BIOLOGY

Paper 9790/01
Structured

Key messages

- Time spent noting the key command word or words in the question, assessing the instructions in the question (e.g. which figure or table to refer to) and considering what ideas are relevant and not relevant to answer the question is time well-spent. Candidates benefit from planning their answers and being selective in the points they make given the limited time and space they have to address each question.
- Better performing candidates express ideas precisely, using the most appropriate biological terms. They realise that different terms have subtly different meanings, e.g. gene/allele, species/population.
- Classification is of fundamental importance for the study of all other aspects of biology and the principles of the Linnaean system should be reinforced throughout the course, for example, by giving expanded titles to practical drawings.

General comments

Scripts showed a range of ability and achievement. Better performig candidates showed an impressive depth and breadth of knowledge, sophisticated skills of analysis and deduction and the ability to intelligently discuss and integrate new information. In the middle range, marks were lost mainly through lack of attention to detail and imprecise description of ideas. Candidates who performed less well suffered from a lack of remembered facts and were more likely to misinterpret the demands of the question. Most candidates attempted all or nearly all of the questions and wrote free-flowing responses.

There was some confusion with the term plasmolysis, which is not a term applicable to animal cells.

Comments on specific questions

Section A

Candidates found **Questions 14**, **15**, **16**, **19** and **20** the most challenging, with **Questions 4**, **5**, **7**, **9**, **12**, **13** and **18** causing problems for some, and to a lesser extent **Questions 1** and **5**.

Questions 15 and **16** required an understanding of how to interpret a χ^2 test result. Many candidates were confused as to what their calculated value of 11.56 meant in terms of comparison with Table 14.2 looking at three degrees of freedom. It is useful to explain that the smaller a χ^2 value, the better the data fits the original hypothesis (here, that the two genes assort independently), while the larger the value of χ^2, the greater the difference between the hypothesis expectation and the data. Here, the value showed the results were different to those expected at a significance of between 0.01 and 0.001, so the hypothesis should be rejected as the large difference cannot be due to chance effects.

Question 14 was challenging because it required candidates to make logical deductions from data. Similarly **Question 4** required candidates to base judgements on the data rather than relying on learnt information.

Questions involving multiple judgements proved to be more difficult, for example **Questions 7**, **9**, **12**, **13**, **18** and **19**. For **Question 19**, the commonest wrong answer was **A** as candidates thought *Plasmodium* was pathogenic when in its *Anopheles* mosquito host.

For **Question 20**, candidates needed to state the letters of all the structures that produce carbohydrase enzymes; many candidates identified only one or two of the three. The comparative idea in **Question 5** confused some candidates. In **Question 1**, success required familiarity with both names and events in the cell cycle.

Section B

Question 21

This question used a *Bromus* flower image and experimental data to explore wind pollination, advantages of self-pollination and the development of allergies to pollen.

(a) Many candidates scored maximum marks. Candidates generally had knowledge of a list of features of a wind-pollinated flower. A few struggled to apply their knowledge in the context of a photograph of a *Bromus* flower, confusing the words 'stamen' and 'stigma' and wrongly described the flower as having feathery anthers and dangling stigmas. Descriptions were sometimes inaccurate, such as the anthers hanging outside the plant instead of outside the flower.

(b) Better performing candidates made comparative and interpretive comments about the data, sometimes involving mathematical processing, and describing one or more advantages of self-pollination. Candidates generally made clear that bagging the flower allowed only self-pollination.

(c) (i) Most candidates gained two or more marks. The role of the constant region in binding to mast cells (in this question context) was not often suggested. The variable region was wrongly referred to by some as a receptor site or active site.

(ii) Candidates did well on this question, with most understanding that the monoclonal antibody binds to the IgE molecule itself, hindering the binding and function of that antibody.

Question 22

This question examined aspects of mammalian physiology, cell biology and biochemistry linked to red blood cells.

