BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1 and 36

The vast majority of all candidates answered these questions correctly.

Questions 4, 6, 11, 12, 20, 21, 26 and 29

Most candidates answered these questions correctly.

Questions 2, 9, 17, 22, 23, 24, 27, 28, 31, 32, 35 and 38

Many candidates found these questions difficult with a minority answering correctly. Candidates who performed well overall were able to apply their knowledge to the questions.

Question 5

Most of the stronger performing candidates answered correctly, whereas most of the weaker candidates incorrectly thought that a prokaryotic cell has 80S ribosomes.

Question 7

Many candidates found this question difficult, with most selecting options that incorrectly identified the reactants as fructose and glucose. However, these are in fact the products.

Question 10

Only a minority of candidates correctly realised that there were only three different arrangements, i.e. LOP, OLP and LPO.

Question 13

Many candidates incorrectly selected options that included statement 2. If the active site has changed shape and is no longer complementary, the reaction would no longer be able to occur.

Question 19

Whilst many candidates answered correctly, an almost equal number incorrectly suggested that a cell in cytokinesis only contained one copy of each DNA molecule.

Question 30

Most of the stronger performing candidates answered correctly. However, many candidates did not know that lymph contains lipids.

Question 33

The majority of candidates incorrectly selected options containing statement 1. There is no squamous epithelium present in the photomicrographs. Only alveoli in the respiratory system contain squamous epithelium.

Questions 37 and 39

The vast majority of the stronger candidates answered correctly but the weaker candidates selected each option almost equally.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 7, 8, 10, 13 and 25

The vast majority of candidates answered these questions correctly.

Questions 1, 6, 16, 36 and 39

Many candidates found these questions difficult, with a minority answering correctly.

Question 2

Most candidates realised that with a shorter wavelength the resolution would increase and so answered correctly.

Question 5

The majority of candidates answered correctly, but many of the weaker candidates incorrectly thought that ATP forms part of DNA.

Question 6

Many candidates found this question difficult and only the stronger candidates answered correctly. Most of the weaker candidates incorrectly selected options that included mitosis.

Question 12

Whilst the majority of the stronger candidates answered correctly, weaker candidates selected each option almost equally.

Question 15

Most candidates understood the meaning of the Michaelis-Menten constant and answered correctly.

Question 17

Whilst the majority of stronger candidates answered correctly, some candidates did not appreciate the difference between carrier proteins and channel proteins.

Question 21

Most candidates answered correctly, although a proportion incorrectly selected options that included statement 2.

Question 23

Almost all of the stronger candidates answered correctly. Only a minority of weaker candidates correctly selected 2100.

Question 26

The vast majority of stronger candidates answered correctly and realised that only statement 3 applies to phloem sieve tube elements and to xylem vessel elements. The weaker candidates selected all options.

Question 34

Whilst the majority of candidates answered correctly, many of the weaker candidates incorrectly selected options containing statement 2.

Question 36

Whilst many answered correctly, most candidates found this difficult and incorrectly selected options including statement 3. Smallpox is caused by a virus, not a bacterial pathogen, so statement 3 cannot be correct. Many candidates also did not realise that there are vaccines available for cholera.

Question 39

The majority of weaker candidates incorrectly selected option A. The direct cause of the increase in antibodies after the second exposure had to be the plasma cells that actually produce antibodies.

BIOLOGY

Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

Many candidates answered correctly, although some did not appreciate that, because an electron microscope has a much greater resolution than a student light microscope, it enables the cristae of a mitochondrion to be seen.

Questions 2, 6, 7, 8, 15, 16, 18, 21, 22, 24, 25, 31, 32, 33, 35, 36, 38 and 40

For these questions, the vast majority of candidates were able to answer correctly, including at least half of the weaker candidates.

Question 3

The majority of candidates answered correctly, although some weaker candidates incorrectly thought that using a calibrated eyepiece graticule to measure length would have parallax error.

Question 5

This question discriminated well, although many candidates did not take account of the fact that the nucleic acid mRNA would be present in the cytoplasm.

Question 9

Many candidates found this question difficult, although the majority of stronger candidates used their knowledge of sucrose to eliminate statements 2 and 3, so were able to answer correctly.

Question 11

The majority of stronger candidates answered this question correctly. Many of the weaker candidates chose options that included statement 2, which is not correct.

Question 20

The majority of stronger candidates answered this correctly. Some of weaker candidates incorrectly thought only one copy of each DNA molecule would be present in G_2 of interphase and others incorrectly thought there would be only one copy in metaphase.

Question 23

The majority of weaker candidates found this difficult and were unable to answer correctly. However, almost all of the stronger candidates correctly concluded that the answer was 20 amino acids.

Question 26

Many candidates found this difficult although most of the stronger candidates answered correctly. Some incorrectly selected options which included transpiration pull. Since the shoot had been removed, there would be no leaves so there would be no transpiration pull.

Question 29

Most candidates found this question difficult, although most of the stronger candidates answered correctly.

Question 30

The reactions occurring in blood passing through active tissues were well understood by the majority of candidates and almost all of the stronger candidates answered correctly.

Question 34

Most candidates answered this correctly. The most common error was to select options in which the T-helper cells were destroyed. They would become increased in number as they secrete cytokines to stimulate B-lymphocytes and macrophages.

BIOLOGY

Paper 9700/21
AS Level Structured Questions

Key messages

- Candidates with a good understanding of the terms antigen and receptor were able to use these in the appropriate context. The introductory statement in **Question 4(b)** informed candidates that VEGF is a cell signalling molecule that stimulates cell division in endothelial cells. This indicates that the cell surface membrane of these endothelial cells contains protein receptors with a complementary shape to the VEGF molecule. This protein was incorrectly described by some candidates as an antigen, rather than as a receptor in **Question 4(b)(ii)**. In **Question 4(d)**, candidates needed an understanding that the monoclonal antibodies used in the human body as a treatment for cancer could be identified as a non-self antigen and trigger an immune response due to its origin not being from the same body.

- For questions such as **Question 5(c)**, candidates should know the features of the nucleotides in DNA and RNA, that adenine occurs in ATP molecules and that ATP is a phosphorylated nucleotide with a ribose sugar component.

- Candidates should consider the context of questions where the command word is 'suggest' and make links to the appropriate learning outcomes. Then the main ideas can be considered and judgements can be made as to which are the most relevant to answer the question. A good example of this was **Question 5(b)**.

General comments

Question 1(d) highlighted the importance of candidates reading each question carefully and taking time to ensure the information in the answer addresses the question asked. While there were a number of excellent responses to this question, many candidates structured their answer around mosquito vectors without any reference to vaccination programmes. Similarly, a few candidates referred to the difficulties of distributing vaccinations in **Question 1(e)** even though the question asked for factors other than a lack of vaccines.

The best answers used appropriate terminology, such as in **Question 2(b)(ii) and 3(a)(iii)**. In **Question 5(b)**, the strongest responses used the information in the bullet points along with knowledge and understanding from the syllabus about transport in the phloem. These excellent answers linked starch storage in different areas of the plant with sucrose transport in the phloem. Candidates who simply repeated the provided information without developing it were unable to gain credit.

Comments on specific questions

Question 1

(a) This was a straightforward start for many candidates who correctly identified the three structures labelled on **Fig. 1.1**. The most common error was to incorrectly identify structure **B**.

(b) The majority of candidates were able to name a non-infectious disease that affects the human gas exchange system. The most common incorrect response was tuberculosis.

(c) A few candidates were able to provide the full binomial name for the pathogen that causes malaria. Some were able to identify the genus as *Plasmodium* but the species name was also required to gain credit. A common misconception was that a mosquito is the pathogen for malaria rather than a vector of the pathogen.

(d) A small number of candidates wrote excellent answers, which included reference to the pathogen. These answers recognised the challenges presented by eukaryotic pathogens, different species of pathogen and the unique life cycle of *Plasmodium*. Candidates who simply stated that the pathogen changes frequently were unable to gain credit as they did not link this to antigens and mutations, or stages in the life cycle. The idea that vaccination programmes needed to achieve herd immunity was well known. Candidates who developed this idea by suggesting why such immunity was difficult to achieve were able to gain further credit. Many included reference to mosquitoes, which did not gain credit as it did not answer the question asked.

(e) Candidates found this question more straightforward than **Question 1(d)**. Many considered the differences in climate between areas **P** and **Q** and the effect this would have on *Anopheles*. Some went on to link these differences to the increased likelihood of problems of stagnant water being present and the significance of this for *Anopheles* breeding. Fewer candidates suggested that methods such as insecticide use and mosquito nets may be less available in area **P**. Some candidates simply stated methods of mosquito control without linking them to either area **P** or **Q** and so did not gain credit. Weaker candidates made vague references to poorer or unsanitary living conditions in area **P** and these answers were not creditworthy.

Question 2

(a) Many candidates identified the glycosidic bond in lactose. The most common incorrect answer was a hydrogen bond.

(b) (i) The majority of candidates were able to state that the reaction was hydrolysis. This was commonly misspelt as hydrolisis. A minority referred to the reaction as condensation.

(ii) Candidates needed to use the information provided in the question stem and knowledge from the syllabus. High quality answers recognised that lactose, as a solute, would reduce the water potential of the solution in the intestine. Some candidates referred to water concentration instead of water potential and this was not credited. The strongest answers then explained how this would affect the water potential gradient between the solution in the intestine and the blood. Many candidates incorrectly thought that the use of water to hydrolyse lactose would reduce water in the intestine. This answer did not gain credit as the question outlined that diarrhoea results when lactose cannot be digested.

(c) (i) The majority of candidates who gained credit recognised that the rate of reaction would be faster if smaller beads were used. Some were able to develop this idea and explain why this would be. Some candidates recognised the link between size of bead and surface area to volume ratio. The idea of a larger surface area without the link to volume was not credited. Few candidates referred to the number of beads that could be packed into the column and the resulting speed of flow of the milk. Some wrote about the benefits of immobilising enzymes such as the ability for them to be re-used. This did not gain credit as it did not answer the question asked.

(ii) Most candidates noted that **F** and **I** had different optimum temperatures. This was sometimes expressed imprecisely as **I** having a greater activity at higher temperatures, which did not gain credit. The majority of candidates also noted that **F** had no activity at 70 °C, while **I** did. Many candidates could have improved their response by mentioning that both enzymes had the same activity between 0 °C and 20 °C. Those that attempted to compare the gradients of the two graph lines often suggested that the rate of activity of one enzyme increased or decreased more rapidly than the other. However, the graph shows the effect of increasing temperature, with no indication of time, so these answers did not gain credit. Weaker answers did not make reference to specific temperatures or rates of activity. Some answers did not compare the effects of temperature on both enzymes but gave reference to only one enzyme.

Question 3

(a) (i) Descriptions of the structure of cellulose were variable, with many confusing the structure of cellulose and collagen. There were some knowledgeable responses describing a cellulose molecule as a polymer of β-glucose, with only a minority stating a role for α-glucose. Few were able to recall that cellulose forms straight chains and many incorrectly referred to the formation of 1,6-glycosidic bonds and a branched or helical molecule.

(ii) This question was answered well. The majority of candidates gained credit for recognising chloroplasts in **Fig. 3.1**. Some identified the presence of a vacuole but this often could not gain credit as it needed to be qualified as large, as vacuoles can also be found in animal cells. The cell wall was not accepted as the question asked for a visible feature other than the cell wall.

(iii) Many candidates linked the need for ATP in plant cells to biosynthesis reactions, such as protein synthesis and photosynthesis. DNA replication was also a common correct answer. A few stated that ATP provided energy for these reactions. Some incorrectly stated that ATP was used to produce energy. A number of candidates may have gained further credit by recognising that more than one use of ATP was required, indicated by the mark allocation for this question.

(b) There were some very knowledgeable responses that identified water molecules as dipoles and outlined the reason for the attraction between water molecules linked to this property. Many answers described water molecules as charged with positively charged hydrogen atoms and negatively charged oxygen atoms. This was not credited as it is important for candidates to understand the distinction between charged ions and polar molecules. Some candidates confused the terms atom and molecule, describing charged molecules of hydrogen and oxygen. Some of the best responses described the hydrogen bond as a weak attraction between water molecules.

(c) The importance of ions being charged was recognised by the majority of candidates who gained credit for this question. Weaker responses did not identify the importance of the polar nature of water molecules and instead listed other properties of water, such as high specific heat capacity. Most of those who did not gain credit lacked detail on the relevant properties of water and ions. Their explanations included stating that water was a good solvent because many substances are able to dissolve in it, or describing that it is important to dissolve ions for transport around an organism.

Question 4

(a) Most candidates gained full credit in this question. The most common error was an incorrect conversion between mm and μm.

(b) (i) Most candidates identified at least one process that occurs during interphase. Cell growth was the most common correct answer. Fewer candidates successfully identified two processes. Statements such as information being checked were too vague to be credited. The weakest answers confused interphase with a stage of mitosis.

(ii) Candidates had to apply their understanding of cell signalling to the unfamiliar example described in the question stem. The strongest responses identified the endothelial cells as target cells. Many stated that VEGF was a cell signalling molecule. Some could have improved their description of the role of VEGF by using more appropriate terminology or by giving more precise detail. Descriptions such as VEGF being ‘sent out’ from one cell to another cell were not sufficient. The idea of binding to a specific receptor was often missed: here VEGF was described as being ‘received’ by a cell or a protein in the cell surface membrane. A few made reference to the complementary shape of VEGF and the receptor protein. Some good responses showed knowledge additional to the learning outcome and these described an effect within the target cell of VEGF binding to the receptor, such as enzyme activation.

(c) The most successful responses were concise step-by-step accounts describing how monoclonal antibodies are produced. A common error was to state that antibodies would be extracted from the small mammal rather than from plasma cells. A few candidates described mixing plasma cells with myeloma cells rather than fusing the two cell types. Some wrote about extraction of antibodies and subsequent fusion of these antibodies with myeloma cells, but may still have gained credit for knowledge of hybridoma cells. Some stronger responses included detail of the hybridoma method beyond the production of hybridoma cells. Weaker answers confused the process of production of monoclonal antibodies with their therapeutic use and wrote about the injection of VEGF into humans and the subsequent immune response.

(d) This question was challenging for many candidates. Some were able to recognise that because the monoclonal antibodies originated from non-human cells, the human body may identify them as non-self, or foreign, antigens. Some linked the idea of side-effects to an allergic response. The most common incorrect answers were to state that the body got used to the antibodies and no longer responded to them or that the body developed resistance to them.

Question 5

(a) There were many good answers to this question. Some candidates suggested new labels, which did not gain credit. Some candidates suggested the possible presence of mesosomes in the cell surface membrane. Reference to mesosomes should no longer be made as they are known to be artefacts in slide preparation. Weaker candidates confused peptidoglycan with chitin as the material of the cell wall. Some confused prokaryote and eukaryote cells, suggesting labels including mitochondria and nucleus.

(b) Candidates were given information in the question stem that needed to be analysed and developed. The most successful answers made links between starch stored in the leaves and sucrose transported in the phloem. Those who gained credit often recognised that both phloem tissue and the pathogen were widely distributed throughout the plant. A large number of candidates wrote about the lack of transport of starch in the phloem rather than sucrose. The need for starch to be hydrolysed to produce sucrose for transport was not widely recognised. A small number of candidates gained credit for suggesting that xylem cells were dead cells with no cell content and so would not be able to support living pathogens.

(c) Some candidates had few problems completing **Table 5.1** correctly. For others, greater knowledge of the structure of ATP was required. Many candidates did not realise that ATP contained nitrogen, or that it contained the base adenine. Similarly, only a few answers gave ribose as the sugar found in ATP. Many named this sugar adenosine. It was common to find 'yes' in the row asking if the molecule contains a pyrimidine base, indicating a lack of knowledge of which bases are purines and which are pyrimidines. Most candidates were able to gain credit for their knowledge of the number of phosphate groups in each of the three types of molecule. A common error in the final row was to name the sugar in each molecule as pentose or a monosaccharide.

