold alcohol concentration below which there was no effect on cell membranes, they only considered the possibility of a linear relationship between alcohol concentration and leakage of betalains. As a result, they identified results at low alcohol concentrations as anomalous because they were trying to fit the data to a trend that was not supported by their data.

A few candidates suggested that a failing of the investigation in **Question 1** was the lack of a preliminary (or 'pilot') investigation to trial a number of different issues before starting the main investigation. This is good practice and is an aspect of practical work that could be incorporated into practical training for future candidates.

The quality of observations in **Question 2** showed improvement over previous years with increased accuracy of drawings and associated information, including annotations and magnifications. Some candidates showed excellent understanding of the chi-squared test in **Question 3**.

Many candidates did not count the asci correctly in Fig. 3.2 and many made errors in the steps in parts **(b)(iii)**.They were then unsure about how to state a null hypothesis and how to interpret the result of their calculation of the chi-squared value.

Nearly all candidates interpreted chi-squared values correctly. Many correctly went on to state that the null hypothesis (there is no significant difference between the observed and expected results) should be accepted. There were some very good answers that demonstrated an understanding of the convention to use a threshold at $p = 0.05$ against which to evaluate significance and some candidates took this further by defining the actual range within which the value for p could be found.

Comments on specific questions

Section A

Question 1

This question involved an investigation of the effect of alcohol (a mixture of ethanol and methanol) on the permeability of membranes of beetroot cells to the pigment betalain. Part **(i)** required candidates to give an outline procedure for taking results using a colorimeter. Answers to this question revealed that few candidates knew how this would be done. Candidates carrying out a preliminary or pilot investigation found that there was no significant difference between 60% and 100% alcohol and so were able to narrow the range for the main investigation.

(a) Many candidates stated that betalain molecules are too large to pass through the membrane. Better responses referred to the polar nature of betalains and their inability to pass through the phospholipid bilayer. Few explained that it is the hydrophobic interior of the bilayer that provides the barrier to movement of polar molecules. Some candidates explained that there might not be any transport proteins in the tonoplast, but few referred to the absence of proteins specific for betalain transport.

(b) All candidates were able to estimate the concentration of betalain in the solution. A few could not match the concentration in the sample to a particular concentration standard and so gave a range of concentrations. This was a perfectly acceptable response. Some candidates were more precise in their estimations than could be justified.

(c) Many candidates used the full range of concentrations between 0% and 100% alcohol and included sufficient intermediate concentrations. Most used an interval of 20% between successive concentrations and prepared these by proportional dilution. Some candidates omitted 0% in their table of dilutions. A small minority prepared other concentrations by serial dilution but did not stress the importance of stirring, shaking or, even better, inverting the specimen tubes several times before removing samples to use in the next dilution in the series. All candidates made a suitable table to show how to prepare the solutions and included one or more relevant details of their procedure, such as using separate syringes for the alcohol solution and for distilled water. Many used a smaller syringe to dispense smaller volumes to reduce measuring errors.

(d) This question prompted a wide range of responses. Some candidates knew exactly what was required and included sound ideas that were written concisely. A number of candidates gave very simplistic accounts of their method and included trivial steps, such as numbering specimen tubes. They also tended to repeat information from page 3 of the paper rather than giving specific details about their method. For example, many candidates stated that they cut uniform discs from the cores of beetroot without describing how they achieved this. Similarly, some candidates explained that they used a method to standardise the shaking or stirring of the test-tubes without describing how they achieved this. Some candidates stated that they kept the temperature constant because the test-tubes were kept at room temperature. Better answers included a check that the temperature was recorded at the beginning and end of the investigation. Some candidates placed their test-tubes into water-baths to maintain a constant temperature, which was a much better idea.

(e) Almost all candidates used a single table for their results. Tables showed the column for the independent variable to the left of the column for the dependent variable, with suitable headings given to both. Replicate results, when collected, were included with means. Candidates should be reminded that anomalous results, if present, should also be shown.

Results should be recorded to a consistent and appropriate level of precision. Some candidates quoted results to variable numbers of decimal places.

Few candidates were unsure about how to record their results.

(f) It is encouraging to report that almost all candidates presented suitable graphs. A small number plotted the axes the wrong way around. Most drew straight lines from point to point, rather than lines of best fit, showing that they were uncertain about the trend in the results. Such lines must not be extrapolated beyond the range of data. Where results for 0% alcohol had been collected these should have been plotted.

Most candidates used suitable scales although some used axes that were far too short.

(g) Almost all candidates gave a suitable description of the data, but many were unsure how to explain the trend that they described. Very few candidates made use of information earlier in the question that the investigation concerned the effect of alcohol on membrane permeability. Common errors were to state that alcohol disrupts cell walls and bursting of the tonoplast follows endosmosis.

Few candidates commented on any anomalous results that were identified in tables or graphs, either by explaining why they were identified as anomalous or how they were dealt with. Some candidates ignored obvious anomalies in the lines that they plotted for the means of their results in part **(f)**.

Few candidates made any reference to their results for 0% alcohol. This was an important result since the appearance of some betalain in the water shows that the other results were probably an overestimate of the effect of alcohol on the membranes.

Explanations of trends using knowledge of plant cell structure and membrane structure were generally limited. Some candidates' results showed a very gradual increase in betalain concentration with increasing alcohol concentration at first, followed by a very steep increase towards the higher concentrations. No candidates either recognised that such a pattern suggests the existence of a threshold alcohol concentration below which alcohol has no effect or attempted to explain this in some other way. Similarly, candidates recognising in their results that there was no further increase in betalain concentration when alcohol concentrations exceeded 80%, omitted to comment on this although sensible explanations could have been expected.

