BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 3

Nearly half of the candidates incorrectly selected option **B**. Mature red blood cells do not contain a nucleus and cannot divide.

Question 4

Stronger candidates knew that *Vibrio cholerae* is the scientific name for the bacterium that causes cholera. As this is a prokaryote option **D** was correct.

Question 7

Weaker candidates were unable to identify option **C** as showing a glycosidic bond which links the individual units of glycogen and amylose.

Question 8

Weaker candidates found this difficult and each option was chosen almost equally.

Question 9

The majority of weaker candidates incorrectly think that triglycerides are insoluble in alcohol.

Question 16

The vast majority of candidates found this difficult. All four statements were correct, therefore matching option **D**.

Question 21

The majority of stronger candidates were able to process the information provided.

Question 26

Almost half of the weaker candidates selected option **A** which was the direct opposite of the correct answer.

Question 27

The majority of candidates found this difficult although most were able to eliminate statements 1 and 2.

Question 28

Weaker candidates found this difficult and each option was chosen almost equally.

Question 32

The majority of candidates did not realise that the epidermis is the outer layer of a plant or human skin, but is not found in the wall of the trachea.

Question 36

The majority of candidates did not appreciate the role of macrophages such as those found in the alveoli.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 5

A significant number of candidates did not use the information that the cell was found in the trachea and produces mucus. As such it must be a secretory cell and the secretory vesicle is the last region in which the amino acid will be found.

Question 8

Weaker candidates were unable to identify option **D** as showing a glycosidic bond which links the individual units of cellulose and glycogen.

Question 11

Weaker candidates found this difficult and each option was chosen almost equally.

Question 12

The majority of candidates did not appreciate that all three statements were correct descriptions of enzyme actions.

Question 13

The majority of weaker candidates were unable to correctly process the information provided.

Question 17

Over half of candidates did not appreciate that osmosis is the net movement of water.

Question 19

Weaker candidates found this difficult and each option was chosen almost equally.

Question 21

The majority of stronger candidates were able to process the information provided.

Question 24

Weaker candidates found this difficult and each option was chosen almost equally.

Question 27

Weaker candidates found this difficult and each option was chosen almost equally.

Question 34

The majority of candidates did not realise that taking antibiotics at evenly spaced time intervals maintains a lethal concentration of antibiotics in the body.

Question 35

The stronger candidates correctly knew the role of neutrophils.

Question 37

Weaker candidates found this difficult and each option was chosen almost equally.

BIOLOGY

Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 5

Stronger candidates knew that *Vibrio cholerae* is the scientific name for the bacterium that causes cholera. As this is a prokaryote option **A** was correct.

Question 13

Less than half of all candidates were able to select the correct description of the induced fit mode of action.

Question 16

The majority of candidates found this difficult and did not know that channel proteins are not always fixed in position.

Question 20

The majority of candidates were unable to process the information provided in order to eliminate statements 1 and 3.

Question 21

Weaker candidates found this difficult and each option was chosen almost equally.

Question 25

Over half of weaker candidates did not appreciate the role played by osmosis in sucrose transport in phloem.

Question 27

Weaker candidates found this difficult and each option was chosen almost equally.

Question 30

The majority of weaker candidates found this difficult and were unable to answer correctly.

Question 33

The majority of stronger candidates found this straight forward and eliminated statement 3.

Question 34

Less than half of the stronger candidates were able to process the information provided to eliminate statements 1 and 2 as false.

Question 37

The majority of candidates were unable to process the information provided and did not realise that person G was initially given artificial passive immunity. Therefore, when infected with bacteria on day 20, they would show the same response as person H following their initial vaccination.

BIOLOGY

Paper 9700/21
AS Structured Questions

Key Messages

- When candidates are asked to 'name one', or 'state the name of', they should ensure that they give only one answer and do not go beyond the requirements of the question. In, for example, **Questions 1(b)** and **3 (a)** credit cannot be given if the candidate has been unable to make the decision and has given two or more choices.
- Candidates should avoid using abbreviations in their responses, unless the abbreviation has been used in the text or stem of a question. For example, when asked to name the level of protein structure in **Questions 2(b)(i)** and **(ii)**, the best responses stated 'secondary' and 'quaternary', rather than '2' or '4'. Where a term has already been abbreviated in the text that is associated with a question, it is acceptable for the abbreviated version to be used in the candidate's response. In extended responses, candidates may write out the terms that they use in full, give suitable abbreviations in brackets, and then use their abbreviations in the rest of their answer.
- Candidates should be very clear as to the distinction between transcription, translation and DNA replication. In **Question 3(d)** a number gave correct biological descriptions of transcription when they were asked to describe DNA replication.
- Candidates should consider the command word in the question, as this can indicate the type of answer required. 'State what is occurring at …' should prompt a single word, a short phrase or a single sentence; it should not prompt a lengthy answer. For example, in **Question 3(d)**, the main events that occur and some supporting detail should be included. Candidates should also look for questions that have two command words, such as **Question 4(b)(ii)**.

General comments

There were a number of candidates who performed consistently well in all questions in this paper. Many candidates were able to draw together knowledge and understanding from different areas of the syllabus, such as in **Questions 2(c)** and **5(d)**.

Generally, handwriting was legible and candidates were guided by the number of lines available to fit their response into the space provided. Although some candidates left some part-questions blank, almost all candidates attempted every question and all appeared to have time to complete the paper. Most candidates responded correctly to the command terms used in each part-question, but in **Question 4(b)(ii),** where two command terms were used, only some made good attempts to both describe and explain the graphical data provided.

Question 1 included a magnification calculation that involved a scale bar. Although many realised that the calculation could be completed using the scale bar alone, a number attempted to measure the mitochondrion in the image provided. In **Question 2(c)** candidates needed to consider two ideas: how polypeptides are held together and how polypeptides interact with the membrane phospholipids. Only those candidates who gave points covering both sections could gain full credit. **Question 3(a)**, **(b)** and **(c)(i)** were straightforward for most candidates. However, in **Question 3(c)(ii)** many were unsure as to why a plant would produce haploid cells. For a number of candidates, the extended response of **Question 3(d)** lacked details. Care was required when reading **Question 4(a)(ii)** and **(b)(ii)**. In **(a)(ii)**, some gave curled leaf as a named adaptation when the wording of the question made it clear that this answer would not be credited. In **(b)(ii)**, some included species **Q** in their response when asked to write only about species **P**. Candidates who were skilled in applying knowledge and understanding did well in **Question 5(a)**: others found this question to be particularly challenging. **Question 6(a)** required one-word answers and this proved to be very straightforward for the majority. Overall, this question was the most accessible one on the paper for most candidates.

Comments on specific questions

Question 1

This question assessed knowledge of cell structure and function from ***Section A***.

(a) For full credit, the more precise response of aerobic respiration was required, rather than respiration alone. Many gained credit with the knowledge that ATP is synthesised by mitochondria. It was not correct to state that mitochondria synthesise energy, or ATP energy, although the idea of supplying energy to the cell was allowed.

(b) Generally, stronger candidates knew the name of structure **A**. Others stated that it was the mitochondrion, which was already named, or gave answers such as double membrane, matrix and thylakoid. Quite a few left this blank.

(c) Some realised that the presence of a scale bar simplified the task of calculating the magnification of Fig. 1.1, as only the length of the straight line of the bar needed to be measured. This length was the equivalent of image length that could then be divided by actual length, the latter being the measurement of 0.7 μm given under the bar. For these candidates, some only gained partial credit as they did not correctly convert all measurements to the same unit, or they gave their response to decimal places.

(d) The best responses used their understanding of the limitations of light microscopes in terms of their resolving power and magnification and applied this to their knowledge of the structure of mitochondria. Good answers related the concept of resolution to the width of the membrane comprising the inner membrane and cristae. Not all gave a correct value for the limit of resolution, with some, for example, stating 200 μm instead of nm. Similarly, the best responses stated a correct maximum achievable magnification, with others being a factor of 10 out.

(e) Candidates who did well on this question remained clear that they were comparing similarities between mitochondria and prokaryotes, rather than the more general idea of comparing eukaryotes with prokaryotes. These responses gave details which showed their knowledge of mitochondrial and prokaryotic structure. There were many who gave more vague statements and many who wrongly compared eukaryotes with prokaryotes. Others wrote as if the mitochondrion was a whole cell.

Question 2

For this question, candidates were expected to make links between ***Sections B*** and ***D***. Many found parts **(a)(i)** and **(b)** to be more accessible than **(a)(ii)** and **(c)**, both of which required more than one thought process to arrive at the correct answer. Many weaker candidates found this question to be very challenging.

(a) (i) Many candidates answered correctly. Some named active transport, which is incprrect since the information given described the proteins as channel proteins rather than as carrier proteins. While facilitated diffusion can take place with both carrier and channel proteins, active transport requires carrier proteins. A number left this question blank.

(ii) Many candidates answered correctly and realised that the charged nature of ions meant that they could not cross the hydrophobic core of the bilayer. However, a good number described ions as polar rather than charged and many stated incorrectly that ions were too large, or 'the wrong shape' to pass across a cell membrane. Weaker responses wrote about molecules such as glucose.

(b) (i) This was well generally well known, with tertiary structure being the most common incorrect answer.

(ii) This was also well known, with the same candidates tending to perform well in both this part and **(b)(i)** . Although alpha helix is an example of protein secondary structure, candidates were credited when this was given, but not reference to helix alone. Some became confused with carbohydrates and wrote 'alpha-glucose structure'.

(c) A small number gave creditworthy suggestions for both how the channel protein polypeptides are held together and how they interact with phospholipids in the membrane. Most were unable to make any acceptable suggestions for the interaction with phospholipids. A good number gained credit for suggesting hydrogen bonding holds polypeptides together, with far fewer going on to explain that this would be between R-groups of amino acids on different polypeptides. Good responses avoided reference to peptide bonds. For the second part of the question, a few made valid suggestions concerning the hydrophobic and hydrophilic regions of phospholipids and regions created by hydrophobic and hydrophilic R groups on the outer facing area of the channel protein. This needed precise information to be given: a number wrote about hydrophilic heads and hydrophobic tails for both phospholipids and proteins.