Question 6

(a) (i) Many candidates stated that haemoglobin molecules have a quaternary structure, which was not required. However, those who correctly linked this to the presence of four haem groups in each molecule gained credit. Many could have gained further credit by stating that that the haem group contained iron. Those who recognised that the haem group was responsible for the transport of oxygen often needed to give more precise statements about oxygen transport to gain credit. Some candidates incorrectly described each haemoglobin molecule has having only one haem group and others confused the terms atom and molecule. Many answers confused haemoglobin with the structure of a red blood cell, referring to adaptations such as large surface area and biconcave shape.

(ii) The strongest answers described folding of each polypeptide so that the hydrophilic R groups of amino acids are found on the outside of the haemoglobin molecule. A few went on to link this to the ability of haemoglobin molecules to form hydrogen bonds with water. Weaker answers recognised that hydrophilic regions would be on the outside of the molecule but were unable to identify these as amino acids or R groups. Some simply described haemoglobin as a small molecule or made links to its presence in red blood cells. The idea that haemoglobin is a globular protein was not credited as this information was included in the question stem.

(b) (i) The scale on the *x*-axis proved a challenge for some candidates who incorrectly took readings at 6.8 kPa, rather than 6.4 kPa. This resulted in the percentage saturation of haemoglobin with oxygen being recorded as 91% for the llama and 80% for the human. The readings from the graph should have been taken to an accuracy of half a square so the percentage saturation of haemoglobin of the llama should have been recorded as 78.5% rather than 78%.

(ii) Most responses showed an understanding that the percentage saturation of haemoglobin with oxygen was higher at every partial pressure of oxygen. The idea that the percentage saturation of haemoglobin was higher at low partial pressures was insufficiently detailed to gain credit and needed to link this to the idea of was a lower partial pressure of oxygen at high altitude. Weaker responses mentioned lower concentrations of oxygen without reference to partial pressure. A few candidates were able to deduce from the graph that the llama haemoglobin has a higher affinity for oxygen than human haemoglobin.

BIOLOGY

Paper 9700/22
AS Level Structured Questions

Key messages

- Candidates with a good understanding of the terms receptor and antigen were able to use the terms in the appropriate context.

    - In **Question 3(c)**, the cell surface membrane protein of liver cells to which cell signalling molecules bind was incorrectly described by some as the antigen, rather than as a receptor.
    - In **Question 4(c),** an understanding was required that p24 acted as an antigen, and that this could trigger an immune response within a small mammal, such as the mouse.

- It was not necessary to learn the molecular structures of the purine and pyrimidine bases of DNA and RNA. However, candidates should know that:

    - adenine and guanine are purines and are double ring structures.
    - cytosine, thymine and uracil are pyrimidines and are single ring structures.
    - uracil does not occur in DNA nucleotides and thymine does not occur in RNA nucleotides.

    Some candidates who completed **Table 5.1** in **Question 5(c)** were confused as to which bases were purines and which were pyrimidines and not all knew that RNA nucleotides do not have the base thymine.

- Some of the questions that include the command word ‘suggest’ use unfamiliar material to assess the ability of candidates to apply knowledge and understanding of the syllabus learning outcomes. Candidates should consider the context of the question and make links to the appropriate learning outcomes. Once the correct link has been established, the main ideas can be considered and judgements can be made as to which are the most relevant to answer the question. An example of this was **Question 2(b)(ii)**, where credit was also available for other acceptable suggestions in addition to the learning outcome knowledge.

General comments

The first sentence of the response for **Question 2 (d)(i)** was provided so that candidates would be guided as to where to begin their description of the cardiac cycle in the left side of the heart. Some candidates wasted time by including details of how heart action is initiated and controlled in their answer, and their focus was taken away from giving a more detailed description of the cardiac cycle.

Question 3 provided candidates with some unfamiliar material about the response of different parts of the body to tissue damage. In **Question 3 (c)** candidates used knowledge and understanding of the principles of cell signalling from Topic 4 of the syllabus, and applied this to answer a question about the response of the body to liver damage. Although many candidates did well, some did not seem familiar with the relevant learning outcome.

Graphs such as **Fig. 4.1** in **Question 4** require detailed scrutiny to extract the correct numerical data. Values were required to calculate a percentage in **Question 4 (b)(i)**, and to support stated trends in **Question 4 (b)(ii)**. Candidates needed to firstly work out the number of pregnant women represented by each small square on the *y*-axis and, secondly, obtain a value for a particular year. Candidates should use a ruler to read back from a point on the curve to the *y*-axis.

Question 5 (b) assessed knowledge of the test for reducing sugars. Candidates should be able to give written descriptions of the biochemical tests stated in syllabus Topic 2, and should also be able to describe the positive results for these tests.

In **Question 6(b)**, some candidates were not able to gain credit for descriptions **B** and **C** because the spellings of the terms given in their answers were too different from the actual spelling and there was insufficient assurance that the candidate knew the correct answer.

<u>Comments on specific questions</u>

Question 1

(a) Many candidates could correctly identify **H** in **Fig. 1.1** as a bronchiole. The most common incorrect answers were alveolus or trachea. Mitochondrion and capillary were also given by some candidates, who needed to take into consideration the fact that the size of the alveolus labelled in **Fig. 1.1** was considerably smaller in diameter than **H**.

(b) Most of those who gave a formula that could be used directly to calculate the actual diameter of the alveolus at **X**–**Y** also gave the correct value. Some gave a formula that would need rearranging, which was credited, but a proportion of these then made an error in the calculation. The majority used a correct conversion factor to convert from their measurement in cm or mm to μm.

(c) High quality answers showed knowledge that the alveolus was the site of gas exchange in the lungs and referred to both oxygen and carbon dioxide as respiratory gases. These answers also addressed both parts of the question by giving a good description of the process of gas exchange and then comparing this with the diseased lung shown in **Fig. 1.1B**. It was important here to give comparative descriptions. For example, stating that the alveoli in healthy lungs provided a large surface for gas exchange was not sufficient to be given credit for a comparison with the diseased lung. The most common misconception was that diffusion of gases occurred into or out of the lungs and the journey of the respiratory gases between the blood and the alveolar air was not considered. Some could have improved on vague sentences such as 'oxygen diffuses from the lungs to the blood and 'air passes across the alveolar wall' and could also have improved their answer by writing about carbon dioxide, rather than solely writing about oxygen. When comparing the ability of alveoli to stretch and recoil during ventilation, some incorrectly used the phrase 'relax and contract', which should be reserved for muscle action. Weaker responses concentrated on the pathway air takes from the external atmosphere and gave a sequential description of this, without continuing to gas exchange at the alveolar surface.

Question 2

(a) The majority gained credit, with most correctly spelling the term xerophyte or xerophytic. Some gave the term 'xenophyte', which has a different biological meaning and so did not gain credit.

(b) (i) Some candidates were confident with the term vascular tissue and knew that they just needed to identify which of the two tissue types, xylem or phloem, would contain sugary sap. As the question asked for a tissue, it was not necessary to give any further detail or to name cells. Sieve tubes or sieve tube elements were given by many candidates and were also credited.

(ii) Candidates who did well showed an understanding of the role of phloem in the transport of organic compounds and knew about sources and sinks. Some used the additional information given at the start of **Question 2** to make the creditworthy suggestion that the cardiac glycosides would act as a defence mechanism against consumers.

(c) (i) Many candidates knew that water was used in the hydrolysis of ATP although fewer went on to say that this was in order to break the bond (to release the phosphate). Some candidates realised that a bond was broken but then incorrectly stated it was a hydrogen bond or glycosidic bond. Some restated the information given about the hydrolysis, which was not required.

(ii) Most stated active transport as the transport mechanism. As this process involves the use of ATP for the uptake of potassium ions and for the exit of sodium ions, active uptake as a transport mechanism was not credited. Most of the incorrect answers stated cotransport or facilitated diffusion.

(iii) There were many comprehensive and well-expressed answers here. The best made it clear that oleandrin did not bind to the active site to prevent binding of the substrate but to a site elsewhere on the enzyme and then continued beyond the effect on the enzyme to explain the effect on the movement of ions.

(d) (i) High quality responses gave a step-by-step account of the cardiac cycle and, as requested, only included details for events occurring in the left side of the heart. The responses included correct timings of the opening and closing of valves and described the pressure differences between the left atrium and ventricle that led to the openings or closures of the valves. Valves had to be named correctly to gain credit. The most frequent error was to name the bicuspid (left atrioventricular valve) as the tricuspid valve. Some candidates based their answer on the right side of the heart, while others gave an account from the point of view of blood entering the left side of the heart and then entering the right side after a journey round the body. The latter were able to gain credit if details for the left side were correct. Some of the weaker responses wrote incorrectly about semi-lunar valves in the pulmonary vein entering the left atrium or described blood leaving the left ventricle through the pulmonary artery. A number did not mention atrial or ventricular contraction and wrote only about the pathway of blood and valve openings and closures.

(ii) Many realised that the strength of contraction of cardiac muscle would increase with digoxin treatment. Most of these could have gained further credit by suggesting the benefits of this in terms of increased blood supply to the lungs for oxygenation and to the rest of body to deliver more oxygen. The best responses also went on to explain how the health of the person would improve. Some candidates incorrectly referred to an effect of the compound on heart rate.

Question 3

(a) Many candidates gained full credit here. The fact that cells are produced by mitosis was not sufficient explanation for the importance of the process for tissue repair – stronger answers explained that damaged or dead cells would be replaced, and that the new cells would have the function of the damaged tissue. Candidates should avoid describing one role of mitosis as repair of cells as this is an incorrect concept. It is also more accurate to say that the cells are genetically identical as two new cells that result from mitosis may not have identical quantities of the various cell organelles that have been shared out during cytokinesis.

(b) High quality answers showed an understanding that there would not be a diminishing stock of stem cells following tissue repair and made it clear that stem cells can divide to give more stem cells and cells that can differentiate. Many realised that stem cells could differentiate, and further credit was possible if they explained that the tissue containing these new cells could continue to function.

(c) Candidates were not expected to know about the involvement of cell signalling in liver tissue to answer this question. Many showed an understanding that the released chemicals acted as cell signalling molecules. Some weaker responses described the chemical as binding to the liver cell or to the cell surface membrane and could have gained credit by mentioning binding to a receptor. Many also showed understanding of the specificity of cell signalling, with most of these explaining that the receptor had a complementary shape to the cell signalling molecule (chemical). Less frequently seen was the statement that the liver cells were target cells or that the specific response of the liver cell to the signalling was to enter the cell cycle. Some were vague on this and stated that the cells helped to repair tissue.

Question 4

(a) A number of candidates were confident in their knowledge of the key structural features of viruses and gave concise responses, with all points made being factually correct. Many others gave very confused answers. The most common credited point was the protein coat or capsid of viruses. Many gave answers that included the protein coat but stated features seen in prokaryotes or gave answers that concentrated on stating cell structures that were not found in viruses. It was also more common for candidates to state incorrectly that a key feature was RNA as the genetic material, rather than outline the genetic material as either RNA or DNA. Some responses described an outer layer which was an amalgamation of a protein coat and a phospholipid bilayer.

Although not asked for in the question, some chose to describe the human immunodeficiency virus, HIV, or its mechanism of infecting cells.

(b) (i) Many candidates gave a value within the acceptable range for the calculated percentage to gain credit. Some correctly used 960 000 for the number of pregnant women living with HIV receiving ART in 2013 but then divided this by 2 000 000, the highest value on the *y*-axis, rather than 1 460 000 (the total number of pregnant women living with HIV).

(ii) Many candidates were able to gain most of the credit, with the majority of answers correctly describing the overall trend of the two curves. Very few commented on the increasing proportion of women receiving ART over the time period. Credit was available for quoting correct data to support a trend and many did this successfully. Some missed out by adding a '0' on one or more values, emphasising the need for precision and care when using numerical data. Some gave values for one year for both curves, generally either 2005 or 2013, which went only part way to using data to support a trend. Others gave two comparative values for numbers of women for a curve, but did not give the years.

(iii) To gain full credit, candidates needed to continue beyond the idea of mother to child transmission and consider the effect of the therapy on the mother and its wider importance. Some did point out that ART would lead to a decrease in the number of women developing HIV/AIDS and there were some very thoughtful suggestions made about how ART would have overall social and economic effects on the larger community. General statements about reducing the overall number of people with HIV or decreasing spread needed to be supported by an example relating back to pregnant and breastfeeding women or their babies. Good descriptions of mother to child transmission were careful to explain that ART would help decrease the overall transmission of HIV to the developing foetus or the breastfed baby and avoided making any incorrect links to immunity. More confused answers stated that HIV/AIDS transmission to the baby would decrease or that ART would mean that the mother would pass on to her baby immunity to the virus. Some wrote at length only about mother to child transmission and missed the opportunity to gain further credit.

(c) (i) Most of those candidates who did not gain credit stated that the actual viral strain, HIV-1, was injected into the mouse. It is important for candidates to understand the difference between a pathogen and an antigen and to realise that an antigen alone, in this case the viral protein p24, can stimulate an immune response within a mammal, such as a mouse. Other incorrect responses seen were human blood or the antibodies specific to HIV-1.

(ii) The most complete answers used the term immune response in the correct context and gave details of the immune response relevant to the hybridoma method for the production of monoclonal antibody. Some erroneously thought that the aim of **step 1** in **Fig. 4.2** was to allow time for the mouse to produce the required antibody, even though **step 2** states 'remove cells from mouse spleen'. Others wrote about the production of memory cells, which was not relevant to the question.

(iii) The majority of candidates who gained credit considered the ability of myeloma cells to divide. Descriptions involving uncontrolled mitosis were allowed although the best answers simply stated that myeloma cells were capable of cell division. Of the other acceptable points, the most common was the fact that myeloma cells are long-lived. A number of candidates mistakenly suggested that myeloma cells were also able to produce large quantities of antibody.

(iv) Most knew that the fused cells were named hybridoma cells. The most common incorrect responses named plasma cells, B-lymphocytes or hybrid cells.

(v) A wide range of answers was seen, with some showing an excellent understanding of why screening was required after separating cells. As not all hybridoma cells will secrete the antibody specific for antigen p24, it is necessary to find those that synthesise the desired antibody and only culture these cells (**step 7**) to obtain the highest quantity of monoclonal antibody. Some candidates realised that the specific monoclonal antibody was required but thought that **step 6** was important in harvesting the antibody. Others repeated the information given in **Fig. 4.2** for **step 6**. Weaker responses showed a lack of understanding of the process by suggesting that the cells needed to be checked before they were given to people or suggesting that cells infected with virus needed to be found and discarded.

Question 5

(a) The explanation of RNA as a polymer was better known than as a macromolecule. A number of candidates explained that RNA was composed of nucleotides but did not continue to relate this to a definition of a polymer. Others named the subunits as bases or sugars. Some suggested that RNA as a macromolecule meant that it had a number of components (sugars, phosphates and bases) or suggested incorrectly that it was composed of many strands. In some weaker responses reference was made to polypeptides and amino acids.

(b) Almost all candidates knew a positive result for the reducing sugar test, with the best responses stating the start colour, (clear) blue, and the different colours that would result depending on the concentration of the reducing sugar, in addition to explaining that a precipitate would result. While most knew the correct reagent to use for the test, fewer gave a correct temperature at which the mixture should be heated. Many stated that a water bath should be used to heat, or stated that the mixture should be warmed. A very small number described the Fehling's test for reducing sugar, which is not required for this syllabus.

(c) Many candidates were successful in completing **Table 5.1** to show the difference between DNA nucleotides and RNA nucleotides. Candidates gaining partial credit usually knew the different pentose sugars but were more challenged in naming the correct purine and pyrimidine bases.

Question 6

(a) Functions of the rough endoplasmic reticulum and the Golgi body were well known by candidates. For the Golgi body, more detail than 'forms vesicles' was required. Some stated that the Golgi body was for exocytosis and could have gained credit if they had stated that the Golgi body formed secretory (or Golgi) vesicles for exocytosis. Although most realised that centrioles were involved in mitosis, many were too vague in their response and needed to have mentioned organisation of microtubules for the spindle or formation of spindle fibres to be sure of gaining credit.

