BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

There was a good spread of scores that discriminated well between candidates. The ten questions that candidates found relatively straightforward were **Questions 5, 7, 10, 14, 16, 18, 23, 30, 31 and 34.** The six hardest questions were **Questions 2, 15, 27, 35, 37 and 40.**

Comments on specific questions

Question 2

In order to answer this question, there are a number of approaches. If candidates do not immediately recognise the statement which is incorrect they should try to eliminate those statements they know to be correct. The maximum resolution of a light microscope is 0.2 μm which means that it can be used to resolve specimens as small as 200 nm in diameter. For an electron microscope the maximum resolution is 0.5 nm which means that it can be used to resolve specimens as small as 0.5 nm in diameter. Therefore **B** is correct.

Question 3

More than half of all candidates answered this correctly. Despite being told that the electronmicrograph was of an animal cell almost a quarter of less able candidates incorrectly thought that glucose was synthesised in large quantities.

Question 5

The majority of more able candidates knew that the Golgi apparatus processes proteins to form glycoproteins and were able to select goblet cell (which produce the glycoprotein mucin).

Question 7

The majority of less able candidates do not know that glycogen contains only α-1,4 and α-1,6 bonds.

Question 8

Almost all of the less able candidates answered this incorrectly. The correct answer, if not known directly, can be worked out by eliminating those options which were not amino acids (**A**, **B** and **D**).

Question 10

The majority of more able candidates knew that list 1 contained no substances containing nitrogen atoms.

Question 13

Most of the less able candidates did not know the roles of the cell surface membrane components.

Question 14

Those candidates who knew that facilitated diffusion does not involve ATP answered correctly. Some candidates thought proteins in the membrane were not involved.

Question 15

Many candidates found this question difficult. The sucrose solution with the highest water potential would result in the most water entering the cells in the stalk. This would result in the largest increase in size of the cells with thin walls, whilst the thick walled cells would be restricted in increasing in size.

Question 21

In order to answer this question, candidates need to know that DNA polymerase synthesises a strand of DNA, i.e. the choice of option **B** or option **C**. Only DNA acts as a template for the formation of DNA, meaning **C** is correct.

Question 27

Many candidates found this question difficult to answer. Candidates should read each reaction and decide if they would occur in the situation given. Reactions 1, 2 and 4 will all occur, giving option **B** as correct.

Question 28

The majority of candidates realised that one valve should be open and one closed, but less than half selected them correctly.

Question 30

The majority of more able candidates answered correctly using their knowledge of the AVN, Purkyne tissue and SAN to eliminate the SAN.

Question 33

Whilst most candidates knew that options **A** and **C** were incorrect, many were unsure as to which of options **B** or **D** was correct. This can only be answered by having the relevant knowledge. However, candidates who have studied slides of trachea should have seen smooth muscle and so be able to eliminate option **D**.

Question 35

This question drew on knowledge of a number of learning outcomes. In order to answer this, candidates need to decide what causes HIV/AIDS, malaria and TB. Since HIV/AIDS is caused by a non-living virus it does not respire or have a cell surface membrane. This means option **D** is correct.

Question 37

Just over half of all candidates knew that T-lymphocytes do not secrete antibodies. Since they can differentiate into memory cells and destroy infected body cells, option **C** is correct.

Question 40

This question tested knowledge of the nitrogen cycle, but in a novel context. From the information provided, candidates were required to know which bacteria breakdown ammonia, which many candidates found difficult.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

There was a good spread of scores that discriminated well between candidates. The ten questions that candidates found relatively straightforward were **Questions 4, 6, 8, 10, 13, 18, 22, 23, 34 and 36.** The six most difficult questions were **Questions 27, 29, 30, 35, 38 and 40.**

Comments on specific questions

Question 15

Some candidates found this question difficult. Candidates should work through each statement and then check which of the options can be eliminated. Only active transport moves substances against a concentration gradient. Therefore statement 1 is incorrect so options **A** and **B** cannot be correct. Statement 3 is in both **C** and **D**, but statement 4 is correct, so option **D** is the answer.

Question 20

The majority of candidates were able to work out that statement 1 was correct and this meant option **D** was incorrect. Candidates should work through statements 2, 3 and 4 to eliminate one of them in order to obtain the correct answer.

Question 27

Many candidates found this question difficult. Candidates should know that pressure of blood decreases as it flows through the arteries, capillaries and then veins. Therefore only options **B** or **C** could be correct. Knowledge of velocity of blood flow or total cross sectional area would lead to selection of option **C**.

Question 29

To answer this question, candidates needed a good understanding of the blood circulatory system.

Question 30

Many candidates found this question difficult. Since haemoglobin (and so carbaminohaemoglobin) is only found in red blood cells, option **A** is correct.

Question 35

Almost equal numbers selecting each option, suggesting that these terms are not clearly understood.

Question 38

Many candidates found this question difficult. In order to answer this, candidates should look at each factor and find the curve to match it. Since the sun is more intense during the summer than the winter, this must be curve **B**. During the winter most plant and animal life will be very limited as many have died and therefore the nutrients are more in winter than summer, curve **A**. This leaves curves **C** and **D**. Since primary consumers feed on producers, there should be more producers than consumers, hence curve **C** is correct.

Question 40

This question tested knowledge of ecosystem in a novel manner. From the information provided candidates had to determine which statement was not valid. Statement **A** is valid since in ecosystem Y the dominant producer is large and woody, so would not be easily consumed. Statement **B** is valid since there is a smaller fluctuation of temperature in marine aquatic ecosystems and also there is less oxygen. Statement **C** is also valid, since with lower energy losses between trophic levels the ecosystem X can support more trophic levels. Therefore the answer is statement **D**.

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Paper 9700/13
Multiple Choice

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

General comments

There was a good spread of scores that discriminated well between candidates. The ten questions that candidates found relatively straightforward were **Questions 2, 4, 6, 13, 14, 15, 27, 32, 33 and 37.** The most difficult questions were **Questions 7, 11, 16, 24, 29 and 30.**

Comments on specific questions

Question 7

The majority of candidates did not realise that all three features explain why haemoglobin is suitable as an oxygen carrier.

Question 8

Whilst almost all the most able candidates answered this correctly, less than half of less able candidates knew the correct answer.

Question 10

The less able candidates found this difficult. Candidates should know that hydrogen bonds are weak and disulphide bonds are strong, so should have chosen **C** or **D**. Since ionic bonds are weak, option **D** is correct.

Question 11

Many candidates incorrectly selected option **C**. Competitive inhibitors do not have exactly the same shape as the substrate, so **C** cannot be correct, leaving option **B** as the answer.

Question 16

Whilst just under half of candidates correctly answered **C**, many chose option **A**, air. This demonstrates a poor understanding of the process of osmosis in plant cells.

Question 17

The majority of more able candidates correctly processed this information. Since mitosis is not a reduction division, any answer containing 1 is incorrect.

Question 24

Many candidates found this question difficult and incorrectly choose options where sugars are moved into the sieve tube elements in the root.

Question 29

This was poorly answered by candidates. In order to answer this question, candidates should know that blood pressure decreases with distance from the heart and so will be higher when entering the capillaries than leaving the capillaries. The loss of plasma from the capillaries results in a loss of pressure as well. The composition of veins is a result of low pressure, not a cause of low pressure.

Question 30

The adaptation of increasing the red blood cell count when humans remain at high altitudes is poorly understood by weaker candidates. Candidates should have been able to eliminate 'to increase the Bohr effect' as this is not relevant to the situation described. Then candidates need to decide if statements 2 and 3 are correct. The diffusion gradient for oxygen in the lungs will not change as the partial pressure of oxygen in the lungs will not change. This leaves the 3rd statement as the only one that is correct, option **A**.

Question 31

The majority of more able candidates answered correctly due to their ability to reason that all the organelles would be needed to produce and secrete mucin.

Question 38

Some candidates found this question difficult. Knowledge of any one of the descriptions in the column headings would reduce the number of possible answers to two. Then the candidate should work through the other descriptions until they are left with a unique answer.

BIOLOGY

Paper 9700/21
AS Structured Questions

Key Messages

- Candidates were given the opportunity to suggest how they could determine the efficiency of an energy transfer. This entailed providing details of a formula that could be used. Examples of other calculations that candidates could have been asked to perform include: determining the magnification of an image; calculating actual sizes; determining rates of reaction; or calculating percentage increases and decreases. Where the final calculated value is incorrect, partial credit can often be given if the candidate provides evidence that a correct formula has been used and/or correct working is shown. It is for this reason that candidates should heed the instruction to 'show your working'.

- Mitosis is a topic that highlights how practical and theoretical biology are intertwined. Candidates should be encouraged to study photographs and slides showing stages of mitosis and to become skilled at:

    - producing written descriptions of the events occurring in each stage;
    - identifying a stage of mitosis and being able to describe the cell before and after the identified stage;
    - drawing, and labelling or annotating, simple diagrams to illustrate the main features of each stage;
    - being able to explain the relationship between the cell surface membrane, nuclear envelope, chromosomes and the spindle as mitosis occurs.

    This will leave candidates well prepared for questions that may occur in both practical and theory assessments.

- Candidates should understand that the main function of a mitochondrion is to produce ATP as a result of aerobic respiration. A common error is to state that the mitochondrion produces energy. ATP is the universal energy currency of the cell, and when hydrolysed, energy is released for use by the cell. Candidates should not refer to ATP as 'ATP energy' and should also avoid using terms such as 'energy in the form of ATP' and 'energy as ATP'.

General comments

The paper discriminated well. Many candidates demonstrated a very thorough knowledge and understanding of the syllabus and used a wide range of skills to produce a good overall performance. The best of these were adept at tackling questions set in an unfamiliar context and were able to bring together strands from different areas of the syllabus.

Many candidates were clear and confident in their use of scientific terminology. There were occasions where candidates confused terms that have an overlap in spelling or have a close relationship within a topic, such as: centromere and centriole; antigen and pathogen; and genetic code and gene coding for…. Examples of these appeared in **Questions 1(a)(iii)**, **3(b)(ii)** and **5(b)**, respectively. **Questions 2** and **4** were good examples of the need to use knowledge and understanding in an unfamiliar context. **Question 2** also included a table of results of differences in the concentrations of mineral ions inside and outside of root tissue, which needed to be both interpreted and referred to in order to produce a high quality response. **Question 4** involved studying an unfamiliar electron micrograph. Candidates used this to identify a cell structure, and then in part **(b)**, to help them confirm, or prompt, the idea that cholesterol secretion from the cell occurred by exocytosis. Some candidates made comments about the secretion of cholesterol that suggested that they had not studied the electron micrograph. **Question 6** was the most challenging question overall, with two question parts that required candidates to make suggestions. This command term was well

understood only by the stronger candidates, with others mistakenly describing in part **(b)** the food web given in Fig. 6.1, and in part **(c)**, making statements about energy flow, which were not required.

There was sufficient time to complete the paper and well prepared candidates completed each section of every question, showing consideration for both the level of response and the quantity of writing required to elicit full credit for each part question. In extended responses, some candidates could have improved the quality of their answer by avoiding repetition and by planning so that points appeared in a logical sequence. Most candidates made good use of the space provided. Candidates should not need to use additional space, but if unavoidable, should indicate clearly where the remainder of the response is located.

Comments on specific questions

Question 1

This question assessed learning outcomes from ***Sections A*** and ***E*** of the syllabus and proved to be a straightforward question for candidates who had revised thoroughly.

(a)(i) There were a number of clues that would allow candidates to deduce the stage of mitosis shown in Fig. 1.1: the spindle in an early stage of development, with centriole pairs beginning their migration towards the opposite poles; chromosomes orientated at random; and a nuclear envelope that had not yet disassembled. Most candidates identified the stage as prophase; those that didn't generally chose metaphase.

(ii) The question asked candidates to shade a pair of homologous chromosomes and while most did shade in two of the eight chromosomes in Fig. 1.1, there were many who only shaded in one chromosome, presumably believing that the question was referring to a pair of sister chromatids. The majority of candidates were able to pick out correctly a homologous pair, using chromosome length and position of the centromere to make their judgements.

(iii) A high proportion of candidates knew that structure **W** was a centriole, with many outlining how the centriole is involved in mitosis to gain full credit. For those that did not gain full credit, there tended to be a lack of precision, giving a role of the spindle as a function of the centriole, such as attachment to centromeres or shortening in anaphase to pull apart sister chromatids to the poles.

(b) The responses of the highest quality tended to name structures **X** and **Y**, the cell surface membrane and the nuclear envelope, before making clear statements about 'what happens ….'. These responses showed an understanding that telophase occurs before cytokinesis. For those who incorrectly identified the stage in Fig. 1.1 as metaphase, it was still possible to gain credit for knowing that the nuclear envelope disassembled. Candidates were expected to name the stage when the envelope reassembled in order to gain further credit. As only statements, rather than detailed descriptions were required, a reference to cytokinesis in some correct context was sufficient, although it was noted that candidate knowledge of this stage of the cell cycle tended to be patchy.

Question 2

This question discriminated well, with some candidates organising their thoughts to produce high quality responses in the extended part questions, **(b)** and **(c)**. In **(c)**, these candidates were able to stay on track and answer the question based on cell surface membranes. Candidates also required knowledge and understanding from ***Sections B, C, D, F, G*** and ***K*** of the syllabus in order to do well on this question.

(a) Most candidates followed the instruction to write only **one** letter from Table 2.1 to match each of statements **(i)** to **(v)**. Candidates either knew or could deduce that polynucleotides were composed of nucleotides and from here phosphate ions was a logical choice for statement **(i)**. Many candidates realised that **(ii)** was a statement about carbon dioxide carriage by haemoglobin and so avoided the most common error of stating **D**, Fe^{2+}, which is a component of haemoglobin. This was the answer for **(v)**, which many knew. Strong candidates realised that the ion used in the production of amino acids, NO_3^-, would be the same whether in chloroplasts or elsewhere in the cell, and were able to write the correct letter to match statement **(iii)**. For this statement, NH_4^+ was also acceptable, but not SO_4^{2-}, because sulphur is not present in all amino acids. Statement **(iv)** was concerned with one of the events occurring to allow the loading of sucrose into phloem sieve

tubes, the inward flow of H^+, having previously been actively pumped out of the companion cell, re-entering the cell and cotransporting sucrose.

(b) A good response explained the mode of action of enzymes by using the nitrogenase-catalysed reaction given. Although candidates were provided with the reaction, only some described the presence of nitrogen and hydrogen ions in the active site, with most forgetting to include hydrogen. Stronger candidates drew from their knowledge of the syllabus and gave additional detail such as the use of ATP for the reaction and the requirement for anaerobic conditions. A good number of candidates were thrown by the mention of vanadium and molybdenum ions and some thought that these were the substrates, while others thought that they were inhibitors and described inhibition. A common error was to give more of an overview and write about the uptake of nitrogen by the bacteria and the use of the ammonium ions for the production of amino acids by the plant.

(c) There were some well-planned responses to this question, with some candidates paying good attention to detail and using the data in Table 2.2 to illustrate their response. The results were described with reference to the permeability of cell surface membranes and the involvement of membrane transport proteins in active transport. Many candidates realised that a higher concentration of ions within the root tissue implied that active transport was the main transport mechanism involved. The best responses noted the non-permeability of the membrane to leakage out of ions and some made a link to the specificity of transport proteins. The introduction to **(c)**, which told candidates that the solution of mineral ions was aerated, offered a clue to consider active transport as the mechanism involved. The ATP that would be required would be produced by aerobic respiration. Good use of Table 2.2 included quoting comparative data to support the observation that uptake by the different mineral ions was not equal. Some candidates did not refer to specific data from the table and gave suggestions that involved differences in water potential, thinking that this would somehow encourage uptake of ions. To gain full credit, it was necessary to state a variety of points.