Question 3

This question required candidates to firstly consider both mitosis and meiosis from ***Section E*** and then in part **(d)** to move on to describe the process of DNA replication from ***Section F***. It is good practice for candidates to study prepared slides or images of root tips in order to identify the different mitotic stages. They are also helpful for candidates to appreciate that a particular stage will take on different appearances depending on how far into the stage the cell has progressed: this is seen particularly well in the prophase and anaphase stages.

(a) Many candidates correctly recognised this stage.

(b) Many candidates were credited with at least one correct idea. Good answers noted that mitosis allows new cells to be formed and went on to qualify this with a relevant use for this in plants. They were careful to state that mitosis was for tissue repair and avoided stating that it was for cell repair. Detail was important: mitosis for reproduction was not credited unless it was stated that this was asexual reproduction. Growth was frequently linked to root or shoot growth. The production of genetically identical cells is a correct description rather than the production of identical cells since cells produced as a result of mitosis may not be exactly identical following cytokinesis and the separation of cytoplasm and organelles, but they will have exactly the same DNA.

(c) (i) Most candidates answered correctly. The most common incorrect answers were 16, 32 and 23. A few candidates attempted to explain the meaning of haploid.

(ii) Some candidates gave fluent and thorough explanations and showed a sound understanding of the concepts involved. Others were either aware that meiosis was involved but could not elaborate further, or gave vague responses about haploid cells being required for reproduction. Some stated incorrectly that asexual reproduction required haploid cells.

(d) Responses to this question were very varied in quality. The best answers gave sequential accounts, clearly stating the main events occurring in the process and filling in with additional details. Credit was given for stating that the process was semi-conservative replication or describing what this meant in addition to giving a description of the process. Precision was also required: good responses noted that DNA nucleotides were involved and that the enzyme was DNA polymerase, rather than just stating ‘nucleotides’ and ‘polymerase’. There were a number that gave a very sketchy view of the process which rarely gained any credit. Some candidates gave correct descriptions of transcription, which was a costly error. Weaker candidates confused DNA replication with mitosis and gave accounts of the stages of mitosis leading to the formation of daughter cells.

Question 4

This question, assessing plant transport topics from ***Section G***, covered transpiration and how the leaves of xerophytes are adapted to reduce transpiration rate. Part **(b)** included a graph of rates of transpiration and absorption of water for two species of plant. While each curve was very straightforward in itself, the fact that four different curves appeared on the same graph meant that candidates needed to stay focused and extract data from the correct curve.

(a) (i) Responses of a high standard answered only the question asked and gave a definition of transpiration. Others gave a description of the entire transpiration stream, which gained some credit if correct ideas about transpiration were included.

(ii) Most were able to explain that, for adaptations such as trichomes or folded inner surface, this created a humid environment or trapped water vapour. Far fewer went on to explain that this meant the water potential gradient for transpiration became less steep. For those who stated a thick cuticle, while the impermeable nature of the cuticle was well understood, only some explained that this helped to prevent the exit of water vapour. Other acceptable adaptations were rarely seen. Some candidates gave xerophytic features that could not be seen in Fig. 4.1.

(b) (i) The majority understood what data was to be extracted from Fig. 4.2 and most of these then went on to accurately extract the correct values to make the easy calculation.

(ii) The best responses wrote clearly about the effect of daylight and night hours, and light intensity, in relation to stomatal opening and its effect on transpiration rate. Others gained some credit for an understanding that transpiration would drive water absorption. A number only wrote about temperature affecting the rate of transpiration. An hour-by-hour account of the shape of the curves was not required. Candidates who described that the rate reached a peak, or that there was an increase followed by a decrease, were more accurate than those who stated that the rate reached a maximum. Fewer stated that the peak of water absorption was after that of transpiration. The use of figures was credited, but not all were able to extract values precisely and some incorrectly gave values for rate of water absorption rather than for transpiration rate. Some candidates included species **Q** in their description, which is not required.

(iii) Good responses suggested that species **Q** was a xerophyte and gave an example of an adaptation that would produce the results seen in Fig. 4.2. These candidates had realised that there was an extreme difference between the two species. Others gave more vague answers and stated that the patterns were different because they were two different species with different water requirements.

Question 5

As noted in **General Comments**, although this question had a theme of measles, in parts **(c)**, **(d)**, and **(e)**, it actually required candidates to think about subject material from other syllabus areas. ***Sections C, F, I***, and ***J*** were covered in this question.

(a) Morbillivirus as the causative organism of measles was known by candidates who tended to do well overall. Others wrote measles virus, chose to leave it blank or suggested a type of causative organism, which was not required.

(b) For those that understood that measles is transmitted by droplet infection, the best responses explained how the pathogen was able to leave an infected person as an aerosol and enter an uninfected person when the airborne droplets containing virus is inhaled. Others tended to begin their response with the airborne droplets. It was common to state that the pathogen was airborne rather than in airborne droplets. Some only stated that measles can be transmitted by contact. Weak responses described modes of transmission related to cholera or gave several modes of transmission.

(c) For well-prepared candidates it presented few problems, with most stating that RNA contains uracil instead of the thymine in DNA and to state the difference between the pentose sugars. Some wrote about single stranded RNA versus double stranded DNA. Some took one difference and used both numbered lines, for example stating uracil for RNA on line 1 and then giving thymine for DNA on line 2. A number tried to make suggestions linked to viral replication.

(d) Only a few able candidates went beyond the idea of enzyme specificity and understood that in the host cell RNA synthesis occurs on a DNA template, rather than an RNA template. Some were also able to suggest that the host cell would not possess an enzyme for a reaction that does not normally take place within it. Responses that did not gain credit suggested that the host cell did not synthesise RNA or that the cell's enzymes would act as inhibitors.

(e) The best responses paid attention to detail, showing an understanding of the events occurring in the presence of non-self antigens and making clear the different roles between T-helper and T-killer (cytotoxic) lymphocytes. These also explained the effects of cytokines released by T-helper lymphocytes. Others knew about the roles of T-lymphocytes but wrote as if one cell type was responsible for all the different actions. Some did not write about T-lymphocytes and instead gave an account of B-lymphocytes, plasma cells and antibodies. A common error was to think that

memory cells that form as a result of the primary immune response are only one type of cell from which B cells and T cells can arise in the secondary immune response.

Question 6

This question assessed learning outcomes in ***Section K***. Although this question was very straightforward, only thoroughly prepared candidates who had learned the nitrogen cycle were able to do well in part **(b)**.

(a) (i) All candidates were able to name grass as the producer in the food web in Fig. 6.1.

(ii) Almost all candidates gave a correct answer. Some chose mice which also act as secondary consumers, so this was incorrect.

(iii) The vast majority identified foxes as top predators in the food web in Fig. 6.1. Only a few incorrectly named snakes.

(b) This caused no problem for all those who knew the nitrogen cycle. A number mistakenly thought that nitrogen gas to ammonium ions, nitrification, was ammonification, while some got denitrification (nitrate ions to nitrogen gas) and nitrification the wrong way round. Many only attempted to name one or two processes of the three.

BIOLOGY

Paper 9700/22
AS Structured Questions

Key Messages

- When candidates are asked to 'name one', or 'state the name of', they should ensure that they give only one answer and do not go beyond the requirements of the question. In, for example, **Questions 1(a)(i)**, **(b)(i)** and **(c)(i)** credit cannot be given if the candidate has been unable to make the decision and has given two or more choices.
- Candidates should avoid using abbreviations in their responses, unless the abbreviation has been used in the text or stem of a question. For example, stating 'rough endoplasmic reticulum' and 'smooth endoplasmic reticulum 'is a correct response when being asked to name the cell structures, whereas 'RER' and 'SER' are not acceptable. In extended responses, candidates may write out the terms that they use in full, give suitable abbreviations in brackets, and then use their abbreviations in the rest of their answer.
- Candidates should be very clear as to the distinction between transcription, translation and DNA replication. In **Question 2(e)** many gave correct biological descriptions of transcription when they were asked to describe translation.
- Candidates should consider the command word in the question, as this can indicate the type of answer required. 'State what is occurring at …' should prompt a single word, a short phrase or a single sentence; it should not prompt a lengthy answer. For example, in **Question 2(e)**, the main events that occur and some supporting detail should be included. Candidates should also look for questions that have two command words, such as **Question 5(c)(i)**.

General comments

There were many high quality responses for all questions in this paper, demonstrating thorough knowledge and understanding of the syllabus learning outcomes, together with an ability to carefully read all the information given to help formulate the correct response.

Most candidates paid good attention to the command terms used in each question and there were few instances of handwriting that was difficult to read. Candidates worked to the end of the paper and there were few part questions that were left blank.

Question 1 proved to be quite straightforward for candidates, with most knowing at least one or all of the structures described, and the majority showing an ability to convert from nm to μm. **Question 2**, included a section where candidates needed to bring together a number of new ideas and use their problem-solving skills. This was a difficult section for weaker candidates, although some of these went on to do very well in the extended response in **2(e)**. In **Question 3**, candidates found it easier to identify the stages in the mitotic cell cycle and sequence stages than to explain how the behaviour of the chromosomes and spindle would enable daughter cells to be genetically identical. In **Question 4(b)** some candidates did not give enough data from Fig. 4.1 to support their answer. In **Question 5**, the introduction given before **(b)** contained material that was of use for **(b)**, **(c)** and **(e)**, and it was evident that some candidates used this to help them answer these questions. In **Question 6(c)**, many confused transpiration with the entire transpiration stream and movement within the xylem.

Comments on specific questions

Question 1

This question assessed knowledge of cell structure and function from ***Section A***. Candidates were also required to be familiar with units of measurement and how to convert correctly. Included in this question was an electron micrograph so that candidates could identify microvilli. Knowledge from ***Section G*** was also helpful in helping candidates consider the function of plasmodesmata.

(a) (i) The majority correctly identified mitochondria as the organelle described. Some candidates also gave chloroplasts: although they have double membranes, the description of a folded inner membrane would only apply to mitochondria. Some responses named the nucleus.

(ii) Mitochondria can be found in a variety of shapes, although generally the shape of a mitochondrion as shown in different textbooks tends to be the same. Some suggested that the flexible nature of the membrane allowed shape changes or suggested that sections of these organelles may be cut at different angles. Some thought that different shapes were as a result of different cell types. A large proportion misread the question and gave suggestions as to how mitochondria might be of different sizes. Most of these gave ideas linked to different levels of activity and/or quantity of ATP produced. Some gave descriptions of how the internal structure of the mitochondria could differ, which was not required.

