BIOLOGY (US)

Paper 9184/13
Multiple Choice

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

General comments

There was a good spread of scores. The questions that candidates found relatively straightforward were **Questions 3, 6, 12, 17, 21, 24, 33, 34, 35 and 37.** The most difficult questions were **Questions 1, 5, 8, 20, 32 and 39.**

Comments on specific questions

Question 1

The majority of candidates did not realise that an eyepiece graticule can only be used to determine the length of cells if it has been calibrated against a stage micrometer scale. Additionally the size of the eyepiece graticule does not change as the objective lens is changed.

Question 2

Whilst most candidates understood the use of standard form and answered this question correctly, a minority were unable to manipulate the figures to obtain the answer.

Question 5

The relative difficulty of this question was due to the majority of candidates being unaware that chloroplasts, mitochondria and prokaryotes all contain circular DNA. Therefore options **A**, **B** and **C** are incorrect.

Question 8

Whilst most of the more able candidates answered this correctly, a minority of less able candidates did not understand that condensation reactions are used to form amylose and amylopectin, whilst hydrolysis reactions break them down.

Question 9

A small number of candidates found this difficult. Candidates should know that amylose is formed only from α-glucose.

Question 20

A significant number of candidates did not take into account the size of the cell labelled 4. Cell 4 and the cell to the right of it have been produced recently as a result of cytokinesis. Cell 3 is at least 3 times larger as a result of the G phase in interphase allowing the cell to proceed to prophase.

Question 21

All of the more able candidates were able to process this information and answered correctly.

Question 25

Whilst most of the more able candidates had no difficulty with this question, more than half of less able candidates incorrectly thought that stomata are likely to close when atmospheric humidity is high.

Question 27

Analysis of the responses to this question would indicate that whilst almost 90% of the more able candidates knew the answer, the less able candidates just guessed.

Question 29

In order to answer this question, candidates needed to apply their knowledge of plant transport in a novel situation. They should have been able to eliminate statement 4, since active transport does not affect the transpiration stream. Statement 3 should be eliminated as more water will be transported to the leaves (along with the heavy metals) when the plants photosynthesise.

Question 32

Most candidates found this question difficult as they did not know that all four substances are found in blood, lymph and tissue fluid. Many did not realise that fatty acids will be found in all the fluids.

Question 39

The majority of candidates do not understand that the least efficient energy transfer in a food chain is always between the sun and the producer.

BIOLOGY

Paper 9184/23
AS Structured Questions

Key Messages

- Candidates should read questions all the way through before answering part **(a)** of each question and then should rehearse their answers in their minds before writing. When appropriate, they should use key scientific terms and sequential responses.

- When using the term 'transmission' or phrase 'mode of transmission' as applied to an infectious disease, candidates should consider the transfer of the pathogen from the infected person to an uninfected person. Descriptions of transmission should begin with the infectious person and should include the sequence of events that lead to the pathogen gaining entry into the uninfected person. In **Question 2(c)**, the phrase aerosol infection or droplet infection is a useful way to complete the tabular summary of the transmission of tuberculosis (TB). If asked for a written description, the following is an example of a complete response: 'droplets containing *Mycobacterium tuberculosis* are released into the air when an infected person coughs or sneezes; these airborne droplets are inhaled by an uninfected person'. This can be compared to: 'airborne droplets are taken in by an uninfected person', which is incomplete and does not include the name of the pathogen, or state that the pathogen is contained within the droplets, or state the origin of the airborne droplets.

- In **Question 2 (a)(i)** and **(d)**, a number of candidates referred to the role of memory cells as part of their response, with only some of these producing clear statements. As a general note when answering questions involving knowledge of memory cells, candidates should realise that there are memory B-lymphocytes and memory T-lymphocytes, but not a general memory cell that, during the secondary immune response, forms both more B-lymphocytes (plasma cells) and more T-lymphocytes.

General comments

Many candidates coped extremely well with this paper, showing an excellent grasp of the wide range of subject matter assessed. These candidates gauged well the level of detail required to answer successfully the parts of each question and produced well-organised and well-expressed accounts in the more extended responses. Others could have improved their overall performance by producing more detailed responses to fully answer the question: this was particularly apparent in **Question 3(a)** and **(b)**, and **Question 5(a)**. Some candidates clearly had large gaps in their knowledge and were not able to write enough on many part-questions to gain much credit. All questions discriminated well, with **Question 1**, followed by **Questions 2** and **6**, proving to be the most accessible and **Question 5** the most challenging.

Question 1 was a short, straightforward question, especially for those candidates who had a good grasp of the structure of biological molecules from ***Section B*** of the syllabus. This question contained many scientific terms and some candidates could have benefited by being more confident as to the meaning of these terms. For example in **Question 1(b)**, it was clear that many did not know the meaning of the term 'polymer', as named monomers were frequently seen. In **Question 2** knowledge of the definition of infectious disease was generally good. The response given by many candidates for the definition of vaccination was too vague and lacking in scientific knowledge. The importance of a sound understanding of scientific terms was also highlighted in **Question 4(c)**, where a large proportion of candidates gave a complete description of water movement from the roots to the leaf and out to the atmosphere when asked to describe the process of transpiration, and in **Question 5(c)**, where a number incorrectly described translation rather than transcription.

In **Question 3**, many candidates gave correct details in part **(a)** by explaining how glutamycin could act as a competitive inhibitor for the enzyme GluTR. Some then went on to give an 'either' 'or' choice by continuing

to write details about non-competitive inhibition. This was not appropriate for this particular question and it meant that full credit could not be given for the first part of the response.

Most candidates, including those who did extremely well overall, were able to complete responses using the printed lines provided. Some of the best responses in the extended answers were so concise and succinct that less than half the number of lines was required for full credit to be awarded. Those that required extra space, particularly when answering **Questions 3(a)** and **4(c)** could have improved their response by planning their answer first and considering whether any part of it was not relevant to the question.

Question 6(b) was aimed at assessing candidate knowledge and understanding of structure to function for arteries and capillaries from ***Section G*** of the syllabus. Many did very well on this: others gave structural features accompanied by only more general functions of the blood vessels.

There appeared to be sufficient time for candidates to complete the paper and the blanks that were left in the script indicated gaps in knowledge rather than lack of time. **Question 3(c)** parts **(i)**, **(ii)** and **(iii)**, about the relationship between *Rhizobium* and legumes, was most frequently left blank.

The responses for most candidates were clearly legible, although there were also quite a few scripts where it was difficult to read answers because of extremely poor handwriting.