Question 3

In this question, candidates switched their focus between ***Sections D, H, I*** and ***J*** of the syllabus. Many who did very well realised in **(b)(ii)** that the question was asking about phagocytosis and not a specific immune response involving lymphocytes, having noticed that earlier in the question they were told that macrophages are large phagocytic cells.

(a) Many candidates were able to give excellent explanations of the differences between infectious and non-infectious diseases, but not all remembered to include a reference to the named diseases, tuberculosis (TB) and COPD, so only gained partial credit. Some used different examples to support their explanation, which was not relevant. Attention to detail was evident in the best answers, with the pathogen causing the infectious disease TB attributed to bacteria and the idea of the infectious disease being transmissible linked to the particular mode of transmission of TB. Candidates who understood that activities such as tobacco smoking could be a factor in causing the non-infectious disease, COPD, were also given credit. Weaker candidates gave a variety of responses, for example some thought that COPD was an infectious disease and gave vague answers about the disease being passed on, while others stated that COPD, as a non-infectious disease, was less dangerous than TB.

(b) (i) A short diffusion distance was evident in Fig. 3.1 and many candidates noted this. As the question focused on alveoli, it was more relevant to state that the wall of the alveolus was one cell thick. Care was needed when wording a response. A single alveolus does not offer a large surface area, but two or more alveoli provide a larger surface area than one large air space, and the presence of elastin allows the alveolus to stretch and recoil, rather than contract and relax.

(ii) Strong candidates were able to tackle this question in a sequential manner, using the correct scientific terminology and giving precise detail. Hence pathogens, rather than antigens, were engulfed, and lysosomes fused with the phagocytic vacuole and their digestive enzymes, rather than the lysosomes themselves, digested pathogens. The introduction to parts **(b)** and **(c)** had drawn the candidates' attention to phagocytosis, yet it was not unusual for a candidate to give a description of macrophages as B-lymphocytes or plasma cells releasing antibodies.

(c) Many were able to do well in part **(c)** by naming the disease caused and stating the consequential effects of the destruction of alveoli on a person's health. Some misread the question and wrote

about the sequence of events leading to emphysema rather than how this would affect a person's well-being.

Question 4

In this question, which was one of the most challenging of the paper, candidates applied knowledge and understanding from ***Sections A***, ***B***, ***D*** and ***L*** of the syllabus. It was particularly important to read carefully all the information provided at the start of the question. Those candidates who took time to do this profited from gaining a better insight into the processes in the liver cell concerned with lipoprotein formation and secretion.

(a) Most candidates knew that structure **T** was a mitochondrion and many then went on to state that the function of the mitochondrion was the production of ATP. It was not acceptable to say that energy was produced or to say that the mitochondrion produced ATP *for* respiration. The best responses continued and gained full credit by stating a use in liver cells for the ATP produced. Some took their cue from the information provided previously.

(b) (i) The strongest candidates surmised that packaging of cholesterol into lipoproteins was for the transport of the molecule in the blood, rather than the passage of cholesterol across the cell surface membrane, and were able to make a valid suggestion. Candidates had been told of the involvement of Golgi vesicles in the introduction, so this should have averted them from one of the most common errors of stating that cholesterol could not pass across the membrane unless packaged into a lipoprotein. The other common error was to assume that the packaging into lipoprotein meant that cholesterol could not then be linked to atheroma formation by cholesterol deposition.

(ii) Many candidates knew that cholesterol was an important component of cell membranes and gave a number of creditworthy points. The best responses made it clear that cholesterol has an important role in regulating the fluidity of the membranes, rather than stating that cholesterol causes the fluidity of membranes. There were a few candidates who knew that cholesterol is used to make other steroids. Some thought that the main role of cholesterol was to act as an energy source for the cell.

(c) It was important for candidates to read the information given at the start of part **(c)**. This pointed them towards the process of exocytosis, and indeed some gave very precise descriptions of the events involved. Many candidates did not take the correct cue from the information and gave descriptions of passive or facilitated diffusion.

(d) The most common correct responses for the function of the Golgi apparatus were lysosome formation and protein modification. The strongest candidates gave specific detail of protein modification, such as glycosylation or protein folding. Protein synthesis, which was not acceptable as a response, was cited by many candidates.

Question 5

In this question, candidates were assessed mainly on ***Section F*** of the syllabus, with knowledge from ***Section B*** also required. Part **(b)** was an extended question that needed reading twice or more before responding to it.

(a) (i) Most candidates were able to complete Fig. 5.1 correctly.

(ii) This proved to be a challenging question, with only the stronger candidates realising that the definition given in the question was that of the primary structure of proteins. There was a large variety of responses seen, with the most common incorrect answers generally concerning terms linked to nucleic acids, such as nucleotides and codons.

(b) Candidates were given the information they needed about the single change in amino acid that led to sickle cell anaemia. This enabled them to use the information in Table 5.1 and Fig. 5.1 in their response to gain credit, and generally the stronger candidates did so. The best answers began by describing the mutation in the DNA and then completed their answer by giving a clear, sequential, account that ended in the altered polypeptide chain. Other candidates, who had grasped the idea as to what was required, did not use the information given so that the answer was too general and not related to sickle cell anaemia. Weaker responses confused DNA triplets with mRNA codons and wrote about altered amino acid sequences for DNA. A high proportion of candidates, however,

gave lengthy responses concerning the phenotype resulting from the mutation. Here, there were descriptions of normal versus sickle cell haemoglobin and the problems that would occur if a person had sickle cell anaemia. This did not answer the question set.

Question 6

This question, concerning ***Section K*** of the syllabus, began with assessing candidates' knowledge of definitions of ecological terms, and then moved on to more challenging parts **(b)** and **(c)**, where application of knowledge and understanding was required.

(a) There were a few candidates that gave perfect definitions in part **(a)** and most were able to gain credit by showing an understanding of the correct ideas behind the definitions of 'niche' and 'community'. The most common error was to begin the definition of 'community' by stating, 'the place where…..'. Another common poorly worded response was to suggest that a community was a population of different species.

(b) Those candidates who gained full credit for part **(b)** used the information in Fig. 6.1 to show how an alteration in the numbers of sea otters would affect the entire food web. This included explanations as to how kelp would be affected and what the consequences of this would be to the rest of the food web. By doing this, they showed how the sea otter was important in maintaining biodiversity. Others described the food web without emphasising the importance of the sea otters, or just stated one consequence of a loss or gain of sea otters. At most, this only gained partial credit.

(c) The question asked candidates to suggest how a specific energy transfer could be determined, namely between kelp and sea urchins. The most able candidates realised that energy contents should be determined first and then a comparison made that gave a proportion or percentage of energy transfer. Net production of the kelp and energy absorbed and assimilated by sea urchins was suggested by some of these candidates, which was acceptable. Most candidates wrote in general terms about the efficiency of energy transfer between trophic levels, which was not the subject of the question, and did not make any links to the sea urchins and kelp. Some stated that energy transfer between trophic levels was 10%.

BIOLOGY

Paper 9700/22
AS Structured Questions

Key Messages

- Candidates were required to suggest how they could determine the efficiency of an energy transfer. This entailed providing details of a formula that could be used. Examples of other calculations that candidates could have been asked to perform include: determining the magnification of an image; calculating actual sizes; determining rates of reaction; or calculating percentage increases and decreases. Where the final calculated value is incorrect, partial credit can often be given if the candidate provides evidence that a correct formula has been used and/or correct working is shown. It is for this reason that candidates should heed the instruction to 'show your working'.

- Mitosis is a topic that highlights how practical and theoretical biology are intertwined. Candidates should be encouraged to study photographs and slides showing stages of mitosis and to become skilled at:

    - producing written descriptions of the events occurring in each stage;
    - identifying a stage of mitosis and being able to describe the cell before and after the identified stage;
    - drawing, and labelling or annotating, simple diagrams to illustrate the main features of each stage;
    - being able to explain the relationship between the cell surface membrane, nuclear envelope, chromosomes and the spindle, as mitosis occurs.

    This will leave candidates well prepared for questions that may occur in both practical and theory assessments.

- Candidates should understand that the main function of a mitochondrion is to produce ATP as a result of aerobic respiration. A common error is to state that the mitochondrion produces energy. ATP is the universal energy currency of the cell, and when hydrolysed, energy is released for use by the cell. Candidates should not refer to ATP as 'ATP energy' and should also avoid using terms such as 'energy in the form of ATP' and 'energy as ATP'.

General comments

The paper discriminated well. Many candidates demonstrated a wide range of skills when answering the questions and were able to stay focused throughout the paper to produce a good overall performance. The best candidates were able to use their knowledge of the syllabus to answer questions set in an unfamiliar context and to bring together strands from different areas of the syllabus.

Calculation questions may tell candidates to give their answer accompanied by a particular unit. In calculating actual sizes of specimens, this is often micrometres. In **Question 1(a)**, if the candidate had measured the diameter in mm, the calculation did not require the use of a conversion factor. Some candidates attempted to manipulate the values used in a correct formula, unnecessarily. **Question 2(b)** was very well attempted by stronger candidates who interpreted confidently the data shown on the two graphs, Figs. 2.2 and 2.3, to produce a response that both described and discussed the data. These candidates were adept at answering questions containing unfamiliar data for description and discussion and ensured that they wrote about Fig. 2.2 as well as Fig. 2.3. The importance of reading all the information provided with each part-question was also highlighted in **Question 3(b)**, as astute candidates noted that the cells were involved in the transport of dissolved organic molecules and hence avoided writing about the carriage of water and mineral ions by xylem. **Question 5** was the only question that required recall from only one syllabus section and was a good example of the need to use knowledge and understanding in an unfamiliar context.

There appeared to be sufficient time to complete the paper and most candidates completed each section of every question. In extended responses, some candidates could have improved the quality of their answers by avoiding repetition and by planning so that points appeared in a logical sequence. Most candidates made good use of the space provided. Candidates should not need to use additional space, but if unavoidable, should indicate clearly where the remainder of the response is located.

Comments on specific questions

Question 1

This question assessed learning outcomes from ***Sections E*** and ***G*** and also included a calculation of actual size from ***Section A***.

(a) This was a straightforward calculation for most candidates. The formula used for the calculation was evident in the majority of responses, which meant that those candidates who made an error in measuring the length of the line at **X-Y** or in calculating the final answer, were able to gain partial credit. Weaker candidates gave a response to an excess of decimal places or attempted a calculation that gave them an answer in micrometres. Some candidates had correctly set out their calculation but incorrectly divided 35 by 49.

(b) Candidates who answered clearly described one structural feature of a vein per numbered line, and used correct scientific terminology in naming the lumen and the three main layers of the wall of the vein. There were some very good descriptions, giving details about the different layers of the wall rather than just stating 'thin wall' (which was not given credit). Many candidates completed their description by giving a correct comparison with an artery. Some qualified their description with an explanation and this was not required. Weaker responses gave two or three ideas on a numbered line, or did not make it clear as to which layer in Fig. 1.1 they were referring. Some candidates erroneously believed that veins were smaller than arteries, making reference to size differences, while others described the presence of valves, which had been stated in the question.

(c) (i) Candidates needed to consider how the structural feature of the single layer of cells comprising the endothelium was related to the capillary's function. Most candidates gave creditworthy explanations linked to a short diffusion distance or an increased rate of diffusion. Weaker responses used descriptions such as 'easier diffusion', without further explanation, and did not gain credit.

(ii) Explanations that gained credit clearly stated how the capillary could fulfil a function by having a diameter of approximately 8 μm. A number of candidates made reference to the fact that 8 μm is a small size, which means that it is possible for all body cells to be in close proximity with capillaries. Many knew that a red blood cell could squeeze through the capillary, but in itself this was not sufficient to gain credit as candidates were expected to show an understanding of how this enabled cells to be provided with their requirements. Some candidates understood that the smaller diameter would mean an increased resistance and hence slower flow of blood to provide more time for delivery of oxygen and nutrients. A number wrote about blood in capillaries being at a low blood pressure and did not make any links to the diameter of the capillary or to cell requirements, so were unable to gain credit. There were also a few candidates who thought that red blood cells could leave the capillary.

(d) (i) Many candidates made correct reference to mitosis and the replacement of damaged or worn out cells and to the repair of endothelial tissue. Others incorrectly stated that mitosis allowed the repair of cells, while some wrote about asexual reproduction, which is an important role of mitosis in other situations. Growth by an increase in cell number as a result of mitosis was given credit where an understanding was shown that this was for the tunica intima only in the development of blood vessels. A few candidates wrote about increasing the thickness of the layers of the blood vessel or allowing arteries to stretch during pressure changes, or had erroneously written about the lining of the gas exchange system. A proportion of candidates gave features of mitosis that would have been worthy answers for part **(ii)**.

(ii) Most candidates demonstrated an understanding of why there are two different types of nuclear division. Some could have improved their response by giving more precise detail, such as stating that cells formed from mitosis are genetically identical rather than just identical, and that meiosis

produces cells with one set of chromosomes, rather than just stating that meiosis is a reduction division. A common misconception was that meiosis occurs in gametes, rather than results in the production of gametes. Some candidates knew the correct terminology but did not show a correct understanding, for example writing about mitosis producing a diploid number of cells and/or meiosis producing a haploid number of cells.

(e) This was a straightforward exercise for candidates who had experience of identifying and drawing the different stages of mitosis. There were some excellent diagrams showing the four chromatids / daughter chromosomes moving towards each pole, with the centromeres of each attached to a spindle fibre. By the beginning of metaphase, the nuclear envelope has disassembled, so candidates were only able to gain partial credit if they had included a nuclear envelope in their diagram. The question asked for Fig. 1.3 to be completed to show the same cell as in Fig. 1.2 in the anaphase stage. A number of candidates missed this instruction and drew more than four chromatids in each half of the cell, while others drew the chromatids with the centromeres pointing towards the metaphase plate, or drew anaphase 1 of meiosis. Some drew the metaphase stage, while others produced diagrams that consisted of wavy lines or 'sausage-shaped' structures within the cell.

Question 2

This question, which included two graphs, required candidates to take their time in order to consider all the information provided to them. Stronger candidates used a range of skills to perform well. There was evidence that a number of candidates carefully planned their response to **(b)(ii)** to produce thorough, easy-to-read accounts, which both 'described' and 'discussed', as instructed. Candidates were assessed on knowledge and understanding from ***Sections B*** and ***C*** of the syllabus.

(a) This question required candidates to integrate knowledge from different areas of the syllabus. Many demonstrated a good ability to apply their knowledge and gained full credit. Common incorrect ideas included the belief that amylopectin had a structural role within the cell and that triglycerides contained nitrogen. Some of the stronger candidates assigned a structural role to triglycerides, presumably as they were thinking about phospholipids and membrane structure. As there were six available correct responses, these candidates were still able to gain full credit.

(b) (i) The majority of candidates extracted the information required from Fig. 2.1 to give the correct value.

(ii) In order to do justice to this question, candidates needed to realise that:

- Fig. 2.2 provided information about how temperature affected the activity of chitinase;
- Fig. 2.3 provided information about how the stability of chitinase changed over time, when maintained at five different temperatures;
- for each temperature shown in Fig. 2.3, the activity over time was expressed as a percentage of maximum activity at that particular temperature.