(b) (i) Most gained credit by either using an understanding of size estimates and units of measurement, or by remembeing that ribosomes are not bound by a membrane.

(ii) Most were able to correctly convert 25 nm into μm.

(c)(i) Many candidates correctly identified the described structures as plasmodesmata, although there were fewer correct answers than in **(a)(i)** and **(b)(i)**. Some incorrect answers stated the structures were a chloroplast, cell wall, vacuole and, occasionally, the middle lamella.

(ii) Most candidates who stated 'plasmodesmata' in **(c)(i)** were able to gain credit in **(ii)**. Even if plasmodesmata were incorrectly named, candidates gained credit for responses that explained an advantage of plant cells having strands of cytoplasm passing through channels in the cell wall. A range of correct responses were seen, with the most common advantages relating to symplastic movement or to a description of ease of movement of substances between adjacent cells. Some correctly stated that this avoided movement across the cell surface membrane and cell wall. A few incorrectly described the movement of water through the channels as apoplastic. Most of those who had named a cell structure found in plants continued to ignore the description of cytoplasmic strands and gave a correct advantage of their named structure.

(d) Almost all those who correctly identified the cell structures in Fig. 1.1 stated a correct function and gained credit. The two most common incorrect answers were villi and cilia.

Question 2

This question used the effect of tobacco smoking as a theme to assess knowledge and understanding from a number of syllabus areas, ***Sections C, F, H*** *and* ***J***. For part **(d)**, candidates had to process information about inhibition of two types of elastase. In order to do well in both parts **(i)** and **(ii)** a full analysis and understanding of this information was required.

(a) There were many well-expressed and concise responses given for this question, with each component linked correctly to the effects it has on blood vessels that could contribute to atherosclerosis. A common misconception was to think that tar entered the blood stream. Many could have gained more credit with more precise information, for example, damage to the endothelium was frequently described as damage to the wall. Others gave features that contributed to atherosclerosis which were not as a consequence of components of tobacco smoke. Some candidates gave an outline of how tobacco smoking would contribute to emphysema, which was not required. A good number of candidates did not appear to know what was meant by atherosclerosis.

(b) (i) Most gained credit by giving an acceptable role of a phagocyte. With weaker responses, there was confusion between antigen and pathogen, with some stating that antigens were engulfed or that antigens were killed.

(ii) Many candidaets showed a good understanding of the function of elastic fibres, stating clearly the sequential consequences of their loss in the alveolar walls. The best responses addressed only lung enlargement. Many wrote about consequences leading to emphysema, which was not required. Most who gained partial credit wrote about the lack of recoil of alveoli after inflation. Few realised that the enlargement was associated with overstretching of the alveoli after loss of their

elastic fibres. Candidates who used the terms contraction and relaxation did not gain credit since these terms are associated with muscles, rather than events occurring in the alveoli or lungs.

(c) (i) Full credit was given for responses that showed understanding of an enzyme as a biological catalyst, rather than just as a catalyst. A number wrote about 'speeding up reactions' without inferring that the enzyme was a biological molecule or that they catalysed metabolic reactions. These gained credit if they went on to give a feature of an enzyme, such as remaining unchanged at the end of a reaction. Some wrote about 'enzymes not taking part in the reaction' or 'not being used in the reaction', when they clearly meant that they were unchanged at the end of the reaction.

(ii) Candidates varied in their approach to this question, which was usually very well answered. Frequently, a well-annotated set of diagrams was sufficient to highlight the required points and in these cases, it was not necessary to explain the diagrams. Some decided to draw one diagram to show how the shape of the elastin (the substrate) was complementary to the shape of the active site of elastase and then continue to write about the formation of the enzyme-substrate complex and the formation of products. High-quality responses also included detail of how activation energy is lowered. On occasion the diagrams helped those who were less able to express themselves well in the written response. However, at times, a diagram contradicted the text and credit could not be awarded. The main example of this was to state that the active site and the substrate were the same shape but to correctly show complementary shapes in a diagram. Some candidates wrote about the induced fit rather than the lock and key mechanism.

(d) (i) Although many candidates found this a straightforward question, some mistakenly stated that it would not inhibit macrophage elastase, while others thought that A1AT was the enzyme and so wrote about a change to the A1AT active site and an inability for the substrate to attach to A1AT.

(ii) The best responses gave a sequential, logical response, taking into account all the consequences of a lack of A1AT. Many understood that neutrophil elastase would not be inhibited and went on to describe an outcome that would lead to emphysema, hence gaining partial credit. Few wrote about TIMP-1 and a number stated that macrophages and neutrophils would have changed active sites. Some gave symptoms of emphysema, which frequently meant that no credit was gained.

(e) In order to do well in this question, it was important for candidates to know the difference between transcription and translation. There were many that were able to gain full credit with a detailed description of the process. Many noted the role of the START and STOP codons and gave details of the enzymes involved. Some candidates confused the three bases of a codon and described instead three codons, while others did not mention the critical event of codon-anticodon binding. Well-expressed answers showed an understanding that one tRNA binds only one amino acid and that only two tRNA molecules bind to the ribosome at any one time. Many of these also made clear that an anticodon was part of a transfer RNA molecule and that a specific tRNA molecule attaches to a particular amino acid. Weaker responses did not mention the role of the ribosome and described tRNA as the main molecule responsible for the formation of the polypeptide chain. One common error was to describe the peptide bond as a polypeptide bond. A good number erroneously thought that mRNA or tRNA synthesised amino acids, while some thought that mRNA was converted into polypeptides. Many went beyond the requirements of the question and wrote about post-translation modification to produce the fully functioning elastase enzyme. Others began their account with a description of transcription, which was not required. Weak candidates wrote only about transcription.

Question 3

This question required candidates to consider the mitotic cell cycle from ***Section E***, and show an understanding that the cell cycle includes interphase as well as the mitotic phases and cytokinesis. Some important information given at the start of **Question 3** was the fact that all stages in Fig. 3.1 were at the same magnification and that only **A**, **B** and **C** were in the correct order.

(a) Both stages needed to be identified correctly to gain credit. Candidates who had studied prepared slides or images of root tips should be able to recognise stage **A** of Fig. 3.1 as interphase. Some identified the stage as prophase, despite the fact that there is no visible graininess in the nucleus and only chromatin is visible. Most were able to identify metaphase for stage **C**.

(b) Most candidates were able to correctly sequence the stages **K** to **N**. Where incorrect, it tended to be stages **N** and **M** that were the wrong way round.

(c) There was considerable variation in the quality of response seen for **(c)**. The best answers gave explanations that included relevant points of both the spindle and the chromosomes. Many did not state that chromatids that separated were identical. Fewer noted that the centromeres divided although more realised that the centromeres were attached to the spindle fibres to allow separation to occur. Weaker responses stated that the chromosome at metaphase consisted of one structure that needed to be split to form the two chromatids.

Question 4

Part **(a)** of **Question 4** assessed candidate understanding of transport mechanisms, from ***Section D***, by presenting them with examples taken from other parts of the syllabus. Part **(b)** was based on understanding of the oxygen dissociation curve from ***Section G*** and this proved to be quite challenging for many.

(a) Many did well in correctly completing all of Table 4.1. Most were able to name active transport for the first example described. Where full credit was not gained, it tended to be for the last example of sucrose movement through the plasmodesmata from the companion cell into the phloem sieve tube. Many thought that this described facilitated diffusion rather than passive diffusion.

(b) Only some candidates realised that they had to use the graph to describe how only a small decrease in partial pressure of oxygen allowed a large quantity of oxygen to dissociate. Many others gave an account from the point of view of oxyhaemoglobin formation in the lungs. This was not the focus of the question, although credit could still be gained with knowledge that the partial pressures concerned occurred in respiring tissues or for extracting correct data from Fig. 4.1. A few stated correctly that the affinity of haemoglobin for oxygen decreases in these low partial pressures and only a small proportion gave data from Fig. 4.1 to support their answer.

Question 5

The most challenging part of **Question 5** was part **(c)**, which approached malaria from a global aspect and required candidates to think about reasons for differences between the distribution of the disease and the distribution of the Anopheles mosquito as the vector, as well as considering why *Anopheles gambiae* is the most important vector of the disease in Africa. This meant that they had to use their knowledge and understanding of the transmission and prevention and control of the disease. Subject material from ***Sections B***, ***I***, ***J*** and ***K*** was covered in this question.

(a) Candidate understanding of the difference between infectious and non-infectious diseases was generally sound, with most gaining full or partial credit. The best responses gave explanations that included both infectious and non-infectious features. Where partial credit only was gained, this was generally for knowing that infectious diseases were transmissible, unlike non-infectious diseases. Fewer went on to explain that pathogens caused infectious diseases. A number gave some good examples, or described one or more categories of non-infectious disease. The weakest responses stated that infectious diseases were more easily caught than non-infectious or that non-infectious diseases were not accompanied by symptoms or that non-infectious diseases did not cause an immune response.

(b) As the question told candidates that blood was a good source of protein, the majority of candidates realised that they had to give further detail. The availability of plasma proteins and haemoglobin were frequently cited, with well written responses linking haemoglobin to red blood cells. Named plasma proteins were also credited in addition to named protein types that would be available from ingestion of blood cells. For those that did not gain credit, this tended to be for a statement that blood contained proteins or for explaining that amino acid were present that could be used to synthesise proteins.

(c) (i) Some candidates realised that Fig. 5.2 only contained half the information required to answer the question and that they would have to draw on their knowledge of the global distribution of malaria, and hence of *Plasmodium*. Of these candidates, most were able to explain that the distribution of *Anopheles* was wider than malaria and to state an example to support this explanation. Fewer went on to suggest suitable explanations for the difference. Of those who did not gain credit, some misinterpreted the information in Fig. 5.2 and thought that *Anopheles gambiae* was the only vector of *Plasmodium*, while many others wrote only about the global distribution of *Anopheles,* without referring to the global distribution of malaria.

(ii) Many candidates gained full credit with three or more relevant suggestions as to why *A. gambiae* is responsible for most of the transmission in the darker grey shaded areas on Fig. 5.2. Some wrongly suggested that the mosquitoes were resistant to drugs used in the treatment of malaria. A good number gave an outline description of the part of the transmission cycle of *Plasmodium* involving the *Anopheles* vector, which was not required.

(d) (i) Almost all candidates were able to correctly identify a tertiary consumer in Fig. 5.3.