Comments on specific questions

Question 1

Many were very familiar with the biological molecules shown in Fig. 1.1 and ***Section B*** of the syllabus and so steadily and easily worked through the very short answers required for each part-question. Some of these candidates gained full credit for the complete question. Those lacking in knowledge appeared to use a lot of guesswork and some very illogical incorrect answers were seen.

(a) Most candidates were able to identify **B** as a nucleotide in part **(i)**. Parts **(ii)** and **(iii)** required another step in the thought process as candidates were required to mentally match the bond type to a molecule and then identify the molecule in Fig. 1.1. More knew that peptide bond formation was matched to molecule **D**; fewer knew that ester bonds were present in molecule **A**.

(b) (i) This was the most challenging part of **Question 1**. Generally the candidates who knew the correct answer were those that performed well overall. Glycogen was a correct response that was seen infrequently, with most who gained credit giving starch, amylose or amylopectin. Glucose was the most common incorrect answer and possibly some may have misread the question and thought that they were being asked to name molecule **C**. Cellulose was also named by a number of candidates, but as the monomer for this polysaccharide is β-glucose then it was an incorrect answer. There were quite a few that gave 'polysaccharide' as their answer.

(ii) Many gave clear, scientific answers for **(b)(ii)**, generally in terms of pointing out the double bond in the part labelled **2** compared to no double bond in the part labelled **1**, or by using the terms unsaturated and saturated. Some made sure of gaining credit by including both points. There were quite a few that only gave a descriptive comment of the different shapes seen, describing in various ways the continuous pattern of part **1**, or the parallel lines in part **2**.

(iii) Most knew that the question was about protein structure and many of these gave two correct R-group interactions. There were a number that only gained partial credit by including peptide bond as one of their choices, and some made it obvious that knowledge was lacking by only naming one bond and leaving the second line blank. A few gave tertiary structure and quaternary structure, presumably as two levels of protein organisation that display three-dimensional structure. Others gave main bond types such as peptide bond and ester bond.

Question 2

Using tuberculosis (TB) as a main theme, the subject matter from ***Sections I*** and ***J*** was assessed in **Question 2**. There was a great difference noted in the quality of response when defining vaccination and infectious disease, with far fewer giving satisfactory definitions of vaccination. Part **(c)** on the transmission of TB was attempted well by stronger candidates who ensured that detail was provided; others were much more vague or lacking the necessary detail to do well.

(a) (i) In their definition of vaccination, many candidates were able to explain or infer that vaccination did not cause the disease in the person; far fewer were able to state that the vaccine contained the (foreign) antigen and/or that the vaccine caused an immune response to be generated. A number gained credit by showing knowledge that specific memory cells were produced and some did give the full term used to describe the type of immunity provided. As noted in the general comments, some did not seem to understand that there is more than one type of memory cell. There were many answers that would have been improved by greater accuracy. Some were too vague to gain credit, for example "an injection to prevent an infection" while others did not refer to antigens and pathogens, for example "injection of dead infection". Many referred incorrectly to a vaccine as a medicine to prevent disease.

(ii) There were many that gave correct detail in defining infectious disease to gain full credit. Most concentrated on the meaning of infectious, with the best responses using the term pathogen and explaining clearly about transmission of the disease. Examples of the types of organisms that are considered pathogens or the modes of transmission were not required and in many cases were surplus to the response, but in others formed the entire response. In these instances, credit could not be given if more than one correct type of pathogen was given and if there were a number of different modes exemplified to show an understanding of passage between organisms. Only a few completed their response with an explanation of 'disease'.

(b) A very high proportion of candidates had a good attempt at part **(b)** and gave at least one valid suggestion from the list of expected points. Candidates could gain full credit with only one suggestion accompanied by extracted comparative data from Table 2.1 to support their point. Values comparing India and Swaziland were frequently given to support the explanation of how number of cases per 1000 000 population took into account the population size of the country.

(c) Many organised a well-expressed and full description of the transmission of TB. The best responses noted that the pathogen, *Mycobacterium tuberculosis* occurred in airborne droplets released from the infected person and gave examples of the way the droplets passed into the atmosphere. These responses continued with details of entry into the uninfected person and used the terms 'inhaled' or 'breathed in'. Some excellent responses also noted that transmission could occur by eating meat or drinking unpasteurised milk contaminated with the pathogen; others attempted also to state this but forgot to state that the meat or milk was contaminated. Quite a few gave the impression that all unpasteurised milk was unsafe to drink. Some did realise that the mode of transmission was airborne but did not mention the aerosol nature and a good number only stated that the organisms were present in the air ready to enter the uninfected person when breathing in the air. Some thought the droplets could land on food and enter via the digestive system. The weakest responses gave a list of different modes of transmission, clearly displaying their lack of specific knowledge about the disease.

(d) Almost all candidates gained some credit with knowledge that people with HIV/AIDS have a weakened immune system. Far fewer gave further explanations in terms of T-lymphocytes and of these only some gave correct details. A number thought that T-lymphocytes produce antibodies. Some gave relevant information about a lack of memory cells, the best of these made it clear that they knew that there are different types of memory cell.

Question 3

The extended response required for part **(a)** meant that candidates had to be diligent in giving a number of correct points and had to be confident about the nature of the inhibition and write only about competitive inhibition. Part **(b)** was generally well understood and those candidates that gained full credit for this question gave a number of correct features about active transport. Part **(c)** was most challenging for many candidates, with the best responses covering both sides of the mutualism shown between *Rhizobium* in their answers to parts **(ii)** and **(iii)**. There were various learning outcomes from ***Sections C***, ***D*** and ***K*** assessed in **Question 3**.

(a) The detail of glutamyl-tRNA and glutamycin shown in Fig. 3.1 made it very apparent to many candidates that the two structures were similar enough for competitive inhibition of enzyme GluTR to occur. As stated in **General comments** some candidates gave excellent descriptions of the features of competitive inhibition and would have done very well if they had not continued to describe all the details of non-competitive inhibition. In instances such as these candidates could still be credited for statements about: the similarity between the substrate and the inhibitor; the fact

that substrate cannot enter the active site; and for knowledge that there would be a slower rate of reaction. The latter two points were not always seen: frequently when both competitive and non-competitive inhibition were described, detail only about where the inhibitor would bind to the enzyme was given.

(b) Active transport was well known and many candidates were aware that a detailed response was required in order to gain full credit. These candidates ensured that they mentioned the involvement of a carrier or transport membrane protein in addition to stating points about movement against the concentration gradient and the requirement of ATP for the transport. The majority of those who gained partial credit did not remember to include points about the membrane protein. Some also gave detail about the conformational change involved in the transport protein. A high proportion of those that were aware of a membrane protein incorrectly stated that it was a channel protein, a type of protein used in facilitated diffusion but not active transport.