The quality of response from some candidates was excellent. Each graph was clearly referred to in turn, and was both described and discussed, with care taken to extract precise data to support statements. For Fig. 2.2, stronger candidates were cued in both by the high optimum temperature of chitinase (highlighted by answering **(b)(i)**), and the high activity shown by the enzyme at 50 °C, and so reserved comments about denaturation for the highest temperatures. This contrasted with many who stated that the enzyme had denatured after the optimum temperature. Although most candidates did attempt to cover aspects from both graphs, a good number only wrote about Fig. 2.3 and ignored completely Fig. 2.2, which was the more straightforward and familiar of the two graphs. It was evident that some candidates had not understood the differences between the two graphs and had not considered the *y*-axis label 'relative activity' of Fig. 2.3, which led to responses that were very confused. Some candidates were able to use correct data to support statements more proficiently than others. For example, in Fig. 2.3, stability decreasing over time needed to be evidenced by taking one temperature and comparing the relative activity at two different times or over the whole 72 hour period. The observation that the lower the temperature, the more stable the enzyme, should have been supported by comparative data for at least two different temperatures at more than one time, in order to give the best supporting evidence. The weakest candidates gave considerable data from one or both graphs, but did not explain why they had done this, or attempted to take a particular temperature and compare activities from both graphs, or tried to explain results in terms of substrate concentration.

Question 3

This question not only assessed knowledge and understanding of plant and animal transport systems (***Section G*** of the syllabus), but also asked candidates to compare the two.

(a) This question was based on a learning outcome that expected candidates to be able to explain the need for a transport system in plants in terms of size and surface area to volume ratio. Many showed a sound understanding of the principles involved to gain full credit. Others were less aware of this part of the syllabus and gave general answers discussing the transport of gases, assimilates, water and minerals, within plants. Although these responses may have implied an understanding that the large size of multicellular organisms, and hence long distances for these substances would not be supported by diffusion alone, this was not stated. In these cases, some credit could be given if candidates had named the transport tissues xylem and phloem and given further details.

(b) (i) Most candidates identified correctly cell **A** as the companion cell; fewer were able to name precisely cell **B** as a sieve tube element or sieve tube cell. It was common for candidates to name cell **B** as a phloem cell, which gave the impression that they did not realise that a companion cell is also a cell comprising phloem tissue.

(ii) The best responses referred to the structural features of each cell shown in Fig. 3.1 and briefly linked these to the function of the cell type. These responses were well set out and covered most of the main points to gain full credit. Candidates were told at the beginning of the question that the cells were involved in the transport of dissolved organic molecules, but it was not uncommon for weaker candidates to focus on the structure of xylem in relation to the transport of water and minerals. Some did not read the question sufficiently carefully and described the sequence of events occurring in the companion cell that result in the movement of sucrose into the sieve tube cell. In these cases, it was possible for a candidate to be given some credit if a reference was made to the production of ATP, by the mitochondria, for the pumping out of hydrogen ions.

(c) Strong candidates approached this question in a methodical way, addressing the comparable feature in plant and animal transport systems. Where there was a biologically correct statement in one column, credit was given where possible when there was a comparable statement, however, this was difficult where a statement such as 'moves because of differences in hydrostatic pressure' was written, without any further qualification, in order to make a comparison with the heart. There were some features of the mammalian transport system where it was feasible to state that the feature was not present. Many of the stronger candidates started with the idea of the closed, double circulation of mammals; by having the two ideas on separate rows and giving a comparable statement for the plant system, it meant that this was already halfway to gaining full credit. This was often then followed by a consideration of the types of vessels involved in transport and the mechanisms used to move fluids. Hence, structural features such as arteries, veins and capillaries, as transport vessels, were compared to xylem and phloem. Additionally, the heart, acting as a pump, was compared to the two separate mechanisms for movement in the xylem and phloem, or a statement given that no pump existed in the latter.

Good candidates realised that water is the transport medium in both the mammalian and plant transport systems and avoided comparisons of blood versus water as transport media. The best responses made valid comparisons. For example, if it was stated that oxygen and carbon dioxide were transported in the mammalian system, it was necessary to state that these were not transported in the plant system. It was not sufficient to state that in plants carbon dioxide diffused in via stomata, as this did show that the candidate understood that the gas did not then enter the transport system, nor was it valid to state that water and minerals were transported as this was not a comparable statement. Some of the weakest responses steered away from the question and used one or two rows to compare gas exchange systems.

Question 4

This question, set in a context of ***Section I*** of the syllabus, also used candidates' knowledge and understanding from sections ***A***, ***B***, ***D*** and ***F***. Part **(a)(i)** proved to be the most straightforward section, with part **(c)** illustrating the difference between candidates who had a sound understanding of the role of antibiotics and those that confused antibiotics with antibodies.

(a) (i) Most candidates demonstrated a good understanding of the differences between prokaryotes and eukaryotes. The best responses showed clarity of expression and avoided ambiguous statements such as: 'naked DNA so it is not surrounded by a nuclear envelope' and 'a strand of DNA in loops'. The first statement suggested that candidates thought naked DNA meant that it is not surrounded by an envelope, rather than it is not associated with histone proteins. A strand of DNA is biologically incorrect so would negate the idea of circular DNA. Similarly, detail of the ribosomes, such as 70S or smaller, was sufficient for a correct statement, but 'ribosomes lying freely in the cytoplasm', was not as eukaryotic cells also have free ribosomes. For those that interpreted the outer part of the cell as a thin wall and stated that the cell had a surrounding capsule, credit was also available.

(ii) The majority of candidates knew cellulose was the feature to be stated for plant cell walls and the stronger candidates were able to give peptidoglycan or murein for bacteria. Chitin, commonly found in fungal cell walls, was the most common incorrect response stated for bacterial cell walls. Weaker candidates did not carefully read the question and wrote about differences in permeabilities, or gave a response that hinted at cell surface membranes rather than cell walls.

(b) The question stem used the term 'water potential' to cue candidates into using this term. Many did this, avoiding descriptions of water concentrations and water concentration gradients, which did not gain credit. Many candidates gave precise, correct descriptions of how the movement of water would affect the bacterial cell, showing an understanding that water leaving the cell still allows the cell wall to remain intact and giving descriptions of, or stating, the term 'plasmolysis'. Hence, 'the cell shrinks' was not sufficient to gain credit. Some weaker candidates were confused with the meaning of 'more negative water potential' and thought that the cell would become turgid.

(c) Some candidates gave confident responses, beginning with a brief definition of a mutation and continuing to show how this could give a new protein with a function that gave resistance to antibiotics. Many others realised that a mutation could produce a different protein, but could not proceed to give further correct detail. The most common misconception was that the new protein was an antigen that was not recognised by an existing specific antibody. Other candidates ignored the information given in the stem of the question and gave a general response describing the spread of antibiotic resistance.

Question 5

This question assessed ***Section K*** of the syllabus. Many candidates assimilated the information given in the question stem and used this to inform their answers.

(a) A number of candidates gave excellent explanations based on the glossary provided in the syllabus, including the idea of 'at one time', and extracted correct examples from the text to complete their response. Attention to detail was essential. When explaining the term *population*, 'roundworms' was not an acceptable example of one species as candidates had been told that different species of roundworms existed. When explaining a population, stating 'a place where individuals of one species…' is not the same as stating 'all individuals of one species …..living in one place'. Some candidates gave correct definitions of the ecological terms, but did not give any examples from the text, so had not fully answered the question.

(b) Candidates were expected to use their knowledge of the definition of an ecosystem and consider how this could be applied to the sloth and its fur, exemplified with ideas from the text. Stronger candidates gave concise details of the links with energy flow and food webs.

Question 6

This question, assessing ***Sections H*** and ***I*** of the syllabus, discriminated well, with many candidates showing a very good knowledge of the details of antibody structure and function, and of the effects of nicotine on the cardiovascular system.

(a) Credit was given where a structural feature of an antibody was linked to a function, so a label as simple as 'antigen binding site' was acceptable, whereas 'region specific to antigen' required additional detail to show knowledge that binding occurred. Many were able to gain full credit, but there were quite a number who only labelled correctly the antibody's structural features and did not continue to show a function. A proportion of candidates did not attempt this question.

(b) The best responses focused on the effect of nicotine on the cardiovascular system and hence did not include details of the effect of nicotine on the brain. Weaker responses were vague, stating that nicotine would lead to heart attacks, or described atheroma formation, which did not answer the question. Some did not notice that the effect of nicotine on platelets had been stated in the text and so was not credited in the response. The weakest candidates mistook nicotine for tar and gave descriptions of how the gas exchange system would be affected.

BIOLOGY

Paper 9700/23
AS Structured Questions

Key messages

- Candidates may be required to perform calculations, such as determining the magnification of an image, calculating actual sizes, determining rates of reaction or calculating percentage increases and decreases. Where the final calculated value is incorrect, partial credit can often be given if the candidate provides evidence that a correct formula has been used and/or correct working is shown. It is for this reason that candidates should heed the instruction to 'show your working'.

- Mitosis is a topic that highlights how practical and theoretical biology are intertwined. Candidates should be encouraged to study photographs and slides showing stages of mitosis and to become skilled at:

    - producing written descriptions of the events occurring in each stage;
    - identifying a stage of mitosis and being able to describe the cell before and after the identified stage;
    - drawing, and labelling or annotating, simple diagrams to illustrate the main features of each stage;
    - being able to explain the relationship between the cell surface membrane, nuclear envelope, chromosomes and the spindle, as mitosis occurs.

  This will leave candidates well prepared for questions that may occur in both practical and theory assessments.

- Candidates should understand that the main function of a mitochondrion is to produce ATP as a result of aerobic respiration. A common error is to state that the mitochondrion produces energy. ATP is the universal energy currency of the cell, and when hydrolysed, energy is released for use by the cell. Candidates should not refer to ATP as 'ATP energy' and should also avoid using terms such as 'energy in the form of ATP' and 'energy as ATP'.

General comments

Many of the candidates showed excellent subject knowledge and thorough preparation in the following areas: humoral immune response, properties of enzymes, mitosis and the anatomy and function of the circulatory system. The answers to the calculation in **Question 3(b)** were usually correct. Many candidates gave all the main points for **Question 6(c)**. The relationship between the structure and function of cellulose, assessed in **Question 5(a)**, seemed to be an area of weakness for some candidates. Here, they had difficulty explaining the linking of β-glucose by glycosidic bonding and failed to state that there were many hydrogen bonds between the cellulose molecules that make up the microfibrils. Another area of weakness for some candidates concerned the difficulties in developing a vaccine for malaria, highlighted in **Question 1(c)**. Many candidates did not refer to the malarial parasite in their response. Questions that required candidates to respond by writing sequences of events, such as **Question 1(b)** and **Question 2(d)**, were generally answered very well.

Comments on specific questions

Question 1

This question mainly assessed knowledge and understanding of ***Section J*** of the syllabus, with quaternary knowledge of protein structure from ***Section B*** linked to antibody structure. In **Question 1(b),** on immunity, it was not enough to write clonal selection and clonal expansion without any reference to the lymphocytes

involved. Similarly, it was not sufficient in **Question 1(c)** to write antigenic concealment without reference to the pathogen and its antigens being inside cells.

(a) In part **(i)**, many candidates identified the part of the antibody labelled **X** in Fig. 1.1 correctly as the variable region, antigen-binding site, or light polypeptide. Incorrect answers included 'antibody receptor', 'antigen holder' and 'short chain'.

The disulfide bond shown as **Y** in Fig. 1.1 was identified successfully by many candidates. Other bonds associated with macromolecules were given by some candidates: peptide, glycosidic, hydrogen, ionic and phosphodiester, were among those given. Misspellings of the name of the bond included 'disulphate', 'sulphur' and 'sulphide'. In part **(iii)**, many candidates thought that the term quaternary structure referred to a protein having a 3D shape. Answers had to be carefully worded. The antibody molecule shown in Fig. 1.1 has four polypeptides, but the term quaternary structure refers to any protein composed of more than one polypeptide. 'Two or more polypeptides' was a common correct answer. 'More than two polypeptides', 'one or more polypeptides', and 'a protein with several or many polypeptides', were careless answers. This question attracted many inappropriate descriptions or lists of the bonds holding the tertiary structure together.

(b) There were many responses describing the events that occur during an immune response that scored full marks. Many of these included brief descriptions of antigen presentation, clonal selection, clonal expansion, the production of plasma cells and the secretion of antibodies. Few candidates made the point that the pathogen has antigens that are regarded as foreign or non-self. When describing antigen presentation, some candidates did not include any information about phagocytosis. Instead they simply stated that an antigen appears in the surface of the antigen presenting cell. Some candidates thought that this was a question about the primary and secondary immune responses. Others were less secure on the relationship between T helper cells and B-lymphocytes.

(c) This part question proved more challenging. Common errors were to omit any reference to the malarial parasite, *Plasmodium*, scoring no credit. Some candidates stated that a virus or a bacterium is the causative organism of malaria. Good answers stated that the parasite changes its antigens, has different antigens for the different stages of its life cycle, and lives for much of the time inside liver and/or red blood cells.

Question 2

This question was based on proteins.

(a) There were many confused accounts of nitrogen fixation and the use of nitrogen-containing compounds by legumes and herbivores. Many candidates started well by stating that nitrogen fixation involves converting atmospheric nitrogen into ammonia or ammonium ions, but then assumed that this occurred in the soil as they wrote about the reactions of nitrification to produce nitrate ions. Their answers continued by discussing the uptake of nitrate ions by root hairs and the conversion of nitrate into amino acids. Only a minority of well-prepared candidates dealt with the details of nitrogen fixation in *Rhizobium*, mentioning nitrogenase, the need for ATP to provide energy for the process, and the presence of anaerobic conditions within the nodules. Some of the candidates who wrote about nitrification ended their answers by stating that amino acids are used by plants to make proteins. They continued by stating that plant protein is digested by herbivores and then assimilated by conversion into animal protein. There was a considerable number of candidates who thought that nitrogen fixation was forming nitrates and/or nitrites.

(b) Many candidates identified the tRNA anticodon as UAC. Incorrect answers included: AUG, ACT, ATG and TAC.

(c) Good answers stated that tRNA is constantly reused. Some candidates negated this correct answer by stating that mRNA is not reused, so lost credit. Others stated correctly that mRNA is less stable and is only used for a short space of time or is easily broken down.

(d) Some candidates, seeing the word 'role' in the question, gave an outline of protein synthesis and concentrated on what happens to protein after it has left the ribosome. There were many good answers to this question, although some omitted important points. Candidates often described tRNA molecules entering the ribosomes and binding to mRNA, but did not go on to say that each

tRNA molecule carries an amino acid, or it is the anticodon on the tRNA that binds to the codon on mRNA. Some answers included good detail such as the action of peptidyl transferase and the correct roles of the P and A sites within the ribosome. Weaker candidates could say little more than ribosomes are attached to rough endoplasmic reticulum. Many candidates stated that tRNA attaches to the ribosome, but did not refer to the attachment by base pairing to mRNA within the ribosomes. Transcription and translation were sometimes confused.

Question 3

Candidates were given a photomicrograph of animal cells in different stages of mitosis for reference in parts **(a)(i)** and **(ii)** and for use in the calculation of part **(b)**. In part **(c)**, candidates merged knowledge from microscopy in ***Section A*** and the cell cycle in ***Section E*** to consider the advantages of using light microscopy for studies of the cell cycle.

(a) In part **(i)**, many candidates identified the two phases of the cell cycle correctly as prophase and interphase, although some gave these phases the wrong way around, with **A** identified as interphase. Common incorrect answers included early prophase, telophase, metaphase and cytokinesis, as **B**. Almost all candidates gave four or more features of prophase in part **(ii)**. The condensing of chromosomes was included in many answers, although some candidates did not make it clear that each chromosome appears later in prophase as two chromatids joined at the centromere. Some stated that the two chromatids 'come together' to form a chromosome, or that 'homologous chromosomes pair up'. Many stated incorrectly that centrioles replicate during prophase.