(b) **A** was the most well-known of the three descriptions. The most common incorrect answer was prosthetic group and some incorrectly referred to an iron molecule rather than an iron atom. For description **B**, it was fairly common for carboxyhaemoglobin to be incorrectly stated for carbaminohaemoglobin. Many candidates knew that haemoglobinic acid was the appropriate term for description **C**. The abbreviation 'Hhb', although correct, was insufficient to gain the credit if the correct term was not also stated..

BIOLOGY

Paper 9700/23
AS Level Structured Questions

Key messages

Candidates should take care to use correct terminology. For example, in **Question 1(a)** 'secretory cells' was sometimes stated instead of Golgi vesicles and in **Question 4(c)** 'receptor cells' was used to describe the receptors for noradrenaline on the cell surface membrane of the sinoatrial node shown in **Fig. 4.1.**

When writing about energy in biology, candidates should avoid the phrases 'make energy', 'produce energy' and 'create energy'. These phrases were seen in answer to **Question 1(b)(i)**.

Candidates should consider the context of questions where the command word is 'suggest' and make links to the appropriate learning outcomes. Then the main ideas can be considered and the most relevant learning outcomes selected to answer the question. **Question 1(b)(ii)**, **1(c)(ii)** and **Question 5(a)(ii)** were examples of such questions.

General comments

The paper attracted some excellent, well-written responses, showing a deep understanding of the subject matter. In some responses, candidates needed to make better use of the information provided in the question to decide where to start and end their answers. An example of this was in **Question 1(a)**, where some began their answer with rough endoplasmic reticulum and others ended with a description of exocytosis. This contrasted with the best responses, where the answer was confined to the role of Golgi bodies to gain maximum credit.

Question 1(a) also showed the importance of using the context provided for each question. Some candidates used the information provided about the cells in the secretory glands of aphids to stay within the context of secretion of proteins used in feeding. Other candidates wrote instead about the production of mucus in the gas exchange system.

Sometimes candidates wrote extensive answers and contradicted themselves, where a more concise answer may have limited them to the facts. For example, in **Question 1(b)(i)**, some candidates gave correct features of mitochondria and then went on to state that they have a nucleus which stores DNA.

Some candidates were able to engage well with the stimulus material provided, while others should have made much more use of the stimulus material and relied less heavily on recall of knowledge. This was particularly highlighted in **Question 3(b)**, where some wrote about DNA replication or transcription instead of looking carefully at **Fig. 3.2** and using the information on telomerase provided. Responses needed to show understanding that RNA was being used as a template for the assembly of DNA nucleotides to produce a single polynucleotide of DNA rather than mRNA.

Replication as a term in this syllabus is more usually confined to describing the process when a DNA molecule is used for the production of two identical DNA molecules. In **Question 6(b)**, it was more appropriate to use the term production, rather than replication when explaining that many lymphocytes are produced during clonal expansion. Similarly, candidates should avoid using a phrase such as replication of antibodies when synthesis or production of antibodies would be a correct phrase to use.

Comments on specific questions

Question 1

(a) There were many very good descriptions of the role of the Golgi body. Many candidates gave details of the modification of proteins, especially glycosylation. Common errors included confusing the Golgi body with rough endoplasmic reticulum and stating that proteins are synthesised from amino acids in the Golgi body. Some candidates did not restrict their answer to the role of Golgi bodies, but spent time describing protein synthesis and the transport of proteins from the rough endoplasmic reticulum towards the Golgi body.

(b) (i) Candidates explained that mitochondria produce ATP or provide energy for cells. However, many stated that the energy is required for active transport and then described exocytosis. Stronger responses described exocytosis as a form of bulk transport, thus avoiding the confusion of exocytosis with the active transport of molecules and ions by carrier proteins.

(ii) Most responses correctly identified the presence of DNA and ribosomes in mitochondria. Stronger answers stated that mitochondria have circular DNA and 70S ribosomes. Some stated incorrectly that circular DNA forms a chromosome. Credit was not awarded for stating that mitochondria share similar cell features with prokaryotic cells, that they are surrounded by two membranes, or for any of the features of mitochondria that allow them to produce ATP.

(c) (i) The best responses included reference to the typical sizes of viruses, stating an acceptable range of sizes, or explained that they are acellular. Many candidates described cellular features that are not found in viruses or said that they were not living cells. There was confusion between the terms capsid and capsomere and also between viral and prokaryotic features. Many candidates referred to antigens and reverse transcriptase, which were not credited.

(ii) Many candidates realised that this was a question about plant cell structure and stated that owing to their small size, viruses were able to travel from cell to cell through plasmodesmata. Others stated that they moved through the symplast pathway to gain credit. Some referred incorrectly to the apoplast pathway. A few candidates did not answer the question, stating that viruses were transferred from plant to plant when aphids feed from the phloem.

Question 2

(a) (i) There were many excellent diagrams, which used the space available to show a dipeptide and also indicated the origin of the water molecule in the condensation reaction. Most candidates took care to avoid mistakes when drawing out the molecular structures. Common errors were to omit the water produced and to draw a bond between the two amino acids formed as an oxygen bridge.

(ii) Many candidates answered correctly or gave an acceptable alternative to R group, such as residual group, variable group or functional group. Carboxyl and amino groups were not accepted on their own as they are also at the N and C terminals. Many candidates described the involvement of R groups in stabilising the structure of proteins without explaining that they are specific to the different types of amino acid. Some answers implied that the R group was the amino acid itself.

(b) Most answers included correct details of the carbohydrate monomers in cellulose and amylose. More thorough responses went on to compare the structure of these two polymers: linear for cellulose as opposed to helical for amylose. The symbol for alpha and beta glucose was not always written clearly and a-glucose and B-glucose did not gain credit, unless the words alpha and beta were also given. In addition, some candidates confused the alternate orientation of beta glucose monomers through 180° with an alternate orientation of cellulose molecules. Several candidates did not stress the differences and just made a statement about cellulose, so did not gain full credit. A common error was to state that amylose had a branched structure with both 1,4 and 1,6-glycosidic linkages.

(c) Many candidates had a good understanding of the function of cellulose, but only a proportion had a good knowledge of its structure. The best responses made it clear that they were describing cellulose molecules, or cellulose fibres composed of many cellulose molecules. Credit for some points was only awarded if structure and function were related. For example, the permeability of cell walls had to be linked to the gaps between cellulose fibres. Some candidates confused cell walls with cell membranes, stating that cellulose had hydrophilic and hydrophobic parts and that cell walls were partially permeable. However, many did state the link between the high tensile strength of many cellulose molecules and the ability of cell walls to withstand turgor pressure and prevent plant cells from bursting. Common errors included stating that cellulose is made of lignin or that it is waterproof. There was also confusion with the structure of collagen (e.g. glycine is every third amino acid). Some candidates stated that cell walls support cells when they are plasmolysed, rather than when they are turgid or stated that cells collapse rather than burst under internal pressure.

Question 3

(a) (i) Many candidates answered correctly. **D** was often identified as a nitrogenous base or simply as a base. Some candidates gave more detailed answers by stating it was a pyrimidine, such as cytosine or uracil. **E** was usually identified correctly as ribose. Here, some candidates could have been more specific than just stating pentose. Almost all candidates identified **F** as the phosphate group. A common error was to give answers to **D** and **E** the wrong way around.

(ii) This was a straightforward question for many candidates. Candidates needed to state that DNA has deoxyribose or that DNA has two strands in order to gain credit. Simply stating that DNA and RNA have different sugars or different numbers of strands was sufficient. Other acceptable differences included the helical structure of DNA, the presence of thymine, the occurrence of base pairs and overall length.

(b) Explanations of the role of telomerase in synthesising additional lengths of DNA often did not refer to the diagram provided, but gave events that candidates recalled from their knowledge. A small proportion referred to the active site of telomerase that was shown in **Fig. 3.2** and appreciated that telomerase is an enzyme. These were able to make reference to the events occurring in the enzyme's active site. Common errors included describing the events of semi-conservative replication or transcription, describing the role of telomeres without any reference to the activity of telomerase given in **Fig. 3.2**, not making clear the distinction between the RNA template and the DNA nucleotides and pairing codons rather than referring to base pairing between nucleotides.

(c) There was a variety of answers to this question. Candidates needed to use their knowledge that prokaryotes have circular DNA rather than the linear DNA of the chromosomes of eukaryotes. This would have helped them to realise that circular DNA has no 'ends' that can be 'lost' during replication of DNA. Prokaryotes do not have chromosomes, so do not have linear DNA molecules. The simplest answer was that prokaryotes have no telomeres and so would not be likely to have a gene that codes for telomerase. Among the incorrect answers were statements that prokaryotes have no nucleus, no DNA or no enzymes, or do not divide at all.

(d) Many candidates made the link between telomerase activity during replication and the uncontrolled mitosis of cancer cells. There were some extremely lucid explanations for the presence of telomerase, often stated to be in high concentration, in cells that continue to replicate their DNA so that they can continue to divide. Other responses gained maximum credit by succinctly stating these two facts. In some answers, candidates clearly had an understanding of cancer cells dividing uncontrollably, but the link between telomerase activity and a diagnosis of cancer was less clear.

Question 4

(a) Many answers were sequenced very well and described clearly the events that occur to initiate and control the cardiac cycle. Candidates tended to be more secure in their knowledge of the atrioventricular node than the sinoatrial node and there were good explanations for the delay at the AVN in terms of synchronising the activity of the atria and ventricles. Some well written answers often finished by explaining that the same events occur again during the next cardiac cycle. A common error was to state that the AVN generates a new impulse rather than relaying the same impulse generated by the SAN. Some thought that the AVN was the pacemaker. Many candidates stated incorrectly that nerve impulses originate in the SAN. The SAN was known by many as the (primary) pacemaker. A few candidates gave confused answers and stated that the sinoatrial node and atrioventricular node prevent the backflow of blood.

(b) A small proportion of candidates answered this question well. Others needed more detail than just stating that Purkyne tissue stimulates contraction of the ventricles. Some stated incorrectly that the Purkyne tissue prevents the heart bursting or exploding.

(c) Most candidates used the information in **Fig. 4.1** successfully to write answers that were clear and well expressed. Many described the complementary binding of the signalling molecule to the cell surface receptors and ended by describing the events shown in **Fig. 4.1** that occur following the binding. A few correctly stated that the cell in the SAN is the target cell in this example of cell signalling. Details of the events of exocytosis leading to the release of noradrenaline were not expected. One common error was to state that the noradrenaline was first taken into the target cell by endocytosis before binding to receptors inside the cell.

Question 5

(a) (i) Many candidates gave either *Mycobacterium tuberculosis* or *Mycobacterium bovis* as the pathogen of tuberculosis to gain credit. Misspellings included Micobacterium and Microbacterium. Some candidates abbreviated the generic name to M. without writing it out in full.

(ii) Candidates often realised that this question required knowledge of emphysema and wrote about the effect of loss of elasticity of alveoli. Many candidates gained full credit. Correct answers stated that alveoli could not stretch and recoil in people with TB. Some were confused with muscle and incorrectly stated that elastic contracts and relaxes. Few answers referred to the breakdown of alveolar walls.

(b) The discussions ranged from a list of very brief bullet points to fully argued comments that covered most or all of the main aspects and demonstrated an excellent understanding of the topic. Many answers were well organised, with candidates beginning with transmission, discussing the difficulties in diagnosing TB, the lengthy treatment, the problem with people who do not complete the treatment and the development of drug resistance in *M. tuberculosis*. The limited effectiveness of the BCG vaccine was also included in the best scripts. It was not necessary to distinguish between features that were social factors and which were biological factors and many gave thorough sentences that showed the overlaps between the two. Some could have gained more credit by providing a greater variety of factors rather than elaborating on one or two factors. These responses tended to concentrate only on transmission of the pathogen or the development of antibiotic resistance. Some confused the transmission of *Mycobacterium tuberculosis* and *M. bovis* with the transmission of *Vibrio cholerae* and here control methods concentrated on improved sanitation and sewage treatment. Some candidates thought that there was no vaccine for TB. A few responses confused features of the microbe with the idea that it was a eukaryote. There was some confusion about the means of transmission of *M. tuberculosis*. Some candidates simply described it as airborne without making clear that the pathogen is in airborne droplets.

Question 6

(a) (i) Almost all candidates sequenced the stages of the mitotic cell cycle correctly.

(ii) Many candidates were successful at identifying the stages in the cycle from the events described. Common errors were to give prophase or metaphase for the division of the centromeres and telophase for the contraction of spindle fibres.

(b) Many candidates wrote a lot of general information about an immune response without concentrating on clonal expansion, the production of many plasma cells for production of antibodies and memory cells for the secondary response. Very few explained that before the primary immune response the clones of B-lymphocytes and T-lymphocytes with the ability to respond to any specific antigen have very few cells, hence the need for clonal expansion. Many candidates concentrated on the rapid speed of mitosis rather than the production of many cells, which was the key point required for this question. Some described the cells produced as identical, rather than as genetically identical cells.

BIOLOGY

Paper 9700/31
Advanced Practical Skills 1

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills that can be applied to the requirements of the examination.

Candidates should be familiar with looking at experiments and assessing the relative importance of errors in measurement or in making observations so that they can judge which sources of error are most significant. Making a slight error when adding set volumes of buffer to set volumes of yeast cell suspension would not decrease the accuracy of the results as there are other sources of error which are more significant such as the accuracy of measuring the height of the sediment.

General comments

Many candidates demonstrated that they had a good understanding of the skills required and the majority of candidates were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly drew on test-tube **B** a line level with the liquid in test-tube **A** and a layer indicating the level of sediment at the bottom and a label to the sediment.

(ii) Many candidates were able to describe correctly how the graph paper scale was used by stating that they would count the number of squares between the top of the sediment and the bottom of the test-tube.

(iii) Many candidates correctly stated that measuring the height of the sediment would be done for at least four regular time intervals.

(iv) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading ‘pH’ and the heading ‘height of sediment (mm)’. The majority of responses gained credit for recording the heights of sediment at each time interval and for each pH. Some candidates recorded pH 3 or pH 4 as the greatest height of sediment. The stronger responses recorded the heights as whole numbers.

(v) Some candidates correctly completed **Table 1.2** by recording the height of the sediment at each time interval for **BU**. Some candidates correctly estimated the pH of **BU** according to their results.

(vi) A few candidates suggested using at least five pH values to modify the procedure so as to obtain a more accurate estimate of the pH for **BU** followed by a comparison of their results with the results for the known pH values.

(vii) A few candidates suggested correctly that at the pH where the greatest sedimentation occurred, yeast cells were more attracted towards each other causing the yeast cells to stick together and drop to the bottom of the test-tube.

(viii) Some candidates correctly stated that a significant source of error was the difficulty of determining the boundary of the sediment when measuring the height of the sediment.

(b) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (time/hours) and the *y*-axis (number of yeast cells / arbitrary units cm^{-3}). Some candidates labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *x*-axis, used a scale of 5.0 to 2 cm and for the *y*-axis, used a scale of 200.0 to 2 cm.

Many candidates plotted the five points correctly and joined the points accurately.

(ii) Most candidates showed on the graph how to find the number of yeast cells at 18 hours and stated the correct answer according to their graph.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the shaded area as shown in **Fig. 2.1**. Many candidates gained credit for drawing at least four layers of tissue and for showing the outline of the vascular tissue as a wavy line. Most candidates used a label line and label to correctly identify the xylem.

(ii) Credit was awarded for drawings made up of continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent cells from the tissue close to the epidermis, each cell touching at least two of the other cells, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely. Many responses were credited for showing a cell which had at least three angular sides. Most candidates used a ruled label line and label to identify the cell wall of one cell.

(b) (i) The majority of candidates measured the line **X** within a range, with units. Most answers showed the measurement of **X** (mm) multiplied by 1000 and divided by 13 and gave the answer to the correct degree of accuracy.