(c) (i) Most knew that nitrogen fixation was carried out by *Rhizobium*, although some wrote 'fixation' and did not gain credit. The weakest responses named other stages of the nitrogen cycle, or respiration, and even named stages of mitosis were seen.

(ii) If candidates had read ahead to part **(iii)** they would have realised that information about nitrogen fixation was more relevant to that part-question and part **(ii)** required more detail about mutualism and the advantage to *Rhizobium* of being in the relationship. The best responses used the term mutualism or mutualistic relationship and gave correct detail about the benefits to *Rhizobium* of living in the root nodules of the legume, briefly making a correct statement of the benefit to the plant. Most gave details that they repeated in part **(iii)** and did not mention at all how *Rhizobium* would be advantaged.

(iii) Although candidates often included two correct details here, there were some very confused responses seen. Strong responses were clear that the product of nitrogen fixation was ammonium, not nitrates, and that the plant could obtain the products directly rather than rely on events occurring in the soil to form nitrate to be absorbed. Many knew that amino acids and proteins could be synthesised for the growth of the plant.

Question 4

This question assessed plant transport from ***Section G*** of the syllabus. Part **(a)** required candidates to identify xerophytic features taken from Fig. 4.1 and could have been better attempted by a large proportion of candidates. Features of leaves of xerophytes are usually well known, so the additional process of identifying particular features from an image must have been more challenging for these candidates.

(a) In **(a)** some correctly described the location of the stomata as being in pits or crypts (or other acceptable wording) rather than just stating 'sunken' stomata, which is descriptive of stomata that are just below the plane of the epidermis, in a slight depression. Many identified the thicker cuticle and the trichomes or hairs. Some did spot the trichomes but called them cilia. Others named 'waxy cuticle' but as this is present in all leaves it could not be credited without the idea of 'thick'. There were many weak responses stating general features of leaves, and even weaker responses that named cell structures.

(b) The diameter of the vascular bundle was correctly calculated by many candidates. Fewer had noted the instruction in the question to give the answer to the nearest 100 μm to gain full credit, while others were not sure how to convert their measurement, made in cm or mm, to μm. There were quite a few that did not know the formula to use for the calculation and only made the measurement or left all of part **(b)** blank.

(c) The best responses did not require all the space provided as they gave very concise accounts that were packed full of the correct detail. Excellent responses seen were variations of the following: "Transpiration is the loss of water vapour from the leaves. Water evaporates from the surface of spongy mesophyll cells into the airspaces. The water vapour then diffuses out through open stomata into the atmosphere down the water potential gradient". Some candidates were confident enough to only start their account from the evaporation of water from the mesophyll cell wall but many others felt the need to write about water leaving the xylem, then note the apoplast and symplast pathways and/or give further detail about the transpiration stream. Where possible, these additional irrelevant details were ignored and points pertinent to the question were credited. Not all remembered to state that the water vapour left the leaf through *open* stomata or noted that it was

water *vapour* that exited. Many stated that water evaporated from the surface of the leaf or from the guard cells or stomata. A fairly common error was to state that water moved out of the leaf by osmosis.

Question 5

In this question, candidates were required to think about carriage of oxygen and haemoglobin from ***Section G,*** and then consider learning outcomes from ***Section F*** of the syllabus. Almost all parts in this question required extended prose and only the most focused and well prepared candidates gave sufficient detail in all parts to do well. Most found **(c)(iii)** to be very challenging and gave suggestions that were not feasible.

(a) Many came up with one good point, usually showing an understanding that respiring tissue will produce areas of low oxygen partial pressure. Others knew also that the partial pressure of carbon dioxide would be high, and some of these continued to explain how this would generate hydrogen ions within the red blood cell to combine with haemoglobin. Good responses knew the term haemoglobinic acid. Only some stated the Bohr effect as a term and few noted that the haemoglobin's affinity for oxygen would be lower in this situation. There were numerous responses that had a good general idea but could not give the precise detail required. For example, stating that actively respiring cells produce carbon dioxide but not qualifying this with the idea of a higher partial pressure of carbon dioxide. Another example was to state that haemoglobin had an affinity for carbon dioxide but not mention the affinity for oxygen. For those that knew that carbon dioxide combined with haemoglobin, only a small number knew that carbaminohaemoglobin was formed: many stated carboxyhaemoglobin. Many did not realise that they were required to think about carbon dioxide and only focused on describing the dissociation of oxygen from oxyhaemoglobin to pass into the tissues from the red blood cell.

(b) Many had a very good understanding that the increase in red blood cells was to compensate for the lack of oxygen that entered the circulation to be distributed to tissues, and generally responses were clear to explain this. A number gave further qualification to gain full credit. The fact that there would be a lower percentage saturation of haemoglobin was noted by some. A common error was to state that more oxygen could be carried at high altitude rather than to explain that overall the same amount of oxygen would reach the cells as at lower altitudes.

(c) (i) The best responses were very precise in the information provided about transcription. For example, stating that a copy of the DNA is made by synthesising mRNA from a DNA template strand is very clear. This is in contrast with responses stating that "mRNA copies the DNA", which imply that mRNA is already present and that both strands of the DNA are copied. Some did give creditworthy detail about the process, noting the requirement for RNA polymerase and the presence of RNA nucleotides. Imprecise references to DNA and RNA carrying 'the code' were commonly seen; not all candidates seemed to know the difference between the genetic code and the idea of DNA as a molecule containing coded information for the production of a polypeptide.

(ii) As with **(c)(i)**, there were some excellent responses that used correct scientific terminology to give a detailed sequential account, contrasting with many vague or confused responses. Stronger responses showed an understanding that a mutation is a change in the sequence of nucleotides (or bases) in the DNA that is then present in the mRNA formed. There were good descriptions of the consequential effect occurring during translation. Some candidates gave examples of types of mutation. Most responses that gained partial credit did so for their descriptions of how a change in primary structure of the polypeptide formed would affect the tertiary structure and hence function of the protein.

(iii) Those candidates that had gained credit for **(c)(ii)** had thought carefully about the process of transcription and made suggestions as to how a protein could prevent some stage of this process in **(c)(iii)**. Hence there were, for example, acceptable statements about inhibiting the enzyme involved in unwinding the DNA double helix and statements about preventing the attachment or progression of mRNA polymerase. Most did not go down this pathway and wrote about transcription factors as mutagens or suggested that they prevented the mRNA from exiting the nucleus. Others wrote about hindering transcription.