(b) Many candidates calculated the diameter of the nucleus as 6 μm. Some candidates forgot to round their answer to the nearest micrometre and some did not convert their measurement made in centimetres to millimetres before converting to micrometres. Most gave details of their working, although some became confused with using standard form in their calculations.

(c) The answers to this question revealed that candidates had not read the question carefully. Candidates were expected to state the advantages of using the light microscope for studying the cell cycle. Few candidates interpreted this question correctly; most wrote about the general advantages of the light microscope or the general disadvantages of the electron microscope. Although many candidates stated that live specimens can be observed in the light microscope but cannot be observed in the electron microscope, few went on to relate this to being able to watch the movement of chromosomes during mitosis. Many candidates stated that it is not possible to see colours in an electron microscope whereas they are visible in the light microscope, but few related this to the need to use stains to see chromosomes in the light microscope.

Question 4

Sections G and ***H*** of the syllabus were assessed in this question. Parts **(a)** and **(b)** were very straightforward and many candidates gained full credit.

(a) Almost all candidates labelled the three structures on Fig. 4.1 correctly. If the letters were drawn over the structures, then credit was awarded. A common mistake was to place **X** (tricuspid valve) between the left atrium and the left ventricle. **X** was also used to label the semi-lunar valves. Some candidates confused the left and right sides of the heart and put the label line for the aorta on the pulmonary artery.

(b) Many candidates described the pathway taken by blood from the left ventricle to the lungs, often including details of the cardiac cycle, which were not required. Among the many excellent answers to **Question 4(b)** on the blood flow through the mammalian circulatory system, were some that did not give enough detail or were completely incorrect. Errors included: taking blood from a ventricle to an atrium and then to an artery; stating that blood flows to the lungs in the pulmonary vein; blood flows 'from the aorta to the lungs', or 'from the left ventricle to the pulmonary artery to the lungs'. There was no requirement in this question to describe pressure changes or the opening and closure of valves.

(c) There were many good answers to this question on the efficiency of the human gas exchange surface. Candidates stated that there are many alveoli providing a large surface area, that there is a network of capillaries that maintain the concentration gradients for oxygen and carbon dioxide,

and that the thin alveolar wall is composed of one layer of squamous epithelial cells for a short diffusion distance. In addition, some candidates included descriptions of elastin and its role in allowing the alveoli to increase in volume and surface area during inspiration and to recoil to force air out during expiration. Some included the surfactant secreted by cells lining the alveoli and its role in reducing surface tension. Candidates lost credit by stating that the alveoli have a large surface area to volume ratio and that the many alveoli increase the surface area rather than give it a large surface area. Weaker candidates were able to identify the relevant structures, but did not give correct adaptations to them.

Question 5

Candidates encountered the cell wall in ***Sections A*** and ***D*** of the syllabus, and also learn about cellulose in ***Section B***. Part **(a)** allowed candidates to bring together their subject knowledge to show the link between the structure of cellulose and its function as a component of the cell wall. Part **(b)** presented candidates with unfamiliar data. Few candidates appreciated that part **(b)(ii)** was a question that required conclusions to be made from the relationship given in answer to part **(b)(i)**.

(a) This question asked candidates to describe the structure of a cellulose molecule and explain how it is suitable as a material for plant cell walls. Most candidates gained more credit for descriptions of the structure of the cellulose molecule than for their explanations. Most knew that the cellulose molecule is composed of β-glucose monomers joined together by glycosidic bonds. The alternate positioning of the monomers was described by many candidates, with a much smaller number explaining that this allows for the formation of many hydrogen bonds between molecules. Many candidates were able to describe the fact that the cellulose molecule is a straight or unbranched chain. Many candidates referred to hydrogen bonding, but some stated that each bond is strong and many did not make it clear that there are numerous hydrogen bonds between cellulose molecules, although they did explain that there are microfibrils which are formed into fibres. Some candidates were confused with fibrous proteins and described features associated with collagen, rather than cellulose. Stronger candidates made it clear that permeability was a property of the cell wall or arrangement of the cellulose fibres, rather than of the cellulose molecule.

(b) (i) Almost all the candidates identified the trend in the scatter graph. Fewer described the variation in results about a notional trend line, although there were some who gave examples of the different percentages of digestion for the same retention time. Many answers could have been improved by including relevant and correct data quotes from Fig. 5.1. A few candidates correctly stated that none of the herbivores tested could digest all (100%) of the cell wall material and there were some who quoted the lowest and the highest figures to give the range of retention times.

(ii) Part **(ii)** proved to a difficult question for many candidates, since it relied on a good understanding of the main principle identified in the answer to part **(i)**. Some did not appreciate that the question was asking about the energy available to the herbivores (primary consumers) that would then be available to the next trophic level (secondary consumers) and potentially to higher trophic levels. The answer 'more energy is needed to digest the cell wall material' was not credited, since there is no information in the scatter graph about energy required for digestion of cell wall material. Some candidates simply rewrote their answer from part **(i)**. Others resorted to the 10% energy transfer model, explaining that much of the plant material eaten by the herbivores cannot be digested. Many stated that if 65% of the cell wall material is digested, much is 'lost' without thinking about where this undigested material in a herbivore might go and what might happen to it. For a creditworthy response, candidates should have used the data in the graph to show that the quantity of undigested cellulose varies between the herbivores in the study and then go on to consider how this would affect energy flow in the ecosystem. A few candidates did do this, with some remembering to write about how the results would impact on energy flow to the decomposer food chain.

(c) There were many good answers to this question on the similarities and differences between active transport and facilitated diffusion. Most candidates seemed to be more confident in giving differences. Candidates often missed the obvious similarity that both transport mechanisms involve the movement of substances across membranes. The answer that both involve proteins did not gain credit as the proteins involved in active transport are not channel proteins; candidates had to qualify the proteins involved such as carrier, membrane or transport.

Question 6

This question assessed knowledge and understanding from ***Sections C*** and ***G*** of the syllabus.

(a) Candidates found it difficult to give two features of the sieve tubes visible in Fig. 6.1 that distinguish them from xylem vessels. It was not relevant to include companion cells in the response, as the question was about sieve tubes, and this meant that many candidates could only gain partial credit by giving another correct feature of sieve tubes. The presence of sieve plates or end walls was a distinguishing feature that was commonly stated. Candidates recalled that xylem vessels are hollow and that sieve tubes contain some cytoplasm, so both statements were credited as alternative answers. The thin cell walls were also identified and this was often linked to the absence in sieve tubes of thickening in the walls, or the reverse argument for xylem vessels. Some candidates gave features that would correctly identify sieve tubes, but were not visible in Fig. 6.1, so did not gain credit.

(b) The responses to this question involved some quite lengthy answers – often far too long for the space provided and the request to 'explain briefly …'. These responses included much detail on the active loading of sucrose by companion cells. These did not really answer the question which referred specifically to movement in the sieve tubes. There were many attempts at explaining how a pressure gradient is responsible for mass flow in the sieve tubes. Not all of these were successful as they did not state that there is a pressure difference between source and sink, with the highest pressure at the source.

(c) There were many competent answers describing the complementary shape of the active site and substrate, the formation of enzyme-substrate complexes and the lowering of activation energy. Some candidates thought that their answers had to refer specifically to movement in the phloem and gave confused accounts which did not gain credit.

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 required for the examination. They should also be given opportunities to reflect on this work in order to be able to identify where parts of the procedure could be improved to increase confidence in the results. The selection of improvements should involve consideration of whether an error caused any variation in the trend of the results. Then the suggested improvement to their investigation will reduce the effect of this error, for example by having a mould to provide regular sized agar blocks.

Candidates should be given the opportunity to draw graphs from a variety of different data so that the orientation of the axes is correct and the selected scales use most of the grid. Candidates should take into consideration the value of half a square (1 mm), this being the most accurate value from which a reading or plot can be made. When deciding how to draw the line, the data must be considered.

Candidates should undertake a range of microscope practicals, looking at the material stated in the syllabus as well as unfamiliar material.

General Comments

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

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

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

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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

Candidates who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

Comments on Specific Questions

Question 1

(a) (i) Many candidates correctly showed how to make at least three further simple dilutions of 0.08%, 0.06%, 0.04% and 0.02% ascorbic acid.

(ii) Those candidates who are familiar with carrying out investigations presented their results most clearly and gained most credit. The majority of candidates presented a fully ruled table with all the cells drawn, and a ruled outer boundary. The better candidates included an appropriately detailed heading for the independent variable (percentage concentration of ascorbic acid) and the dependent variable (time/s). The majority of candidates gained credit for recording results for the four concentrations of ascorbic acid and recording the correct pattern of results with the shortest time for the 0.10% concentration of ascorbic acid.

The most common errors were to include units (% or s) in the cells of the table, or to record the time taken in minutes or minutes and seconds.

(iii) The better candidates were able to identify significant causes of error such as the colour disappearance was hard to judge or the sizes of the agar pieces were not the same.

(iv) The better candidates correctly realised that, in order to improve the confidence in their results, a different range of at least five known concentrations of ascorbic acid should be made. Confidence could also be improved by carrying out the experiment on each concentration one at a time. Additionally a more accurate way of cutting the agar blocks could be used along with an automatic shaker.

b) (i) Whilst many candidates correctly used the headings given in the table, percentage concentration of ascorbic acid and volume of indicator/cm^3, these were frequently incorrectly on the *y*-axis and *x*-axis respectively. The *x*-axis must be the dependant variable.

The better candidates used scales of 2 cm to 0.20 percentage concentration and 2 cm to 0.50 for volume of indicator/cm^3. A common error was to not use all the significant decimal places.

Better candidates, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear, ruled line, accurately connecting each pair of points. The most common errors were using an unsuitable scale on the *x*-axis plotting points which were too large or too small (point not visible when a line is drawn through it) and drawing lines which were too thick or not ruled to the centre of the point.

As a general rule, lines should not be extrapolated.

(ii) Most candidates who had used the correct scales of 2 cm to 0.20 percentage concentration and 2 cm to 0.50 for volume of indicator/cm^3 were able to show how to obtain the reading from the graph at 0.875 cm^3 and obtain a correct reading. Better candidates combined this value with a % sign.

Question 2

(a) (i) Most candidates used a label line to show the position of the muscle tissue correctly and some had used the eyepiece graticules to help them draw well-proportioned drawings. The better candidates produced drawings made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used the space provided without drawing over the text of the question. They included sufficient lines to delineate different areas in the specimen and drew the correct sector.

The most common errors were lines drawn that did not meet up precisely or were too thick, insufficient detail of the irregular nature of the innermost line, and incorrect identification of the pith.

(ii) The majority of candidates were able to state one observable feature, often identifying the lumen and then had observed the presence of red blood cells, using this to explain how the tube was involved in transport.

(b) (i) The majority of candidates followed the instructions and marked on the red blood cells counted on Fig. 2.2. They then recorded a whole number of blood cells and showed this number multiplied by eight in order to estimate the number of blood cells in the whole field of view.

(ii) The majority of candidates correctly carried out the stages required in order to calculate the area of the field of view.

(iii) In order to obtain the answer, candidates had to show the answer from **(b)(i)** divided by the answer from **(b)(ii)**, giving the answer as a whole number.

(iv) The majority of candidates were able to successfully describe and explain the trend. The most common error was to answer in terms of days rather than the height above sea level as in the question.

(c) Those candidates who had experience of drawing cells as part of their course gained the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used the space provided without drawing over the text of the question. The majority of candidates gained credit for carefully following the instructions, selecting two cells of each type of white blood cell and drawing these cells with the correct differences in size. Most candidates clearly labelled just one nucleus as requested.

The most common errors were candidates who were unable to recognize the two types of white blood cells and so included red blood cells.

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. They should also be given the opportunity to reflect on this work in order to be able to identify where parts of a procedure could be improved to increase confidence in the results. The selection of improvements should involve consideration of whether an error caused any variation in the trend of the results. Then the suggested improvement to their investigation will reduce the effect of this error, for example the use of a colorimeter which removes the variability of the subjective colour assessment.

When carrying out practical work candidates should be encouraged to gain experience in deciding which variables have been standardised and how to standardise other variables to provide accurate results. If key variables are allowed to change during an investigation the results may change.

Candidates should be given the opportunity to draw both graphs and charts. When drawing a chart the candidates need to consider whether the bars should be separate (for non-quantitative data on the *x*-axis) or joined (for quantitative, e.g. heights or lengths on the *x*-axis). In this case the data, type of milk, was non-quantitative on the *x*-axis and the bars should be separated from each other. The scale on the *y*-axis in this case should have had zero at the origin. The bars should be plotted accurately and drawn exactly along the horizontal lines with a fine ruled line. All the lines, both vertical and horizontal should be clear, sharp and unbroken (about 0.5 mm thick).

General Comments

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

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

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

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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

Candidates who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

Comments on Specific Questions

Question 1

(a) (i) Many candidates correctly completed Table 1.1 by showing three further concentrations of **M** as 2%, 3% and 4% and the volumes of milk solution and water making up these concentrations as 8 cm^3 and 12 cm^3, 12 cm^3 and 8 cm^3, and 16 cm^3 and 4 cm^3 respectively.

(ii) Many candidates correctly stated that the concentration of triglycerides expected to reach the end-point in the shortest time was 5%.

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

The majority of candidates gained credit for recording the times as whole numbers. The better candidates recorded the concentrations of triglycerides starting with the lowest concentration and the times showing the highest concentration of triglycerides taking a shorter time than lower concentrations.

A common error was including additional method information in the table, such as the volumes of milk and water used to make up the concentrations of triglycerides. Another error was including unprocessed data in the table such as start and end-point times.

(iv) The better candidates correctly calculated the rate of lipase activity for the 5% concentration of triglycerides by dividing 1 by the result for 5% and showing the correct units as s^{-1}.

(v) Some candidates correctly described how to set up a control by replacing the milk with an equal volume of water as substrate concentration was the variable being investigated.

(vi) Some candidates correctly identified a significant source of error as the difficulty of judging the colour change from pink to colourless. Other sources of error that gained credit included that the shaking of the test-tubes was different for each test-tube and that all the test-tubes had not been kept in the water-bath for the same length of time.

(b) (i) The majority of candidates drew the chart, using the headings given in the table, with type of milk on the *x*-axis and time taken to reach the endpoint/s on the *y*-axis.

The better candidates used even bar widths and 100 to 2 cm for the *y*-axis, with zero at the origin, the exact plotting of each bar, in the order of Table 1.2 (F, V, L, C and D), with each horizontal line drawn as a sharp, clear ruled line and the labels for each type of milk located directly below the relevant bar.

The most common errors were not including a full axis label for each axis, omitting the units for both the *x*-axis and the *y*-axis, not having a space between each bar and drawing lines which were too thick or not ruled.

(ii) The better candidates correctly suggested the reason for the difference in the time taken to reach the end-point between evaporated milk and dried milk was that the evaporated milk had a greater concentration of triglycerides than dried milk.

(c) Many candidates correctly identified two variables that the candidate would need to standardize to compare the activity of different concentrations of lipase immobilized in alginate beads.

Correct variables included volume of milk, temperature of milk, concentration of enzyme, bead size and pH. The better candidates described how one of these variables would be standardized.

Correct descriptions included using same volume of milk, using a thermostatically controlled water-bath, using the same concentration of enzyme and the same bead size.

Question 2

(a) (i) The better candidates produced drawings using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided without drawing over the text of the question. Many were able to draw the layers of different tissues within the mid-rib of the leaf. Some candidates had used the eyepiece graticules to help them draw well-proportioned drawings.

The most common errors were drawn lines that did not meet up precisely or were too thick and not showing the outline of the vascular area, which would be observable using the microscope.

Most candidates used a label line to show the epidermis correctly.