(ii) There were many well-expressed answers that gained full credit. These made it clear that energy losses occur in the food web leading up to the trophic level with the eastern green mamba and gave relevant examples of energy losses. They also remembered to explain how the loss of energy would mean that there would not be sufficient reaching the eastern green mamba via the yellow winged bats. Energy losses from the solar input to the ecosystem or by the eastern green mamba were not required in the response.

(iii) Most candidates gave good answers and the majority of these focused on the idea of introducing predators of *A. gambiae* adults and larvae to the other areas of Kenya. Suggestions of eliminating phytoplankton from the areas were not credited as this would mean collapse of the rest of the ecosystem. A number suggested reducing sweet potato crops or planting other crops, which was acceptable. There were some that noted that this was a form of biological control. Some candidates did not answer the question and ignored Fig. 5.3, giving suggestions of other methods to eliminate *A. gambiae*.

(e) Most did well on this question. All above-ground parts of the sweet potato plant named were acceptable. No credit was given where the named parts included reference to extraction from xylem or from underground sweet potatoes or roots. The full range of explanations was seen. Those who did not gain credit only wrote about feeding on the sweet potatoes below ground.

Question 6

This question assessed learning outcomes in ***Section G***. In general, candidates found this question to be very approachable.

(a) There were many candidates that gained full credit as they included in their explanation the idea that a greater thicknesses would generate higher pressure (or vice versa). There were also a few that gave an explanation in terms of resistance to flow. Some were unclear as to the role of the atria and just explained that they received blood at low pressure. Some thought that they pumped blood to the lungs. Others thought that the function of the thick ventricle walls was to withstand high blood pressure. Insufficient answers only explained that blood needed to travel different distances.

(b) Most candidates answered correctly. Some were unable to get close enough to the correct spelling and so did not gain credit. Incorrect answers included chamber, aorta and Purkyne fibres. Terms such as interatrial septum, interventricular septum and median septum were not required as the term for the wall dividing both sides was required.

(c) (i) Some good comparative explanations were seen. Stronger responses showed an understanding that transpiration involved water vapour rather than water and that loss of water vapour was from the aerial parts of the plant or the leaves. Where the explanation for transpiration was lacking in some detail, partial credit was given if the feature for translocation was relevant.

(ii) Fewer gained credit here than for **(c)(i)**, with most correct responses being brief and giving a general shared feature such as the involvement of water or transport. A number did point out that both required energy. Some incorrectly gave mass flow as a shared similarity, while others thought that translocation occurred as a result of differences in concentration, rather than in hydrostatic pressure.

BIOLOGY

Paper 9700/23
AS Structured Questions

Key Messages

- When candidates are asked to 'name one', or 'state the name of …' they should ensure that they give only one answer and do not go beyond the requirements of the question. In, for example, **Questions 1(a)(i)**, **1(a)(ii)** and **Question 3 (d)**, credit cannot be given if the candidate has been unable to make the decision and has given two or more choices.
- Candidates should avoid using abbreviations in their responses, unless the abbreviation has been used in the text or stem of a question. For example, in **Question 1 (a)(i)** the term 'rough endoplasmic reticulum' is a correct response, whereas 'RER' is not acceptable. In extended responses, candidates may write out in full the terms that they use, giving suitable abbreviations in brackets, and then use their abbreviations in the rest of their answer.
- Candidates should be very clear as to the distinction between transcription, translation and DNA replication. In **Question 1(a)(iii)** many gave correct biological descriptions of transcription when they were asked to describe translation.
- Candidates should consider the command word in the question, as this can indicate the type of answer required. 'State what is occurring at …' should prompt a single word, a short phrase or a single sentence; it should not prompt a lengthy answer. Candidates should also look for questions that have two command words, such as **Question 1 (d)** on antibody structure and function.

General comments

There were many well-written answers that showed good understanding of the topics assessed in this paper. Responses to the data interpretation required in **Questions 2** and **3** were often illustrated by accurate examples of data taken from Fig. 2.1 and Fig. 3.1. Units were generally used correctly. Some of the comments in the analysis of these graphs showed some common misunderstandings. For example, some candidates stated that when the graphs showed a constant rate, the process (transpiration or the decomposition of hydrogen peroxide) had stopped. If this were the case, then both lines would show a decrease to the *x*-axis. This occurred frequently in **Question 2(a)(i)**, where the rates in the two groups of plants between 15 μm and 20 μm were compared. Some candidates quoted values for transpiration rates without stating the appropriate stomatal apertures. Others confused the independent and dependent variables, stating that as the transpiration rate increased, the stomatal aperture opened wider.

Differences were seen in the use of correct terminology. For example, in **Question 1 (d)**, the correct term 'antigen-binding sites' in antibodies was sometimes referred to as 'receptors' or 'active sites'. In **Question 2 (a)(ii)**, candidates referred to concentration gradients rather than to water potential gradients. Some misused the term water potential gradient by stating that 'the water potential gradient is higher outside the leaf than inside the leaf'.

Comments on specific questions

Question 1

This question centred on protein synthesis and the structure of antibody molecules and assessed material from ***Sections A***, ***B***, ***D***, ***F*** and ***J***. Many candidates performed well and were successful at identifying what was occurring in Fig. 1.1, but were less successful in applying their knowledge in part **(c)**.

(a) (i) Many candidates identified all three structures correctly. The most common error was to identify the rough endoplasmic reticulum as the plasma or cell surface membrane or to omit the word 'rough'. The bracket by structure **A** on Fig. 1.1 should have prompted candidates to give the nuclear

envelope as their answer. However, many gave 'nuclear membrane'. Candidates often qualified their answer to **C** by giving the large sub-unit or the size of the ribosome. These were not required.

(ii) A common error was to name transfer RNA as 'transport RNA'.

(iii) Some candidates misidentified transcription as translation, but there were many who gave concise details on each of the three stages of protein synthesis. Amino acid activation was the term that many did not use, but there were good descriptions of tRNA binding to amino acids, which were often described as 'the specific amino acid'. Credit was not given when candidates gave correct names and then described a different process. or when answers stated simply 'the polypeptide is made'.

(b) The definition of glycoprotein was given correctly by many candidates, although some stated incorrectly that glycogen is attached to the protein. The most common answer was that a carbohydrate or chain of sugars is attached. The term oligosaccharide was seen occasionally. Some candidates gave the function of glycoproteins rather than give detail about their structure, so did not gain credit.

(c) Even though most correctly described heavy and light chains for an antibody molecule in part **(d)**, in part **(c)** only the more able candidates applied their knowledge that a gene codes for a polypeptide to the structure of the antibody. There were several incorrect reasons given, including the idea that each gene codes for a single amino acid. Many thought the question was asking about the degenerate nature of the genetic code. Some candidates were confused between polypeptides and polynucleotides and between amino acids and nucleotides. They often thought that antibodies are made of genes rather than made indirectly by genes. Some did state that the antibody was made of four polypeptides and so more than one gene was needed to code for them, but missed the idea that there are two different types of polypeptide and so a different gene was needed for each.

(d) The majority of candidates described the structure of antibodies belonging to the class IgG with two antigen-binding sites, although many did not state clearly that each antibody has *two* variable regions, each of which binds to the same antigen. There were a number of excellent answers that explained how the features described would aid the function of the molecule. A few responses were accompanied by correctly labelled diagrams of the Y-shaped structure, which helped them to gain credit. Some candidates referred to the antibody's active site rather than to its antigen-binding site. A small number referred to the hinge region allowing the antibody as a whole to move, rather than giving flexibility to the variable region when binding. Some thought that disulfide bonds formed the hinge region and were responsible for flexibility. Some candidates referred to the constant region binding to cells other than phagocytes.

Question 2

In this question on transpiration, from ***Section G***, many candidates did not distinguish carefully between evaporation of water from the cellular surfaces inside leaves and the diffusion of water vapour through stomata or through the cuticle to the surroundings. In their responses, many candidates referred to effects on evaporation when it was more appropriate to discuss effects on diffusion of water vapour.

(a) (i) Candidates' descriptions were generally very good, with appropriate choices of data quotes. Most candidates stated that the rates of transpiration under the two conditions increased as stomatal aperture increased. This was then qualified by stating that in non-moving air, the rate remained constant after an aperture size of 15 μm. Some stated that the rate of transpiration remained constant at 21 $g\,m^{-2}\,h^{-1}$ without any reference to the increase in stomatal aperture. No credit was awarded for stating that the rate of transpiration is higher in moving air than in non-moving air. Few stated that stomatal aperture controls the rate of transpiration in moving air at *all* apertures. Some referred to limiting factors here. Many described the increase in transpiration in non-moving air as aperture increased, but did not say that aperture only has an effect on controlling the rate at apertures below 15 μm. Very few stated that there was no transpiration under either condition when the stomata were closed.

(ii) Stronger candidates avoided giving a description of the results shown in Fig. 2.1. There were a few well-argued answers that linked the diffusion of water vapour through stomata with the water potential gradient between internal air spaces and the air surrounding the leaves. There were more good answers that explained that the wind blows away water vapour as it diffuses through stomata,

so preventing the accumulation of a humid layer surrounding the leaf. Some also went on to explain that this maintains steep water potential gradients. A common error in this question was to state that water passes out of stomata by osmosis.

(b) (i) Good answers explained that water vapour accumulates in the pits above the stomata so reducing the water potential gradient between intercellular air spaces and the air within the pit. They also stated that this reduces the rate of transpiration. Few went on to say that as a result these plants absorb less water.

(ii) Almost all candidates stated that closing stomata during the day will reduce the rate of photosynthesis or prevent it happening at all.

(iii) This required explanations as well as simple statements. Candidates who gave creditworthy answers gave two suitable structural features of leaves that help them survive in dry habitats and stated how they are effective. A common error was to state that curled or rolled leaves reduce the surface area for transpiration rather than reducing the water potential gradient between the leaf and the atmosphere. Some candidates gave adaptations of stems and/or roots. Candidates that offered no explanations did not gain credit.

Question 3

This question on roles of proteins in cell biology included the results of an investigation into two forms of catalase from the mosquito *Anopheles gambiae*. A common error was to compare the activity of the two forms of catalase in part **(a)**. Material from ***Sections C*** and ***D*** was covered in this question.