(ii) A few candidates correctly stated that the eyepiece graticule could be used by counting the number of eyepiece graticule units equivalent to the length of the vascular bundle and referring to a calibration technique to determine the actual length of the vascular bundle.

(c) The stronger candidates organised the table into three columns, with one column for features, one headed **J1** and one headed **Fig. 2.2.** Many candidates listed at least three observable differences between **J1** and **Fig. 2.2,** such as the vascular bundles are joined together in **J1** and separated in **Fig. 2.2**.

BIOLOGY

Paper 9700/33
Advanced Practical Skills 1

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills that can be applied to the requirements of the examination.

Candidates should be aware that the wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. When the question states 'explain how this feature would prevent water loss', candidates needed to make clear in their answer why something happens, such as referring to a rolled leaf that would result in the trapping of moisture, thus helping to reduce evaporation.

General comments

Many candidates demonstrated that they had a good understanding of the skills required and the majority of candidates were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) The majority of candidates correctly measured the diameter of one cylinder, calculated the radius within a range and stated the units as mm.

(ii) Many candidates were able to calculate the curved surface area to the nearest whole number and stated the units as mm^2.

(iii) Many candidates were able to calculate the area of one circular end to the nearest whole number.

(iv) Some candidates correctly recorded the numbers 4 and 8 in the sequence for the number of pieces cut from one cylinder in the first column of **Table 1.3**. Many candidates correctly stated the total surface area for 2 pieces cut from one cylinder in the last column of **Table 1.3**.

(v) Most candidates were able to describe how to standardise the position of the delivery tube in the test-tube of water. The majority of correct descriptions referred to marking the delivery tube so that each time the end of the delivery tube was placed in the water it was positioned at the same depth under the water.

(vi) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading 'number of bubbles (at each 30 seconds)' and the heading 'total surface area (mm^2)'. Most candidates gained credit for recording 30, 60, 90 and 120 seconds in the table and recorded results for at least three different total surface areas. Many candidates recorded results which showed that for the highest total surface area the number of bubbles given off over 120 seconds was the highest.

(vii) Some candidates used the appropriate results calculated for the largest surface area and correctly calculated the mean number of bubbles in 30 seconds. Some candidates then correctly calculated the rate of activity and included units (min^{-1}).

(viii) Many candidates correctly suggested that the volume of oxygen could be measured using a gas syringe or by a method involving water displacement. Many candidates gained credit for stating that another significant source of error was the different amounts of the enzyme catalase in different potatoes and the improvement was to use cylinders cut from the same potato.

(ix) The stronger candidates stated that preparing five or more known concentrations of hydrogen peroxide by proportional dilution would allow modification of the procedure to investigate the effect of concentration of substrate on the activity of the enzyme (catalase) in the potato tissue.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole leaf. Many candidates gained credit for drawing at least three layers of tissue and showed the vascular bundle positioned beneath the palisade layer. Most candidates used a label line and label to correctly identify the palisade tissue.

(ii) Credit was awarded for drawings made up of continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw three touching epidermal cells and a trichome, with double lines representing the walls. The more successful candidates drew an inclusion in at least one of the cells. The most common error was to draw lines that did not meet up precisely. Most candidates used a label line and label to identify the cell wall of one cell.

(iii) The stronger candidates suggested that the ends of the leaf were rolled and explained that this feature enabled moisture to be trapped under the leaf which would help prevent evaporation of water from the leaf.

(b) Many candidates showed evidence, on **Fig. 2.1**, of counting whole stomata and half stomata.

Credit was given to those candidates who estimated the number of stomata inside the square within a range.

(c) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (time of day) and the *y*-axis (percentage of open stomata). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *x*-axis, used a scale of 2.0 to 2 cm and for the *y*-axis, used a scale of 20.0 to 2 cm.

Many candidates plotted the five points accurately and joined the points accurately.

(ii) Some candidates correctly explained that between 02:30 and 05:00 more stomata were open and that there was an increase in the rate of transpiration. The stronger responses suggested that there was more evaporation of water and faster diffusion.

BIOLOGY

Paper 9700/34
Advanced Practical Skills 2

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills that can be applied to the requirements of the examination.

Candidates should be familiar with how to use the microscope provided in the examination. When asked to draw structures or cells, candidates should follow instructions carefully to draw the required number of the correct structures or whole cells, using a suitable pencil to obtain clear, sharp lines. Only the structure specified should be labelled.

When drawing the observable features of cells in a specimen, the drawings must have the correct proportions and shape. Plant cell walls should be drawn with two lines, with a middle lamella between adjacent cells and the relative thickness of the cell walls should be in the correct proportion to the size of the cells.

Candidates should be given the opportunity to draw both graphs and charts. In this case, a line graph was required. The plots should be plotted accurately and lines drawn through the plots with a sharp unbroken line (0.5 mm thick or less).

General comments

In general, candidates demonstrated a good understanding of the skills required in this paper. The majority of candidates showed they were familiar with the microscope and demonstrated good drawing skills. There was good discrimination between the weaker and more able candidates.

Comments on specific questions

Question 1

(a) (i) The majority of candidates recorded the volume of iodine solution for **W** which was less than the volume for **A**.

(ii) Most candidates correctly completed the dilutions in **Table 1.2**, showing at least three correct percentage dilution concentrations in the table, for example 0.08%, 0.06%, 0.04% and 0.02%. Many candidates correctly stated the volumes of **A** and **W** to make 20 cm^3 of these concentrations.

(iii) The majority of candidates organised their results by presenting a ruled table, with correct headings and units for the independent variable as percentage concentration of ascorbic acid and the dependent variable as volume of iodine / cm^3. The most common error was to include units (% or cm^3) in the body of the table. The majority of candidates gained credit for the correct trend in the results.

(iv) The majority of candidates recorded the volume for **Y** which was less than the volume for **X**.

(v) Many candidates placed the concentrations from **Table 1.2** on the line in the correct order and then showed the correct estimation of both **X** and **Y** on the line using their results. A common error was to leave out the concentrations on the line from **Table 1.2**.

(vi) Most candidates were able to identify one significant source of error, for example, the drops sticking to the side of the tube or difficulty in judging the appearance of the first colour change.

(vii) The majority of candidates were able to suggest at least one improvement, with the stronger candidates able to suggest more. The most common error was to suggest improvements which would not lead to a more accurate estimate of the concentration of ascorbic acid in **X** and **Y**.

(b) (i) Most candidates used the headings given in the table to correctly label the *x*-axis and the *y*-axis. Some candidates labelled the incorrect axis or gave incomplete headings. Most candidates used a scale of 0.002 to 2 cm for the *x*-axis and 20 to 2 cm for the *y*-axis. Many candidates plotted the points accurately, with a small cross or dot in a circle and some also drew a sharp, clear, ruled line with precisely connected points. The most common error was drawing lines which were too thick or not ruled to the centre of the point. Candidates should be reminded of the need to use a sharp pencil.

(ii) The majority of candidates showed on their graph how to estimate the mass of maltose produced and accurately estimated this concentration from the graph. The most common error was stating a figure which was not to the appropriate degree of accuracy.

(iii) The majority of candidates were able to suggest one explanation for the results between 0.000% and 0.010%. Many suggested that ascorbic acid could act as an enzyme inhibitor while others made reference to the lowering of the pH and both of these suggestions gained credit.

Question 2

(a) (i) Many drawings were of an appropriate size and did not include any cells. The stronger candidates gained credit for carefully following the instructions and drawing the appropriate amount of detail within the section. Many candidates gained credit for drawing the vascular tissue in the correct proportion to the width of the whole root. The most common error was to include more labels than required or to draw too few layers of tissue.

(ii) Most candidates drew the required number of cells with no shading. Many used a sharp pencil to draw clear thin lines that were continuous. The most common error was to draw cells that were too small or with lines that were not continuous. Most candidates used a label line to show the cell wall of one cell.

(b) Many candidates measured the length of the total diameter and the central vascular tissue correctly and recorded them using the same correct units. A common error was to exclude the units. Most candidates expressed the ratio as a larger whole number to a smaller whole number and to the lowest common denominator. Some candidates incorrectly included units in the ratio or did not use whole numbers.

(c) The stronger candidates organised the table into three columns, with one column for features, one headed **M1** and one headed **Fig. 2.1**. Many candidates listed at least three observable differences between **M1** and **Fig. 2.1**, such having more xylem vessel elements in **M1** than in **Fig 2.1**.

BIOLOGY

Paper 9700/35
Advanced Practical Skills 1

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills that can be applied to the requirements of the examination.

Candidates should be familiar with how to use the microscope provided in the examination. When asked to draw structures or cells, candidates should follow instructions carefully to draw the required number of the correct structures or whole cells, using a suitable pencil to obtain clear, sharp lines. Only the structure specified should be labelled.

When drawing the observable features of cells in a specimen, the drawings must have the correct proportions and shape. Plant cell walls should be drawn with two lines, with a middle lamella between adjacent cells and the relative thickness of the cell walls should be in the correct proportion to the size of the cells.

Candidates should be given the opportunity to draw both graphs and charts. In this case, a line graph was required. The plots should be plotted accurately and lines drawn through the plots with a sharp unbroken line.

General comments

In general, candidates demonstrated a good understanding of the skills required in this paper. There was good discrimination between the weaker and more able candidates. The majority of candidates showed they were familiar with the microscope and demonstrated good drawing skills. The majority of candidates were able to suggest appropriate controls such as replacing the enzyme with the same volume of water or denaturing the enzyme by boiling.

Comments on specific questions

Question 1

(a) (i) The majority of candidates stated appropriate temperatures. A common error was to use temperatures outside the range given on the question paper.

(ii) The majority of candidates organised their results by presenting a ruled table, with headings and units as temperature / °C for the independent variable and time / s for the dependent variable. The most common error was to include units (°C or s) in the body of the table.

(iii) Many candidates correctly showed how to calculate the rate of enzyme activity by dividing 1 by 75. The most common error was to divide the temperature given by the time taken. Candidates should be encouraged to show all their workings.

(iv) Most candidates were able to suggest that the maintenance of the temperature could be improved by using a thermostatically controlled water-bath. Many candidates also suggested improvements in judging when the endpoint was reached, for example putting a mark and timing how long it takes to see it. The most common error was to suggest the use of black card as an improvement, which was not credited since it was already included in the instructions for step 6.

(v) Many candidates were able to describe an appropriate control, such as replacing the enzyme with the same volume of water or by using boiled enzyme. The most common error was to state variables that needed to be controlled instead of suggesting a control.

(b) (i) The majority of candidates were able to state the independent variable as pH.

(ii) Most candidates used the headings given in the table to correctly label the axes. Some candidates labelled the incorrect axis or gave incomplete headings. Most candidates used a scale of 1 to 2 cm for the *x*-axis and 20 to 2 cm for the *y*-axis. Many candidates plotted the points accurately, with a small cross or dot in a circle, and some also drew a sharp, clear, ruled line, with precisely connected points. The most common error was drawing lines which were too thick or not ruled to the centre of the point. Candidates should be reminded of the need to use a sharp pencil.

(iii) Many candidates were able to describe the effect of pH on the activity of the enzyme. Some did not recognise that enzyme activity rises then falls slightly and then drops more sharply. Most candidates quoted data from the graph to justify their description and gained credit for it.

(iv) The majority of candidates were able to state that more enzyme was denatured at pH6 than at pH3 and that this results in fewer enzyme-substrate complexes being formed.

(v) Many candidates suggested using a narrower range of pH values. The stronger answers included pH values in the range of 1.5 to 3. The most common error was using pH values outside the range of 1.5 to 3.

Question 2

(a) (i) Many drawings were of an appropriate size and did not include any cells. The stronger candidates gained credit for carefully following the instructions and drawing the appropriate amount of detail within the section. Many candidates gained credit for drawing the subdivisions seen in the vascular bundle. A common error was to draw more vascular bundles than instructed or to include more labels than required.

(ii) Most candidates drew the required number of cells with no shading. Many used a sharp pencil to draw clear thin lines that were continuous. The most common error was to draw cells that were too small or with lines that were not continuous. Most candidates used a label line to show the cell wall of one cell.

(iii) The majority of candidates were able to suggest why the presence of air spaces supported the conclusion that the plant grows in water.

(b) Many candidates measured the total length of **J1** and **J2** and **J3** correctly and recorded them using the same correct units. A common error was to exclude the units. Most candidates expressed the ratio as a larger whole number to a smaller whole number and to the lowest common denominator. Some candidates incorrectly included units in the ratio or did not use whole numbers.

(c) Many candidates listed at least three observable differences between **L1** and **Fig. 2.1**, such as the shape of the stem being irregular in **L1** but round in **Fig.2.1**. A common error was to make reference to three-dimensional shapes or to state differences that are not observable.

BIOLOGY

Paper 9700/36
Advanced Practical Skills 2

Key messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills that can be applied to the requirements of the examination.

Candidates should be given the opportunity to draw both line graphs and bar charts. In this case, a bar chart was required. The bars should be plotted accurately and drawn exactly along the horizontal lines with a ruled line. All the lines, both vertical and horizontal, should be unbroken.

For **Question 1(b)(ii)**, the arrangement of the bars was important. As each of the three types of food sample included the mass of two types of fat found in each food sample, each of the bars drawn should have been separated from each other.

General comments

Many candidates demonstrated that they had a good understanding of the skills required and the majority of candidates were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to carry out a simple (proportional) dilution of the ethanol, showing how to prepare at least three more concentrations. Most candidates completed **Table 1.2** correctly, selecting 95%, 90%, 85% or 80% and showed the correct volumes of ethanol and water to make these concentrations.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. Stronger responses included the heading for percentage concentration of ethanol and the heading for cloudiness. The majority of candidates gained credit for using the key in **Fig. 1.2** to record the cloudiness of the emulsion for the concentrations of **A**. Many candidates recorded results which showed that the higher the percentage concentration of **A** the greater the cloudiness. The more successful candidates recorded the results for two trials and included the mean result for each concentration of ethanol.

(iii) The majority of candidates correctly stated that the independent variable in the investigation was the concentration of ethanol.

(iv) Many candidates described the significant source of error as the difficulty of judging the cloudiness of the emulsion. The stronger answers suggested an improvement to reduce this source of error by using a colorimeter.

(v) Many candidates stated whether their results supported or rejected the hypothesis and then explained how their results provided evidence for this decision. The stronger candidates referred to at least two concentrations of ethanol with supporting data from their results.

(vi) The stronger candidates described how to measure the volume of ethanol added to the test-tube by using a burette. Full credit was given to those candidates who suggested that the time when the layer above the emulsion disappeared was the time to stop adding the ethanol. The volume of ethanol required to dissolve all the lipid in **L** could then be calculated.

(b) (i) Many candidates correctly showed 10.75 divided by 34.25 (addition of 10.75 and 23.5) multiplied by 100 and gave the correct answer to the correct degree of accuracy.

(ii) The majority of candidates drew the bar chart, using the headings given in the table, with 'food sample' on the *x*-axis and 'mass of fat in 100 g of food / g' on the *y*-axis.

The stronger candidates ensured that all six bars were the same width and used a scale for the *y*-axis of 5.0 to 2 cm. The most successful responses separated the three food samples and labelled the food types as **X**, **Y**, or **Z** and identified the bars as unsaturated or saturated.

Many candidates plotted the horizontal line at the top of each bar exactly with a thin line.

The most common errors were not including a full axis label for each axis, omitting the units for the *y*-axis and not labelling the scale every 2 cm.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing part of the epidermis, the outline of two vascular bundles and other tissues. Credit was gained for drawing two caps on at least one vascular bundle. Most candidates used a label line and the label **C** to correctly identify the tissue containing chloroplasts.

(ii) Credit was awarded to candidates for drawings made up of continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw a group of four touching xylem vessel elements, each xylem vessel element touching at least one of the other xylem vessel elements, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely. Many candidates were credited for showing a cell with at least three angular sides. Most candidates used a label line and a label to identify the lumen of one xylem vessel element.