(ii) Those candidates who had experience of drawing cells as part of their course gained the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided without drawing over the text of the question. The majority of candidates gained credit for carefully following the instructions by drawing a group of four whole xylem vessels, showing the different shapes of the vessels and by drawing the cell walls as double lines.

The most common errors were to draw lines that did not join up or not drawing the vessels as a group. Candidates should be encouraged to draw what they observe on the particular slide provided.

Most candidates used a label line to show the one lumen correctly.

(b) (i) The better candidates showed the calculation of the area of the field of view by showing the radius as 0.2 mm and used the formula for the area, πr^2, to calculate the area as 0.126 mm^2, to no more than 3 significant figures.

(ii) Most candidates followed the instructions and marked clearly each of the chloroplasts counted in the quarter of the field of view, showed the number of chloroplasts in the quarter multiplied by four, showed this number of chloroplasts divided by the area of the whole field of view from **(b)(i)** and showed the number of chloroplasts per mm as a whole number.

(c) (i) The better candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed Fig. 2.3 and the other headed Fig. 2.4. The majority of candidates were able to gain partial credit for recording appropriate differences. The most common errors were to incorrectly identify the features.

(ii) Most candidates correctly stated that the trophic level of the organism in Fig. 2.4 was a primary consumer and described one observable feature of the specimen in Fig. 2.4 which supported this conclusion as green algae that had been engulfed

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. They should also be given opportunities to reflect on this work in order to be able to suggest modifications to the procedure in order to extend the investigation. In this question paper this would include describing how a range of at least five concentrations of reducing sugar should be prepared by serial or simple dilution. These concentrations would be tested for reducing sugar by timing to the first colour change and would then be compared to the unknown sample to estimate the concentration.

Candidates should be familiar with how to use the microscope provided in the examination and how to draw plan diagrams with no details of cells. When asked to draw cells candidates should follow instructions carefully to draw the required number of the correct cells, using a suitable pencil to obtain clear, sharp lines. Only the structure or structures specified should be labelled.

Candidates should be given the opportunity to draw both graphs and charts. When drawing a chart the candidates need to consider whether the bars should be separate (for non-quantitative data on the *x*-axis) or joined (for quantitative, e.g. heights or lengths on the *x*-axis). In this case the data, type of fruit was non-quantitative on the *x*-axis and the bars should be separated from each other. The scale on the *y*-axis in most cases should start at zero. The bars should be plotted accurately and drawn exactly with a fine ruled line.

General Comments

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

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

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

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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

Candidates who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

Comments on Specific Questions

Question 1

(a) (i) Many candidates used the information provided to select reducing sugars as molecules small enough to pass through the selectively permeable wall of the Visking tubing.

(ii) Many candidates correctly identified that temperature should be standardised. Some candidates gained credit for also identifying that the volume would need to be standardised and describing how these variables would be standardised using the apparatus provided. The most common errors were to use apparatus which was not provided such as a colorimeter or thermostatically controlled water-bath.

(iii) The majority of candidates correctly showed both water levels above the Visking tubing and followed the instructions to label them 'before' and 'after'.

(iv) The candidates who are familiar with carrying out investigations presented their results most clearly and gained most credit. The majority of candidates organised their results clearly by presenting a fully ruled table with all the cells drawn, and a ruled outer boundary. The better candidates included appropriately detailed headings including time in minutes and the test.

The majority of candidates gained credit for recording results according to the instructions for 0, 5, 10 and 15 and recording the correct pattern of results with either a quicker time for the appearance of the colour for reducing sugar or a more positive colour. Many candidates also recognized that only the reducing sugar would pass through so tests for protein and starch would be unnecessary.

The most common errors were to use m as a unit for time or to record conclusions such as present or absent rather than the results as a time/s to first colour change or the colour at end of test.

(v) Those candidates who realised that the biological molecule test only records presence or absence of reducing sugars (not glucose specifically) gained credit.

(vi) Many candidates correctly used their results to support the hypothesis.

(vii) Only the better candidates were able to predict the trend in the results that there would be a quicker time to the first colour change after 15 minutes or no further change (as an equilibrium had been reached).

(viii) The better candidates were able to describe making up at least five concentrations of reducing sugar by serial or simple dilution. Having obtained the results for these concentrations of reducing sugar, these were compared to the result for the unknown solution to estimate the concentration.

(b) The majority of candidates drew the chart, using the headings given in the table, with type of fruit on the *x*-axis and percentage of sugars on the *y*-axis. The better candidates used even bar widths and 2.0 to 2 cm for the *y*-axis, with zero at the origin, the exact plotting of each bar, in the order of Table 1.1 (A, B, K, L and M) with each horizontal line drawn as a sharp, clear ruled line and the labels for each type of fruit located directly below the relevant bar.

The most common errors were not including a full axis label for each axis, omitting the units for the *y*-axis, not having a space between each bar and drawing lines which were too thick or not ruled.

Question 2

(a) The better candidates produced drawings using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided without drawing over the text of the question. Many were able to draw the layers of different tissues within the wall of the organ. Some candidates had used the eyepiece graticules to help them draw well-proportioned drawings.

The most common errors were drawn lines that did not meet up precisely or were too thick, and not showing all the different tissues and their correct distribution, which would be observable using the microscope.

Some candidates used a label line to show one other difference (than smooth) for example the different thicknesses of the layers.

(b) (i) The majority of candidates correctly measured the line **Y** in mm with the correct precision. Many candidates showed the division of this measurement by 310 and the correct conversion from mm to μm (x1000).

(ii) The majority of candidates stated one observable feature as folds and explained how this feature would increase the rate of absorption by providing a larger surface area.

(iii) The better candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed **M1** and the other headed Fig. 2.1. The majority of candidates were able to gain partial credit for recording appropriate differences. The most common errors were to use features only observable on electron micrographs or to confuse tissues and cell structures or to include functions rather than observable features.

(c) (i) The majority of candidates followed the instructions to label one of the blue cells with a label line and cell **X** or goblet cell.

(ii) The better candidates used clear, sharp lines to show only the whole cells as a group of touching cells. Some candidates drew the shapes and sizes of the cells carefully to gain credit. The majority of candidates gained credit for correctly identifying one of the nuclei as the feature which identified the cells as eukaryotic.

The most common errors were drawn lines which were too thick and cells and nuclei which did not show the shapes and sizes correctly.

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. They should also be given the opportunity to reflect on this work, which will enable them to suggest sources of error in the procedure and modifications required to extend the investigation. The identification of sources of error should involve considerations of whether the error caused any alterations in the trend of the results. In this question paper, this would include describing how a range of at least five different concentrations of copper sulfate should be prepared by simple or serial dilution.

When carrying out practical work, candidates should be encouraged to gain experience in deciding which variables need to be standardised and how to standardise these so as to provide accurate results. If key variables are allowed to change during an investigation, for example, the volumes and concentrations of enzyme, then the results may not be comparable.

Candidates should be familiar with how to use the microscope provided in the examination and how to draw plan diagrams with no details of cells. When asked to draw cells, candidates should follow instructions carefully to draw the required number of the correct cells, using a suitable pencil to obtain clear, sharp lines. Only the structure or structures specified should be labelled.

Candidates should be given the opportunity to draw graphs from a variety of different data so that the orientation of the axes is correct and the selected scales use most of the grid. Candidates should chose scales that ensure the graph is easy to use to obtain data, such as 1, 2 or 5 units to a 20 mm square.

General Comments

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

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

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

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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

Candidates who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

Comments on Specific Questions

Question 1

(a) (i) Most candidates correctly described how to carry out a serial dilution of **H**, reducing the concentration by half between each concentration, by transferring 20 cm^3 of the previous concentration to the next beaker and adding 20 cm^3 of water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a fully ruled table with all the cells drawn, and a ruled outer boundary. The better candidates included an appropriately detailed heading for the independent variable (percentage concentration of hydrogen peroxide) and the dependent variable (height of foam / mm). The most common errors were to omit the full heading for the independent variable or units for the dependent variable or to include mm or % in the cells of the table. The majority of candidates gained credit for recording the results in the correct order, with some candidates recording the correct pattern of results.

The most common error was to include unprocessed data in the table such as height of the mixture and height of the mixture and foam. The better candidates recorded only processed results. Another error was including additional method information, such as volumes of **P** and **H**.

(ii) Some candidates correctly identified significant sources of error such as the difficulty in judging the height of the foam. The most common errors by candidates in this question were suggesting errors in the procedure that would affect all tubes equally or suggesting it was a parallax error.

(iii) Many candidates correctly realized that in order to modify the procedure to investigate the effect of copper sulfate concentrations on the enzyme, a range of different concentrations was needed. The most common error was to give only four concentrations of copper sulfate. The better candidates correctly stated that at least five different concentrations of copper sulfate should be made, by serial or simple dilution. Many candidates recognized the need to ensure the volume and concentration of **H** and **P** remained constant. A common error was to state improvements to the investigation rather than modifications to the procedure.

(b) (i) The majority of candidates drew the graph, using the headings given in the table, with time / seconds on the *x*-axis and number of bubbles of oxygen released on the *y*-axis. The better candidates used scales of 50 to 2 cm for the *x*-axis and 20 to 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a clear sharp ruled line, accurately connecting each pair of points.

The most common error was using a scale (60 to 2 cm) for the *x*-axis that would not make it easy to obtain data (as 1 mm would be equal to 0.333 seconds). Other errors were not including a full axis label for each axis, putting incorrect units for the *y*-axis (for example cm^3 not bubbles), not labelling the scale every 2 cm, plotting points which were just blobs or too large or too small (point not visible when line drawn through it), and drawing lines which were too thick or not ruled or not drawn through the centre of each plot.

(ii) The majority of candidates recognized that copper sulfate acted as an inhibitor to the enzyme, with many describing the action of the copper sulfate in binding to the enzyme and reducing the formation of enzyme-substrate complexes.

Question 2

(a) (i) The better candidates produced drawings using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided without drawing over the text of the question. Many were able to draw the layers of different tissues within the mid-rib of the leaf. Some candidates had used the eyepiece graticules to help them draw well-proportioned drawings. Most candidates used a label line to show the vascular bundle correctly.

The most common errors were drawn lines that did not meet up precisely or were too thick and not showing the outline of the vascular tissue, which would be observable using the microscope.

(ii) Those candidates who had experience of drawing cells as part of their course gained the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided without drawing over the text of the question. The majority of candidates gained credit for carefully following the instructions by drawing one group of adjacent touching cells made up of three epidermal cells and three palisade cells. Most candidates used a label line to show one palisade cell correctly.

The most common errors were to draw lines that did not join up or were too thick, drawing cells that did not have cell walls as double lines, drawing more than the six cells, or drawing palisade cells that did not touch an epidermal cell. Candidates should be encouraged to draw what they observe.

(b) (i) Many candidates correctly identified the radius of the field of view, and therefore were able to calculate the area of the field of view using Fig. 2.2.

The most common errors included, failing to round up the answer to the correct number of decimal places or using the incorrect diameter or radius (a diameter of 16 mm instead of 1.6 mm or a radius of 8 mm instead of 0.8 mm).

(ii) The majority of candidates followed the instructions and marked on Fig. 2.3 the stomata that were counted. They then recorded a whole number for the number of counted stomata, multiplied it by 4, then divided this answer by the area calculated in **Question 2(b(i)**). This enabled them to record the number of stomata in the field of view.

(c) The better candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed Fig. 2.3 and the other headed Fig. 2.4. The majority of candidates were able to record observable differences between the two figures.

The most common error was to include only two columns in the table. Other errors included stating features which were not observable on Fig. 2.3 or Fig. 2.4.

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. They should also be given the opportunity to reflect on this work in order to be able to modify a procedure, for example in this question paper, changing the dependent variable to removing samples and testing with iodine showing the removal of starch and the iodine remaining orange.

When carrying out practical work candidates should be encouraged to gain experience in deciding which variables need to be standardised and how to standardise these variables to provide accurate results. If key variables are allowed to change during an investigation, for example the volumes and temperature in the Benedict's test, then the results may not be comparable.

Candidates should be given the opportunity to estimate unknown concentrations from results for known concentrations. If the value for the unknown concentration is greater than the known concentration then the estimate must state this, e.g. the unknown concentration is greater than 0.4%. If the value for the unknown concentration is between two known concentrations the answer must state this, e.g. the unknown concentration is between 0.1% and 0.2%. Candidates should avoid stating a concentration that has not been made, e.g. 0.5% or a concentration between two known concentrations i.e. 0.15%.

General Comments

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

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

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

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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

Candidates who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

Comments on Specific Questions

Question 1

(a) (i) Many candidates correctly stated that the volume of Benedict's solution should be the same or more than the volume of the samples to be tested and that the temperature should be between 80 °C and 100 °C.

(ii) Many candidates correctly described how to carry out a serial dilution of **G**, reducing the concentration by half between each concentration by transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of water to each beaker.

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

The majority of candidates gained credit for recording the times as whole numbers. The better candidates recorded times showing the highest concentration of reducing sugar took less time than lower concentrations.

(iv) Most candidates correctly recorded a shorter time for **E1** than for **E2**. The better candidates used their results from **(a)(iii)** to estimate the concentration of reducing sugar in **E1** by stating that it was between known values of percentage concentrations of reducing sugars. A common error was to state a concentration that had not been made.

(v) Many candidates correctly described a modified investigation to follow the time course of the hydrolysis of starch without the use of Benedict's solution by sampling the starch solution and enzyme mixture at equal intervals and testing for starch using the iodine test then recording the time for the iodine to remain the same colour.

(b) (i) The majority of candidates drew the graph, using the headings given in the table, with percentage of beads with iron sulfate on the *x*-axis and mass of reducing sugar produced / µmoles min^{-1} on the *y*-axis.

The better candidates used scales of 10 to 2 cm for the *x*-axis and 20 to 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear, sharp ruled line accurately connecting each pair of points.

The most common errors were not including a full axis label for each axis, omitting the units for both the *x*-axis and the *y*-axis, not labelling the scale every 2 cm, plotting points which were just blobs or too large or too small (point not visible when line drawn through it), and drawing lines which were too thick or not ruled.

(ii) The better candidates correctly described the trend by stating that as the percentage of beads with iron sulfate increased the mass of reducing sugar decreased.

(iii) Many candidates correctly explained that the reason for the difference between 0 and 10 percentage of beads with iron sulfate by stating that iron sulfate inhibited the reaction, by altering the active site or binding with the enzyme resulting in fewer enzyme-substrate complexes.

Question 2

(a) The better candidates produced drawings using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided without drawing over the text of the question. Many were able to draw the layers of different tissues within the wall of the organ. Some candidates had used the eyepiece graticules to help them draw well-proportioned drawings. Most candidates used a label line to show the lumen correctly.

The most common errors were drawn lines that did not meet up precisely or were too thick and not showing all the different tissues and their correct distribution, which would be observable using the microscope.

(b) Those candidates who had experience of drawing cells as part of their course gained the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided without drawing over the text of the question. The majority of candidates gained credit for carefully following the instructions by drawing the whole cells in the box marked on Fig. 2.2, showing the different shapes of the nuclei within small enclosed areas. Most candidates used a label line to show one nucleus correctly.

The most common errors were to draw lines that did not join up or not drawing the nuclei as a variety of different shapes as observed in the photomicrograph. Candidates should be encouraged to draw what they observe.

(c) (i) The better candidates showed the measurement of lines **Y** and **Z** to the correct precision and using the same units for both lines (mm).

Most candidates presented the ratio of **Y** to **Z** correctly as a larger whole number: smaller whole number.

(c) (ii) Most candidates correctly suggested that the observable feature of the tubular specimen shown in Fig. 2.2 was a large lumen or thin muscle layer.