(a) There were many very good descriptions of the activity of catalase **P** over the range of substrate concentrations used in the investigation. Some candidates compared the activity of catalase **P** with catalase **Q** and although some credit could be given for these answers, rarely did they gain full credit. Some candidates were imprecise in their descriptions. However, many candidates gained full credit for accurate descriptions of the results and explanations of those results in terms of the appropriate limiting factors.

(b) Only a few candidates stated that the amino acid at position 2 in the primary sequence of this catalase is part of the active site. Many, however, were able to describe the likely effect that the change from serine to tryptophan will have on the structure or functioning of the enzyme.

(c) Stronger candidates were able to link the information given at the beginning of the question about the toxic nature of hydrogen peroxide with that given in **(c)** and so realised that the removal of a toxic end product of metabolism was critical to the success of egg production. Many did not use the information and so suggested that it was the oxygen produced in the reaction that was critical, which was not credited.

(d) Many candidates gained full credit for their answers about the action of non-competitive inhibitors. Some did not use the term active site, often stating that the inhibitor binds at the allosteric site, so changing the shape of the enzyme. These answers gained only partial credit. Some explained that copper ions act both as a competitive inhibitor *and* a non-competitive inhibitor. This was not accepted.

(e) Generally, there was good knowledge shown by candidates and many responses stated correctly that carrier proteins are required for active transport and facilitated diffusion and explained why they were necessary. However, many candidates referred to the size of molecules rather than their charge.

(f) There were many good answers to this question. Some candidates ignored the instruction and wrote about the movement of substances across membranes. Some also referred to the roles of intracellular membranes, including the compartmentalisation of cell contents, which was not required.

Question 4

This question assessed learning outcomes in ***Sections B*** and ***K***, with **(a)(ii)** proving to be challenging for a number of candidates.

(a) (i) Almost all candidates recognised the bond shown in Fig. 4.1 as a glycosidic bond.

(ii) A few gained full credit here by giving detail in addition to the fact that glycogen is a compact molecule. Some stated that glycogen can be hydrolysed quickly to provide glucose, with far fewer stating that the reverse reaction occurs on many places over the whole molecule when glucose is stored. Only the very best candidates explained that a branching molecule has many terminals or 'ends' that allow enzymes to add many glucose molecules for storage, or remove them for providing energy, either in the cell or elsewhere in the body (after transport in the blood). Many stated that there are many 'ends' but did not say why this was an advantage. Some appeared to be confusing glycogen with triglycerides by stating that glycogen has many C-H bonds, so provides much energy when oxidised.

(iii) Almost all candidates gained full credit for their answers.

(b) (i) Many candidates gave the correct answer for the calculation, although some candidates did not attempt this question.

(ii) Most candidates stated ways to account for less energy being available to humans from feeding on animal products than if the energy came direct from crop plants. Most candidates concentrated on energy losses in the primary consumer trophic level. No credit was given for discussing and comparing the length of the food chain with the efficiency of energy transfer or for stating the '10% rule'. Very few stated that there would be energy losses in the processing of crops to make animal feed.

Question 5

Sections G and ***H*** were assessed in this question. Most found part **(b)(ii)** to be very straightforward and there were many well-expressed responses seen. Part **(b)(i)** was less well answered.

(a) Most candidates concentrated their answers on the cardiovascular system, although some described effects on the gas exchange system as well. Some candidates stated that nicotine is responsible for the release of dopamine, but this was not relevant to this question. Many described the effect of carbon monoxide on haemoglobin without stating a consequential effect on reducing the supply of oxygen to the walls of the coronary arteries.

(b) (i) Stronger candidates applied knowledge of the external and internal structure of the heart to explain that by-pass vessels allow oxygenated blood to flow from the aorta to cardiac muscle. Other responses were too vague to gain credit. There were few explanations that dealt with the provision of oxygen to cardiac muscle to maintain aerobic respiration.

(ii) Most responses dealt mainly with education about heart disease, promoting a balanced diet, putting taxes on sugar and/or saturated fat, encouraging people to take exercise and stop smoking. Other ideas included providing screening facilities and regular check-ups as well as providing finance for facilities for people to take exercise. Reference to healthy lifestyles was not credited unless further detail was provided. Some focused on the steps that individuals can take rather than government, so were not able to gain any 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 that can be applied to the requirements of the examination.

Candidates should be able to assess the risk of a procedure. A risk assessment could include judging that the use of a boiling water-bath would be assessed as a high risk while using methylene blue, would be assessed as a low risk.

Candidates should be used to looking at experiments and assessing the relative importance of errors in measurement or in making observations so that they can judge which sources of error are most significant.

Using a 1 cm^3 syringe that can measure to an accuracy of 0.01 cm^3 would not increase the accuracy of the results as there are other sources of error which are more significant such as the accuracy of cutting the plant tissue and the method used to estimate the intensity of colour.

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

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 when marking the candidates' scripts.

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) Many candidates were able to carry out a serial dilution, showing the correct percentage concentration of sodium chloride solution below each beaker (1.00%, 0.10%, 0.01% and 0.001%)

and transferring 18 cm^3 of the previous concentration to the next beaker and adding 2 cm^3 of distilled water to each beaker.

(ii) Some candidates stated a volume of sodium chloride solution to use in each test-tube and correctly explained that the reason for using this volume was to ensure that the plant tissue was fully immersed.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The better candidates included an appropriately detailed heading for the independent variable (percentage concentration of sodium chloride solution or **S**) and the dependent variable (colour intensity).

The majority of candidates gained credit for recording the colour intensity observed using the scale (+++). Most candidates showed the result for 10% sodium chloride solution as the highest intensity and the result for water as the lowest intensity.

(iv) Many candidates correctly stated that the hazard with the greatest level of risk was the use of methylene blue and rated it as low or medium.

(v) Many candidates correctly stated that it was necessary to collect the result for the control experiment in order to show that the results were due to sodium chloride solution and not any other factor.

(vi) Some candidates correctly explained that there were other more significant errors than using a 1 cm^3 syringe that measured to an accuracy of 0.01 cm^3.

(b) (i) The majority of candidates drew the graph, using the headings given in the table, with time in sodium chloride solution / days on the *x*-axis and mean length of roots / mm on the *y*-axis. The better candidates used scales of 2 to 2 cm, labelled each 2 cm for the *x*-axis and 5 to 2 cm, labelled each 2 cm for the *y*-axis with 30 or 35 at the origin, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting each of the points.

(ii) The majority of candidates correctly calculated the rate at which root length increased between day 3 and day 5 for plants in 25 mM sodium chloride solution by showing 39.5–38 divided by 2, and stating the answer as 0.75 mm day^{-1}.

(iii) Some candidates correctly explained the difference in the rates between day 3 and day 5 for the two concentrations of sodium chloride solution by referring to the water potential inside and outside of the cells and the movement of water into the cells.

(iv) Some candidates correctly described how the independent variable (temperature) was to be investigated by using at least 5 temperatures and using the appropriate means of carrying this out by using a greenhouse or an incubator or a temperature-controlled room. Credit was also given to a description of how one other variable was standardized. The most common error was stating that a water-bath could be used to control the temperature.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The better candidates gained credit for carefully following the instructions, only drawing the part of the leaf as shown in Fig. 2.1 and for showing at least two layers of tissue. Many candidates gained credit for drawing the end of the leaf curving inwards and using one label line to identify either the cuticle or a trichome or the folding of the leaf. Some candidates annotated this label correctly stating how the feature identified adapted the plant to living in a dry habitat.

(ii) Many candidates were able to draw four cells, with each cell in the group touching two of the other cells and with double lines representing the cell walls. The better candidates produced drawings using a sharp pencil which did not include any shading and used most of the space provided. The most common error was to draw lines that did not meet up precisely or were too thick. Most candidates used one label line and label to identify the cytoplasm of one cell.

(b) (i) Most candidates used one label line and the label **X** to identify the xylem.

(ii) The majority of candidates correctly stated that the correct number of eyepiece graticule units for the length of **Y**, showed this number multiplied by 12 and gave the correct answer. The most common errors were to measure line **Y** in millimetres or not showing all the steps in the calculation.

(c) Many candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed **J1** and the other headed Fig. 2.2. The majority of candidates were able to gain full credit for recording two observable differences in xerophytic adapatations between the two specimens.

BIOLOGY

Paper 9700/33
Advanced Practical Skills 1

Key Messages

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

Candidates should be able to assess the risk of a procedure. A risk assessment could include judging that the use of methylene blue would be assessed as a low risk while using hydrogen peroxide would be assessed as a medium or high risk.

Candidates should be able to estimate quantitatively, by calculating the actual error, to evaluate the uncertainty in quantitative measurements. Actual error is taken to be half the value of the smallest division on the apparatus used and then considering whether the measurement involves uncertainty at each end.

Candidates should understand the difference between the terms 'explain' and 'describe'. The term 'explain' may imply reasoning or some reference to theory, depending on the context. The candidate needs to state why something happens, such as in **Question 1(c)(ii)**. The term 'describe' requires the candidate to state in words the key points that can be found from the data or information given in a graph, table or diagram.

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

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 when marking the candidates' scripts.

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

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

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

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

Comments on Specific Questions

Question 1

(a) Many candidates correctly stated that the hazard with the greatest level of risk was the use of hydrogen peroxide and rated it as medium or high.

(b) (i) Many candidates were able to carry out a simple dilution, showing at least three correct concentrations in the table. Many candidates correctly stated at least three percentage concentrations of **S** and three percentage concentrations of sodium chloride in **SY**, with the correct volumes of **S** and **W**, making 10 cm^3 to use in the investigation.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The better candidates included an appropriately detailed heading for the independent variable (percentage concentration of sodium chloride solution in **SY**) and the dependent variable (temperature / °C). The majority of candidates gained credit for recording at least four initial and four final temperatures observed, to the correct accuracy. The better candidates showed the result for 0% sodium chloride solution in **SY** first and included each rise in temperature (processed data) in their table.

(iii) Many candidates correctly stated that it was necessary to collect the result for the 0% sodium chloride solution and yeast mixture, **SY** by referring to a control experiment.

(iv) Some candidates correctly stated the value of the smallest division on the scale of their thermometer and calculated the actual error when measuring an increase in temperature using this thermometer was ± half the value of the smallest division multiplied by two.

(v) Some candidates correctly suggested that the error that caused the highest temperature recorded to be inaccurate was the loss of heat to the surroundings.