(a) This question was done well by candidates who not only understood the oxygen dissociation curve of haemoglobin but also had the ability to put their understanding into words without ambiguity. Candidates who struggled did not clearly distinguish between the two variables involved, the partial pressure of oxygen in the surrounding plasma and the saturation of haemoglobin molecules with oxygen. Candidates generally followed the prompts in the question and began with oxygen loading in the lungs. Some did not realise that following the curve from right to left helps to explain the subsequent dissociation. The strongest answers showed understanding of cooperative binding and the significance of the steepest part of the curve.

(b) Candidates applied their knowledge of the roles of lysosomes and smooth endoplasmic reticulum to the context of their absence in erythrocytes. Some candidates gave the normal role, rather than the consequence of the organelle's absence which is that it is *not* able to fulfil the role. Candidates need to respond to the question that is asked, including when the question is phrased in a negative way.

(c) (i) Most candidates referred to glycolysis and anaerobic respiration in explaining how ATP can be produced without mitochondria.

(ii) Many candidates suggested that a lack of mitochondria meant that oxygen being transported would not be used up in respiration. The commonest incorrect answer was that less energy or resources were needed to make mitochondria. A few candidates mentioned oxidative stress.

(d) Most candidates gave reasoned explanations for why the quantity of RNA decreases during the development of a mature erythrocyte involving either the absence of DNA to code for mRNA, or the lack of ribosomes making mRNA redundant.

(e) (i) This question required knowledge to be placed in the context of interpretation of a photomicrograph. Candidates showed good understanding of the basic principles of osmosis and the direction of travel of water molecules from a high water potential inside the abnormal cells to a low water potential in the surrounding glucose solution. Some did not specify which cells they were discussing; the abnormal crenated cells or the normal biconcave discs. Many candidates could not explain why a proportion of the cells still appeared normal. Better performing candidates suggested that the cells may have been placed in the glucose solution only a short time before. The major error that occurred was referring to plasmolysis in the context of animal cells. While terms like isotonic, hypotonic and hypertonic are acceptable, candidates are expected to be familiar with the terminology of water potential to explain osmosis.

(ii) Many candidates showed detailed knowledge of the regulation of blood glucose concentration by the liver, referring to the effects of insulin and glucagon. Some mistakes were made with the spelling of terms like glycogenesis, glycogenolysis, glycolysis and gluconeogenesis.

Question 23

This question required candidates to interpret new information about a variety of unfamiliar named proteins that interact to control the cell cycle.

(a) Most candidates integrated the question information with their own knowledge to state that MPF plays a role in the breakdown of the nuclear envelope.

(b) Many candidates precisely described the action of an endopeptidase in terms of the hydrolysis of peptide bonds within the polypeptide. Some candidates did not pick up on the idea of an endopeptidase and answered in terms of general enzyme active site conformation with no biochemical detail of the reaction occurring when cohesin in broken down by separase.

(c) (i) The majority of candidates related folding to forming the correct shape of the active site.

(ii) Most candidates interpreted the diagram correctly and stated that securin blocks the active site of separase.

(d) There were many very good answers to this, with candidates integrating knowledge and question information to explain how ubiquitination triggered cell cycle transitions. Generally, the metaphase to anaphase transition was described best; stronger answers related an absence of cyclin at the end of mitosis to chromosomes de-condensing and the nuclear envelope re-forming.

(e) Candidates mostly realised that inhibition of proteasomes would stop the essential degradation of the cell cycle proteins after they have performed their roles.

Question 24

Classification, triglyceride structure, behaviour, selection and conservation were covered in this question on aspects of the biology of coho salmon.

(a) Strong candidates achieved two marks on this classificiation question. Weaker candidates frequently used a small letter to begin the genus name '*Homo*' or a capital letter to begin the species name '*sapiens*'. Some were not familiar with the names Mammal, Primate and Hominidae,

(b) Knowledge of triglyceride structure was generally good but some candidates wrongly thought that a single carbon-carbon double bond in more than one chain makes a triglyceride polyunsaturated.