(iii) The better candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed **N1** and the other headed Fig. 2.2. The majority of candidates were able to gain partial credit for recording appropriate similarities and differences. The most common errors were to incorrectly identify the tissues.

BIOLOGY

Paper 9700/41
A2 Structured Questions

Key Messages

- Candidates should read each question carefully and be selective in choosing information in their response to avoid wasting their time, for example in **Question 11(b)** where photosynthesis was not required.

- Correct terminology can be a great discriminator and should be emphasised in teaching to maximise potential credit, e.g. in **Question 6(b)** and **6(c)** depolarisation or action potential should be used at this level, rather than vague references to impulses.

General comments

The paper was of appropriate difficulty and was comparable to those of previous sessions. There was no obvious misinterpretation of the rubric although some candidates occasionally had difficulty understanding what was being asked of them. Some questions proved to be difficult for most candidates, particularly **Questions 2(c)**, **4(b)** and **5(b)**. Most candidates attempted every question and there was little observable evidence that there was not enough time to complete the paper.

Able candidates tackled the questions with sound knowledge and understanding of the areas being tested and demonstrated their ability to interpret new information and data and scored highly as a result. However, the nature of the questions proved very challenging to the weaker candidates who struggled to understand what was being asked of them, such that many only scored reasonably well on questions that required recall.

Comments on specific questions

Section A

Question 1

(a) Most candidates correctly defined an allele as an alternative form or version of a gene. A significant number said, incorrectly, that it was a 'part' of a gene. A few defined it as a specific locus on a chromosome or strand of DNA which contained alternative nucleotide or base sequences, which was an acceptable alternative.

Most gained credit for correctly saying that a dominant allele expresses a phenotypic character when present in the heterozygous or homozygous genotype.

(b) Many candidates correctly linked the number of repeats with the age of the appearance of the symptoms, i.e. the more repeats the lower the age at which symptoms of Huntington's disease starts. Quite a number incorrectly thought that, as the person's age increased so did the number of repeats, i.e. that the increasing age caused the repeats and not vice-versa.

Although many gave correct figures from the graph, quite a few did not, quoting 30 instead of 32 repeats or 60 instead of 59 repeats.

(c) Whilst many candidates correctly mentioned the fear of a positive result or the cost of the test it was uncommon for full credit to be awarded. Many discussed the fear of other diseases being found, not in the context of HD. A large proportion of candidates felt the 'symptoms' of HD would prevent them from taking the test.

Question 2

(a) Only the more able candidates showed real understanding of the evolution of one species from another. Many gained credit for a correct reference to changing environmental conditions or that survivors breed and pass on alleles. Some were able to show that mutation leads to variation which then makes evolution possible. Some candidates mistakenly referred to mammoths mutating or adapting by growing long fur because they needed to in order to survive. Many assumed allopatric speciation was involved, or referred to both species of mammoth existing together and competing until one died out.

(b) On the whole, candidates understood the question, and answered in the context of a haemoglobin molecule. Reference to a change in function was the most common answer, and many gained full credit by simply referring to differences in primary, tertiary and quaternary structure. Few referred to side chains, R groups or the greater effect on the β chain.

(c) (i) Most candidates found this question difficult and did not refer to the ability of haemoglobin to offload oxygen or compare surface tissue to core tissue. Many talked about the ability of haemoglobin to carry or upload oxygen, or to being able to maintain normal internal body temperature.

(ii) Those candidates who realised that the *y*-axis showed the effect of temperature on the affinity for oxygen (rather than just the affinity for oxygen) usually went on to explain correctly that the greater reduction in effect of temperature, on haemoglobin with red cell effector in woolly mammoths, showed that woolly mammoth haemoglobin was better adapted. Only a few referred to the negligible difference in the effect of temperature on haemoglobin alone.

Many candidates thought the *y*-axis showed simply either temperature or affinity alone and therefore had great difficulty trying to understand the data.

Question 3

(a) Most candidates correctly identified adenine and ribose. A few referred to adenosine, ribulose, deoxyribose, nucleotides, nucleosides, and several gave the correct names but on the wrong lines.

(b) Although many candidates made reference to ATP being the source of energy, they did not always realise the significance of the quantity present any one time. Most candidates linked the small quantity with the inability of the cell to carry out active processes and possible death of the cell. Consequently, the fact that ATP is broken down and then the cell regenerates ATP from ADP and Pi was not understood. Similarly, there was a misconception that because ADP and AMP rarely pass through the cell surface membrane, ATP could not be generated.

(c) (i) Many candidates recognised that palmitic acid has more hydrogen or C-H bonds than glycogen. Very few then linked the need for hydrogen in ATP production. A lot of candidates simply stated that palmitic acid produces more energy or has a higher calorific value, and therefore produces more ATP. Others simply quoted ATP figures from the table.

(ii) Most candidates found this question difficult. Many linked the use of alanine as a respiratory substrate with a low concentration of glucose only and did not realise the significance of lack of fat or carbohydrate generally as a result of starvation. Use of lactate as a respiratory substrate was rarely understood. Most answers wrongly stated that lactate is used during anaerobic respiration instead of afterwards when oxygen is available.

Question 4

(a) (i) Although many candidates arrived at the correct answer of 28 days for the length of a woman's menstrual cycle, the calculation was either not always correct or there was no evidence. Clearly many did not understand the importance of the oestrogen peaks on the graph.

(ii) Misinterpretation of the graph was evident here and candidates struggled to accurately pinpoint the days. Many seemed to choose figures quite randomly with no real understanding. Nevertheless many were able to score partial credit.

(iii) Most candidates correctly identified the correct organ. Few candidates knew it was the anterior pituitary and a minority incorrectly identified the posterior pituitary.

(iv) Good candidates exhibited a sound knowledge of the roles of LH in the menstrual cycle. Its role in stimulating the follicle to secrete oestrogen was understood along with the stimulation of ovulation. Others demonstrated their understanding of its role regarding the corpus luteum and progesterone secretion. The significance of the surge in LH secretion was rarely identified.

(b) (i) Only better candidates were able to correctly identify that the repetition of methods improved reliability. Some mistakenly thought that accuracy was the same as reliability. Others were credited for recognising that the menstrual cycles are irregular.

(ii) Answers were very much restricted to the fact that oestrogen concentration was different on each day and stated that it was high on day 22 and low on day 2 and therefore supported the hypothesis. Very few picked up on any other valid points. Some good candidates did observe the similarity of oestrogen concentration with progesterone concentration and the significance of this. Only a few made reference to the small sample size investigated.

Question 5

(a) The majority of candidates were able to provide good descriptions of the changes in grain yield between 1860 and 2010 as illustrated in Fig. 5.1. Most stated that the grain yield was constant between 1860 and 1930, usually giving a correct figure with units. They then went on to describe the moderate increase between 1930 and 1960, again with a correct figure, followed by the steeper increase between 1930 and 2010. Occasionally candidates misquoted the figures or omitted the units. Nearly all candidates gained some credit in this question.

(b) Explanations as to why single-cross hybrids were genetically uniform while double-cross hybrids were not, often lacked detail or simply reworded the stem of the question. Only better candidates recognized that the single-cross hybrids arose as a consequence of crossing homozygous parents whereas double-cross hybrids resulted from crossing heterozygous parents. Few appreciated that the single-cross hybrids would inherit the same alleles from each parent and therefore would all be uniformly heterozygous. Similarly, references to the double-cross hybrids inheriting different combinations of alleles were rare, although some understood that the offspring would be homozygous for some genes but heterozygous for others.

(c) (i) Good candidates interpreted Fig. 5.2 correctly and recognized the inverse relationship between the inbreeding coefficient and grain yield. Many attempted to supply figures to support their argument but these were often misquoted or candidates did not identify the site and year they were using. Few candidates mentioned that the grain yield decreased in each site for each year.

(ii) Candidates frequently had difficulty in explaining why the results in Fig. 5.2 showed that the environment affects grain yields. Although better candidates appreciated that the latter varied from site to site and year to year, few identified the inbreeding coefficient they were using when quoting figures. References to a suitable environmental factor which could be causing the differences in yield were rarely seen.

Question 6

(a) (i) Most candidates stated that myelination would speed up the conduction of impulses in mammals and many quoted correct figures from Table 6.1 for mammals **A** and **B**. However, some included amphibians in their response and others omitted units.

(ii) Similarly, most candidates appreciated that an increase in axon diameter would increase the speed of conduction of impulses in amphibians, again frequently going on to supply correct figures with units. However, some simply stated that axon diameter, rather than an increase in diameter, would increase the speed of conduction. Occasionally a mix of mammals and amphibians were used to illustrate their answer.

(b) Explanations as to how myelination affected the speed of conduction often attracted little or no credit as candidates did not use the term action potential. Few stated that myelin insulates the axon, rather than simply covering it, although many candidates appreciated that there would be no myelination at the nodes of Ranvier. Some also mentioned that myelination would prevent the

movement of ions into or out of the axon. While a small number of candidates referred to local circuits, they often neglected to qualify their response by adding that these circuits would be set up between the nodes. Nevertheless, many candidates understood that saltatory conduction would occur in these neurones.

(c) (i) Few candidates commented that the myelin sheath would be recognized as foreign or non-self, by the immune system. Some mistakenly suggested that mutation might have taken place in the myelin sheath which then triggered an immune response. Nevertheless, many candidates stated that the immune system would produce antibodies that would attach to the sheath, often adding that these antibodies would be produced by plasma cells. More vague responses referred to hydrogen peroxide being produced by lymphocytes but few candidates correctly described the actions of T killer cells. However, some candidates stated that phagocytes might engulf and digest the Schwann cells.

(ii) Few candidates were able to give a satisfactory explanation as to why damage to the myelin sheath would lead to a decrease in the information reaching the brain. Many stated that impulses, rather than action potentials, would slow down or stop. References to a reduction in the insulation of the axon were very rare.

Question 7

(a) (i) Many candidates were able to state that the pH had risen but needed to link this to photosynthesis in order to gain full credit. Better candidates correctly linked the absorption of blue light with photosynthesis and went on to state that CO_2 was used leading to a decrease in pH. Common errors were to discuss an increase in hydrogen ions or oxygen rather than carbon dioxide.

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(iii) Those candidates who found this question difficult were not precise enough, giving thylakoid or grana as their answer, with no mention of the membrane.

Question 8

(a) Despite a wide range of answers that would be creditworthy, many candidates found this difficult.

(b) The most common reasons given were loss of habitat and direct human effect, which was usually hunting. Some candidates did not name an endangered species and were not precise enough to gain full credit, for example by simply stating climate change or pollution.

Question 9

Many candidates scored full marks on this. There were some spelling issues, particularly for aleurone, and many referred to maltase instead of maltose. Some confused embryo, aleurone and endosperm.

Section B

Question 10

(a) Only the more able candidates could gain full credit. Many were able to state that a mutation is a change in the base sequence and that it is random. Good examples given were base substitution, addition or deletion and the consequences of these mutations. Some candidates either did not mention bases or gave amino acids instead.

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(a) This question was answered well by candidates. Many were able to state that plants are usually photosynthetic and have chloroplasts and their cell walls are made of cellulose. References to starch and plasmodesmata were less commonly seen.

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BIOLOGY

Paper 9700/42
A2 Structured Questions

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(b) Most candidates were able to describe the structure and function of the mitochondrion in a lot of detail. Some mistakenly went on to describe the stages of photosynthesis in trying to link this to ATP production in both mitochondria and chloroplasts. This was unnecessary and would have wasted time for candidates.

BIOLOGY

Paper 9700/43
A2 Structured Questions

Key Messages

- Candidates should read each question carefully and be selective in choosing information in their response to avoid wasting their time, e.g. in **Question 10 (a)** where the symptoms of cystic fibrosis were not required.

- Correct terminology can be a great discriminator and should be emphasised in teaching to maximise potential credit, e.g. in **Question 6(b)(iii)** depolarisation or action potential should be used at this level, rather than vague references to impulses. Similarly the correct use of the term allele, rather than gene, is often critical in obtaining credit.

General Comments

The paper proved to be quite accessible to a wide range of abilities. Most candidates attempted all parts of the questions. Success in some questions seemed to be Centre orientated, as in **Question 1(a)** where candidates familiar with sex linkage were able to score maximum credit. Data was generally interpreted well, as in **Questions 2(a)(i)** and **5(a)(i)**, although in **Question 4(d)** candidates experienced difficulty in linking their own knowledge of the menstrual cycle to the less familiar data recorded in the study.

Comments on Specific Questions

Section A

Question 1

(a) Candidates with a good understanding of sex linkage had little difficulty in completing the genetic diagram from the results in Table 1.1 together with the information that the allele for red eyes (**R**) is dominant to the allele for white eyes (**r**). The most common error was to assume that the red-eyed parent was female, in which case, it was possible to gain credit for the correct gametes produced from the parental genotypes given as an error carried forward, but the genotypes produced from these gametes could not be credited, as a greater variety of genotypes would be produced than the two given genotypes. It needs to be stressed that no superscripts should be attached to the Y chromosomes (a common error), as this demonstrates a basic misunderstanding of sex linkage by implying that an allele is present on the Y chromosome.

(b) (i) The table was frequently completed correctly, giving values of either 0.32 or 16/50. Candidates then calculated the value of chi-squared as 0.64. Credit for chi-squared was given for answers resulting from correctly adding together the final figures calculated in the table.

(ii) Most candidates realised that the difference between the expected and observed results was not significant and was due to chance. Many references were made to figures in the table of probabilities, but many incorrectly referred to the probability of 0.50 rather than the critical value of 0.05. Some candidates showed confusion between the figures for chi-squared and the probability values in the table.

Question 2

(a) (i) The majority of candidates understood the data in Table 2.1 comparing the amino acids of coelacanths and lungfish to three species of amphibians. They were able to explain that most of the data supported the idea that coelacanths and amphibians share a more recent common ancestor than do lungfish and amphibians. Supporting figures were usually supplied but it was not always clear which amino acid chains or which species were being compared by the candidates. Few candidates noted that although most of the data supports the suggestion, the data for β chains in lungfish compared to adult amphibians show a higher percentage of matches, so these figures do not support the suggestion.

(ii) Candidates needed to suggest why the adults and tadpoles of amphibians have different amino acid sequences in their haemoglobin. Many candidates did not refer to the tadpole living exclusively in water, while the adult lives on land in addition to water. As a result, few responses linked the different amino acid sequences in haemoglobin to the need for differences in oxygen affinity, due to the different oxygen concentrations available in the amphibians' environment.

(b) (i) Explaining how low oxygen concentration can act as a stabilising force in deep water, candidates usually recognised that the oxygen concentration acts as a selective agent, so that extreme phenotypes would be selected against. A few references to the conditions staying constant were credited, but the idea that only the organisms best adapted to these conditions would survive was less well described. A frequent misconception is that organisms were able to adapt themselves if they were in these conditions, instead of explaining that it was a selection process choosing the most suited phenotypes out of the range already present. References to allele frequency needed to refer to narrowing of the range of genetic variation. A few attempts to illustrate this using graphs were made, but without clear labels or annotations could not gain credit.

(ii) Explaining how low oxygen concentration can act as an evolutionary force, candidates usually referred to the oxygen concentration acting as a selective agent, but rarely mentioned that the oxygen concentration would need to change. Some candidates knew that this was directional selection, but many found it difficult to explain that only some individuals would be better adapted to the changed conditions and therefore would survive. The alternative idea of disruptive selection, with separate populations developing in different oxygen concentrations, was rarely seen. As in **(i)** sketch graphs were rare and usually not labelled or annotated.

(c) The role of isolating mechanisms in the evolution of new species was generally well known with many responses gaining maximum credit.