Question 6

Part **(a)** of this question made links between ***Section H*** and ***Section G*** by looking at the effects of smoking on arteries. Part **(b)** assessed knowledge of artery and capillary structure and function.

(a) (i) To gain full credit, candidates needed to use correct scientific terminology, such as 'the lumen is narrower' rather than 'the artery is smaller' and, for example, references to the build-up of atheroma rather than just stating that 'the artery is partially blocked'. Frequent incorrect descriptions were to state that tar had built up on the artery wall, or to state that the artery walls were thinner. Some thought the atheroma was a large blood clot.

(ii) All the correct points were seen in responses. Answers needed to address the question directly and explain how the arteries were affected. It was not sufficient for candidates to state that nicotine caused an increase in blood pressure; the response here should have continued by stating that this could lead to damage to the tunica intima, which could ultimately lead to atheroma formation. Some candidates were still focused on tar and erroneously stated that nicotine would make it easier for tar to collect.

(b) (i) Many knew a correct structural feature of the artery wall but fewer took this feature to link it directly to a function. Credit was awarded for a full, correct description of a general function of arteries. Most candidates described a thicker muscular wall as a structural feature, but a common error was to think that this allowed stretching under high blood pressure. Stronger responses correctly noted the elastic tissue present in the arterial wall as having this function.

(ii) Candidates knew that capillaries had thin walls or walls that were one cell thick. Some were less careful in the way that they worded their response and stated that the capillaries had thin cell walls. For a function, candidates needed to explain more than stating 'easier' diffusion. Many good responses wrote about the short diffusion distance. Others wrote about the small cross-sectional area of the capillary allowing all body cells to be reached. Weaker responses were less clear and wrote about capillaries delivering blood to the tissues, a function that could be assigned to arteries and arterioles.

BIOLOGY

Paper 9184/35

Advanced Practical Skills 1

Key Messages

Candidates should be encouraged to learn the methods for the tests for biological molecules, such as for the Benedict's test. The volume of Benedict's solution must be the same or more than the volume of the sample being tested and the temperature of the water-bath must be maintained at 80 °C or up to 100 °C. As this test was being used to compare concentrations of glucose in **S3**, **G1** and **G2** the same temperature needed to be maintained for all the tests.

Candidates should be encouraged to understand the command terms used in the questions. For example, the term 'explain' should be understood to mean that scientific reasons are required to explain why, for example, the graph has a particular trend.

Candidates should be given the opportunity to estimate unknown concentrations from results for known concentrations. If the value for the unknown concentration is greater than the known concentration then the estimate must state this, e.g. the unknown concentration is greater than 1.0%. If the value for the unknown concentration is between two known concentrations the answer must state this, e.g. the unknown concentration is between 0.1% and 1.0%. Candidates should avoid stating a concentration that has not been made, e.g. 0. 5%.

Candidates should be encouraged to evaluate and identify sources of error in an investigation such as the difference between a systematic and a random error. For example, if a thermometer reads 1 °C above the actual reading this would affect the true value of the result but not the general trend. A random error would include variations in the temperature of a room during the investigation.

General Comments

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

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) Many candidates completed the table correctly to predict the colour that was observed when the three samples **S1**, **S2** and **S3** were tested for starch.

Many candidates correctly predicted that for the extract taken in the middle of winter, the colour of the iodine solution would be blue or black (starch present), for the extract taken at the beginning of spring, the colour would be a lighter blue or lighter black (a small amount of starch present), for the extract taken in the middle of spring the colour would be orange or yellow or brown (no starch present).

(ii) The majority of candidates correctly stated that the reagent to be used to compare the concentrations of starch was iodine solution. Some candidates correctly described that the same number of drops or the same volume of iodine solution as well the same number of drops or the same volume of starch would be used in order to standardise the test for each sample.

(iii) The majority of candidates organised their results clearly by presenting a fully ruled table with all the headings. Most gained credit for recording the colour changes for the three samples. The better candidates recorded correct colours for **S1** (lighter blue or lighter black), **S2** (most blue or black) and **S3** (orange or yellow or brown).

The most common error was recording 'no change' for **S3** which was not accepted as a colour.

(iv) Most candidates gained credit for completing the table correctly, matching the samples with the time of year that each extract was taken from the root (**S2** the middle of winter, **S1** beginning of spring, and **S3** the middle of spring).

(v) The majority of candidates organised their results clearly by presenting a fully ruled table with all the cells drawn, and a ruled outer boundary. The better candidates included an appropriately detailed heading for the independent variable (samples) and the dependent variable (time / s). The most common errors were to omit the heading for the dependent variable or to include 'seconds' in the cells of this column or row.

The majority of candidates gained credit for recording the times as whole numbers. The better candidates recorded the time for **G1** as the longest time and the time for **S3** taking the shortest time.

(vi) Some candidates used their results to correctly estimate the concentration of glucose in **S3** as being greater than 1%.

The most common error was to make up a value for the concentration of glucose that had not been tested instead of stating that the value was between two known concentrations of glucose.

(vii) Many candidates correctly described a modified investigation to obtain a more accurate estimate of the glucose concentration in **S3** by testing more concentrations of glucose above 1% with Benedict's solution. The better candidates stated two concentrations of glucose such as 2% and 3%. Many candidates correctly suggested modifications such as using a thermostatically controlled water-bath, carrying out each test separately and repeating the experiment at least twice.

(viii) Many candidates correctly stated that by using the same syringe for measuring the volumes, the trend was not affected because the error was consistent. Some candidates correctly stated that if more than one syringe was used the accuracy of the volume put into the test-tube is affected and it will not be the true value.

(b) (i) The majority of candidates drew the graph, using the headings given in the table, with time in storage / days on the *x*-axis and mean percentage change in water content on the *y*-axis. The better candidates used scales of 5 to 2 cm for the *x*-axis and 5 to 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting each pair of points.

The most common errors were not including a full axis label for each axis, omitting the units for both the *x*-axis and the *y*-axis, not labelling the scale every 2 cm, and drawing lines which were too thick or not ruled

(b) (ii) The better candidates stated that the sample of ten roots stored for 20 days would have the highest percentage gain in mass after soaking in the dilute sucrose solution. Some candidates explained that the cells of these roots stored for 20 days had the lowest water potential and more water would diffuse or move by the process of osmosis into these cells.

The most common error was not providing an explanation in terms of water potential.

Question 2

(a) The better candidates used a sharp pencil to produce drawings which did not include any shading and used most of the space provided. Many candidates were able to draw one of the blood vessels with thicker walls than the other vessel and at least one of the blood vessels with at least two layers of tissue. The most common error was not showing any layers of tissues which would be observable using the microscope.