(c) The analysis of the innate and learnt behaviour of the coho salmon at different stages of its life cycle was done well, with candidates applying their knowledge of the principles of behaviour to the species-specific information given. Some candidates misread the information about rheotaxis and made contradictory statements, saying that the smolts showed positive rheotaxis and the adults negative.

(d) Candidates mostly answered this in terms of a large surface area to volume ratio in the young alevin, allowing gas exchange through the skin. A frequent incorrect idea was that the diffusion distance was short, which showed a lack of appreciation that the young fish have a circulatory system.

(e) The commonest correct answers were that the death of the adult salmon reduces predation or competition for food.

(f) (i) Only a minority of candidates got this right and drew a double hump to represent disruptive selection. The idea of two competing male strategies involving two extremes of the length distribution was missed by most candidates.

(ii) Candidates who had shown a distribution attributable to directional selection in favour of generally smaller body length in **(f)(i)** got a mark for error carried forward if they named directional selection in **(f)(ii)**.

(g) (i) Many candidates gained marks by referring to decreasing genetic diversity and the loss of alleles. The strongest answers explained the source of the genetic diversity in the different sub-populations as a result of local selection pressures or mutations.

(ii) Answers often focused more on the importance of conservation strategies than on their use, or sometimes only on strategies and not on the reasons for enacting them. Candidates should be reminded to attempt to answer all parts of a question. A good range of examples of conservation strategies was seen from those who did consider this part of the question, including examples specifically relevant to the salmon context, such as fish ladders over dams. Many candidates mentioned keystone species and some considered the SLOSS debate in their answer. In general, the breadth of knowledge and degree of enthusiasm shown in answers to this question were impressive.

Question 25

Only the strongest candidates scored highly on C4 leaf anatomy but the link to using immobilised enzymes to process maize syrup provided most candidates with an opportunity to earn two marks.

(a) Some candidates wrote about C4 biochemistry rather than anatomy, which did not gain marks. Many mentioned bundle sheath cells; only some knew that in C4 plants these have chloroplasts and that they are themselves surrounded by a ring of mesophyll cells.

(b) The products of the light dependent reaction were well known. Few candidates completed the description of the relationship by stating how these are used in the light-independent reaction.

(c) The commonest correct answers were that xylem vessel elements are wider or have thicker walls. The way of distinguishing the two types of cell needed to be visible when viewed under a light microscope.

(d) Benefits of using immobilised enzymes that were frequently given were that they can be re-used, do not need to be separated from the product, are more thermostable and have a longer shelf-life.

Question 26

This question considered mating strategies in the dunnock.

(a) Many answers could have been improved by specifying whether male or female birds were being discussed. For example, a male and female share overlapping territory in the monogamous strategy but female territories do not overlap; this was not clear from answers that just referred to territories that do or do not overlap.

(b) Most candidates correctly selected polyandry and most specified that the young would receive more food from the male parents; others suggested the female parent would be the recipient.

(c) The general direction and layout of a reflex pathway were well-known, with most candidates gaining two or three of the marks available. The strongest answers combined anatomical knowledge (e.g. dorsal root ganglion) with ultrastructural details (e.g. synapse, neuromuscular junction) and adapted their knowledge to the question context (e.g. the effector was specified as muscles around the beak contracting). A minority of candidates wrote that the impulse goes to the 'spine' instead of 'spinal cord'. Some candidates used inappropriate terms for a nerve impulse, such as 'signal' or 'message'.

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Paper 9790/02
Data Analysis and Planning

Key messages

- 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.
- 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.
- 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 question and is in sufficient depth for a Pre-U qualification.
- When planning an experiment or procedure, a clear logical structure ensures 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 this paper ***Section A*** was split into two questions.

The first question explored the presence of two transaminase enzymes in the human body, AST and ALT, and their use in the diagnosis of liver damage.

The second question compared the structure and function of the gut from three different animals, including the diversity of their microbiota.

Section B asked candidates to plan an investigation into the effectiveness of a new antibiotic, teixobactin.