(iii) The majority of the candidates used a ruled label line and the label **T** to identify the xylem wall or the lumen. The stronger candidates then explained how the xylem wall prevented the vessel collapsing or that the lumen had no contents so there was less resistance to the flow of water.

(b) (i) Many candidates used a ruled label line and the label **Q** to identify the cartilage tissue in **Fig. 2.2** as the feature preventing the tube from collapsing.

(ii) Many candidates were able to determine the simplest whole number ratio of the length of **P3** to the total length of **P1** and **P2** by using the same units for all three measurements, measured **P1**, **P2** and **P3** within a range and showed the answer as a larger whole number to a smaller whole number to the lowest common denominator.

BIOLOGY

Paper 9700/41
A Level Structured Questions

Key messages

Candidates should familiarise themselves with subject-specific terms so that they can be used correctly. For example, population (**Question 4(b)**), allele (**Question 5(a)**), receptor and action potential (**Question 8(b)(ii)**). These terms precisely describe important concepts and were needed to gain high credit on these questions.

General comments

Candidates were most successful on **Questions 1(a)**, **2(b)**, **3(c)(i)**, **4(a)(i)** and **6(a)(i)**. Questions that candidates found more challenging were **Question 1(b)**, **2(c)**, **4(a)(iii)**, **5** and **8b(iii)**. Candidates performed equally well on the two questions in **Section B**.

Comments on specific questions

Section A

Question 1

(a) (i) Candidates had no difficulty in suggesting alternative reasons for the low numbers of Bali starlings in the wild, such as deforestation (habitat loss), lack of food, disease and predators. A few mentioned pollution, but there is no evidence to suggest the low numbers are due to climate change.

(ii) Most answers mentioned captive breeding, though there were many inappropriate references to methods only applicable to mammals, not birds, such as in vitro fertilisation and embryo transfer to surrogate mothers. Inbreeding was not an acceptable answer since zoos take care to avoid this in small populations of endangered animals. Many answers made reference to the role of zoos in educating the public and in relevant research.

(b) Responses were varied in terms of detail. Some candidates only stated that the genetic variation or size of the gene pool would be low. Others made correct references to inbreeding depression, lack of hybrid vigour and the increased likelihood of harmful recessive alleles coming together. Occasionally, candidates confused homozygosity (which would increase) with heterozygosity (which would decrease). Strong answers explained that the population would be unlikely to be able to adapt to a new selection pressure or environmental factor.

Question 2

(a) Most answers correctly identified the statistical test as the chi-squared test. The most common incorrect answer was the *t*-test. The correct expected ratio of 9:3:3:1 was occasionally misquoted with a single figure wrong, or the 1:1:1:1 ratio from the test cross in part **Question 2(b)** was given.

(b) Responses to this question showed very good understanding and were well set out, with most candidates correctly identifying the genotypes of the parents, the gametes, the four offspring genotypes and the four phenotypes asked for in the question. Some candidates did not show which offspring genotypes were linked to which offspring phenotypes. A few candidates produced haploid flies or flies with alleles for only one of the two genes.

(c) Some candidates scored well but many struggled with this question. Descriptions of how the results differed from expected sometimes only included the quoting of the expected 1:1:1:1 ratio. Some identified the phenotypes of the majority or minority classes and the best answers made use of the terms parental and recombinant. Some candidates made only passing reference to the results before making detailed explanations about gamete formation, so missed out on much of the credit available. Explanations frequently referred to the genes being linked but more detailed explanations about the occurrence of crossing over, lack of independent assortment and identification of the linked pairs of alleles were rarer. Candidates who did not identify linkage as the reason for the difference in results from those expected mostly referred incorrectly to mutation and selection as reasons for the difference.

Question 3

(a) (i) Most candidates answered correctly with metaphase II. Some incorrectly stated metaphase I.

(ii) Descriptions of anaphase I were often poor, with reference to spindle fibres or microtubules pulling but not shortening or contracting, and to the involvement of centromeres without stating that they lead or move first. Some answers described anaphase II and said that chromatids rather than chromosomes moved to the poles of the cell. The strongest answers clearly explained that each bivalent, consisting of a pair of homologous chromosomes, separated into two individual chromosomes.

(iii) Use of the correct scientific language was needed to answer this question. Good answers referred to non-sister chromatids, chiasmata and alleles or sections of DNA being swapped or exchanged to give new combinations of alleles. Weaker answers were less precise in their use of words, referring to just genetic material or genes being exchanged, demonstrating a confusion between the term gene and allele. Other incorrect statements described new alleles being formed rather than new allele combinations being formed.

(b) (i) As the question asked about the difference between two populations, all of the marking points were comparative. Most candidates stated that the test leaves took a longer time to degrade the mesotrione herbicide and reasoned correctly that this meant they were less resistant than the control leaves. Some candidates needed to describe what the figures showed rather than simply restate figures from the data. Few candidates commented on the difference in standard deviation, showing that there was more variation in resistance amongst the test leaves.

(ii) A good answer related this example of variation to natural selection within the water hemp population, referring to the selective advantage of the resistant plants leading to the long-term survival or adaptation of the water hemp population in areas where mesotrione was used. Many candidates thought only in terms of individual plants having an advantage which allowed them to survive, reproduce and pass on alleles for resistance which increased in frequency. These responses were too generic and needed to refer more closely to the population of water hemp as described in the question.

(iii) Most candidates realised that laboratory testing allowed farmers to identify a suitable herbicide to control water hemp weeds in their fields. A few candidates mistakenly thought that the water hemp was the desired crop for the farmer and described how the farmer could promote the growth of the water hemp.

(c) (i) Most candidates were able to substitute the correct figures into the equation to calculate the *t*-test statistic. The most common error was omitting to square the standard deviation figures in the denominator. Candidates were clearly instructed to show their working, so those candidates who gave an incorrect final answer from a correctly substituted equation gained partial credit.

(ii) There some high quality explanations of whether to accept or reject the null hypothesis. Nearly all candidates decided to reject the null hypothesis and correctly based this on the reasoning that their calculated value of *t* was larger than the critical value. Only a few incorrectly referred to the critical value of 2.23 as the significance level. Those who went on to state that there was a significant difference, mostly finished the statement correctly by saying that there was a significant difference between the two populations or between the two mean times.

Question 4

(a) (i) Candidates had little trouble in calculating the beetle species density on O'ahu. The answer should have been rounded to the same number of decimal places as the figures for the other islands.

(ii) Strong answers focused on the relatively young age of Hawai'i and linked this to a lack of time for beetle species to migrate there or for speciation to occur on the island. Linking the large size of Hawai'i to the low beetle species density was insufficient for full credit. Candidates who misunderstood the data thought that beetle species density referred to how spread out a population of a single species of beetle was.

(iii) To gain full credit, candidates needed to follow the instruction to use **Fig. 4.1** as well as **Table 4.1** in this question. They also needed to take note of the significant information in the question stem that the source of all the *Mecyclothorax* beetle species on the archipelago was a single species that arrived in Maui. Using the figure, strong candidates noted that O'ahu was further away from Maui than Moloka'i, so the chance of beetle species reaching it was correspondingly lower.

(b) Candidates performed well on this question, which presented a novel scenario of beetle speciation on the slopes of a volcano where lava flows separated forest into microhabitats. Candidates usually used terms like allopatric speciation, geographical isolation, natural selection and genetic drift correctly, though a minority of candidates did not realise that drift operates independently of any supposed selective advantage or disadvantage. Some answers used inappropriate terms, considering genetic variation and mutation as occurring in microhabitats rather than in populations of beetles located in the separate microhabitats. Similarly, candidates described a lack of gene flow between microhabitats instead of between populations. The strongest responses made it clear that multiple populations were undergoing separate evolution as a result of different selection pressures, resulting in genetic differences accumulating in each population.

Question 5

(a) (i) The strongest candidates were able to apply their knowledge of the preparation of recombinant vectors in the context given. Weaker responses tended to rely on recall of learnt information. This led to errors, such as mentioning plasmids, despite the information given in the question that the vector was a virus and not a plasmid, and stating that mRNA was extracted from the cells of the islets of Langerhans in the pancreas, despite this being an eye disease involving a gene that is expressed in the retina. It was common for candidates not to understand that a viral vector consisted of a protein coat and a length of nucleic acid (in this case, DNA) and to speak of enzymes like restriction endonuclease cutting or ligase joining the virus rather than the viral DNA. Many candidates lost credit by saying they would obtain the normal gene rather than the normal allele of the gene, and few accessed the credit available for amplifying the correct allele using PCR or identifying it using electrophoresis.

(ii) Candidates with sufficient knowledge of genetic terminology gained credit for explaining that a dominant allele could be added. Few mentioned that only one copy of the dominant allele per cell would be needed to reverse the symptoms of the disease, or that there would be no need to edit or delete the faulty recessive allele. A common error was to state that the recessive allele would need to be replaced with a dominant allele.

(iii) Most candidates used the information provided to reason that the danger of the injection method detaching the retina would make little difference to LCA patients who were blind already, but that this presented a risk of worsening the vision of the other group of patients with less severe lack of vision. Some candidates could have gained more credit if they had been more careful in explaining which group of patients was being discussed. The information provided made it clear that the age-related diseases must have a genetic basis or researchers would not have been contemplating using gene therapy to alleviate symptoms, so the suggestion that age-related diseases were not genetic was not credited.

(b) (i) Candidates found this question challenging. Answers that scored credit focused on the wrong pairing of free nucleotides with the template strand of DNA during the elongation stage, and the perpetuation of the error in the sequence of one strand of DNA during further rounds of PCR.

(ii) Answers were often vague and did not show an ability to visualise the experimental situation and to consider each step logically, from the arrival of the virus containing the GFP gene in the fluid of the eyeball to the movement of the virus across this fluid to the photoreceptor cells. Here it infected the cells and introduced the gene which was expressed using photoreceptor cell machinery to make fluorescent protein in these cells. The most common error was to confuse the gene for GFP, which is a section of DNA, with the protein product GFP, which glows green under UV light.

(iii) Very few candidates were able to integrate the information given in the context of this question, to conclude that the discovery of the 7m8 adeno-associated virus meant that gene therapy would now be a safe treatment option for age-related retinal diseases, or that take-up, acceptability or use of gene therapy for this group of diseases would increase.

Question 6

(a) (i) Most candidates identified the precise cellular location of glycolysis as the cytoplasm. The commonest incorrect answer given was the matrix of the mitochondrion.

(ii) Identifying the steps where phosphorylation occurred proved difficult for many candidates. This was usually because they gave an additional incorrect answer, frequently **step 2**, in addition to naming the correct steps. Many candidates were unable to name **step 5** as the step where oxidation occurs. The most frequent error referred incorrectly to **step 4**. The reaction in **step 5** was correctly named as substrate-linked phosphorylation by many candidates, though some wrote phosphorylation alone, chemiosmosis or condensation.

(b) Good responses used the information provided to explain that using glycolysis meant that cancer cells would require less oxygen. A few candidates linked the high energy demand of cancer cells with the low ATP production in glycolysis to reason that there would be a higher demand for glucose. Some candidates used their knowledge of the high energy demands of cancer cells without reference to the question stem and suggested cancer cells would need both more glucose and (incorrectly) more oxygen, as though they were undergoing more aerobic respiration.

Question 7

(a) This question was generally answered well, although a significant number did not recognise that structure **A** was a starch grain.

(b) Almost all candidates stated that two peaks of oxygen production occurred at wavelengths of 450 nm and 650 nm, although some lost credit by using incorrect units. Many candidates also explained that these peaks were a result of the plant (or pigments) absorbing these wavelengths of light most effectively. Few explained that the light was used for photophosphorylation or photosynthesis, although some correct references to the light dependent stage were seen. The strongest candidates related the light absorption to photolysis occurring faster at the peaks on the graph, so producing more oxygen.

(c) Candidates generally knew that accessory pigments absorbed light at wavelengths different to the primary pigments, and that the energy captured was passed to the primary pigment. A few candidates incorrectly stated that electrons, rather than energy, light or photons, were transferred from the accessory pigments to the primary pigment.

Question 8

(a) Many candidates limited the credit they could score due to incorrect use of subject-specific terminology. Many wrote of sensory receptors sensing or receiving a signal in the environment rather than detecting or responding to a stimulus, and passing stimuli, signals or messages to the central nervous system rather than passing impulses to or along sensory neurones. Few used the term transducer or gained the credit available for listing two examples of sensory receptors.

(b) (i) The majority of candidates identified **C** as the stage when Na^+ channels are open and **D** as the stage when K^+ channels are open. Most knew that the Na^+/K^+ pump operated at stage **E** but did not realise that it also operated throughout stages **C** and **D** as well.

(ii) Most answers gained credit for stating that the threshold was not reached but few candidates used the correct terminology to name the initial depolarisation of the sensory receptor as the receptor or generator potential. A few incorrectly stated that the action potential did not reach the threshold.

(iii) Most candidates correctly referred to one-way transmission of the impulse being dependent on the refractory period, but few also considered the role of the refractory period in limiting the frequency of action potentials.

(iv) Most candidates gave responses that explained the role of the myelin sheath, which limited the credit that could be achieved. Candidates also needed to consider the establishment of local circuits between a depolarised node of Ranvier and the next node, leading to the opening of Na^+ channels at that node and a second depolarisation there. A stepwise logical approach benefited candidates. Some credit was available where more general answers were given, for referring to salutatory conduction and a single role of the sheath such as insulating the axon or speeding up the transmission.

Section B

Question 9

(a) Many candidates were able to gain credit for listing the features of organisms in the domain Bacteria. Most referred to the absence of a nucleus and membrane-bound organelles, circular DNA, 70S ribosomes, a peptidoglycan cell wall and the possession of structures such as plasmids or flagella. Answers also commented on the unicellular nature of many bacteria and their multiplication by binary fission. A few answers confused plasmids (extra small circles of DNA) with the main circular genome of the cell, and some incorrectly thought that bacterial DNA was single-stranded.

(b) Candidates focused more on the roles of zoos rather than botanic gardens, with some candidates knowing little about how botanic gardens work to conserve plant species in the same way as zoos work to protect animals. Responses also repeated the term endangered species without referring to living plants being grown in botanic gardens, although seed banks were often mentioned. A good answer discussed collecting plant specimens or seeds from the wild from threatened locations around the globe, growing the plants in carefully controlled conditions suited to those plants and possibly increasing the population numbers for reintroduction to the wild at a later date. The need to cooperate with governments and international agencies, and to conserve or restore habitats, was noted in the strongest answers. Some candidates mentioned the need to maintain genetic diversity but then suggested selective breeding and cross-breeding as solutions, which would not conserve a wild endangered species. General statements about research and education scored credit for many answers.

Question 10

(a) Some candidates wrote generally about renal structure and function. Good answers focused on the precise question asked and confined themselves to relating the structure of relevant parts of the nephron only to the process of ultrafiltration. Descriptions of the proximal convoluted tubule and the loop of Henle were not relevant to the question asked and so could not gain credit. Good responses included structural detail of the glomerulus and the difference in diameter of its associated arterioles leading to the creation of a high blood pressure. Few were able to describe fluid being forced out of the glomerulus, many incorrectly referring to diffusion instead. The importance of the basement membrane as the main filter was appreciated by the strongest candidates. Correct terminology was important here, so ‘basal membrane’ was not an acceptable alternative to the basement membrane (of the nephron epithelial cell layer). References to the membrane preventing blood cells and large molecules from passing through were provided by most candidates, although vague references to large substances did not gain credit. Commonly, candidates identified water or solutes such as glucose or urea or ions as being able to pass through from the glomerular capillaries to the lumen of the Bowman’s capsule. Although most responses mentioned podocytes, some candidates described these as being finger-like processes rather than being whole cells that have interdigitating or finger-like extensions. Structural details related to the function of the three layers, including the many large fenestrations in the capillary endothelium, the filtration slits formed by the podocytes or the collagen meshwork of the basement membrane, were not often described.