Some candidates used ruled label lines to describe (annotate) the layer lining the inside of the artery as being folded and the not folded in the vein. The most common error was not looking at the layer lining the inside of each vessel using a higher magnification.

(b) Those candidates who had experience of drawing cells as part of their course were likely to gain the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly and used most of the space provided.

The majority of candidates carefully followed the instructions by drawing the five whole white blood cells on Fig.2.1, showing the nucleus in each of these cells as a different shape and occupying most of the cytoplasm. Most candidates used ruled label lines to one cell to correctly identify the nucleus, the cytoplasm and the cell membrane as cell structures that can also be found in plant cells.

The most common errors were to draw lines that did not join up or drawing the nuclei as having the same shape. Candidates should be encouraged to draw what they observe.

(c) (i) Most candidates stated that the difference between the blood shown in Fig. 2.1 and that in Fig. 2.2 was the greater number of white blood cells present in Fig. 2.1. Many candidates correctly explained that the reason for this difference was the uncontrolled production of white blood cells.

The most common error was incorrectly linking the increase in the number of white blood cells to their role in defending against infection and that the increase in numbers of white blood cells was the response of the body to the cancer.

(ii) Many candidates showed the measurement of **P**, **Q**, **R**, **S** and **T** to the correct precision, showed the addition of these measurements and division by the number of measurements. The better candidates gained credit for showing the conversion of these measurements to micrometres by multiplying by the appropriate number and by showing division by 500.

The most common error was not showing how the conversion from millimetres to micrometres had been achieved.

(d) The better candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed Fig. 2.2 and the other headed Fig. 2.3. The majority of candidates were able to gain partial credit for recording appropriate differences.

BIOLOGY (US)

Paper 9184/43
A2 Structured Questions

Key messages

1. Candidates should be reminded to interpret question command words correctly. A glossary of terms is to be found in an appendix towards the back of the syllabus. 'Describe' and 'explain' are most frequently confused.

2. Candidates should practise combining their own biological knowledge with the contextual information provided in an exam question. There are many occasions when a memorised text book answer does not fully answer the question.

3. Candidates need more practice in interpreting and making sense of tables of data. They should use past paper questions and mark schemes to learn how to gain credit for quoting data and for describing trends in words as well as figures.

4. Candidates should be alerted to notice questions that ask for a comparison between two entities or processes, or a comparison between a situation at one time (such as the beginning of a process or experiment) and another. In these cases answers should be comparative, often using words like more/less, lower/higher, increased/decreased, etc. Examples such as these can be seen in **Questions 1(a)(ii)**, **1(b)**, **4(c)(i)**, **5(b)(ii)** and some marking points on **9(b)**.

General comments

There were many excellent scripts this year, with well-prepared candidates scoring highly. The candidates who did best were able to combine their factual knowledge with an ability to interpret the demands of the question and to understand and use new information from the question context. Careful reading of the whole question was needed for this.

Generally candidates were most successful on **Questions 1** (photosynthesis recall), **7** (genetics cross) and **8** (respiration recall). Questions that involved data handling (**Questions 3** and **4**) were lower-scoring. Both essays were done well by prepared candidates but in **Question 9** there was a tendency for candidates to be more knowledgeable about endangered species than about protoctists.

Comments on specific questions

Section A

Question 1

(a) (i) The precise location in the chloroplast of RuBP and GP was clearly given as the stroma by many candidates, although incorrect responses frequently referred to the thylakoids.

(ii) Most candidates correctly linked the change in concentration of RuBP to the reduced concentration of carbon dioxide over the time period. Further explanation needed was the idea of less carbon fixation or less RuBP converted to GP. A few responses noted that RuBP was also being reformed from TP. Candidates needed to refer to concentration changing rather than to 'amounts' or 'levels' to gain full credit.

(iii) The calculation frequently produced the correct answer of 0.01 arbitrary units per second. Incorrect responses were usually due to not noticing the instruction to give the answer to two decimal places.

(b) Few candidates explained that a decrease in GP concentration would lead to less TP being made, and that this is needed for the production of other organic molecules for growth. Some responses gained credit for stating that less carbohydrate, lipid or protein would be produced, but rarely were these linked to growth or *Chlorella* cell division. Candidates should note than a question about a decrease in a parameter refers to a changed situation over time. The answer therefore should also use comparative terms like 'less / decreased' to explain the resulting change over time in other parameters.

Question 2

(a) Candidates found it difficult to express their ideas clearly. The point most often stated was that cross-pollination involves two parents, not one, although some lost credit by saying two *flowers* without making it clear that these must be on different plants. Some candidates also made correct references to inbreeding or outbreeding. Candidates needed to select the correct term 'alleles' for explanations of how genetic variation occurs. It was a common error for candidates to think that the offspring of self-pollination are genetically identical. They did not consider that meiosis also occurs to form gametes for self-pollination so independent assortment, crossing-over and random fusion of gametes all still occur.

(b) It was rare to find a candidate who clearly described DNA sequencing, rather than just an application of electrophoresis. A correct description of automated Sanger sequencing needed to refer to modified PCR using chain-terminating dideoxynucleotides, followed by electrophretic separation of the different length DNA copies, plus the use of a laser scanner to detect the fluorescently tagged dideoxynucleotides.

(c) Most candidates scored full credit for suggesting cross-breeding the old and new *Silene stenophylla* to see if the resulting offspring were themselves able to reproduce. Errors included mention of 'viable offspring' rather than 'fertile offspring' being produced by breeding within a species, and answers that suggested a molecular approach such as electrophoresis.

Question 3

(a) (i) The symbols AABBCC were usually given correctly.

(ii) Candidates were more successful in explaining why hybrid AB was sterile than in detailing the events that led to polyploidy at point **Y**. Many candidates realised that meiosis could not occur in AB due to not all the chromosomes having a homologous partner, so gametes cannot be produced. However, despite clearly stating this in the first part of their answer, many candidates then argued that at **Y** some type of fusion of gametes occurred. In fact the unequal chromosome division leading to polyploidy occurs during mitosis.

(b) (i) Few candidates achieved full credit on this interpretation of data question. Candidates' analysis of the data and the experimental design was generally very limited.

Credit was available for giving a comparative data quote in a question like this, but in order to score this credit, candidates must use the correct units. In this instance, however, the figures referred to numbers of aphids, so no units were required unless a percentage had been calculated. As there were different starting numbers of aphids in each experimental set-up, both the starting and finishing numbers needed to be stated, or else a percentage leaving or remaining should have been calculated.