Candidates did very well on both sections of the paper and used the data effectively. Some areas of theoretical knowledge were weak at times, but most areas of data analysis were done well. The planning exercise included some very well written and concise plans.

Comments on specific questions

Section A: Data Analysis

Question 1

This question presented candidates with data concerning two transaminase enzymes, AST and ALT. The candidates had to explain what transamination is, consider AST and ALT as indicators of liver damage and finally use some data to carry out patient diagnosis.

(a) Candidates were asked to use the diagram to explain transamination. This was poorly answered with two main reasons for candidates losing marks:

- some candidates did not refer to the diagram and gave very general accounts of transamination; this prevented them from gaining full marks. It was expected that at least one of the molecules shown in Fig. 1.1 was mentioned.
- a number of candidates appeared to be under the impression that transamination involves the transfer of an R-group from one amino acid to form a different amino acid.

There was also a lot of confusion between essential and non-essential amino acids.

(b) For this question, a description of glucose biosensors was required; it was clear that some candidates had not learnt this information. Other descriptions were generally good.

(c) For this question, candidates were asked to link the presence of ALT enzyme in the cytoplasm of hepatocytes with damage to the liver. Most candidates made a good attempt at this. Others tried to link the damage to the liver to transaminase reactions rather than damage to liver cells and the release of enzyme into the blood.

(d) Candidates were expected to link the location of AST (primarily in mitochondria of a wide range of cell types) and its relative short half-life to its role as an indicator of liver damage. Most candidates realised that it is found in a variety of tissue types; fewer linked it to its location in mitochondria. Better responses considered its short half-life as a possible drawback in using it as a diagnostic test.

(e) (i) Almost all candidates were able to calculate the blood AST concentration from a ratio of 0.8:1.

(ii) Most candidates worked out which people could be diagnosed with the two types of liver damage. Some candidates wrongly assumed that there would be only one person with each diagnosis.

(f) For this question, candidates had to link the presence of AST in mitochondria and the relatively large number of mitochondria in hepatocytes, with alcohol damage to the liver. This application of knowledge proved challenging for some candidates but was still well answered by most.

Question 2

Question 2 looked at the differences and similarities between different regions of the gut in three different animals – a herbivore, a carnivore and an omnivore.

(a) Largely a factual recall question, this proved relatively straight-forward for most candidates. A few candidates appeared not to know the functions of the different regions of the digestive system.

(b) Most candidates answered this question well. There were a few made minor errors where some candidates:

- compared the values for the three animals but did not offer any explanation.
- compared the total intestine length (from Table 2.2) instead of the ratio values. Others compared values from Table 2.1 instead of Table 2.2. This mainly comes down to not reading the question carefully.

(c) Candidates were asked to comment on the volumes of the stomach, small intestine and large intestine for the horse and the dog. The majority of candidates answered this well and made valid comments. Answers that were purely descriptive or comparative gained some marks, but more was expected for full credit.

A small number of candidates did not read the question carefully and commented on the lengths and ratios instead of volumes or included the wild boar when it was not asked for.

(d) Some candidates had not learnt adaptation of ciliates.

(e) This question asked for methods of identifying different species. DNA fingerprinting or DNA hybridisation would not, in this case, be suitable methods.

(f) This question was effectively asking if candidates could recall the equation for a diversity index such as Simpson's. Most candidates performed well.

(g) This was an evaluation question in which the validity of a claim was put under scrutiny. Most candidates performed well, being able to select relevant information from the data and gave both sides of an argument.

Section B: Planning

This section required candidates to plan an investigation that could be carried out to determine the effectiveness of the antibiotic teixobactin.

Generally, candidates who were familiar with aseptic technique and microbial culture found this reasonably straightforward and performed well.

Overall, most candidates included a reasonable hypothesis that was backed up by relevant theory.

The independent variable was clearly identified by most candidates as the concentration of the antibiotic. The dependant variable was also correctly stated by most candidates but depended on the method they chose to investigate bacterial growth. These included colony size, numbers of colonies or turbidity of bacterial broth.