(b) Most candidates described a scenario where blood glucose concentration was initially elevated, leading to insulin secretion and a subsequent decrease in blood glucose concentration (not blood sugar level). Two target tissues were often named (most commonly muscle and liver), although some responses did not name any target tissues. Strong answers distinguished between vesicles containing GLUT 4 receptors which fuse with the membrane of muscle cells, increasing these cells' permeability to glucose, and the GLUT 2 receptors in liver cells that are always present in the cell surface membrane and are not increased in number in response to insulin. The permeability of the liver cell membrane to glucose is not increased in response to insulin, so this answer was not credited. Many candidates knew the names of enzymes activated by insulin binding to its cell surface receptor. Some candidates erroneously stated that insulin converts glucose to glycogen directly, rather than acting through intermediary enzymes. The use of glucose in respiration was often referred to, but only a minority made it clear that respiration of glucose increases in response to insulin. Strong answers also mentioned decreases in lipolysis and gluconeogenesis. Many candidates lost credit by saying insulin makes a process like respiration or diffusion of glucose into a target cell happen, instead of making it clear that these processes occur anyway but that their rate is increased in response to insulin.

BIOLOGY

Paper 9700/42
A Level Structured Questions

Key messages

- In calculations, working should be clearly displayed and the number of decimal places should be appropriate to the data provided, unless otherwise stated in the question.
- Candidates should use the number of marks available in the question as a guide to the amount of detail they need to provide in their answer. For example, if a question has three marks, then the answer should contain a three valid statements to achieve full credit.

General comments

Questions 5, **6** and **8** proved to be particularly challenging for most candidates in this paper. There were some excellent scripts as well as a higher number of very low scoring candidates.

Comments on specific questions

Section A

Question 1

(a) (i) The majority of candidates gained full credit, most commonly for stating habitat destruction and the hunting or killing of pigs for food or sport. There were also many who appreciated that disease or a reduction in food supply might have caused a decrease in the pig population.

(ii) This question answered well. Most candidates recognised the importance of captive breeding programmes to increase their numbers, often going on to state that this would enable their re-introduction into the wild. Many referred to medical care or vaccination programmes to keep the pigs healthy as well as the benefits of raising awareness and educating the public. While some candidates commented that research could be carried out, it was often unqualified. Very few mentioned zoos working with the government in the setting up of reserves. Weaker answers simply listed all the methods that might be used in assisted reproduction.

(b) The consequences of interspecific breeding between the warty pig and the domestic pig were poorly understood with very few candidates achieving full credit. Many responses incorrectly referred to outbreeding and scored no credit. The most common correct response was that the offspring would be sterile or infertile and some understood that a hybrid pig would arise. References to the hybrids being genetically different to warty pigs or less well adapted to the environment were rare, as were comments on the change in susceptibility to parasites or disease.

(c) The completion of **Table 1.1** proved difficult for many candidates. The more able correctly identified the class and domain. Incorrect spellings of Eukarya were not credited. The weakest answers either did not attempt this part or gave incorrect responses for both.

Question 2

(a) (i) The majority of candidates were aware that directional selection was responsible for lactose persistence. Weaker answers repeated natural selection from the stem of the question.

(ii) Most candidates gave a clear account of the process of natural selection. There was clear understanding that individuals with lactose persistence survived and were able to pass on the mutant allele, although there was a general lack of awareness that the increase in allele frequency took place over many generations. Few candidates correctly identified the selection pressure as lactose or a reliance on milk products, but a minority were aware that a selective advantage was conferred on those with lactose persistence. Some candidates gave incorrect descriptions of selection pressure implying that it was the increase in farming of cows that caused a mutation. Many candidates wrote that the gene, rather than the allele, was being passed on.

(b) (i) A reasonable number of candidates were aware that q represented the frequency of the recessive allele, *t*, and that q^2 could be calculated from the data given. They were then able to go on and calculate p, which was the frequency of the dominant allele, **T**.

(ii) Many candidates found this question challenging. A few candidates linked the percentage of people with lactose intolerance to the fact that the test population was too small and also that it was not representative or it was biased. Some correctly identified the effect of migration. Incorrect answers were often linked to different areas where lactose consumption was low, not taking into account the fact that the selection would have already happened a very long time ago. A significant number of candidates did not gain credit for writing that the test population was smaller than the general population, as they had not recognised that being smaller in size does not necessarily mean the population was small in size.

(c) (i) Many candidates were aware of the nature of protein transcription factors and their ability to control gene expression in relation to their action by binding to the promoter region of DNA. Most errors were based on an incorrect description of the transcription factor or omitting to state that it bound to the promoter. Some incorrectly stated that it bound to the operator region. Others confused transcription factors in eukaryotes with operons in prokaryotes.

(ii) Very few candidates could correctly name a control sequence in humans such as a promoter.

(iii) Many candidates found this question very challenging and often gave an account of types of mutation rather than appreciating that the majority of genes in a human are regulatory. There was a general lack of awareness that most genes were regulatory, with few correctly stating that structural genes made up only 2%. Very few candidates identified that mutations in regulatory genes were less likely to be harmful. Most answers discussed the transcription effect of mutations in regulatory genes in terms of changes in protein/enzyme function or altered phenotypes.

Question 3

(a) (i) Many candidates correctly calculated the diploid chromosome number of the hybrid offspring of a sheep and a goat. However, some simply added the diploid number of both species together, rather than the haploid number.

(ii) This was poorly understood by a number of candidates. Many simply stated that the chromosome numbers of the two animals were different or that they had different behavioural or physiological characteristics. Stronger candidates recognised that they were different species and belonged to a different genus.

(b) There were many correct genetic diagrams of the required cross, scoring full credit. Some candidates gave haploid genotypes resulting in incorrect gametes and F1 genotypes. Others did not link the genotypes with the phenotypes or confused horned with hornless.

(c) (i) Many candidates stated that an ethical advantage of genetic modification would be to remove the need for the stressful disbudding procedure on young animals, although some suggested that it would protect the farmer or other animals from being injured.

(ii) Most candidates were able to suggest a suitable reason and many recognised that the genetic modification would take less time or have a higher success rate, while selective breeding might still result in some horned offspring. Some stated that there would be inbreeding depression or that the milk yield might be compromised. Few mentioned that genetic modification would only change a single gene.

Question 4

(a) Most candidates correctly identified all of the locations of proteins, the main error arising from identifying the location of ATPase.

(b) A minority of candidates gave a fully correct account of the role of ATP in the contraction of striated muscle. The sequence of events was often mixed up with many incorrect references to the use of ATP. The majority of candidates were aware of the association between the myosin head and actin with regard to the making and breaking of cross bridges, the movement of the myosin head with actin and the power stroke. However, in many cases the involvement of ATP was incorrect. Many were aware that ATP became bound to the myosin head where hydrolysis to ADP and P_i took place, but did not associate the binding purely with the detachment of the myosin head from actin and then the subsequent hydrolysis of ATP to return the myosin head to its original position. The hydrolysis was often incorrectly associated as a requirement for detachment and/or for the formation of cross bridges and the power stroke. Few associated the release of ADP from the myosin head as being responsible for its movement of the actin filament. Many weak responses gave an account of how ATP was generated in mitochondria or its role in generating an action potential or synaptic transmission.

Question 5

(a) Few candidates achieved full credit for this question. The action of DNA ligase was most frequently correctly described with candidates commenting that it would be used to seal the sugar phosphate backbone by the formation of phosphodiester bonds. Weaker answers simply stated that it would join two pieces of DNA together. Many recognised that the restriction endonuclease would be used to cut DNA, with various descriptions of sticky or blunt ends, and a minority mentioned the cutting of the plasmid or vector. The role of reverse transcriptase was poorly expressed, with candidates stating that it would convert mRNA into cDNA or form the latter from the former. Some stronger candidates stated that it would use mRNA as a template for the synthesis of cDNA.

(b) Explanations as to why the *GFP* gene was chosen were often unclear. Few candidates appreciated that the successful deletion of the gene would result in a lack of fluorescence, or vice versa, instead stating that the presence of fluorescence would allow the easy identification of the transgenic pig. Some gained credit for mentioning that the *GFP* gene would act as a marker.

(c) (i) Many candidates were able to calculate the percentage correctly, although there were a number of errors, for example, attempting to calculate a percentage change.

(ii) Few candidates could explain why their calculation was higher or lower than expected. A minority understood that only 50% of the offspring would be expected to inherit the GFP gene from a heterozygous male.

(iii) Many candidates correctly named chi-squared as the appropriate statistical test. The most common error was to suggest the *t*-test.

(iv) Candidates frequently stated that $10\,\text{ng}\,\text{mm}^{-3}$ would be the best concentration of Cas9 nuclease and guide RNA, although some omitted the units. Weaker answers suggested that the highest concentration would be the most efficient. Those who had selected the correct concentration often went on to gain further credit by recognising that this concentration was as effective as the higher ones in deleting the *GFP* gene as no blastocysts were visible under the filter, yet a higher number survived. References to the increasing toxicity at higher concentrations were rare.

(d) Stronger candidates could interpret **Fig. 5.1** effectively and appreciated that the new technique was totally successful in causing a deletion in the gene as all the pigs born showed a band of 4 kbp rather than 6 kbp, many going on to add that 2 kbp had been deleted. While some candidates understood that there had been a deletion, they could have used figures to illustrate their response for further credit. Fewer candidates explained that the PRRSV virus would be unable to infect the cells of these pigs, simply stating that they would be resistant, although some appreciated that the functional cell surface protein to which the virus attaches would no longer be coded for and therefore could not be synthesised.

Question 6

(a) (i) Some candidates answered this well. Others did not respond or just identified the *lacZ, lacY or lacA,* with no corresponding enzyme. Spelling of β-galactosidase was poor and many did not state the β. Some candidates confused the structural genes with the names of the gene products and subsequently the product formed by the gene product as the gene product, and so stated lactase giving galactose and glucose.

(ii) A minority of candidates were aware that the gene products were needed all the time. Many incorrectly referred to the gene being needed or that the proteins may be regulatory or that there was no operon controlling expression.

(iii) The binding of a repressor protein onto the operator region was understood by many candidates, a large number of whom also appreciated the subsequent blocking of the promoter and that RNA polymerase could therefore not bind to it. Credit was lost in some cases for mistaking the promoter for the operator and also for not specifying that structural genes were not transcribed.

(b) (i) Many candidates were aware that an inducible enzyme was produced when its substrate was present, but to gain credit, some needed to specify that it was only produced when its substrate was present. Rarely did candidates link the substrate or inducer to its role in promoting gene expression.

(ii) Conservation, particularly of energy/ATP was appreciated by many candidates and was the most common answer given.

Question 7

(a) (i) Most candidates were able to name the stage of the Calvin cycle occurring at **A** and the enzyme involved. Two named examples of substance **C** proved to be more difficult for many as they had not taken into account that a hexose sugar had already been formed. Stronger candidates named polysaccharides, such as starch or cellulose, or disaccharides, such as maltose or sucrose. Many candidates also mentioned lipids or fats. References to amino acids were not credited since nitrogen would also be necessary for their formation. The biochemical process that produced ATP and reduced NADP was often incorrectly named. A number of candidates stated oxidative phosphorylation or photolysis, while stronger responses stated photophosphorylation or the light dependent stage. However, cyclic photophosphorylation gained no credit since reduced NADP would not be produced in this stage.

(ii) Most candidates appreciated that the process occurring at stage **B** of the Calvin cycle in **Fig. 7.1** was the regeneration of RuBP. Many also commented that ATP would be necessary for phosphorylation.

(b) This generally understood well, although some candidates gave long accounts of the fixation of carbon dioxide by PEP carboxylase and the subsequent processes required to deliver carbon dioxide to the bundle sheath cells. Many recognised that the mesophyll cells prevented oxygen reaching the bundle sheath cells, RuBP or Rubisco, so that Rubisco would not catalyse the reaction between oxygen and RuBP, thereby preventing photorespiration. Some also commented that this would also avoid the wastage of RuBP. However, some simply stated what would happen if oxygen did enter these cells without mentioning that these processes would not occur. References to air, rather than oxygen, were not credited. Statements that there would be less photorespiration were also not credited.

Question 8

(a) The involvement of DELLA proteins was apparent to a minority of candidates, although their role was often incorrectly linked to the action of gibberellin directly upon them, rather than through an enzyme, which was produced as a result of gibberellin binding to a receptor. These candidates were still able to score credit by linking its breakdown to enabling gene expression. The transcription factor PIF was often mentioned in these answers.

(b) The majority of candidates answered this question well. Many gained full credit for very well structured responses that were logically sequenced and biologically correct. The main errors were not including the breakdown of starch by amylase in the endosperm layer and suggesting a direct involvement of starch breakdown products in the embryo in terms of respiration or growth. Many incorrectly referred to the seed using the glucose.

(c) Many candidates gained reasonable marks for this question. Most responses could have been improved by being set out in a more logical and directly comparative manner, dealing with the graphical information in terms of the initial length of both **P** and **Q**, followed by comparative increases in stem length, including data after 20 days, followed by comparative rates with data. Very few candidates calculated growth rates, but when they did, it often followed a good logical answer. Weaker answers did not include units for data quotes. Many responses stated lengths at a range of different days within the experimental period or the rates of each batch at different time periods, rather than an overall assessment of rate of growth.

(d) A very small proportion of candidates gave a correct response. Many did not mention alleles or gibberellin. There were many answers referring to the mechanism of elongation rather than the control of elongation in the two phenotypes. Few candidates were aware of the *Le* and *le* dominant and recessive alleles. Those who were, often did not link the *Le* allele to tall plants or the *le* allele to dwarf plants. A very few candidates who were aware of the active form of gibberellin did not link it to *Le* coding for the enzyme which produced active gibberellin or the recessive alleles being responsible for no active gibberellin being produced.

Section B

Question 9

(a) Many candidates began their response with a list of energy values for carbohydrates, proteins and lipids without stating that lipids would have the highest energy value or energy per unit mass. More able candidates linked the energy values with the number of hydrogen atoms or carbon-hydrogen bonds in each substrate and added that lipids would have the highest, although their location in the fatty acid tails was rarely mentioned. Relatively few went on to describe the release of hydrogen during the oxidation of the substrate, although some appreciated that more NAD or FAD would be reduced and that they would proceed to oxidative phosphorylation or chemiosmosis to produce ATP. Very occasionally, candidates mentioned the release of hydrogen to the electron transport chain and its subsequent dissociation into protons and electrons, while references to the establishment of the proton gradient were more frequent.

(b) Most candidates attempted the definition of the respiratory quotient and a few achieved full credit. While most understood that it was the ratio of the carbon dioxide produced divided by the oxygen taken in, few referred to the volume, or moles of each gas and hardly any mentioned per unit time. Accounts of the use of the respirometer in the determination of the RQ of germinating seeds were lacking in detail in most cases. While many attempted to describe or draw the apparatus, few mentioned a manometer or capillary tube with coloured liquid which would be used to measure the uptake of oxygen, and often seeds were placed in water. Where a mesh or gauze was included, some candidates suggested that it was to hold the soda lime rather than the germinating seeds. However, most understood that the soda lime, or suitable equivalent, would absorb the carbon dioxide produced. Stronger candidates stated that the experiment should be repeated without the soda lime, although there was no mention that the difference in manometer readings would be due to the carbon dioxide expired. Some candidates gained credit for appreciating that independent variables, such as temperature and air pressure, should be kept constant, and that any measurements should be taken after a given time.

Question 10

(a) This question was generally answered well by the majority of candidates who gave logically sequenced accounts of a reflex arc. Answers focused on the transmission of impulses triggered by a receptor responding to a stimulus through the sensory, relay and motor neurones. Impulses were more commonly referred to than action potentials and synapses were not often included. The link in the spinal cord was often omitted or incorrectly given as the spine. Transmission to an effector and an appropriate response were commonly stated. Virtually all were aware of a fast, involuntary response, and most of these included its significance in protecting from harm. Rarely was reference made to the idea of a very strong stimulus or that the response was always the same. There was a proportion of candidates who stated that the sensory neurone detected the stimulus, and some candidates did not refer to action potentials or impulses and referred to messages or information.