As well as illustrating their argument with figures, candidates should clearly state the key trends shown in the results in words. Thus they needed to say that in the presence of Eβf many aphids move away, but in the absence of Eβf very few or no aphids leave.

Few candidates commented on the different volumes of air used in the two experiments, and most assumed that the concentration of Eβf was higher in **Experiment 2** although the correct inference was that the concentration of Eβf in **Experiment 1** was unknown. Few candidates commented on the key distinction between **Experiments 1** and **2**, that in **2** the Eβf was pure, but in **1** other chemicals were present in the leaves.

(ii) Many candidates scored most or all of the available credit here but many are poor at writing brief, clear, factual answers. The key points were that Eβf makes aphids leave, and also attracts the predators of aphids, so aphids eat less wheat.

Some candidates confused the predators of aphids with aphids themselves being 'predators' (rather than herbivores) on the wheat. Others thought that the significance of attracting ladybird predators was that these insects would enhance wheat pollination. Students should be aware that wheat is in fact wind-pollinated.

(iii) The focus of the answer should ideally have been why the GM wheat is acceptable, not the perceived problems with GM maize and cotton. Given the phrasing of the question, the ideal answer would begin 'This wheat might be acceptable because...' and would then list the positives about it. Any negatives about Bt maize or Bt cotton that candidates knew about should have been reversed into a positive for the GM wheat to fit this question. It is this sort of sophisticated manipulation of their knowledge that many candidates need to practise.

Positives for GM wheat are that it is non-toxic to humans and is not a new chemical in the human food chain as it already occurs in peppermint, an edible plant. It does not kill insects directly so the aphids that move away are still available for their predators and the food web is therefore not disrupted.

Question 4

(a) (i) Candidates were mostly able to identify the spermatogonium and primary spermatocyte stages as being 2n or diploid and the later three stages as n or haploid.

(ii) Growth or mitosis were correctly suggested by most for the first stage of development but the answer 'maturation' for the second stage was sometimes spoiled by the inclusion of an additional wrong answer.

(iii) Providing nutrients for spermatids was the best-known role of a Sertoli cell. A few candidates were mistaken in thinking Sertoli cells make testosterone.

(b) Candidates from some Centres were well-prepared and their answers focused on administering an FSH-type drug, development of multiple follicles, use of hCG and retrieval of oocytes with a fine tube and ultrasound. The credit available for retrieving the oocytes from the ovaries was negated if candidates mistakenly stated that ovulation was induced by LH. In fact ovulation is deliberately prevented with an LHRH antagonist. Problems for some candidates included discussing the fertilisation and implantation processes rather than the obtaining of mature oocytes asked about in the question, and stating that FSH causes superovulation rather than development of multiple follicles.

(c) (i) Data-handling skills tested many candidates as in **Question 3(b)(i)**. The main problem on this question was failure to read the question. Candidates were asked to describe the effects of adding the hormones **after 48 hours**. It was not appropriate therefore to reference figures after 24 hours as many candidates did. One of the skills tested on data questions is the ability of the candidate to select the correct information for discussion. A further problem was that the figures were percentages and candidates performed subtractions to find the numerical difference between one category of treatment and another but then called this a percentage increase or decrease, which it was not. The last problem candidates showed was a sense of perspective and ability to weed out small fluctuations and attribute them as insignificant, as in the treatment with testosterone only. Most candidates showed no awareness that changes from the correct baseline reference point (no hormones added, 21%) of 10 (FSH) and 23 (both hormones together) are significant increases but that a change by 2 (testosterone) is a slight effect that could be due to chance.

(ii) This was generally well answered with death of cells being the most frequent correct response.

(iii) The best answers linked the natural temperature of the scrotum outside the body with the experimental conditions chosen. Candidates who wrote that sperm die at 37 °C were obviously not considering the survival of sperm for up to three days in the female reproductive tract. The key issue is that the spermatogenesis differentiation and development process does not occur as well

at the higher temperature, with decreases in sperm quantity and quality resulting from temperatures above 35 °C (in man).

Question 5

(a) Many candidates gained full credit here. The most common mistake was to include deletion or addition as a form of mutation. Very few candidates mentioned the random or spontaneous nature of mutation.

(b) (i) A straightforward description of the relationship between altitude and the frequency of the haemoglobin alleles was required here. Unfortunately many candidates failed to read the question properly and made no reference at all to alleles, only to the haemoglobin polypeptides with their different amino acids.

(ii) Most candidates gained partial credit. The situation at either high or low altitude needed to be described, with those mice with a selective advantage clearly identified and reference made to their increased likelihood of reproduction and passing on the (specified) favoured allele. Candidates should be encouraged to clearly identify the selection pressure and the favourable genotype and phenotype in questions about natural selection. Errors included descriptions of allopatric or sympatric speciation.

Question 6

(a) The ion channels, membrane depolarisation and the effect of strength of stimulus on frequency of action potentials were the more frequent correct answers. Few candidates seemed familiar with the terms 'receptor' or 'generator potential', while slightly more correctly fitted the term 'threshold' into the passage.

(b) A widespread problem with this question was candidates' determination to focus on the establishment of resting potential and the creation and stages of an action potential, when the question was instead asking about the transmission of action potentials along a neurone. Some incorrect answers even went beyond the neurone and described events at the synapse. A typical answer was largely irrelevant, only considering the transmission of the action potential via local circuits in the last two or three lines of the answer. As ever, the advice is to encourage candidates to read the question properly.

Candidates who did focus on the correct part of the process generally scored particularly well if their descriptions included the role of the myelin sheath and salutatory conduction between nodes of Ranvier.

Question 7

(a) Most candidates could name the centromere, although the spelling was not always correct.

(b) Some candidates were unfamiliar with describing genetic change of this magnitude. The words genes and loci were missing from some answers, which instead discussed base changes, frameshifts and alleles rather than missing genes in a section of chromosome. Few candidates made the link between genes, polypeptides and the resulting phenotype.

(c) This was very well answered with most candidates gaining full credit. A few thought the normal male had two X chromosomes, or possessed a faulty X_1 or X_2 chromosome.

Question 8

(a) There were some confused responses which did not gain credit, as they did not make it clear which function was carried out by which organelle. DNA needed to be linked to transcription or the coding of mRNA, and the ribosomes to translation or synthesis of proteins or polypeptides. A few good responses gained credit for naming a protein that a mitochondrion would need to produce. There was some confusion between ATP synthetase (the enzyme on the stalked particles of the

cristae) and ATPase (enzyme that hydrolyses ATP to ADP and inorganic phosphate), which lost credit for candidates who put the wrong name.