Controlled variables were listed by some candidates, but many appeared to forget that factors such as incubation temperature needed to remain constant.

The risk assessment was a vital aspect of this planning activity and took the form of several marking points – safe preparation of materials and workspace, safe working procedures, and safe disposal of materials after the experiment. Most candidates, in particular those who were familiar with aseptic technique, performed well here.

The method itself was very well presented by the majority of candidates. A range of different methods was acceptable including antibiotic discs on bacterial lawns or adding the antibiotic to bacterial broth.

Analysis and evaluation was attempted by most candidates but a number of candidates decided to use a t-test for what was obviously a correlation between their chosen dependent and independent variables. Credit was given for repeats, means, standard deviation and suitable descriptions of graphical presentations.

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Paper 9790/03
Case Study and Synoptic Essay

Key Messages

- Candidates must take 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 the biological examination papers, including Paper 3. Candidates should check all their calculations carefully. It is sometimes wise to momentarily take a step back from the calculation 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 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 list or mind-map, but it can act as a prompt to produce 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, a '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 takes material from a research article and presents it in an accessible way to candidates. Structured questions are then asked that pertain to the research, the results and any conclusions that are drawn from the study. In this case, the topic was the Innate® potato and its production and properties.

Section B is composed of three unstructured questions requiring responses in the form of a discursive essay, from which candidates must choose one title. The essay titles are aimed at testing candidate's knowledge of the syllabus but may also elicit responses that show greater depth of reading around the subject. Essay titles are likely to cover a range of topic areas. The ***Section B*** responses this year were of a good standard overall with some well-planned and logical essays. All three titles were attempted by candidates.

Comments on Specific Questions

Section A – Case study

Question 1

Question 1 focussed on the production methods and genetic modification of the potato plant as well as possible concerns people have with the technology.

(a) This question asked candidates to suggest a possible mechanism for silencing gene expression. A good level of response was seen from the majority of candidates. Many candidates confused transcription with translation.

(b) (i) This question relied on factual recall of the stages of PCR. This was generally quite poorly answered. Many candidates did not mention specific temperatures or if they did, they were incorrect. Others got stages confused or in the wrong order, with many using RNA primers and RNA polymerases. Few mentioned that the process was repeated.

(ii) The definitions of promoters and marker genes proved challenging for a large number of candidates. Many linked promoters to DNA replication or even translation. A common misconception appeared to be that potato cells containing the antibiotic resistance gene could be selected for by using antibiotics.

(iii) This was poorly answered. A simple description of the use of *Agrobacterium tumefaciens* to modify plant cells was required. Many candidates appeared to start at the 'end' of the story after the bacterium had already been modified and so gained few marks. Better responses gave a full account of the modification of *A. tumefaciens* and subsequent infection of plant cells.

(c) This questioned the possible concerns that people have with genetic modification by gene silencing. On the whole, it was very well answered with some reasonable suggestions.

Question 2

This question focused on the benefits of gene silencing in the Innate® potato, both economic and nutritional. It also presented data on the effects of gene modification on the potato itself.

(a) Both economic and nutritional benefits of gene silencing were expected. Most candidates did very well on this question with some well-constructed explanations. When marks were lost it was often due to simply not mentioning which product was being discussed – polyphenols or asparagine.

(b) A very well answered question in which candidates described the effect of gene silencing on asparagine concentration and potato yield. The most common error was with reference to the standard deviation bars. Some candidates simply talked about the size of the bars rather than discussing the extent to which they overlap. A few candidates forgot to mention standard deviation at all.

(c) The majority of candidates were able to state that glutamine was not being converted to asparagine; far fewer went on to explain why.

(d) (i) A number of candidates found the transport of materials in the phloem a challenging question to answer. Many of the descriptions were wrong and few went into sufficient detail.

(ii) This question prompted some good answers. Other responses simply stated that the amino acid was too big to be transported.

Section B: Synoptic Essay

All the essays this year proved popular with candidates. 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.

It was clear that candidates who had read extensively around the topic were far more able to produce a balanced and well-argued account compared to candidates who made little reference to any biological material not on the syllabus.