(b) This question was answered very well, with the majority of candidates gaining full or close to full credit. Most candidates were aware that the structure of the neurone included gaps in the myelin sheath called nodes of Ranvier, which through saltatory conduction increased the speed of the transmission of nerve impulses. Many were also aware that the myelin sheath was made up of Schwann cells which were largely lipid, and these stopped the passage of ions, hence insulating the axon, and that depolarisation only occurred at the nodes. Fewer included the setting up of local circuits or the internode distance of 1–2 mm.

BIOLOGY

Paper 9700/43
A Level Structured Questions

Key messages

Candidates should familiarise themselves with subject-specific terms so that they can be used correctly. For example, population (**Question 4(b)**), allele (**Question 5(a)**), receptor and action potential (**Question 8(b)(ii)**). These terms precisely describe important concepts and were needed to gain high credit on these questions.

General comments

Candidates were most successful on **Questions 1(a)**, **2(b)**, **3(c)(i)**, **4(a)(i)** and **6(a)(i)**. Questions that candidates found more challenging were **Question 1(b)**, **2(c)**, **4(a)(iii)**, **5** and **8b(iii)**. Candidates performed equally well on the two questions in **Section B**.

Comments on specific questions

Section A

Question 1

(a) (i) Candidates had no difficulty in suggesting alternative reasons for the low numbers of Bali starlings in the wild, such as deforestation (habitat loss), lack of food, disease and predators. A few mentioned pollution, but there is no evidence to suggest the low numbers are due to climate change.

(ii) Most answers mentioned captive breeding, though there were many inappropriate references to methods only applicable to mammals, not birds, such as in vitro fertilisation and embryo transfer to surrogate mothers. Inbreeding was not an acceptable answer since zoos take care to avoid this in small populations of endangered animals. Many answers made reference to the role of zoos in educating the public and in relevant research.

(b) Responses were varied in terms of detail. Some candidates only stated that the genetic variation or size of the gene pool would be low. Others made correct references to inbreeding depression, lack of hybrid vigour and the increased likelihood of harmful recessive alleles coming together. Occasionally, candidates confused homozygosity (which would increase) with heterozygosity (which would decrease). Strong answers explained that the population would be unlikely to be able to adapt to a new selection pressure or environmental factor.

Question 2

(a) Most answers correctly identified the statistical test as the chi-squared test. The most common incorrect answer was the *t*-test. The correct expected ratio of 9:3:3:1 was occasionally misquoted with a single figure wrong, or the 1:1:1:1 ratio from the test cross in part **Question 2(b)** was given.

(b) Responses to this question showed very good understanding and were well set out, with most candidates correctly identifying the genotypes of the parents, the gametes, the four offspring genotypes and the four phenotypes asked for in the question. Some candidates did not show which offspring genotypes were linked to which offspring phenotypes. A few candidates produced haploid flies or flies with alleles for only one of the two genes.

(c) Some candidates scored well but many struggled with this question. Descriptions of how the results differed from expected sometimes only included the quoting of the expected 1:1:1:1 ratio. Some identified the phenotypes of the majority or minority classes and the best answers made use of the terms parental and recombinant. Some candidates made only passing reference to the results before making detailed explanations about gamete formation, so missed out on much of the credit available. Explanations frequently referred to the genes being linked but more detailed explanations about the occurrence of crossing over, lack of independent assortment and identification of the linked pairs of alleles were rarer. Candidates who did not identify linkage as the reason for the difference in results from those expected mostly referred incorrectly to mutation and selection as reasons for the difference.

Question 3

(a) (i) Most candidates answered correctly with metaphase II. Some incorrectly stated metaphase I.

(ii) Descriptions of anaphase I were often poor, with reference to spindle fibres or microtubules pulling but not shortening or contracting, and to the involvement of centromeres without stating that they lead or move first. Some answers described anaphase II and said that chromatids rather than chromosomes moved to the poles of the cell. The strongest answers clearly explained that each bivalent, consisting of a pair of homologous chromosomes, separated into two individual chromosomes.

(iii) Use of the correct scientific language was needed to answer this question. Good answers referred to non-sister chromatids, chiasmata and alleles or sections of DNA being swapped or exchanged to give new combinations of alleles. Weaker answers were less precise in their use of words, referring to just genetic material or genes being exchanged, demonstrating a confusion between the term gene and allele. Other incorrect statements described new alleles being formed rather than new allele combinations being formed.

(b) (i) As the question asked about the difference between two populations, all of the marking points were comparative. Most candidates stated that the test leaves took a longer time to degrade the mesotrione herbicide and reasoned correctly that this meant they were less resistant than the control leaves. Some candidates needed to describe what the figures showed rather than simply restate figures from the data. Few candidates commented on the difference in standard deviation, showing that there was more variation in resistance amongst the test leaves.

(ii) A good answer related this example of variation to natural selection within the water hemp population, referring to the selective advantage of the resistant plants leading to the long-term survival or adaptation of the water hemp population in areas where mesotrione was used. Many candidates thought only in terms of individual plants having an advantage which allowed them to survive, reproduce and pass on alleles for resistance which increased in frequency. These responses were too generic and needed to refer more closely to the population of water hemp as described in the question.

(iii) Most candidates realised that laboratory testing allowed farmers to identify a suitable herbicide to control water hemp weeds in their fields. A few candidates mistakenly thought that the water hemp was the desired crop for the farmer and described how the farmer could promote the growth of the water hemp.

(c) (i) Most candidates were able to substitute the correct figures into the equation to calculate the *t*-test statistic. The most common error was omitting to square the standard deviation figures in the denominator. Candidates were clearly instructed to show their working, so those candidates who gave an incorrect final answer from a correctly substituted equation gained partial credit.

(ii) There some high quality explanations of whether to accept or reject the null hypothesis. Nearly all candidates decided to reject the null hypothesis and correctly based this on the reasoning that their calculated value of *t* was larger than the critical value. Only a few incorrectly referred to the critical value of 2.23 as the significance level. Those who went on to state that there was a significant difference, mostly finished the statement correctly by saying that there was a significant difference between the two populations or between the two mean times.

Question 4

(a) (i) Candidates had little trouble in calculating the beetle species density on O'ahu. The answer should have been rounded to the same number of decimal places as the figures for the other islands.

(ii) Strong answers focused on the relatively young age of Hawai'i and linked this to a lack of time for beetle species to migrate there or for speciation to occur on the island. Linking the large size of Hawai'i to the low beetle species density was insufficient for full credit. Candidates who misunderstood the data thought that beetle species density referred to how spread out a population of a single species of beetle was.

(iii) To gain full credit, candidates needed to follow the instruction to use **Fig. 4.1** as well as **Table 4.1** in this question. They also needed to take note of the significant information in the question stem that the source of all the *Mecyclothorax* beetle species on the archipelago was a single species that arrived in Maui. Using the figure, strong candidates noted that O'ahu was further away from Maui than Moloka'i, so the chance of beetle species reaching it was correspondingly lower.

(b) Candidates performed well on this question, which presented a novel scenario of beetle speciation on the slopes of a volcano where lava flows separated forest into microhabitats. Candidates usually used terms like allopatric speciation, geographical isolation, natural selection and genetic drift correctly, though a minority of candidates did not realise that drift operates independently of any supposed selective advantage or disadvantage. Some answers used inappropriate terms, considering genetic variation and mutation as occurring in microhabitats rather than in populations of beetles located in the separate microhabitats. Similarly, candidates described a lack of gene flow between microhabitats instead of between populations. The strongest responses made it clear that multiple populations were undergoing separate evolution as a result of different selection pressures, resulting in genetic differences accumulating in each population.

Question 5

(a) (i) The strongest candidates were able to apply their knowledge of the preparation of recombinant vectors in the context given. Weaker responses tended to rely on recall of learnt information. This led to errors, such as mentioning plasmids, despite the information given in the question that the vector was a virus and not a plasmid, and stating that mRNA was extracted from the cells of the islets of Langerhans in the pancreas, despite this being an eye disease involving a gene that is expressed in the retina. It was common for candidates not to understand that a viral vector consisted of a protein coat and a length of nucleic acid (in this case, DNA) and to speak of enzymes like restriction endonuclease cutting or ligase joining the virus rather than the viral DNA. Many candidates lost credit by saying they would obtain the normal gene rather than the normal allele of the gene, and few accessed the credit available for amplifying the correct allele using PCR or identifying it using electrophoresis.

(ii) Candidates with sufficient knowledge of genetic terminology gained credit for explaining that a dominant allele could be added. Few mentioned that only one copy of the dominant allele per cell would be needed to reverse the symptoms of the disease, or that there would be no need to edit or delete the faulty recessive allele. A common error was to state that the recessive allele would need to be replaced with a dominant allele.

(iii) Most candidates used the information provided to reason that the danger of the injection method detaching the retina would make little difference to LCA patients who were blind already, but that this presented a risk of worsening the vision of the other group of patients with less severe lack of vision. Some candidates could have gained more credit if they had been more careful in explaining which group of patients was being discussed. The information provided made it clear that the age-related diseases must have a genetic basis or researchers would not have been contemplating using gene therapy to alleviate symptoms, so the suggestion that age-related diseases were not genetic was not credited.

(b) (i) Candidates found this question challenging. Answers that scored credit focused on the wrong pairing of free nucleotides with the template strand of DNA during the elongation stage, and the perpetuation of the error in the sequence of one strand of DNA during further rounds of PCR.

(ii) Answers were often vague and did not show an ability to visualise the experimental situation and to consider each step logically, from the arrival of the virus containing the GFP gene in the fluid of the eyeball to the movement of the virus across this fluid to the photoreceptor cells. Here it infected the cells and introduced the gene which was expressed using photoreceptor cell machinery to make fluorescent protein in these cells. The most common error was to confuse the gene for GFP, which is a section of DNA, with the protein product GFP, which glows green under UV light.

(iii) Very few candidates were able to integrate the information given in the context of this question, to conclude that the discovery of the 7m8 adeno-associated virus meant that gene therapy would now be a safe treatment option for age-related retinal diseases, or that take-up, acceptability or use of gene therapy for this group of diseases would increase.

Question 6

(a) (i) Most candidates identified the precise cellular location of glycolysis as the cytoplasm. The commonest incorrect answer given was the matrix of the mitochondrion.

(ii) Identifying the steps where phosphorylation occurred proved difficult for many candidates. This was usually because they gave an additional incorrect answer, frequently **step 2**, in addition to naming the correct steps. Many candidates were unable to name **step 5** as the step where oxidation occurs. The most frequent error referred incorrectly to **step 4**. The reaction in **step 5** was correctly named as substrate-linked phosphorylation by many candidates, though some wrote phosphorylation alone, chemiosmosis or condensation.

(b) Good responses used the information provided to explain that using glycolysis meant that cancer cells would require less oxygen. A few candidates linked the high energy demand of cancer cells with the low ATP production in glycolysis to reason that there would be a higher demand for glucose. Some candidates used their knowledge of the high energy demands of cancer cells without reference to the question stem and suggested cancer cells would need both more glucose and (incorrectly) more oxygen, as though they were undergoing more aerobic respiration.

Question 7

(a) This question was generally answered well, although a significant number did not recognise that structure **A** was a starch grain.

(b) Almost all candidates stated that two peaks of oxygen production occurred at wavelengths of 450 nm and 650 nm, although some lost credit by using incorrect units. Many candidates also explained that these peaks were a result of the plant (or pigments) absorbing these wavelengths of light most effectively. Few explained that the light was used for photophosphorylation or photosynthesis, although some correct references to the light dependent stage were seen. The strongest candidates related the light absorption to photolysis occurring faster at the peaks on the graph, so producing more oxygen.

(c) Candidates generally knew that accessory pigments absorbed light at wavelengths different to the primary pigments, and that the energy captured was passed to the primary pigment. A few candidates incorrectly stated that electrons, rather than energy, light or photons, were transferred from the accessory pigments to the primary pigment.

Question 8

(a) Many candidates limited the credit they could score due to incorrect use of subject-specific terminology. Many wrote of sensory receptors sensing or receiving a signal in the environment rather than detecting or responding to a stimulus, and passing stimuli, signals or messages to the central nervous system rather than passing impulses to or along sensory neurones. Few used the term transducer or gained the credit available for listing two examples of sensory receptors.

(b) (i) The majority of candidates identified **C** as the stage when Na^+ channels are open and **D** as the stage when K^+ channels are open. Most knew that the Na^+/K^+ pump operated at stage **E** but did not realise that it also operated throughout stages **C** and **D** as well.

(ii) Most answers gained credit for stating that the threshold was not reached but few candidates used the correct terminology to name the initial depolarisation of the sensory receptor as the receptor or generator potential. A few incorrectly stated that the action potential did not reach the threshold.

(iii) Most candidates correctly referred to one-way transmission of the impulse being dependent on the refractory period, but few also considered the role of the refractory period in limiting the frequency of action potentials.

(iv) Most candidates gave responses that explained the role of the myelin sheath, which limited the credit that could be achieved. Candidates also needed to consider the establishment of local circuits between a depolarised node of Ranvier and the next node, leading to the opening of Na^+ channels at that node and a second depolarisation there. A stepwise logical approach benefited candidates. Some credit was available where more general answers were given, for referring to salutatory conduction and a single role of the sheath such as insulating the axon or speeding up the transmission.

Section B

Question 9

(a) Many candidates were able to gain credit for listing the features of organisms in the domain Bacteria. Most referred to the absence of a nucleus and membrane-bound organelles, circular DNA, 70S ribosomes, a peptidoglycan cell wall and the possession of structures such as plasmids or flagella. Answers also commented on the unicellular nature of many bacteria and their multiplication by binary fission. A few answers confused plasmids (extra small circles of DNA) with the main circular genome of the cell, and some incorrectly thought that bacterial DNA was single-stranded.

(b) Candidates focused more on the roles of zoos rather than botanic gardens, with some candidates knowing little about how botanic gardens work to conserve plant species in the same way as zoos work to protect animals. Responses also repeated the term endangered species without referring to living plants being grown in botanic gardens, although seed banks were often mentioned. A good answer discussed collecting plant specimens or seeds from the wild from threatened locations around the globe, growing the plants in carefully controlled conditions suited to those plants and possibly increasing the population numbers for reintroduction to the wild at a later date. The need to cooperate with governments and international agencies, and to conserve or restore habitats, was noted in the strongest answers. Some candidates mentioned the need to maintain genetic diversity but then suggested selective breeding and cross-breeding as solutions, which would not conserve a wild endangered species. General statements about research and education scored credit for many answers.

Question 10

(a) Some candidates wrote generally about renal structure and function. Good answers focused on the precise question asked and confined themselves to relating the structure of relevant parts of the nephron only to the process of ultrafiltration. Descriptions of the proximal convoluted tubule and the loop of Henle were not relevant to the question asked and so could not gain credit. Good responses included structural detail of the glomerulus and the difference in diameter of its associated arterioles leading to the creation of a high blood pressure. Few were able to describe fluid being forced out of the glomerulus, many incorrectly referring to diffusion instead. The importance of the basement membrane as the main filter was appreciated by the strongest candidates. Correct terminology was important here, so ‘basal membrane’ was not an acceptable alternative to the basement membrane (of the nephron epithelial cell layer). References to the membrane preventing blood cells and large molecules from passing through were provided by most candidates, although vague references to large substances did not gain credit. Commonly, candidates identified water or solutes such as glucose or urea or ions as being able to pass through from the glomerular capillaries to the lumen of the Bowman’s capsule. Although most responses mentioned podocytes, some candidates described these as being finger-like processes rather than being whole cells that have interdigitating or finger-like extensions. Structural details related to the function of the three layers, including the many large fenestrations in the capillary endothelium, the filtration slits formed by the podocytes or the collagen meshwork of the basement membrane, were not often described.