(b) The majority of responses correctly listed 2, 3, 4 in the order S, U, W and 6, 7, 8 in the order Q, X, T. The most common mistake was to reverse X and T. T following directly after S and U was allowed minimal credit. This exercise was well done even by candidates who scored poorly on the rest of the question.

(c) Most candidates recognised the splitting of the ATP molecule into ADP and inorganic phosphate as hydrolysis or dephosphorylation. Others provided acceptable alternatives, such as catabolic or exothermic. A significant number of responses incorrectly stated the reverse reaction of condensation or phosphorylation.

(d) Most realised that this would involve anaerobic respiration with a net gain of 2 ATP. Few candidates were awarded marks for the idea of substrate level phosphorylation occurring while TP was being converted to pyruvate in glycolysis. Many responses gained further credit for detail of the formation of lactate when pyruvate gains hydrogen, or for the regeneration of NAD, allowing glycolysis to continue.

A common error was to confuse the lactate pathway found in animals with the ethanol pathway, which would not occur in a tapeworm. Another error was to substitute the term 'dehydrogenation' for its opposite, reduction (of pyruvate to lactate).

Section B

Question 9

(a) Very few candidates could clearly summarise the similarities and differences between different members of the kingdom Protoctista. Most did not realise that, apart from sharing eukaryotic features, they are a diverse group with many differences in their cell structure and mode of nutrition. Candidates gained credit for stating that the group included organisms with and without cell walls, means of motility, multicellularity and the ability to obtain food through photosynthesis or by capturing other unicellular organisms. Ideally candidates would at least know that *Amoeba* or *Plasmodium*, *Chlorella* or another unicellular alga, and seaweeds belong to this kingdom in order to write a good answer.

(b) Most candidates named a relevant species, (elephants, rhinos, polar bears and giant pandas were popular), and explained that endangered meant that numbers had reduced to a point where the species was in danger of becoming extinct. It was rare to see a reference to the species being listed on the IUCN red list.

Most candidates correctly referred to hunting, habitat destruction or a decrease in food supply, together with further detail of how these factors impact upon the species in question. Competition, predators and disease were also referred to, but usually failed to gain credit as a decrease or increase in the factor was not specified. References to pollution were usually too vague to be credited as the pollutant and habitat affected were not specified.

Candidates from some Centres were very well-informed about local examples of endangered species in their countries, showing excellent teaching tailoring the syllabus to local issues.

Question 10

(a) Many candidates wrote very clear answers about the action of penicillin on bacteria, gaining full credit. Some areas to highlight for improved understanding include stating that autolysins are produced by the bacteria themselves and the reason for this (allowing cell walls to stretch during growth), including the explanation 'by osmosis' when describing water entering cells, and making reference to turgor pressure as the reason why cells burst.

(b) Many very good answers gained full credit. Some weaker candidates, however, wrote about the advantages and disadvantages of bioleaching. Credit was lost for errors in writing the Latin name of a bacterium like *Acidithiobacillus ferrooxidans* (missing the capital letter for the genus), for failing

to name two metals obtained (other than iron whose oxidation and reduction is part of the process) and for talking about washing out the soluble sulfate product without saying that this liquid is kept in order to extract the metal by displacement.

Some candidates were let down by their knowledge of chemistry, with the terms oxidation and reduction frequently misused. Where biology candidates are not also studying chemistry it is important to ensure that they have a thorough grasp of the key chemical terms and concepts listed towards the front of the syllabus.

Really detailed descriptions including names of relevant sulfide ores and chemical detail of reactions were often from Centres in countries with an active mining industry, again showing excellent teaching tailored to local issues.

BIOLOGY

Paper 9184/53
Planning, Analysis and Evaluation

Key Messages

It is important to read the question carefully before starting to answer. In this particular paper there were many important pieces of information to absorb which would have allowed full and relevant answers to be produced.
Candidates also need to be clear about the meaning and relevance of statistical terms and how they are used in investigations.

General Comments

A good spread of marks was seen and candidates did not seem to have had a problem with completing the paper in the allocated time. There was less evidence of learning from practical experience than previously and there were some areas of statistical analysis that candidates found confusing. Most candidates found that they were able to answer within the space provided.

Comments on Specific Questions

Question 1

This question focused on gel electrophoresis. Overall it seemed to be a technique that was not always familiar to candidates.

(a) (i) The detailed stem of the question provided much of the information needed to answer this question. Many responses covered the key idea that complementary base pairing between the RNA probe and the DNA sticky end made selection possible. Surprisingly few mentioned that the RNA probe was single stranded - perhaps thinking this was too obvious. Very many candidates did not go further than this and so missed out on the selecting of the DNA fragments. This needed a clear statement of the idea that different probes would allow the pairing up with different sticky ends thus selecting the various different DNA fragments.

(ii) Candidates found this question difficult to answer. The question asks for ideas related to genetic variation within species, but answers commonly talked about variation between species. The stem of the question gives some information which the better responses correlated and indicated that they were aware that genetic variation or mutation could be caused by as small a change as one or a few nucleotides. Examples to illustrate this, which were credited, included types of changes such as deletion or inversion (point mutations), or description of how such changes could affect the organism in terms of altering the amino acid sequence in a protein and thus giving variation. A number of answers described the electrophoretic method or its uses in crime forensics or paternity cases.

(b) Not all the responses showed that the candidates realised that this question required a practical approach to carrying out the gel electrophoresis. Many included a detailed account of the theoretical background as to why it worked as a separation technique or started by copying out much of the introduction to the question on how DNA fragments were produced and amplified. The key points were that an agarose gel was used with wells at one end, into which the DNA samples were placed then it was set up in a buffered situation with the cathode at the end where the samples were situated and a potential difference was applied. Detail as to how the samples would be added to the wells to get valid and reliable results was credited. There needed to be a way of showing up the fragments once separated. This could be via staining and using a UV light, staining with dyes that are visible in daylight or by ensuring all the fragments were radioactive at the start and making an autoradiograph. These ideas were rarely mentioned in the correct context. As a practical exercise, there needed to be some mention of safety and precautions. Appropriate ones

here include the risk with electrical apparatus and a precaution for the harmful nature of dyes or radioactive labels.

Many of the responses mentioned radioactive probes or fluorescent markers in the wrong context by describing them as a way of identifying specific DNA fragments rather than showing up the whole genetic fingerprint. Many responses did not mention wells and were too vague as to where on the gel the samples would be placed. In some cases it seemed they were placed near the middle, as fragments were described as moving either to the cathode or anode.