Question 3

All living things rely on the Sun to survive.

Discuss the extent to which this is true.

This was a popular essay with some centres. A well-structured introduction was given by many candidates, in which an overview of the importance of the Sun was discussed.

Most essays covered a good range of topics, focussing primarily on the role of light in photosynthesis. This often led on to a description of the products of photosynthesis and in some cases, the role of producers in the maintenance and functioning of food chains and ecosystems. Better responses also went on to mention the Sun as a source of heat, as well as its influence on evolution due to UV radiation and mutational effects. Some also mentioned behaviour and effects, such as phototropism and photoperiodism. Relatively few candidates considered the climatic effects of the Sun and its effect on survival.

Well balanced essays also considered the counter argument and gave detail of life that exists apparently without energy from the Sun. Some excellent background reading was evident in a number of essays.

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

Question 5

Describe the applications of stem cell research and discuss the implications of this area of research.

This essay title was popular across all centres and produced some work of a high standard. Most essays included a good introduction in which definitions of the different types of stem cells were given as well as descriptions of the cells' origins. It was noted that several of the weaker essays lacked these simple definitions. Many essays then went on to describe the uses of stem cells in a variety of contexts, including gene therapy, tissue replacement and drug testing. In better essays, the ethical and moral arguments were also discussed. The use of extended reading and interesting examples to support the argument was also a strength of the candidates who chose this essay.

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

Question 6

'Biologically the species is the accumulation of the experiments of all its successful individuals since the beginning.' HG Wells, A Modern Utopia. 1905

Discuss this statement.

In some centres, this was a very popular choice of essay. Candidates dealt with the structure of the essay in different ways. Many dissected the statement and considered the various aspects, including general evolutionary principles, such as survival of the fittest, natural selection and speciation. Others took a less structured approach and gave an account of classical Darwinian evolutionary theory. Some unusual examples of evolutionary change were seen.

For this essay it was clear that those candidates that had written a plan performed much better than those who had not. The latter occasionally produced rambling accounts of evolution rather than a well-structured discussion of the statement.

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

BIOLOGY

Paper 9790/04
Practical

Key messages

- Candidates should read questions carefully and pay close attention to the command words used to ensure that give an appropriate type of response.
- Candidates should read carefully the purpose of the investigation in **Question 1** as part of their initial reading of the question and anticipate what they will do in the practical.
- Dilution tables and results tables should always include the names of the variables involved and appropriate units.
- Candidates should use sharp pencils to draw graphs, make their drawings, label lines and write their labels.
- Calculations should be clearly set out to enable error carried forward to be applied if appropriate.
- It is important that candidates have experience of all of the practicals and the different histological specimens as stipulated in the syllabus to be fully prepared for this examination.

General comments

All additional pages must contain all the relevant information about the candidate and be attached firmly to the script. Replacement and continuation answers must be indicated. Centres should issue official additional paper or booklets for candidates who need them.

Graph drawing was good, with only a small number of bar charts rather than line graphs in **Question 1(e)**. Most chose sensible scales that made it easy for them to plot points and determine the mannitol concentration with the same water potential as the potato tissue. Some candidates used scales where 15 cm represented 0.1 mol dm^{-3}. These graphs cannot be read easily and often resulted in inaccurate plotting. It was rare to see the changes in mass multiplied by 100 to make them easier to plot.

It was clear that not all candidates were familiar with the Spearman's rank test. It is important to ensure that canidates work through examples of all the required statistical tests prior to the examinations for this syllabus.

Comments on specific questions

Section A

Question 1

This question asked candidates to investigate plasmolysis in epidermal cells of red onion in **Part 1** and then determine the water potential of potato storage tissue in **Part 2**.