(vi) Many candidates correctly described how the independent variable (concentration of sodium chloride solution) could be standardised by using either 0% **S** or a stated concentration of **S**. Many candidates correctly described how the procedure could be modified to investigate the concentration of hydrogen peroxide by using at least 5 concentrations of hydrogen peroxide and using the appropriate means of diluting the hydrogen peroxide, either by simple or serial dilution.

(c) (i) The majority of candidates drew the graph, using the headings given in the table, with percentage concentration of copper sulfate on the *x*-axis and rate of catalase activity / number of bubbles released per minute on the *y*-axis. The better candidates used scales of 0.05 to 2 cm, labelled each 2 cm for the *x*-axis and 10 to 2 cm, labelled each 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting each of the points.

(ii) Some candidates correctly stated that the relationship between the concentration of copper sulfate solution and the activity of the catalase could be explained by reference to the copper sulfate acting as an inhibitor resulting in fewer enzyme-substrate complexes being formed.

Question 2

(a) (i) Credit was awarded to candidates whose drawings showed the correct proportions and did not include any shading. The better candidates gained credit for drawing the correct shape of the vascular bundle and the correct proportion of the xylem tissue. Many candidates gained credit for using one label line to identify the xylem.

(ii) Some candidates produced drawings using a sharp pencil which did not include any shading and used most of the space provided. Many candidates were able to draw four cells, two cells from the epidermis and two cortex cells which touched each other and at least one of the epidermal cells. The better candidates drew all the cells with double lines representing the cell walls. The most common error was to draw lines that did not meet up precisely or were too thick. Most candidates used one label line and label to identify the cell wall of one cell.

(b) (i) Many candidates correctly measured the length of line **A** in millimetres, showed this number multiplied by 1000 and divided by 125, then gave the correct answer. The most common errors were not including units for the length of line **A** and not showing all the steps in the calculation.

(ii) Many candidates presented the simplest ratio of the radius of the stem in Fig. 2.1 to the length of an air space (line **A**) correctly as a larger whole number to a smaller whole number. This might have required changing 825**:**320 to the simplest ratio of 165**:**64.

(iii) Many candidates correctly suggested that the plant shown in Fig. 2.1 might grow in a wet habitat and that the observable feature is the air spaces.

(c) Many candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed **K1** and the other headed Fig. 2.1. The majority of candidates were able to gain full credit for recording three observable differences between the two specimens.

BIOLOGY

Paper 9700/34
Advanced Practical Skills 2

Key Messages

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

Candidates should be aware of how to standardise variables, e.g. use of a syringe to ensure that the same volume is used for all samples. Candidates should be able to identify the independent and dependent variables in an experiment and explain how they could be investigated.

Candidates should be able to assess the risk of a procedure. A risk assessment could include judging that the use of methylene blue would be a low risk whilst using acidic solutions would be a medium or high risk.

When making observations using a microscope, candidates should be able to draw the observable features and ensure correct proportions.

Candidates should be able to identify anomalous results and be aware that these should not be included in the calculation of a mean.

Candidates should be able to calculate the actual length of a feature using an eyepiece graticule and the calibration from an eyepiece graticule. Candidates should ensure they accurately count the number of divisions and then use the appropriate calculation.

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 when marking the candidates' scripts.

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

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

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

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

Comments on Specific Questions

Question 1

(a) Many candidates correctly stated that the hazard was low risk.

(b) (i) The majority of candidates gained credit for drawing at least two more sizes of plant tissue and showing how they would be cut by halving the previous size. The most common error was to not retain one sample at each size for use in the experiment.

(ii) Many candidates gave the correct dimensions for the plant tissues, however, only the better candidates were able to correctly calculate the surface area. The most common error was to multiply the dimensions.

(iii) Whilst most candidates correctly stated that the same volume should be used, many did not identify the use of a syringe as the method by which this could be achieved.

(iv) The majority of candidates organised their results clearly by presenting a ruled table. The better candidates included an appropriately detailed heading for the independent variable (surface area / mm^2) and the dependent variable (number on the scale). The majority of candidates gained credit for recording values for at least four different sized pieces and for the correct trend in the recorded results. The better candidates recorded values for repeated results.

(v) The majority of candidates correctly identified that a random error affected the trend in the results. The better candidates were able to explain the reasoning for their choice.

(vi) Many candidates correctly identified diffusion as the method by which methylene blue solution was released from the stained plant tissue. The most common error was to describe osmosis and methylene blue moving with the water.

(vii) The majority of candidates were able to describe how to standardise the independent variable (surface area). Many candidates correctly described how the procedure could be modified to investigate the effect of temperature, by using at least 5 different temperatures standardised by use of a thermostatically-controlled water-bath.

Question 2

(a) (i) Many candidates were able to draw 6 starch grains. Some candidates produced drawings using a sharp pencil which did not include any shading and used most of the space provided. The better candidates drew the correct shape of all the starch grains, with many showing the differing sizes. The most common error was to draw lines that did not meet up precisely or were too thick. Some candidates did not include the observable features on the starch grains.

(ii) Many candidates correctly identified the type of starch grain as L.

(iii) Many candidates correctly noted that the blue/black staining from the iodine obscured the features.

(b) (i)(ii) Many candidates correctly identified the anomalous result in the table. However, many still included this value in the calculation of the mean

(iii) The majority of candidates drew the chart, using the headings given in the table, with type of maize on the *x*-axis and mean size of starch grains / μm on the *y*-axis. The better candidates used equally spaced equal bar widths on the *x*-axis and a scale of 0.5 to 2 cm, labelled each 2 cm for the *y*-axis. A common error was to draw lines which were too thick or unruled.

(iv) Some candidates correctly explained the differences in the mean size of the starch grain. The most common error was to describe a lack of nutrients as the cause of the differences.

(c) (i) Most candidates were able to correctly convert the mm into μm.

(ii) Many candidates correctly counted the number of eyepiece graticule divisions and used the previous calculation to show how they would find the actual length of line **Y**. The most common error was to count the larger divisions only or to measure the line with a mm ruler.

(d) Credit was awarded to candidates whose drawings used most of the space provided, showed at least 3 layers of tissue in the correct proportions and did not include any shading. The better candidates gained credit for showing positioning of the vascular bundle. Many candidates gained

credit for using one label line and label to identify the vascular bundle. The most common errors were to draw cells and to draw the whole section rather than just the part indicated in the question.

BIOLOGY

Paper 9700/35
Advanced Practical Skills 1

Key Messages

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

Candidates should be aware of how to standardise variables, e.g. use of a syringe to ensure the same volume is used for all samples. Candidates should be able to identify the independent and dependent variables in an experiment and explain how the independent variable could be investigated.

Candidates should be able to assess the risk of a procedure. A risk assessment could include judging that the use of methylene blue would be a low risk whilst using acidic solutions would be a medium or high risk.

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

Candidates should be able to calculate the actual thickness of a feature using the magnification given. Candidates should ensure they are able to convert mm and cm into mm.

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 when marking the candidates' scripts.

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) Many candidates correctly stated that the level of risk was medium or high. A common error was to give more than one level of risk.

(b) (i) Many candidates stated the correct volume to be used, the most common error was to not identify the use of a syringe as the method by which this volume could be achieved.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. Many candidates included an appropriate heading for the independent variable (solutions) and the dependent variable (colour). The majority of candidates gained credit for recording colours for all six solutions and for the correct trend in the recorded results.

(iii) Many candidates recorded the correct position of pH3, pH4 pH6, **W**, **S1** and **S2** on the scale bar.

(c) (i) The majority of candidates drew the graph, using the headings given in the table, with temperature / °C on the *x*-axis and absorbance of light by the coloured liquid / arbitrary units. The better candidates used scales of 5 to 2 cm, labelled each 2 cm for the *x*-axis and 0.1 to 2 cm, labelled each 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line.

(ii) The majority of candidates correctly estimated the absorbance of light at 40°C with units and showed how this was estimated on the graph by drawing lines from the *x*-axis at 40°C to the plotted line and then drawing a line across to the *y*-axis. The most common error was to omit the units.

(iii) Many candidates correctly identified that an increase in temperature increases the permeability of the cell surface membrane. The better candidates identified that this was a result of the proteins present in the cell surface membranes becoming denatured.

(iv) The majority of candidates were able to state that temperature is standardised using a thermostatically-controlled water-bath.

(v) The better candidates correctly described how the procedure could be modified to investigate the effect of different concentrations of alcohol, by using at least 5 different concentrations and describing how these concentrations are produced, i.e. by serial or simple dilution.

Question 2

(a) (i) Credit was awarded to candidates whose drawings used most of the space provided, showed at least 3 layers of tissue in the correct proportions and did not include any shading. Many candidates gained credit for using one label line and label to identify the xylem. The most common errors were to draw cells and to draw the whole section not just the part indicated in the question.

(ii) The better candidates gained credit for correctly annotating the diagrams to describe the differences between the cells in the pith and the epidermis. The most common errors were to describe the differences below the question and not annotate the diagram or to annotate the incorrect part of the diagram.

(iii) Many candidates were able to draw four cells, with each cell touching at touching two other cells. Some candidates produced drawings using a sharp pencil which did not include any shading and used most of the space provided. The better candidates drew all the cells with double lines representing the cell walls. The most common error was to draw lines that did not meet up precisely or were too thick. Most candidates used one label line and label to identify the cell wall of one cell.

(b) (i) Many candidates correctly measured the length of line **Y** in millimetres, showed this number multiplied by 1000 and divided by 100, then gave the correct answer. The most common errors were not including units for the length of line **Y** and not showing all the steps in the calculation.

(ii) Many candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed Fig. 2.1 and the other headed Fig. 2.2 The majority of candidates were able to gain full credit for recording observable differences between the two specimens.

(iii) Many candidates correctly presented the simplest ratio of the thickness of the leaf grown in sunlight compared to the thickness of the leaf grown in the shade as a larger whole number to a smaller whole number.

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.

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

Candidates should be able to measure area using a grid, counting those half or more within the grid as one whole square and not counting those squares that were less than half a square. When calculating the total surface area of a leaf using a shape placed on the grid it is necessary to indicate on the grid each of the 1 cm x 1 cm squares included in the calculation.

Candidates should be able to describe a procedure to allow the estimation of an unknown concentration from known concentrations. For example, when modifying the investigation to find the sodium chloride concentration of an unknown solution it is necessary to obtain results for at least five concentrations from a known sodium chloride concentration. After calculating the percentage of plasmolysed cells in the known and unknown concentrations the unknown concentration can be estimated by comparison with the results for the known concentrations.