(b) Most candidates described a scenario where blood glucose concentration was initially elevated, leading to insulin secretion and a subsequent decrease in blood glucose concentration (not blood sugar level). Two target tissues were often named (most commonly muscle and liver), although some responses did not name any target tissues. Strong answers distinguished between vesicles containing GLUT 4 receptors which fuse with the membrane of muscle cells, increasing these cells' permeability to glucose, and the GLUT 2 receptors in liver cells that are always present in the cell surface membrane and are not increased in number in response to insulin. The permeability of the liver cell membrane to glucose is not increased in response to insulin, so this answer was not credited. Many candidates knew the names of enzymes activated by insulin binding to its cell surface receptor. Some candidates erroneously stated that insulin converts glucose to glycogen directly, rather than acting through intermediary enzymes. The use of glucose in respiration was often referred to, but only a minority made it clear that respiration of glucose increases in response to insulin. Strong answers also mentioned decreases in lipolysis and gluconeogenesis. Many candidates lost credit by saying insulin makes a process like respiration or diffusion of glucose into a target cell happen, instead of making it clear that these processes occur anyway but that their rate is increased in response to insulin.

BIOLOGY

Paper 9700/51
Planning, Analysis and Evaluation

Key messages

This paper is based on the knowledge and understanding of investigative science, so the more experience of practical skills that candidates gain during their course, the more likely they are to gain credit. Of particular importance are:

- Planning a method using either familiar or unfamiliar apparatus that has a logical sequence with enough information for another person to use the method and obtain reliable results.
- Being able to analyse data and recognise patterns or trends and to evaluate both raw and processed results in relation to a hypothesis.
- Understand what the results of statistical tests show about the results of investigations and be able to explain what probability values indicate about significance.

General comments

Candidates did not appear to be short of time and there were many good responses. The use of specific terminology in questions involving statistics was not always expressed clearly enough for credit.

Comments on specific questions

Question 1

(a) (i) Nearly all candidates realised that the independent variable was the light intensity. Fewer were able to identify the dependent variable as the parameter that was actually being measured. Here, this was the distance the bubble moved in a set time (or the time for the bubble to move a set distance). Some candidates incorrectly stated that the dependent variable was the rate of transpiration.

(ii) There were some good answers which identified a range of appropriate variables and selected two where it was easy to give a valid description of the detail of standardising them. Some answers only focused on plant factors and did not mention any of the other conditions that could be standardised. Whilst it was important to keep these constant, in some cases candidates did not describe how to achieve this in sufficient detail. Temperature was a popular and appropriate choice but using a water-bath would not be appropriate for the potometer. Time was a valid variable, as the timing must be standardised in some way so that a comparison can be made, although the idea of the same time was needed, not just 'use a timer'. It was reasonable to suggest that air currents, humidity and even carbon dioxide levels should be standardised but it proved more difficult to give a precise enough method to achieve this. For air currents, there were some good answers linked to having a fan at constant speed or shutting all doors and windows to create relatively still air. A few responses successfully linked humidity to the idea of a growth chamber where humidity could be monitored and controlled using a dehumidifier or equivalent. A number of candidates suggested putting the plant in a plastic bag to control humidity; this would have the opposite effect as humidity would build up. Controlling background light was another creditworthy response, linked to carrying out the experiment in a dark room with just the varying light intensity under investigation.

(b) There were a lot of good answers to this question, suggesting that many candidates were familiar with this particular apparatus. Some responses were rather unbalanced and focused too much on the variables to be controlled. Details of the actual setting up and use of the potometer were important. As always with the planning aspect of this paper, the aim should be to produce a set of instructions in a clear form which could be followed by others. There were some good examples of this. The method of achieving different light intensities was most commonly described in terms of having a light at a range of different distances from the potometer. At least five different distances or intensities were expected and usually seen in responses. Alternatives such as changing the wattage were also credited. There were a number of good responses describing the actual setting up techniques. These mentioned cutting the stem under water, ensuring the joints were air tight and a description of how to introduce the air bubble. Relatively few responses mentioned the need to let the apparatus equilibrate once the plant was inserted. The great majority of candidates clearly stated that the distance travelled by the bubble in a set time or the time for the bubble to travel a set distance, would be measured. Less frequently described was using the tap to reset the bubble or noting the starting point on the scale. There were a few responses where the answers described counting bubbles in a set time, suggesting confusion between potometers and photosynthometers. Most candidates realised the need for replicates to obtain a mean. Some used the term average which was not accepted. This was a low risk experiment, but not a 'no risk' one.

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Question 2

(a) (i) This question was generally well answered. Some credit was lost for using the general term amount rather than volume or concentration of urine, agar or antibiotic. Incubation was often correctly mentioned, but occasionally unqualified 'time' was given, which was insufficient.

(ii) Although the majority of candidates understood the general idea behind the question, not all realised that this was a question about the practical aspects of how they would determine the sensitivity of *E. coli* to each antibiotic. Thus, the answer should have included measuring or calculating the diameter or area of the clear region for each. This was sometimes omitted. The idea that the larger the clear area, the more sensitive the bacteria are to the particular antibiotic was well understood by most candidates, although a few thought that the larger clear area meant the bacteria were less sensitive.

(b) (i) There was some confusion between standard deviation and standard error. A significant number of responses just gave a definition of standard deviation whilst the question asked for an answer in the context of the data in **Table 2.1**. Candidates who simply quoted a series of figures needed to give statements about what the standard deviations showed. The data values in the table showed a large spread around the mean and thus the data values were not very reliable. References to the mean not being reliable were not credited. Another misconception was to give statements about a wide range of data. Standard deviation does not delimit the range as there will be outliers.

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(c) (i) Overall, many candidates appreciated the requirements for using the Spearman's rank correlation test, usually by reference to one or more of the ideas of non-linear, not normally distributed or discontinuous, data. There were some cases where credit was lost as there was confusion with the Pearson's test or a contradictory mixture of Spearman's and Pearson's requirements were given. Some of the weaker responses simply suggested that it was used to see if there was a correlation, which is a repeat of the information in the stem of the question.

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(iii) Many candidates showed a good understanding of this aspect of statistics. Some candidates only selected one of the relevant antibiotics but were still able to give a clear and accurate explanation in terms of the calculated value (r_s) being higher than the critical value at the appropriate level of significance. Those candidates who selected the incorrect two antibiotics, could still gain some credit for a clear indication that they were working at the correct level of significance.

(d) This question required both a description and an explanation element in the answer. There were many good responses which focused on the overall patterns in the data and were able to suggest possible explanations related to antibiotic use. Many candidates were able to give good descriptions of the trends shown on **Fig. 2.2** and used correct data quotes to illustrate them, rather than just state a list of numbers. Many weaker explanations only related the pattern to changes in the immune system but did not relate these to changes in ampicillin use. Younger or older people may have weaker immune systems but this needed to be linked to increased ampicillin use which creates a selection pressure on the *E. coli* populations in the body. There was also credit for the idea that the higher values in the young and old could be related to the greater contact these age groups may have with hospitals or health care centres and therefore the increased likelihood of exposure to ampicillin-resistant *E. coli*.

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Paper 9700/52
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Key messages

This paper is based on the knowledge and understanding of investigative science, so the more experience of practical skills that candidates gain during their course, the more likely they are to gain credit. Of particular importance are:

- Planning a method using either familiar or unfamiliar apparatus that has a logical sequence with enough information for another person to use the method and obtain reliable results.
- Being able to analyse data and recognise patterns or trends and to evaluate both raw and processed results in relation to a hypothesis.
- Understand what the results of statistical tests show about the results of investigations and be able to explain what probability values indicate about significance.

General comments

Many candidates found parts of this paper challenging, in particular **Questions 1(b)**, **2(b)** and **2(d)**. Other questions were well answered, in particular **Questions 1(a)(ii)**, **1(c)(i)** and **2(a)(ii)**. Candidates did not appear to be short of time. The use of specific terminology, particularly in questions involving mathematical processes and statistics, was often confused and was not always expressed clearly enough for credit to be awarded.

Comments on specific questions

Question 1

(a) (i) Most candidates identified the independent variable correctly but fewer also correctly identified the dependent variable. A large number of candidates incorrectly stated loss of water vapour as the dependent variable. However, that causes the movement of water in the graduated tube. Candidates needed to check what was actually being measured, in this case, as stated in the given information, the downward movement of the water column in the graduated tube. The best answers stated the distance moved by the water or the decrease in volume of water, whereas weaker answers only stated 'the movement of water'.

(ii) Many candidates were able to describe a workable method using the apparatus. The best answers showed an understanding that the circular cup had to be attached to both sides of the same leaf or a different leaf of the same species, recognised that the distance moved by the water should be measured for a specific time and that the water level should be reset after each set of measurements. These candidates also identified key variables, explained how they should be standardised and stated that a mean from a set of three replicates should be calculated. Weaker answers did not always make it clear that both sides of the leaf were measured, rarely explained how to control key variables and did not calculate a mean. Some candidates lost credit by using an inappropriate method of standardising a variable, for example using a water-bath to maintain the temperature or a controlled room temperature (which is not the same as a temperature-controlled room). It was also common for these candidates to describe how to set up the apparatus, but not how to use it. Almost all candidates recognised that this was a low risk investigation. A minority of candidates did not use the information about how the apparatus worked and described sucking up water while timing the water movement. Many candidates spent time listing the different variables in the investigation. Those who went on to describe how these variables would be taken into account in their method could achieve maximum credit.

(b)(i) Candidates found this question challenging. Stronger answers showed the understanding that the circular cup had fixed area of cover, so described how to find the area of a circle. Common errors were to give the formula for circumference of a circle or omit measuring the diameter of the circle and calculating the radius. Weaker answers tended to describe using a grid to measure the whole leaf area rather than the cup area. The weakest answers rarely explained how a grid would be used to find the area.

(ii) Responses to this part of the question were mixed. There were some good answers gaining credit for correct calculations and making comparisons. The best answers also stated that a statistical test should be carried out. Less effective answers often showed one of the two calculations, commonly to divide by area, on the assumption that time was already accounted for. Very few candidates realised that the volume of water also needed to be calculated. The weaker answers simply stated that the values for the upper and lower surface needed to be compared. The least successful answers did not address the question and were descriptions of what the results should be if the hypothesis was correct, instead of how to find out if it was correct.

(iii) Most candidates found this question difficult and did not score well, mainly due to incorrect labelling of axes and incorrect use of units. The relative height of the bars was usually correct. When drawing bar charts, the axis used for the independent variable, commonly the *x*-axis, should have a label that is separate from the labels for the bars. Labels for the dependent variable axis, commonly the *y*-axis, were often incorrect. Loss of water with units for either a volume or distance moved, and an area or time unit were acceptable answers. Only the best answers showed a creditworthy combination of units. Weaker answers often showed incorrect use of the units. Many candidates were confused about what would support the hypothesis, so graphs of water loss against time and time against leaf surface were common. A number of candidates also drew line graphs although the question specified a bar chart.

(c) (i) Almost all candidates circled two correct anomalous results, commonly 6.2 and 1.5. The most common incorrect choices were 0.2, 2.8 and 0.0. A small number of candidates ringed more than two, which is not following the instruction in the question.

(ii) Stronger answers were able to link high light intensity to an increase in the aperture of stomata. Weaker responses often linked high light intensity to increased loss of water but did not then make the connection to the aperture of the stomata. Credit was allowed for more imprecise use of terminology if candidates referred to the stomata opening wider. The weakest answers did not address the question, often using vague statements such as 'the environment affects the stomata' or 'the aperture varies with the environment'. Poor answers commonly related to the number of stomata opening.

Question 2

(a) (i) Candidates often found it difficult to express themselves clearly when describing the patterns shown in the data. There was a tendency for the answers to be about numbers of people taking the antibiotic and the number of resistant bacteria, rather than the DDD and the percentage of resistant bacteria. The strongest answers showed an understanding that as DDD increased so did the percentage of resistant bacteria and that lower DDD of macrolide caused a higher percentage of resistance than penicillin. Candidates were not expected to explain why the resistance increased. Weaker answers tended to be about the general relationship between DDD for antibiotics and resistance but did not distinguish between penicillin and macrolide. Poor answers gave examples of specific countries rather than the overall trends.

(ii) Many candidates gave a correct answer. The common errors were to use the raw numbers 33 and 9, to omit the number 1 if the value for Spain was reduced to 3.67, or to reverse the ratio.

(b) (i) Almost all candidates were able to give at least one reason for using a linear correlation test. The most common correct answer was that the data shows a normal distribution. Weaker answers showed some confusion with the type of data suitable for Spearman's rank correlation. Some candidates stated that the data had a linear correlation, but this was insufficient for credit as a linear correlation can only be determined from a scatter graph of the data. The statement 'the data is a straight line' was not credited as this would not necessarily show a linear correlation. Very few candidates indicated that observations must be paired.

(ii) Many candidates found this question very challenging. A large proportion recognised that there was a correlation between the two sets of data, but only stronger answers made it clear that this was a positive correlation. Better answers also stated that there was a stronger correlation for macrolide than for penicillin. Some candidates were not credited for understanding the meaning of the difference in the *r* values for macrolide and penicillin as they referred to higher and lower correlations. The explanation of significance was very poorly addressed by most candidates due to imprecise or generalised use of terminology. Candidates should understand that the level of significance is a measure of the probability or chance that the results are due to chance. Thus, a low probability indicates that the results, or in this question the *r* values, are unlikely to be the result of chance and are due to the use of antibiotic. For most purposes, biologists use $p < 0.05$ as the probability at which the results are due to an external factor. In this question, $p < 0.01$ gives a greater certainty that the correlations are due to the use of antibiotics. Some of the better answers did get to this idea, although did not always gain credit as they used statements such as 99% sure the results are not due to chance, rather than more than 99% certain that the correlations are due to antibiotic use. Other candidates reverted to using $p < 0.05$. Some of the weaker answers confused critical value with significance, while others confused *r* values with probability. Some weak answers omitted any mention of the meaning of the level of significance other than stating they were the same.

(c) Many candidates gained maximum credit. The most common description was of dilution by 50%. Less successful answers lost credit as they only stated 'repeat for the next dilution' without making it clear that the new solution was diluted each time and not the original stock. Maximum credit was given to clearly labelled diagrams, although candidates did not always achieve this if the volumes of solution and water were not shown. There were some weak answers in which candidates described diluting by percentage concentration rather than by volume.

(d) This question was rarely answered well. The most common incorrect answers were descriptions of the disc diffusion test and aseptic technique, investigations into damage to the environment by the new test and investigations into whether the new test increased resistance in bacteria. Candidates commonly achieved credit by assessing whether the new test gave the same results as the disc diffusion test, whether it was reliable or cost effective,

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General comments

Candidates did not appear to be short of time and there were many good responses. The use of specific terminology in questions involving statistics was not always expressed clearly enough for credit.

Comments on specific questions

Question 1

(a) (i) Nearly all candidates realised that the independent variable was the light intensity. Fewer were able to identify the dependent variable as the parameter that was actually being measured. Here, this was the distance the bubble moved in a set time (or the time for the bubble to move a set distance). Some candidates incorrectly stated that the dependent variable was the rate of transpiration.

(ii) There were some good answers which identified a range of appropriate variables and selected two where it was easy to give a valid description of the detail of standardising them. Some answers only focused on plant factors and did not mention any of the other conditions that could be standardised. Whilst it was important to keep these constant, in some cases candidates did not describe how to achieve this in sufficient detail. Temperature was a popular and appropriate choice but using a water-bath would not be appropriate for the potometer. Time was a valid variable, as the timing must be standardised in some way so that a comparison can be made, although the idea of the same time was needed, not just 'use a timer'. It was reasonable to suggest that air currents, humidity and even carbon dioxide levels should be standardised but it proved more difficult to give a precise enough method to achieve this. For air currents, there were some good answers linked to having a fan at constant speed or shutting all doors and windows to create relatively still air. A few responses successfully linked humidity to the idea of a growth chamber where humidity could be monitored and controlled using a dehumidifier or equivalent. A number of candidates suggested putting the plant in a plastic bag to control humidity; this would have the opposite effect as humidity would build up. Controlling background light was another creditworthy response, linked to carrying out the experiment in a dark room with just the varying light intensity under investigation.

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