(a) Candidates began this practical investigation by preparing two pieces of onion epidermis in a solution of potassium nitrate (slide **A**) and distilled water (slide **B**). The drawings of a single epidermal cell in slide **A** generally conveyed the appearance of a typical plasmolysed cell in the tissue. Two lines should be used to represent the cell wall. Most candidates showed that the cytoplasm had pulled away from the cell wall leaving a gap between the cell wall and the cell membrane. Most included a nucleus; in some cases these were drawn between the cell wall and the cytoplasm rather than surrounded by cytoplasm.

Some candidates made excellent drawings to show the pattern of plasmolysis with strands of cytoplasm (Hechtian strands) still attached to the cell wall. Others drew a turgid cell from slide **B**,

as well as the plasmolysed cell from slide **A**. These answers did not gain any extra credit for this. Some wrote lengthy paragraphs beneath their drawings. Candidates should always plan their drawings so that there is space for annotations so that they are associated with what is shown and kept brief and to the point. Most candidates stated the obvious differences between the two cells but comments on differences on the intensity of pigment in the two cells were not seen very often and even fewer stated that the gap between the cell wall and the cell membrane would be filled with the potassium nitrate solution.

(b) There were many good answers to this question. A number explained that water entered the cells 'down a concentration gradient' rather than down a water potential gradient. Some candidates maintained that the cells 'burst' when irrigated with distilled water. Very few referred to the pathway taken by most of the water through the cell membrane and the tonoplast into the vacuole. Some did refer to the partially permeable nature of cell membranes.

(c) Almost all candidates used appropriate proportional dilutions to produce five or more mannitol solutions within the range 0.0 to 1.0 mol dm^{-3}. Common errors were to express the concentrations as percentages of the stock solution rather than in mol dm^{-3} and some omitted the word *volume* from two of the headings in their tables. A few candidates used serial dilution, which often gave far too many solutions with water potentials much higher than the water potential of the potato tissue. Almost all included water in their range of dilutions. Most used concentrations that differed by 0.2 mol dm^{-3}; fewer by 0.25 mol dm^{-3}.

(d) The presentation of results was generally good. Very few candidates calculated the percentage change in mass of the potato cylinders. Almost all were consistent in their use of decimal places or significant figures in recording their results and in indicating whether the potato cylinders had increased or decreased in mass by using plus and minus signs. Errors were to omit units from column headings and to construct headings so that they did not cover all the relevant columns, leaving some columns without headings. Some candidates omitted the independent variable from their table and instead referred only to test-tube numbers. Where the concentrations of mannitol were given, they often went from highest concentration to lowest. It is conventional to go from the lowest (at the top of the column) to the highest as this makes graph plotting much easier. Some headed their column 'concentration of solution' rather than 'concentration of mannitol'. Candidates should take care when labelling test-tubes as some had clearly muddled them, as evidenced by a reverse trend to that expected.

(e) Most graphs were given full credit. A few candidates could not fit the full range of concentrations into the scale that they had chosen and used a broken axis to show a gap between 0.8 mol dm^{-3} and 1.0 mol dm^{-3}. In this instance, the trend line for such a graph should also be broken. Candidates who calculated the change in mass without indicating whether the change was an increase or a decrease, drew graphs from which it was difficult to extract the data required in **(g)** and **(h)**. Candidates who calculated and then plotted percentage changes often found it much easier to make good use of the graph paper, compared with those who simply used changes in mass.

(f) This was the first of the questions that asked candidates for an evaluation. There were some answers that showed that candidates had thought about this specific practical investigation, showing the steps that they had taken to collect high quality results. The majority gave simplistic answers, such as 'I cut the cylinders accurately', without explaining how they did this. Reasons for the precautions were not expected and not credited.

(g) There were many good answers to this question. Most candidates used their graphs to estimate the concentration of mannitol with the same water potential as the potato tissue by interpolation. A few omitted the units – ideally mol dm^{-3}, but % was also accepted. Most explained that they found the concentration at which the mass of the potato would not change. Many stated that at this concentration there would be no *net* movement of water between the surrounding solution and the cells in the potato tissue. The candidates who did not record whether their potato cylinders increased or decreased in mass inevitably had difficulty in answering this question.

(h) (i) Most candidates calculated the water potential correctly. A few omitted the minus sign and/or the unit.