(c) Candidates focusing on preparation of fragments or their identification missed the point of variables such as volume of DNA sample, voltage difference, type of gel, time of running and others related to the actual electrophoresis. Instead they suggested things like invertebrate used or type of probe. There was also a focus on DNA fragments in some responses, e.g. same number, mass, length. There was a tendency in some responses to use the vague term 'amount' rather than a more precise term like volume of gel or DNA sample.

(d)(i)(ii) The majority of candidates were able to identify a suitable band on all three electrophoretograms, although sometimes very faint ones were chosen or the band was drawn over. These were credited provided it was possible to tell that it was a suitable band. In part **(ii)** most identified varieties 1 and 2 and described in some way that the bands all matched up. They do in fact match up very closely and that was looked for in the answer, so answers like 'similar' rather than very similar or the same did not gain credit. Very occasionally bands other than 1 or 2 were selected and it sometimes proved possible to award some credit if it was clear that the candidate understood that they were looking for matching bands. A small proportion misunderstood the question and instead of choosing varieties chose two of the groups of RNA probes **A**, **B** and **C**. This could not gain any credit as there is no valid explanation of this. Careful reading of the question and Figure 1.1 would have avoided that slip.

Question 2

This question contained some important material to read through. The data tables needed careful study to ensure that the legume fertiliser and the parts of the *Sorghum* were not confused. The question also allowed candidates to show their understanding of statistics and to draw conclusions from given information.

(a) (i) Many responses gained credit here. Some responses incorrectly gave two variables that should have been standardised. This would have been avoided with careful reading of the question. Some other responses were too vague to credit, e.g. 'time' unqualified was not sufficient as it needed to be time before *Sorghum* was planted. Some answers indicated that the question was not read carefully enough, e.g. 'time for *Sorghum* to grow', 'the same type of plant' and 'same type of *Sorghum*'. The whole investigation is on *Sorghum bicolor* so it cannot be a standardising variable. However, same type of legume used as fertiliser was accepted. Size of plot was credited but not size of field.

(ii) Some candidates confused biotic and abiotic factors and talked about microorganisms or the mass of legume. For those who did focus on abiotic factors good responses were usually in terms of light intensity or temperature. Rainfall, wind and abiotic aspects of the soil were also commonly credited. Credit was not given for general references to light or sunlight without the qualification of intensity.

(iii) There were some good answers about why the plots were left for 1 month before sowing the *Sorghum*. These clearly explained that it gave time for the green manure to decompose or to fertilise the soil. However, there was confusion in many responses which suggested it was to give time for the legume to grow or even for the *Sorghum* to grow, despite the stem of the question stating they were left for a month before sowing the grain. There were also a number of rather general responses on the lines of 'letting everything equilibrate' or 'let the nutrients spread evenly' which were not sufficient to gain credit.

(iv) Responses about the reliability of experimental design needed to make it clear that there was more than one replicate of each plot type or treatment. Some did, but there were many generalised answers with unqualified mention of repeats or large sample or large number of seeds. Others repeated the variables that were standardised or mentioned the control or random numbers.

(b) (i) Many responses did well on the calculation of percentage increase and gained full credit for a correct response to an appropriate number of decimal places. A few did not understand how this was done or chose a column of figures other than the whole plant column. In some cases it was possible to award credit for some correct working.

(ii) There were plenty of accurate responses giving 3:1 as the ratio, which is the way a ratio is usually displayed. Overall this calculation was less well approached than the percentage increase. Some gave 1:3 which was accepted provided it was clear which referred to legume roots and which to legume shoots. The figures do allow the ratio to be expressed as 3:1 and thus figures like 384:128 were not acceptable for full credit. But there was some credit for showing in the calculation that the figure 384 (782 - 398) was that to which the given figure of 128 was compared.

(c) (i) The suggested null hypotheses were not always accurate enough, seemingly due to candidates not reading all the information carefully enough. Thus the *t*-tests were not comparing one type of green manure against another type of green manure; they were comparing each type against the control, i.e. against the dry mass increase with no green manure. Thus the null hypothesis would be that there is no significant difference in the dry mass of *Sorghum* grown with green manure and that with no green manure. It is important that the word 'significant' appears in the statement.

(ii) The reasons for using the *t*-test were generally well presented. A few responses suggested that the test allowed you to find the mean rather than to compare means. Some answers were along the lines of 'to see if the data was significant', which effectively just paraphrases the question.

(iii) Although there were some responses that indicated a grasp of the fundamental ideas behind statistical tests, many more were confused and wrote out all the statistical terms they knew without making it clear that they understood their meaning or relevance. Thus 'error', 'confidence limits', 'critical value', deviation' often featured in answers without any explanation as to their relevance, if any, to the question

statistically significant: the best responses understood that this meant the results were caused by a factor other than chance. In this case it would be the green manure treatment. Many candidates gained credit here. Less good responses tended to go round in a circle and effectively say that 'statistically significant means that the results are significant'

$P < 0.05$: Many simply said that the probability was less than 0.05, which was just restating the question. The first requirement was to indicate that this equated to a 5% or less chance. Then this needed qualifying as either a 5% chance that the results gained were due to chance, or a 95% certainty that the results obtained were caused by an outside effect - in this case the green manure treatment.

(d) Many candidates were able to pick out a number of key conclusions from the tabulated data. There was some confusion between the parts of the legume plant used for green manure and the parts of the *Sorghum* plants showing changes in their dry mass. Responses such as 'manure applied to legume roots' were not uncommon, but it was sometimes possible to follow the meaning. Such responses do underline the need for clear unambiguous answers to this type of question. Many responses gave figures. Whilst these could sometimes back up a conclusion, they do not replace a clearly stated conclusion in words derived from a consideration of the figures. There is a general conclusion that can be seen in Table 2.1 that green manure always increases the dry mass. Table 2.1 also allows some comparative conclusions to be drawn regarding the different treatments. Such conclusions are that shoots cause a greater increase in dry mass than roots and that shoots and roots together cause the greatest increase in dry mass. Table 2.2 focuses on significance and thus conclusions from here needed to do the same. Some responses still refer to degrees of significance suggesting something is more or less significant. In a statistical sense this is not valid - a result is either 'significant' or 'not significant'. The term 'insignificant' should not be used. From Table 2.2 it is possible to conclude that roots as green manure do not have a significant effect on the increase in dry mass of any part of *Sorghum* plants whilst roots and shoots together have a significant effect on all plant parts. Shoots alone only have a significant effect on the grain and whole plant.