(h) The evaluations were quite variable. All the points on the mark scheme were seen and some very good answers were given that showed insight into the limitations and errors inherent in this investigation.

A number of candidates referred to marking points from previous examination series that were not relevant here. For example, many candidates referred to the difficulty of judging the end-point but no candidates, in fact, conducted the experiment in such a way that the term could be correctly employed.

Many candidates stated that the method used was 'qualitative', but the results presented by all candidates were semi-quantitative since they used judgment in matching colours to give results in quantitative terms.

Some candidates stated that a limitation of their investigation was the range of alcohol concentrations. In fact, most candidates used the full range of alcohol concentrations from 100% down to 0%. The limitation should have been identified more precisely as the number of intermediate concentrations that were tested.

(i) Some candidates gave generic answers that did not consider details specific to this context and descriptions were often lacking in detail. Few candidates realised that readings would need to be standardised against 100% alcohol rather than distilled water.

Of those considering the specific requirements of the question, a number suggested that beetroot discs should be added to colorimeter tubes filled with 100% alcohol and that continuous measurements could then be taken in the colorimeter. It is unlikely that such an approach would be successful. Better candidates realised that sequential sampling would be required, with each sample placed in turn into a colorimeter to gain absorption or transmission values. Additional details that demonstrated further thought were included by a few candidates, such as replacing the sample into the specimen tube after taking the colorimeter reading, filtering or centrifuging samples to remove debris, taking readings very close together to allow determination of initial rates and explaining how to plot a graph and use a tangent to determine initial rate. Some explained that they would make multiple identical tubes and use each one for a specific sampling time.

Many candidates recognised that calculations of $1/t$ were needed to find the rate but most did not design a suitable method that would allow such a calculation to be carried out, for example by measuring the time taken for absorbance (or transmission) to reach a specified value corresponding to a betalain solution of known concentration. A few described how to plot a calibration graph and then used this to convert absorbance (or transmission) readings to betalain concentrations. This permitted rates to be determined with non-arbitrary units.

Section B

Question 2

Ivy-leaved toadflax, *Cymbalaria muralis*, is a flowering plant that grows on walls. In part **(a)**, candidates made observations on a whole leaf and in part **(b)** they tore the lower epidermis from a leaf and made a temporary preparation to observe the arrangement of cells in this tissue. Some candidates labelled and annotated their drawings in ink, rather than making use of a sharp pencil.

(a) Most of the drawings of the whole leaf were adequate, but they were often accompanied by quite detailed annotations that were not required by the question. Many candidates did not look closely at the leaves so did not draw the lobes with small points or draw the venation pattern in any detail. No candidates labelled the blade or petiole of the leaf and few labelled the mid-rib or any of the veins. Almost all candidates determined the magnification of their drawing. Few drew a scale bar with most drawing a line across, or alongside, the leaf to show its actual dimension as a means to show how they had calculated the magnification.

(b) In **(i)**, there were some very good drawings of small regions of lower epidermis showing one or two stomata surrounded by guard cells and epidermal cells. Other drawings showed little resemblance to the lower epidermis of ivy-leaved toadflax. The epidermal calls resemble jigsaw pieces and in the better drawings these were shown very well. Many candidates, however, lacked accuracy in representing their shapes. Details of guard cells were rarely shown. The inner cell walls (adjacent to the pore) are much thicker than the outer cell walls and, unlike the surrounding epidermal cells, guard cells have chloroplasts. Labelling of stomata and guard cells was good, although some candidates incorrectly referred to the epidermal cells as epithelial cells.

In **(ii)**, some candidates found it difficult to describe what they had done. Many measured the stomatal aperture, but magnifications were not very realistic if drawings were out of proportion. Many candidates knew the calibration of the eyepiece graticule under high power ($\times$400) and were proficient at the required calculation to derive magnification.

(c) Candidates were generally successful at comparing the appearance of the lower epidermis of *C. muralis* with that of *Iris* shown in Figure 2.1. There were some excellent observations on the appearance and organisation of epidermal cells and guard cells in *Iris* and most candidates commented on the regular arrangement of the stomata in *Iris*. Some candidates noticed the ratio between epidermal cells to stomata and gave very detailed and valid observations. Some candidates referred to the size of guard cells and their overall shape, which is more rounded in *Iris* than in *C. muralis*.

Question 3

(a) Not all candidates were able to explain why crossing over occurs in meiosis and not in mitosis. Some candidates were confused about the distinction between chromosomes and chromatids.

(b) A number of candidates made counting errors in **(i)**. In such cases, error carried forward was allowed so that candidates were not penalised for the same error on more than one occasion. In **(iii)**, a significant number of candidates made errors, such as recording *O* and *E* the wrong way around, calculating values incorrectly, leaving the minus sign on the row showing the squared figures and dividing by the value for *O* rather than *E*. As a result, few candidates calculated the correct answer.

The null hypothesis in **(b)(iv)** was often not expressed clearly. Many candidates referred to the chances of crossing over occurring, rather than expected and actual results.

Many, but not all candidates, identified the number of degrees of freedom correctly. Some candidates knew exactly how to interpret their value for chi-squared in **(b)(vi)**, even if it had been calculated incorrectly in **(b)(iii)**. Many candidates chose the correct critical value at $p = 0.05$ and went on to state correctly that the null hypothesis should be accepted because their calculated value was lower than this threshold value. Other candidates took a different approach and rather than only considering the significance at $p = 0.05$, looked for the p values between which their chi-squared value fell at 1 degree of freedom. This allowed them to conclude that the value of p for this investigation was between 0.10 and 0.50. This detailed approach suggested a very thorough understanding of this statistical test.