(ii) The expected result was within the range of the two values taken from the two scientific papers, but all relevant comments were accepted in light of the estimate given in **(h)(i)**. The most common error was to ignore the minus sign and state that the estimated water potential was 'greater' or 'higher' than the values given by the two scientific papers. None had a water potential greater than –100 kPa. Candidates who had read the information in the question closely, stated that the temperature was not 20 °C and that this may be the reason for any difference.

(i) **(i)** In this evaluation question, candidates tended not to write about random errors. Instead, giving systematic errors or about faults with their procedure. For example, some wrote about the potato cylinders being exposed to air and about drying the potato cylinders before weighing - precautions that should have been decided beforehand and recorded in **(f)**. Many gave shortcomings of the apparatus or their practical abilities (human error), rather than the strategy of immersing tissues in different concentrations for a limited length of time.

(i) **(ii)** Candidates had some good ideas for improving their investigation. Among the routine suggestions were repeating the investigation and using more intermediate concentrations. These suggestions only gained credit if candidates stated that the results from repeats should be used to calculate mean changes in length or mean percentage mass changes. Some candidates correctly stated that these additional concentrations should be either side of the estimated concentration given in **(h)(i)**. Less common suggestions were leaving the potato cylinders longer in the bathing solutions until there was no change in mass. A pilot investigation could find the most suitable immersion time and could also be used to trial other strategies. For example, some candidates stated in their answers to the earlier questions that some of the potato cylinders were not totally immersed in the mannitol solutions.

Section B

Question 2

This question asked candidates to make a drawing of a section of a mammalian ovary and concentrate on the detail of the Graafian follicle. The question required candidates to annotate their drawings with functions of the structures within the Graafian follicle.

(a) **(i)** Almost all candidates responded to the instruction to make a large drawing of the ovary. Some drew the whole section of the organ; some drew half of the organ and some drew a sector that included primary follicles and at least one mature Graafian follicle. All of these strategies were given credit. Many omitted to show the germinal epithelium as two lines close together forming the outer tissue of the organ, as would be expected in a plan diagram. The quality of most drawings was adequate with clear lines and no feathering or shading. Many drawings would have been improved if a sharp pencil had been used. Some candidates showed an excellent knowledge of the histology of ovarian tissue and labelled many structures. Some only labelled the three structures listed..

(ii) Some candidates were able to give succinct, relevant annotations that were factually accurate. They had clearly practised this important skill.

(iii) Many candidates drew a line on their drawing of the ovary and stated its length in centimetres or millimetres. They also gave the equivalent length in eyepiece units (epu) and gave the conversion factor to millimetres. Most of these candidates gave magnifications between ×15 and ×80, depending on what exactly they had drawn. When less working was shown, it was difficult to award instances of partial credit. Some candidates measured the length or width of the section on the slide with a ruler. This was acceptable and if this is possible, it is a much quicker method and involves less explanation.

(b) There were some very good answers to this question on the electron micrograph of a primary follicle. Most candidates identified typical cellular features, such as mitochondria, cell surface

membranes and nuclei; other features specifically related to the histology of the ovary were not identified.

Question 3

The first part of this question involved the use of a dichotomous key and was generally very well-answered. The second part of this question focussed on the Spearman's rank test.

(a) Most candidates used the key to identify the external parasites correctly.

(b) (i) There were many appropriate null hypotheses given in response to this question. A common error was to give null hypotheses that would be used with the chi-squared test or *t*-test rather than for a test of correlation.

(ii) Almost all candidates completed a calculation and derived a value for r_s. However, most did not rank the two columns in Table 3.2 in the same way so that their value for r_s was far from the expected answer of –0.969.

(iii) There were many good answers to this question. Few of those who calculated a negative value for r_s stated this in their answer. Very few commented on the strength of the correlation. Many candidates went on to comment on the relevance of this relationship to the prevalence of malaria, even though this was not asked. Often these comments were written in the style of those that would follow a chi-squared calculation.