Question 3

(a) The role of oxygen in aerobic respiration was usually described well. Most candidates referred to its involvement in oxidative phosphorylation and its role as the final electron acceptor. Candidates need to be clear that hydrogen ions, not just hydrogen, are added to the electrons being accepted by the oxygen to form water. Few references were seen to oxygen enabling the electron transport chain to continue, resulting in an increase in ATP production, since in its absence only glycolysis continues.

(b) (i) Most responses described that lipid used as a respiratory substrate would release most energy, usually noting that the energy value was compared per gram. Correct explanations referred to lipid having more C-H bonds than carbohydrate or protein. This idea could have been extended further to explain that the extra hydrogen would be used for ATP production. Common errors included references to the presence of more hydrogen bonds or to hydrogen molecules being in the lipid.

(ii) Many responses referred to the extra hydrogen but this needed to be linked to the conversion of oxygen to water, so frequently could not gain credit.

Question 4

(a) Explaining why the fertile window begins several days before ovulation, many candidates misunderstood the question, referring only to possible irregularities in the time of ovulation or hormone concentrations. References to sperm were frequently lacking or did not refer to their viability. Good answers explained that sperm could live for several days in the female before ovulation, so that fertilisation would still be possible when ovulation occurred.

(b) (i) A number of candidates did not attempt this question. They should be reminded to check that each part question has been attempted. Few were able to correctly sketch a curve that stayed low until around day 13, peaking around day 22 and falling back to a low concentration around day 28.

(ii) Despite being told in the stem of the question that the follicular phase starts at the beginning of menstruation and ends at ovulation, many candidates were unable to correctly equate these events to days 1 and 14. The peak of LH release is day 14 in Fig. 4.1, so only this was acceptable for the time of ovulation.

(c) (i) Suggestions as to why **method 1** alone is an unreliable method of avoiding conception usually noted that the menstrual cycle could be irregular but an example of a factor causing this, such as stress, was rarely provided. Many references to diet could not be credited, as this needed to be qualified as being inadequate in some way.

(ii) Most responses explaining how **method 2** could be used to avoid conception, referred to the days of highest LH concentration, but did not link this to what action should be taken to avoid conception when LH concentrations are high. An alternative explanation is that this knowledge could be used to predict the time of ovulation, but candidates did not appreciate this possibility.

(iii) The reason why **method 3** is likely to be a better predictor of ovulation, than using a thermometer to measure basal temperature each day, was usually given as being more accurate or due to its continuous monitoring. It was rare to see a reference to the fact that the temperature change involved was very small, making this method a better predictor.

(d) Candidates found it difficult to discuss what the results in Fig. 4.2 suggested about the guidelines that the fertile window lasts from day 10 to 17 of the menstrual cycle. Responses needed to discuss the stated probabilities of being in the fertile window throughout the days of the menstrual cycle. Many referred to the peak in probability at day 14 but did not clearly indicate that the results show that the days from 10 to 17 represent the highest probability of becoming pregnant. Very few responses suggested that the dates in the guidelines should be extended as it is possible to become pregnant on most days of the cycle. Candidates usually gained credit for quoting figures, while a few referred correctly to the possibility of irregular cycles varying from the suggested fertile window dates.

Question 5

(a) (i) Comparing the genetic diversity of teosinte with cultivated maize proved easy for most candidates. They appreciated that teosinte has greater genetic diversity, except at locus 7, often quoting correct supporting figures. Where errors occurred it was in describing genetic diversity increasing as the gene locus increased numerically, rather than comparing teosinte with maize at each locus. This showed a lack of understanding of the gene loci as distinct independent regions.

(ii) Suggesting reasons for differences in genetic diversity between teosinte and cultivated maize proved difficult for many candidates. Few concentrated on maize having been selectively bred, by humans only selecting plants with desirable traits. It was necessary to make the link between reduced genetic diversity and artificial selection, but few candidates did this. The increase in homozygosity and the idea of some alleles not being selected in the breeding process were also possible ideas here. Most responses only discussed the greater genetic diversity of teosinte, without mentioning that it needs a greater variety of alleles to survive in the wild.

(iii) Explaining how the data supported the idea that wild relatives of maize need to be conserved produced very confused responses from many candidates. Most mentioned that teosinte might be needed in the future, but this was rarely explained fully in terms of its use in cross-breeding or the properties it might have, e.g. the ability to cope with drought.

(b) Candidates were required to explain why maize seed is produced by crossing two different homozygous plants. Many candidates did not realise that the resulting genetic uniformity of the seed was the main reason for this. Correct ideas usually referred to the hybrid vigour produced being advantageous, that inbreeding depression would be avoided or that uniformity of growth would make harvesting easier. Candidates mentioning harmful recessive alleles did not always make clear that this process reduced the chances of them being expressed, appearing to suggest that these alleles would be absent altogether.

Question 6

(a) (i) Many candidates recognised **B** as the site of depolarisation.

(ii) **E** was usually recognised as the site of hyperpolarisation.

(iii) Few candidates correctly identified **D** as the point where the membrane is most permeable to potassium ions.

(iv) Candidates frequently gave **A** or **F** as the sites of resting potential. Both were required to gain credit here.

(b) (i) Many responses were given credit for a correct spelling of the kingdom Protoctista.

(ii) The role of sodium ion channels was requested, with many candidates correctly describing that the sodium ions move into the axon by diffusion when these channels are open. Less clear was what caused the channels to open or close, as few references to the channels being voltage-gated were seen. Vague references to an impulse arriving is not enough. A full answer needed to describe the link between depolarisation and the opening of the channels, in addition to their closure when the membrane repolarises or reaches +30mV. Weak responses often gave very confused accounts, muddling the active role of sodium–potassium pumps with the passive role of the channels.

(iii) Candidates needed to suggest why saxitoxin may be fatal to humans. A number of vague references to lack of impulses did not gain credit, but many did realise that depolarisation or action potentials would not occur. Only a few were able to link this to being fatal, by referring to the effect on heart muscle or breathing. References to paralysis alone were not sufficient, since paralysis may not necessarily be fatal.

Question 7

(a) Identification of structure **A** as photosystem II and **B** as photosystem I was correctly made by the majority of candidates. Partial credit was awarded for recognition of the photosystem when I and II were linked to the wrong letters. Credit was given for the alternatives P680 and P700 when linked correctly to the letters.

(b) (i) Most candidates gained full credit for the role of RuBP in carbon dioxide fixation and the production of GP. Some references were also seen to the involvement of rubisco.

(ii) Although most candidates knew that reduced NADP was involved in the conversion of GP to TP, its role in donating hydrogen was not always clear, as hydrogen being carried by reduced NADP needed to be linked to it being passed to GP. Unambiguous responses described it as reducing the GP.

(iii) The role of ATP was well known as a supplier of energy. Most candidates also referred to its role in converting GP to TP or in the regeneration of RuBP.

Question 8

(a) Candidates usually knew how to calculate the overall decrease in size of the stocks of Atlantic cod between 1968 and 2000, but many did not notice the units for the size of the stocks on the *y*-axis. The correct answer of 7500 tonnes per year was often reduced to 7.5 tonnes, so only partial credit was gained. A significant number of candidates also misinterpreted the time span, referring to 33 years instead of 32.

(b) Most candidates were able to suggest how the stocks of Atlantic cod could be increased, by referring to reduction in fishing, controlling pollution or by education. A number of responses also mentioned breeding fish in captivity but did not always refer to releasing the fish produced. The creation of marine reserves, changes in net sizes or methods of fishing were other possible alternatives.

Question 9

Many candidates gained full credit for using appropriate scientific terms in the passage. The movement of auxin from cell to cell by active transport or diffusion and by mass flow in the phloem was well known. The prevention of lateral buds from growing was usually referred to correctly as apical dominance, although a few did not gain credit for 'dominant'. Candidates should read the whole passage through to ensure that the words in the gaps fit the sentence. The reduction of auxin in lateral buds was usually referred to correctly, with division or mitosis or elongation being acceptable alternatives linked to bud growth.

Section B

Question 10

While many candidates could give a reasonable outline of the principles of gene therapy in part **(a)**, fewer were able to describe the role of a genetic counsellor in detail or discuss the circumstances in which a couple might be referred to one.

(a) The question required candidates to outline the basic principles of gene therapy for the treatment of cystic fibrosis but many responses unnecessarily gave full details of the symptoms of CF or details of the genetic engineering process instead of an outline. A reference to CF being caused by a mutation of the CFTR gene, resulting in a defective protein, was all that was needed to introduce the idea that a normal form of the gene needed to be inserted into the person with CF. Few candidates noted that it should be inserted into the DNA in the cells of the respiratory system, with many vague references to the lungs unable to be credited. The role of a virus or liposome as a vector was generally well known, but it should be noted that the virus needed to be in a harmless form. Difficulties in using these methods usually gained credit, e.g. possible side effects or that the effects are short-lived, or reference to not all cells taking up the virus.

(b) Some good answers were seen clearly setting out the role of a genetic counsellor, but many did not go further than the idea of the role being to explain the results of genetic testing or to discuss possible treatments or termination of pregnancy. Well prepared candidates gave details of how a genetic test might be carried out and described further roles of the counsellor, such as looking at family history and the implications of having an affected child, which could be financial or result in problems for other siblings. Rarely was a role enabling the discussion of ethical issues mentioned. Commonly only one reason for referral to a genetic counsellor was suggested, usually that there was a history of genetic disease in the family. Other reasons might include a history of recurrent miscarriages or the woman being older, so at more risk of carrying a child with genetic disease.

Question 11

Many candidates were clearly able to describe the role of insulin in maintaining a constant blood glucose concentration in part **(a),** but some very confused accounts were seen in part **(b)** when describing how a pregnancy kit can detect the presence of HCG.

(a) In general many candidates produced good descriptions of the role of insulin in the control of blood glucose concentration. Most candidates recognised that insulin is produced by beta cells in the Islets of Langerhans when there is a rise in blood glucose concentration, but the fact that these cells also detect the rise discriminated between candidates. Good responses also referred to target cells in the liver or muscle being affected by insulin attaching to the cell surface membrane receptors, although many did not refer to cells at all. Most candidates described well the effects of insulin which resulted in a reduction in blood glucose concentration, but should be reminded to refer throughout their responses to glucose concentration rather than level.

(b) Many lengthy descriptions of how monoclonal antibodies are produced were given, even though this was not relevant to this question. Clear responses described a logical sequence of events that occur when the test stick is dipped into urine. This included a description of the initial combination of HCG to a mobile antibody bound to a coloured indicator, followed by the events at both the first and second windows involving immobile antibodies. While most gained credit for references to monoclonal antibodies and their specificity, poor responses confused the mobile and immobile antibodies or referred incorrectly to the presence of enzymes or receptors instead of antibodies. In many cases it was the order of events that was confused. The first resulting band of colour needed to be clearly linked to the presence of HCG in the urine of a pregnant woman, while the second coloured band needed to be stated as showing that the pregnancy test kit was working.

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Key messages.

- Candidates should read questions carefully before answering as there is often information provided that must be understood and used in order to answer fully.
- When describing an experimental method, candidates should organise their description into a logical sequence and include sufficient practical detail for another person to carry out the experiment without any additional information.
- When drawing conclusions or evaluating data, candidates should be aware that it is not sufficient to quote raw data.

General comments

Candidates appeared to have sufficient time to complete the examination paper. Answers varied in quality. In **Question 1(a)(iii)**, many candidates did not have sufficient practical experience to describe how to use a respirometer. The best responses were given by candidates who had practical experience and were able to apply the principles of scientific method. Weaker responses often reflected uncertainty about the analysis and interpretation of results. Many candidates were able to analyse data, although many answers showed a limited understanding of how to write a null hypothesis.

Candidates should answer concisely using the space provided. Candidates should not need to use additional space, but if unavoidable, should indicate clearly where the remainder of the response is located.

Comments on specific questions

Section A

Question 1

This question concerned the use of a respirometer to compare respiration rates in three different organisms by measuring oxygen uptake and carbon dioxide production. Candidates were expected to use the information in the question to formulate a hypothesis and use the type of respirometer illustrated to test their hypothesis.

(a) (i) Many candidates were able to suggest a suitable hypothesis, commonly, either that the rates of respiration would vary between the organisms or, that all the organisms would have the same rate of respiration. There were a large number of inappropriate hypotheses, for example 'the most active organisms would have the greatest rate of respiration' or 'the more respiration the greater the uptake of oxygen'. Some candidates incorrectly gave hypotheses related to the effect of temperature, for example, 'the respiration rate will increase with temperature'.

(ii) Most high scoring candidates correctly identified the independent variable. Other candidates gave answers that were variables that should be standardised in this type of investigation, such as the mass or number of the organisms.

Candidates found it difficult to correctly identify the dependent variable, with most stating 'rate of respiration', which is a calculated value derived from raw data. The dependent variable should be a measurable feature of an investigation. In this case, the information in the question stated that the use of oxygen during respiration would cause water to move in the graduated tube. Candidates were expected to use this information to realise that the distance moved along the graduated tube in a specific time could be measured. There were some candidates who realised that the

movement of water was relevant, but often could not be given credit as they did not refer to the distance moved, or to the volume of oxygen used.

(iii) There were some good answers to this part of the question. These candidates had clearly used a respirometer and understood how it worked. These answers usually included relevant practical details such as ensuring that the apparatus is air-tight, equilibrating the complete system before taking any measurements, replacing the oxygen absorbent, and using a control with an inert material to replace the living organisms. The best answers demonstrated an understanding that the investigation should be carried out in the dark and the need to replenish the oxygen supply so it did not become limiting. Some candidates who had used a different type of respirometer introduced a dye into the capillary tube and placed the air-filled container into the water bath. These answers did not gain credit for the method of measuring as candidates are expected to use the apparatus as described in the question.

Weaker answers often repeated the information in the question without explaining how to measure, or standardise, the variables. There is an increasing tendency for candidates to produce an answer modelled on past mark schemes for this type of question, which often does not gain any credit as the answer needs to apply specifically to the investigation described in this question. Commonly, this is a list of variables that restate the independent and dependent variables, which may have already been tested, followed by the variables to standardise, without any methods. Candidates are expected to describe a method that could be used as a procedure by another person, so practical details in a correct sequence about what apparatus to use, how to standardise variables that may affect the results, and how to measure the independent variable, are required. For example, in this investigation, many candidates stated 'use a water bath to control the temperature', which does not give any indication about a suitable temperature or that the temperature must be constant for all three organisms. Similarly, many candidates stated 'measure the volume of oxygen used', which does not explain how to measure using the graduated tube. How to record and process results is not expected and is often tested in another part of the question paper, in this case in part **(b)**.

The majority of candidates who had used a respirometer stated that the oxygen absorbent was either potassium or sodium hydroxide and were able to give a suitable hazard and precaution. A few candidates also recognised the hazard presented by pushing a glass tube into a container, although few of these candidates were able to describe a suitable precaution such as holding the cork or bung while pushing the air-filled container. Most candidates referred to improving reliability by taking a mean. The best answers made it clear that this was obtained from the results of three separate investigations from all three organisms being tested. Candidates should be encouraged to refer to replicates, rather than repeats. Weaker answers showed some confusion about the data used for obtaining a mean, in many cases the mean of 'readings' from the graduated tube at 1 minute intervals during a single investigation of one organism.

(b) (i) Very few candidates were able to explain how to calculate the volume of oxygen. Better answers described the expected method of measuring the diameter of the capillary and calculating volume using the formula $\pi r^2 h$. Many candidates assumed that the graduations were volume. However, there was no information in Fig. 1.1 to indicate this, so credit could not be awarded unless candidates stated that the capillary was pre-graduated so that 1 cm distance or 1 graduation was equivalent to a specific volume of oxygen. Most candidates knew that the volume had to be divided by mass, but only better answers also divided by time, giving the expected value in oxygen used per unit mass per unit time. Weaker answers referred to dividing 'unit mass' by time or 'unit time' by mass, but did not provide any method of obtaining 'unit mass' or 'unit time'.