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 when marking the candidates' scripts.

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. The most common

error was to draw lines that did not meet up precisely. Most candidates used one label with a label line to identify the cell wall.

(ii) The majority of candidates gained credit for drawing one cell and drew the cell wall as double lines. The better candidates included the cell membrane and a nucleus in their drawing. Some candidates used one label with a label line to identify the membrane, nucleus or the cytoplasm and stated that the feature was stained.

(b) (i) Many candidates stated the magnification of the objective lens to use was either ×10 or ×40.

(ii) Many candidates stated the total number of cells to count was a total above 10 if using an objective lens of ×10 or, if using an objective lens of ×40, was a total less than 10.

(iii) Many candidates correctly calculated the percentage of cells that were plasmolysed.

(iv) The majority of candidates organised their results clearly by presenting a ruled table. The better candidates included appropriately detailed headings. The majority of candidates gained credit for recording results correctly and for replicates. Good candidates showed the processed results (percentage of cells that were plasmolysed) in their table.

(v) Many candidates correctly identified the significant source of error as the difficulty of judging the degree of plasmolysis for each cell.

(vi) Some candidates correctly explained that the effect of water replacing sodium chloride solution on the cells of the epidermis was the movement of water into the cells by osmosis with reference to the higher water potential outside the cells.

(vii) Many candidates correctly described how the procedure could be modified to find the sodium chloride concentration of an unknown solution was by using at least 5 concentrations of sodium chloride solution and using the appropriate means of diluting the sodium chloride solution, either by simple or serial dilution. The better candidates then compared the plasmolysis of the cells in the unknown solution with plasmolysis of the cells in the known concentrations.

Question 2

(a) (i) The majority of candidates drew the outline of the exposed epidermis of the rolled leaf on Grid 2.1 and showed all the 1 cm x 1 cm squares that were included in the calculation of the surface area. The better candidates did not include any squares less than half a square in their calculation and stated the total surface area with the appropriate units (cm^2).

(ii) Many candidates presented the ratio correctly as a larger whole number to a smaller whole number. This might have required changing 60:27 to the simplest ratio of 20:9.

(b) (i) The majority of candidates drew the graph using the headings given in the table, with number of leaves on the *x*-axis and transpiration rate / μl per minute on the *y*-axis. The better candidates used scales of 2 to 2 cm, labelled each 2 cm, for the *x*-axis and 2 to 2 cm, labelled each 2 cm for the *y*-axis. They also plotted the points exactly with a small cross or a dot in a circle and drew a sharp, clear ruled line or curve that accurately connected each of the points.

(ii) Many candidates showed on the graph how the estimation for the transpiration rate of the plant with 12 leaves was estimated and stated the correct reading using their graph with the appropriate units (μl per minute).

(c) Credit was awarded to candidates whose drawings used most of the space provided, showed at least 3 layers of tissue and did not include any shading. The better candidates gained credit for showing subdivision of the vascular bundle and the correct position of the vascular bundle in the mid-rib. Many candidates gained credit for using one label line and label to identify the xylem.

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

BIOLOGY

Paper 9700/41
A2 Structured Questions

Key messages

- Candidates need be able to combine their own biological knowledge with new information and in new contexts. Many questions require the ability to handle information and solve problems.
- Candidates should be aware that precise answers are particularly important in the shorter questions such as **Question 2(a)** and **Question 5(a)**.

General comments

Candidates found this an accessible paper with every question offering some opportunity to show their knowledge and understanding and to gain some marks. There were many high-performing candidates.

Question 4(a) and **Question 6** proved to be challenging for many candidates. Some had difficulties with questions in which comparisons had to be made, such as **Question 2(c)** and **Question 4(c)(ii)**. IN general, candidates performed well on **Question 9** and **Question 10**.

Comments on specific questions

Section A

Question 1

(a) This question was well answered with most candidates gaining full credit.

(b) (i) The majority of cnaddiates calculated the percentage increase accurately. Some candidates carried out part of the calculation but did not multiply their answer by 100 and so gained only one mark.

(ii) Very few correctly stated that ethanol would have evaporated or that it was metabolised by other microorganisms in the sap. Many said that the high level of ethanol would kill the yeast cells, however this would mean that the ethanol concentration would remain high and just not increase.

Question 2

(a) Most candidates stated penicillin as the other example of a secondary metabolite but several gave *Penicillium*, delftibactin or antibiotic. Many were aware that it was produced when there was a shortage of nutrients or under stress conditions. Its production during the stationary phase and non-requirement for normal metabolism were less frequently mentioned.

(b) There was confusion over the roles of *D. acidovorans* and delftibactin. Many gained partial credit by stating that delftibactin turns soluble gold ions into insoluble gold, and that soluble ions are toxic. Few were able to show that this meant fewer gold ions would enter the bacteria.

(c) This question proved a challenge to many candidates, who struggled to make valid comparisons between the numbers attained by the mutant and wild type bacteria in different situations. Common errors were due to referring to growth rather than numbers of bacteria and in using numerical values derived from the log scale given which could not be interpreted linearly. Many considered the absence of a bar for the wild type in the presence of Au^{3+} ions and delftibactin in terms of it not being able to survive in such conditions. Good candidates were able to show that without Au^{3+} ions

both mutant and wild-type bacteria has similar numbers but with the addition of Au^{3+} ions the numbers of mutant bacteria fell whilst those of the wild-type increased.

(d) This was generally well answered, with most candidates realising that a description of the batch culture method was required and gained full credit. Some thought that Au^{3+} should be added to the culture to encourage the bacteria to secrete delftibactin and others thought that the procedure should take place on the surface of an actual gold deposit. Several thought the best way was to extract the gene for peptide synthase, or delftibactin, insert it into a plasmid of *E. coli* and culture the *E. coli*.

Question 3

(a) This question was generally well answered, with most candidates realising that electrophoresis was involved, and referred to the treatment of the DNA before and after electrophoresis. Some limited their answer to a detailed description of electrophoresis, gaining partial credit. Few mentioned separating the DNA strands. Many referred to using various fluorescent dyes and radioactive markers, but then did not mention their purpose, which was to visualise the DNA sequence. Several candidates incorrectly referred to comparing two different species of birds.

(b) Most candidates knew the process of speciation and were able to correctly apply it to this scenario. The majority of candidates identified it as allopatric speciation caused by geographical isolation and different selection pressures on the two populations of blackcaps. A few candidates also recognised that different behaviours could have led to sympatric speciation. The main error was to name the separated populations as different species before the speciation had taken place. The sequence of events is vital in this answer and a number of candidates were not clear that the two populations did not interbreed and that after a long time this caused reproductive isolation and the formation of different species once the populations were unable to breed. Many candidates recognised that mutation would have led to differences between the two populations.

Question 4

(a) A majority of candidates found this question difficult and did not gain credit. Answers were often muddled with vital steps either missing or incorrect. Many candidates were able to identify the original cross between two wild grasses and that the offspring were sterile. A common misunderstanding was that the offspring produced was a tetraploid and made no reference to chromosome doubling or nondisjunction of chromosomes. A few candidates recognised that the tetraploid gave rise to diploid gametes. Many candidates knew that the tetraploid was involved in a second cross with a diploid wild grass but made mistakes with this step. Few candidates were able to explain the sequence of events from tetraploid to hexaploid.

(b) Most candidates answered correctly.

(c) (i) Many candidates knew that gene isolation was more difficult than extracting mRNA and some candidates identified that mRNA would be found in large amounts in the cytoplasm. A rare answer was to recognise that the gene would be expressed in every cell.

(ii) The majority of candidates did not make reference to the darkness of the bands in the figure provided so did not gain credit here.

(d) (i) The majority of candidates knew that the florescence would indicate the position of SUT but many did not link this with the fact that the antibody would bind with the SUT. A few candidates incorrectly thought that the antibody would trigger an immune response. A small number of candidates mentioned that the tissue would be looked at with a microscope.

(ii) A few candidates gained both marks for this question. A good number of candidates made the link between the presence of SUT in the aleurone layer and the transport of sucrose from the aleurone layer to the endosperm, however only a minority of candidates mentioned that the products of the hydrolysis of starch did not include sucrose and in fact was maltose or eventually glucose.

(iii) Candidates tended to either know the whole outline of the process of translocation well or not at all. A number of candidates continued to write about the SUT from the previous question and did not access any credit. The most common answer was that the process was by mass flow and that water moves by osmosis into the sieve tube element. Some candidates knew that the active part of

the process is the pumping of H^+ ions out of the companion cell which led to the cotransport of sucrose back into the companion cell. Some also knew that the movement of water into the sieve tube increased the hydrostatic pressure but only a few recognised the hydrostatic pressure gradient as being responsible for the mass flow of the phloem sap. A common error was to write that water moves into the phloem rather than, more specifically, into the companion cell or sieve tube.

Question 5

(a) Few candidates could give a definition of the term biodiversity that was detailed enough for full credit. Many candidates wrote about diversity but did not include the word genetic.

(b) (i) The main ideas were realised by some candidates but were not always clearly expressed. Some candidates used the term interbreeding rather than inbreeding when describing the idea that there would be less choice of mates so more chance of inbreeding. Candidates realised that the gibbons would be more at risk from dangers from the outside, e.g. poachers.

(ii) This question was answered well. Candidates knew how Zoos could contribute to the conservation of gibbons. Some candidates wrote about captive breeding, which was not required.

Question 6

(a) Many candidates found this question difficult. Most recognised that ion channels may be affected by the toxin but did not go on to say that this prevented movement of Ca^{2+} or Na^+ ion into the neurone. Many candidates also said that ions would not move into the membrane, rather than the neurone itself. Some mentioned a lack of vesicles fusing with the membrane but did not say that the acetylcholine would not be released. Any references to there being no action potentials or depolarisation frequently did not state in which membrane or neurone.

Many realised that the toxin would act as an inhibitor to an enzyme but did not name the enzyme or that it binds to or blocks the acetylcholinesterase. Some candidates stated that it bound to acetylcholine. Many went onto say that the reaction would not take place but not the consequence of failure to recycle acetylcholine. Again there were references to continuous depolarisation or action potentials but not in the postsynaptic membrane or neurone.