(c) Most candidates gained some credit for this part of the question, commonly for removing the carbon dioxide absorbent and repeating the experiment. Credit was allowed for weighing the carbon dioxide absorbent before and after measuring the oxygen uptake, although this is not the usual way of measuring carbon dioxide for this type of small-scale investigation as a high precision balance would be needed. Some candidates replaced the carbon dioxide absorbent by an oxygen absorbent, which was not credited as the respiration would then be anaerobic and not comparable.

Few candidates were able to explain clearly how to obtain the volume of carbon dioxide from the measurements made without the absorbent. There was some confusion with using a respirometer to find carbon dioxide released by anaerobic respiration as candidates referred to placing the water in the centre of the graduated tube and measuring the water pushed out.

(d) (i) Most candidates gave a correct answer.

(ii) Answers to this question were very varied. The values for germinating seeds, insect larvae and single-celled green algae in the question were very close to the expected values for the metabolism of lipid, protein and carbohydrate respectively, which was recognised in the best answers. Candidates often listed the RQ values of the different substrates, although weaker responses often confused lipid and protein. Some candidates appeared to have misinterpreted the question as they described different oxygen consumptions of the organisms and related this to energy release. A common misconception was that the higher the number of the RQ, the more energy is released. Other candidates described the data in the table.

Question 2

This question was based on the experimental evidence for the effect of light on the distribution of auxin in shoot tips. Candidates were expected to analyse the results of the investigation and decide if the results supported a particular hypothesis. The question then expected candidates to apply their understanding of the experimental results to predict the likely effect of externally supplied auxin on the growth of a young shoot. The use of statistics was also tested.

(a) Most candidates gained some credit for identifying that the results for treatments 3A and 3B supported hypothesis **B**, although weaker answers tended to quote the raw data rather than make comparisons. Only better answers considered that the total auxin concentration in 3A and 3B, together with the results from treatment 4, gave greater support for the redistribution of auxin rather than its destruction by light. The best answers also showed an understanding that the results from treatments 2 and 1, or treatment 2 in relation to all the other treatments, supported the redistribution hypothesis. Weaker answers often showed a lack of understanding of the experimental set-up as they stated that hypothesis **B** was supported because the auxin re-distributed into the agar block laying the shade.

(b) (i) Many candidates answered a different question to that asked as they defined standard deviation without any reference to Table 2.1. It is essential that candidates read carefully what is being asked. Better answers referred to the table, but often did not gain maximum credit as they did not explain why the standard deviations showed that the data was reliable. Many weaker answers did not seem to realise that all the values for standard deviation were low and suggested that the results for treatment 1 was very large and unreliable.

(ii) Answers to this question suggested that many candidates had not read the information carefully enough, for example, by stating ‘use more than one tip for each treatment’ or ‘more than 24 tips for each treatment’. Candidates were expected to recognise that six is a relatively small number and to suggest using many more shoot tips per treatment. When analysing experimental data, candidates should be encouraged to think about the numbers tested and their likely effect on the results.

(c) Candidates who had understood the information in Fig. 2.1 and Table 2.1 were able to use this to recognise that the shoot would extend more on the side to which auxin was supplied by the agar block. The best answers showed use of the diagram in Fig. 2.1 after 48 hours to show the appearance of the marks. Weaker answers contained diagrams including combinations of intact tips, bending in the wrong direction, without any bending, and randomly arranged marks. Some candidates did not appear to have used the information and drew diagrams showing lateral shoots.

(d) (i) Well prepared candidates gave clear answers. Weaker answers tended to miss out the word ’significant’ or used a generic statement, for example, ‘there is no significant difference between the two sets of data’. A common imprecise answer was ‘there is no significant difference between the plants in the light and the plants in the dark’. When writing a null hypothesis, candidates should identify a specific feature of the dependent variable, in this case the distance moved by auxin, and include this in their stated null hypothesis. Ideally, a null hypothesis should also specify the conditions being compared, in this case, plant tissue in the light and plant tissue in the dark.

(ii) Many candidates gave a correct answer. The most common incorrect answer was 19, suggesting that these candidates had not taken into account that there were two sets of data. Weaker answers gave a formula, for example n-1, but then stated that n=2, so the degrees of freedom was 2 - 1 = 1.

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(b) (i) Many candidates answered a different question to that asked as they defined standard deviation without any reference to Table 2.1. It is essential that candidates read carefully what is being asked. Better answers referred to the table, but often did not gain maximum credit as they did not explain why the standard deviations showed that the data was reliable. Many weaker answers did not seem to realise that all the values for standard deviation were low and suggested that the results for treatment 1 was very large and unreliable.

(ii) Answers to this question suggested that many candidates had not read the information carefully enough, for example, by stating ‘use more than one tip for each treatment’ or ‘more than 24 tips for each treatment’. Candidates were expected to recognise that six is a relatively small number and to suggest using many more shoot tips per treatment. When analysing experimental data, candidates should be encouraged to think about the numbers tested and their likely effect on the results.

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Key Messages

- It is important to read the question carefully before starting to answer. There may be important pieces of information to note which will allow a full and relevant answer to be produced.
- A description of a method for an experiment should be organised in a logical sequence and include sufficient practical detail for another person to carry out the experiment without any additional information.
- When drawing conclusions or evaluating data, candidates should be aware that it is not sufficient to quote raw data.

General Comments

There was a good spread of marks seen and candidates seemed to have been able to complete the paper in the allocated time. There was evidence in their answers that candidates had experienced laboratory practical work. In general, the handling of the statistical material showed that many candidates understood some basic concepts.

Most candidates answered within the spaces provided. Candidates should not need to use additional space, but if unavoidable, should indicate clearly where the remainder of the response is located.

Comments on Specific Questions

Question 1

This question focused on the use of respirometers and dealt both with the practical aspects of their use, the sorts of data that can be gained and its interpretation. It was clear that many candidates had used this type of apparatus.

(a) (i) Nearly all the candidates had the variables the correct way round with the independent variable identified as the temperature. The dependent variable is the factor that is measured directly, in this case it is the distance moved by the dye.

(ii) Most candidates had the *x*-axis and *y*-axis correctly orientated and appropriately labelled. Here rate of respiration or oxygen uptake as well as dye movement were suitable labels for the *y*-axis. Many responses had an acceptable sketched plot showing an exponential or linear curve. Those who sketched the curve levelling off or dropping had not read the question carefully enough, despite the prompt in bold to refer to the candidate's hypothesis. The result was that their plots were what they expected from a typical enzymic reaction carried out at increasing temperature. The hypothesis just suggested a doubling for every 10 degree rise and so the sketch graph should fit that idea.

(iii) There were many good answers describing how the respirometer could be used, indicating an encouraging level of familiarity with the apparatus in a practical sense. In questions asking for detail on experimental method it is important to encourage candidates to give clear instructions on how to set up the apparatus and take the required readings. The instruction to candidates to 'make their method detailed enough for another person to use' is designed to prompt them on this and should be stressed. Some candidates spent too long on the general principles behind the use of respirometers rather than on detailed instructions for their use in this particular investigation. This question was on use of the apparatus to get valid and reliable readings for the movement of dye. Therefore, detail on converting this data to volume of oxygen or on drawing results tables or graphs

were not relevant here. Most candidates described a strategy using the apparatus shown, but a few described alternative types of apparatus like U-tube manometers, or suggested that the plunger on the syringe would move in as respiration occurred.

Many candidates appreciated that the same mass or same number of seeds should be used in each experiment though some still use the term 'amount' or even 'volume' of seeds. There was also a tendency to talk about the 'organism' rather than germinating seeds. There were many good descriptions of either measuring the distance the dye moved in a given time or the time taken to move a fixed distance. A few responses were too general and just referred to ideas like 'time the movement'. There are a variety of ways that the distance could be measured, for example, using a ruler or graph paper, but the method must be applicable to the apparatus, so a metre rule would not be practicable with this respirometer. Many candidates suggested a suitable range of temperatures. These were often in the range suitable for enzymic reactions, but needed to include at least three 10 °C rises in temperature, as this was the requirement to test the candidate's hypothesis. Thus, for example, using 10 °C, 20 °C, 30 °C and 40 °C, or using 10 °C intervals between 10 °C and 40 °C, were both amongst the acceptable ranges. However, 'intervals between 10 °C and 40 °C' was not acceptable as there was no indication that there were 10 °C rises. As the candidate's hypothesis was being tested, the temperatures did not need to be in the range expected to provide the optimum temperature.

Relatively few responses indicated how the dye would be put into the capillary tube or how it would be set or reset. Use of the syringe could achieve both and just dipping the capillary tube into dye would allow it to enter by capillary action.

There were a number of well-structured responses about control variables. The need to let the apparatus equilibrate at the given temperature was often mentioned though occasionally it was incorrectly suggested that the seeds were brought to temperature before placing in the syringe. Better responses also described the need for the apparatus to be airtight or a method of achieving this. Nearly all the responses indicated that the temperature would need to be controlled and most suggested a water-bath, an incubator or a temperature-controlled room. Some weaker responses suggested heating the syringe directly with a Bunsen burner or thought that a thermometer controls the temperature of a water-bath. Candidates should continue to be discouraged from referring to 'air conditioned rooms'. Similarly, 'the same volume' or 'amount' is not an appropriate way of describing how to standardise the carbon dioxide absorbent. Relatively few mentioned a suitable control (inert material or boiled seeds). Another variable not often mentioned was the need to refresh the oxygen to ensure it did not become limiting.

Candidates realised that replicates of the whole experiment are needed but they did not always indicate that the minimum number of readings for reliability is three, from which a mean is calculated or anomalies identified. Candidates should be encouraged to use the term mean rather than average.

Although a relatively low risk experiment, no experiment is entirely without risk and candidates should be encouraged to identify possible risks and precautions related to the investigation in question. The carbon dioxide absorbent is potentially corrosive or at least an irritant, and there is the possibility of allergic reaction to seeds or the absorbent and candidates should be aware of suitable precautions. If candidates chose a temperature range going to 70 °C or above, suitable precautions against scalding would be appropriate.

(b) Most candidates appreciated that the volume of oxygen would need to be divided by the mass of seeds but not all explained how the oxygen volume would be calculated. Very few mentioned time in the calculation. To follow the accepted convention, the rate would be in cm^3 per g per second or cm^3 per g per minute and thus dividing by time as well as by mass was needed. A number of candidates erroneously described how to calculate the RQ.

(c) In this part of the question the concept was moving away from investigating the candidate's original hypothesis to the idea of finding the optimum temperature for this particular enzyme-controlled reaction. The approximate optimum would be found by using a large range of widely spaced temperatures, and then focussing on the temperatures with the highest rate of respiration (it was also acceptable to describe this in terms of oxygen uptake or dye movement) and narrowing the temperature intervals in this range to find the optimum. Some candidates made an assumption that it would be between 30 °C and 40 °C and started at this point. There was some confusion between temperature range and intervals. There were also some general phrases like 'the

temperatures where the graph levels off', or 'the temperature where the dye stops moving', neither of which are acceptable descriptions. A few responses showed confusion between compensation point and optimum temperature.

(d) (i) In questions of this nature where some evaluation is required, candidates should show some processing of the data. So, to say 'trial 1 is different' is not sufficient as this effectively restates the stem of the question in another way. Candidates needed to indicate that all (or at least those up to 25 °C) of the results were higher than the other trials, or alternatively that they deviate most from the mean. A number of candidates suggested the trend in trial 1 was different. This is a significant misconception as the trend is similar in that the oxygen uptake drops as the environmental temperature rises.

(ii) Appropriate responses were those related to the mammal itself with regard to stress, activity, acclimatisation, etc. These were expressed in a wide range of acceptable ways. Stating faulty apparatus or technique was not the correct approach.

(iii) Candidates found it difficult to make it clear that they realised that oxygen uptake, respiratory rate and body temperature are related. Few candidates explained that greater loss of body heat, leading to a lower body temperature, is likely to occur in low environmental temperatures. This point would have lead them into the right sequence of ideas. Too often there were general statements like 'more oxygen uptake allows respiration to release energy to keep warm'. The mammal will always be respiring and releasing energy. The key is that the extra oxygen will allow more respiration and so more heat is released to maintain body temperature. Those who got the correct ideas and expressed them fully were able to do well.

Many followed irrelevant lines of argument. Examples included confusing low temperatures with low or high altitude and thus giving descriptions of increased numbers of red blood cells carrying more oxygen. Alternatively, at higher temperatures the enzymes in the body were denatured so less oxygen was needed. Other misconceptions included the idea that the RQ changed at low temperatures when the mammal was respiring more lipid, or that at low temperatures gas molecules are closer together so you can inhale more. A lot of candidates linked increased oxygen uptake to increased activity to 'keep warm' or 'pump blood to extremities'. Another route taken was to link increased oxygen use to surface area to volume ratio by comparing small to larger mammals.

Question 2

This question contained some important material to read through and also was designed to allow candidates to evaluate data and show that they understood some basic statistical ideas.

(a) (i) Despite the information given in the question, stem dimensions and time aspects of the experiment, both of which had been standardised, were quite often given. This underlines the importance of reading the information provided in the question carefully. Many correctly suggested concentration of radioactive auxin, light intensity or temperature as factors to control. There were a number of more general answers on size of block or volume of auxin which were not precise enough.

(ii) The investigation was about the movement of auxin and the majority of candidates saw that air or oxygen was needed for this movement. Some talked about the movement of radioactivity which was not appropriate. Some went further with their conclusion to correctly suggest the movement was active and involved respiration. Positive statements about auxin movement were required, so just to say little or no movement occurred in nitrogen, or that nitrogen was inhibitory was not sufficient.

(iii) Nearly all the candidates calculated this correctly.

(b) (i) This question also required the candidates to evaluate the data, this time in terms of supporting a hypothesis. Many got part way there by realising that the mean in the light was higher than the mean in the dark or by giving a general statement that overall rates were higher in the light. A common approach was then to make a direct comparison between individual samples such as 'sample 7 is higher in the light than the dark', suggesting that these candidates had missed the information in the question that there were two groups of stem lengths. Individual samples in the light and dark are not the same samples and are not directly comparable as pairs. The second key piece of information given was the standard deviation from the mean for each set of samples.

Some candidates did the appropriate maths showing that the lowest end of the mean in the light was 51.4 whilst the upper end of the mean in the dark was 50.9. Other candidates got part of the way to this by saying the means did not overlap without explaining this in terms of the standard deviation. Others misunderstood the concept of standard deviation by simply describing them as larger or smaller.

(ii) Many candidates gave a well phrased null hypothesis. Common errors were not phrasing it in terms of significant difference, or leaving out reference to the movement of auxin by saying 'there is no significant difference between plant in the light and the dark. A few responses gave the alternative hypothesis and some wrote in terms of the chi squared test.

(iii) Many candidates gave a clear account of the use of calculated values of *t*. These candidates referred to finding the degrees of freedom for the investigation and then looking in a probability table at p = 0.05 (95%) to find the critical (or table) value for *t*. They also indicated that a comparison between t_{calc} and t_{crit} is made and if t_{calc} is higher, then the difference is significant. This was expressed in a number of valid ways. Some candidates wasted time in showing how *t* was calculated, which was not required. In some cases there was confusion between probability values and *t* values, with candidates suggesting that t_{calc} would be compared with 0.05 to see if it was higher or lower that that value. There were also a few responses which described the chi squared test, by discussing expected and observed *t* values.