(b) (i) Candidates wrote about receiving the stimulus and sometimes about the transmission of the impulse but rarely linked the two so could not gain credit.

(ii) Few correctly named receptor or generator potential. Common errors included action potential, resting potential or depolarisation.

(iii) This question was poorly answered. The idea that large stimuli meant greater frequency of action potentials was not mentioned by many candidates. Most thought that the larger the stimulus the greater the size of the action potential. A few wrote about the all or nothing law or the idea the all action potentials have the same amplitude which gained partial credit. Occasionally more receptors or more neurones were correctly mentioned.

Question 7

(a) (i) Many candidates answered this correctly stating carbon dioxide concentration or temperature but a significant number stated light intensity. Many lost credit by writing carbon dioxide but omitting concentration.

(ii) Many candidates obtained full credit, usually by stating leaf surface area, number of stomata or number of chloroplasts. Fewer referred to intercellular airspaces or rubisco concentration.

(iii) Very few candidates scored well here. Many mentioned low or no photosynthesis but did not acknowledge that respiration was taking place. Only more able candidates recognised that at **X** the rate of the two reactions were equal.

(b) (i) Many correctly stated RuBP, but there were a number who mentioned rubisco or another molecule in the light dependent or independent stage.

(ii) There were some very confused responses here. Many did not state that the grana are the site of light dependent reactions. Some stated that the grana have ATP or reduced NADP, but not that it produces them. There was a large number of candidates that mentioned that these were formed in the stroma.

(iii) Whilst some candidates stated that there was a lack of ATP and reduced NADP they did not link this to their use in the Calvin cycle, simply stating that a lack of these molecules meant that carbon dioxide could not combine with RuBP. More able candidates scored full credit by mentioning the reduction in the Calvin cycle, less RuBP regeneration and less conversion of GP to TP.

(c) Many candidates gained full credit. The most common error was to simply state chlorophyll rather than chlorophyll a. Thylakoids and reaction centre were often quoted and electron carriers or electron chains were accepted for ETC.

Question 8

(a) (i) Most candidates had difficulty choosing suitable symbols that followed convention. Thus a common error was to use an upper case letter with the wrong superscripts. Since this was codominance, it required the use of two different upper case superscripts. The question about alleles for horns was slightly better answered but many candidates had the answers reversed so did not realise that, in this case, the allele for horns is the recessive one.

(ii) Some candidates gained full credit. A common error was to omit one or other of the options for white, hornless cattle. Candidates who did not choose suitable symbols for part **(i)** were sometimes able to gain credit here by following through their answer using the correct convention.

(b) Many candidates were able to state that humans act as a selecting agent and that animals are crossed to provide benefit for humans. Fewer candidates went on to say that this would lead to a reduction in genetic variation, an increase in inbreeding depression and a loss of hybrid vigour.

Section B

Question 9

(a) Stronger candidates achieved full credit. Some appreciated that these pills contain synthetic hormones although few stated that they would act for longer in the body as they would not be broken down as fast as endogenous hormones. References to oestrogen or progesterone concentrations remaining high in the blood were comparatively rare. Some candidates commented that levels, rather than concentrations, would remain high or that concentrations would increase without further qualification. Many candidates recognised that there would be inhibition of LH and FSH secretion by the anterior pituitary gland although inhibition of GnRH release by the hypothalamus was rarely seen. Nevertheless, good candidates understood that a negative feedback mechanism would be involved. The effect of the pill in preventing ovulation was frequently mentioned, as was the secretion of thick cervical mucus to prevent the entry of sperm. However, there were fewer references to its effect on the endometrium or that it would prevent implantation.

(b) There were some comprehensive accounts seen, with many candidates listing the positive effects, including the regulation of the menstrual cycle, the reduced risk of ovarian cysts or uterine cancer, as well as the reduced risk of pelvic, or uterine, infections, often adding that this was due to the mucous plug in the cervix preventing the entry of bacteria. Many also listed the biological disadvantages of the pill, such as increasing blood pressure or susceptibility to thrombosis. There was also frequent mention of the increased risk of breast cancer and transmission of STDs.

The social and ethical issues were well-addressed by most candidates. Many commented that there would be reduction in unwanted pregnancies, or that couples would be able to plan their families more effectively. The importance of the pill in population control was mentioned. However, there were fewer references to women having control over their fertility although some candidates stated women would be able to choose when they conceive.

The negative social and ethical aspects of the pill attracted more comments, especially from less able candidates. Many candidates also stated that the pill could lead to an increase in promiscuity.

Question 10

(a) There were some excellent descriptions of the features of wind-pollinated plants with suitable explanations. Many candidates stated that the anthers hang out of the flower in order to facilitate wind pollination, often going on to add that the anthers are versatile, allowing them to sway in the wind to enhance the release of pollen grains. Similarly, many commented that the stigmas would also hang out of the flower to trap pollen, with better candidates recognising that feathery, or branched, stigmas would increase the chance of pollination. The majority of candidates understood that small, lightweight pollen grains would be produced in large quantities to enable them to be easily carried in the wind. However, some confused pollen with seeds, stating that feathery extensions would make them more aerodynamic. Many candidates also understood that wind-pollinated flowers would have either small petals or no petals at all, and that nectaries, nectar or scent would be absent as there would be no need to attract insects. However very few linked this to a reduction in energy expenditure by the plant.

(b) Only a few candidates achieved full credit for this question. Many appreciated that there would be an increase in both heterozygosity and genetic variation, but some simply stated that the genetic diversity or the gene pool would be maintained, rather than enhanced. Some referred to outbreeding reducing inbreeding depression and promoting hybrid vigour, often adding that this would then reduce the likelihood of harmful recessive alleles being expressed in the offspring and allow the species to adapt to changing environmental conditions. There was also occasional mention of increased resistance to pests or disease. Weaker candidates gave descriptions of cross-pollination giving rise to new species or outlined the benefit to farmers in producing better crops with greater yield.

BIOLOGY

Paper 9700/42
A2 Structured Questions

Key messages

- Candidates need be able to combine their own biological knowledge with new information and in new contexts. Many questions require the ability to handle information and solve problems.
- Candidates should be aware that precise answers are particularly important in the shorter questions such as **Question 2(a)** and **Question 5(a)**.

General comments

Candidates found this an accessible paper with every question offering some opportunity to show their knowledge and understanding and to gain some marks. There were many high-performing candidates.

Question 4(a) and **Question 6** proved to be challenging for many candidates. Some had difficulties with questions in which comparisons had to be made, such as **Question 2(c)** and **Question 4(c)(ii)**. IN general, candidates performed well on **Question 9** and **Question 10**.

Comments on specific questions

Section A

Question 1

(a) This question was well answered with most candidates gaining full credit.

(b) (i) The majority of cnaddiates calculated the percentage increase accurately. Some candidates carried out part of the calculation but did not multiply their answer by 100 and so gained only one mark.

(ii) Very few correctly stated that ethanol would have evaporated or that it was metabolised by other microorganisms in the sap. Many said that the high level of ethanol would kill the yeast cells, however this would mean that the ethanol concentration would remain high and just not increase.

Question 2

(a) Most candidates stated penicillin as the other example of a secondary metabolite but several gave *Penicillium*, delftibactin or antibiotic. Many were aware that it was produced when there was a shortage of nutrients or under stress conditions. Its production during the stationary phase and non-requirement for normal metabolism were less frequently mentioned.

(b) There was confusion over the roles of *D. acidovorans* and delftibactin. Many gained partial credit by stating that delftibactin turns soluble gold ions into insoluble gold, and that soluble ions are toxic. Few were able to show that this meant fewer gold ions would enter the bacteria.

(c) This question proved a challenge to many candidates, who struggled to make valid comparisons between the numbers attained by the mutant and wild type bacteria in different situations. Common errors were due to referring to growth rather than numbers of bacteria and in using numerical values derived from the log scale given which could not be interpreted linearly. Many considered the absence of a bar for the wild type in the presence of Au^{3+} ions and delftibactin in terms of it not being able to survive in such conditions. Good candidates were able to show that without Au^{3+} ions

both mutant and wild-type bacteria has similar numbers but with the addition of Au^{3+} ions the numbers of mutant bacteria fell whilst those of the wild-type increased.

(d) This was generally well answered, with most candidates realising that a description of the batch culture method was required and gained full credit. Some thought that Au^{3+} should be added to the culture to encourage the bacteria to secrete delftibactin and others thought that the procedure should take place on the surface of an actual gold deposit. Several thought the best way was to extract the gene for peptide synthase, or delftibactin, insert it into a plasmid of *E. coli* and culture the *E. coli*.

Question 3

(a) This question was generally well answered, with most candidates realising that electrophoresis was involved, and referred to the treatment of the DNA before and after electrophoresis. Some limited their answer to a detailed description of electrophoresis, gaining partial credit. Few mentioned separating the DNA strands. Many referred to using various fluorescent dyes and radioactive markers, but then did not mention their purpose, which was to visualise the DNA sequence. Several candidates incorrectly referred to comparing two different species of birds.

(b) Most candidates knew the process of speciation and were able to correctly apply it to this scenario. The majority of candidates identified it as allopatric speciation caused by geographical isolation and different selection pressures on the two populations of blackcaps. A few candidates also recognised that different behaviours could have led to sympatric speciation. The main error was to name the separated populations as different species before the speciation had taken place. The sequence of events is vital in this answer and a number of candidates were not clear that the two populations did not interbreed and that after a long time this caused reproductive isolation and the formation of different species once the populations were unable to breed. Many candidates recognised that mutation would have led to differences between the two populations.

Question 4

(a) A majority of candidates found this question difficult and did not gain credit. Answers were often muddled with vital steps either missing or incorrect. Many candidates were able to identify the original cross between two wild grasses and that the offspring were sterile. A common misunderstanding was that the offspring produced was a tetraploid and made no reference to chromosome doubling or nondisjunction of chromosomes. A few candidates recognised that the tetraploid gave rise to diploid gametes. Many candidates knew that the tetraploid was involved in a second cross with a diploid wild grass but made mistakes with this step. Few candidates were able to explain the sequence of events from tetraploid to hexaploid.

(b) Most candidates answered correctly.

(c) (i) Many candidates knew that gene isolation was more difficult than extracting mRNA and some candidates identified that mRNA would be found in large amounts in the cytoplasm. A rare answer was to recognise that the gene would be expressed in every cell.

(ii) The majority of candidates did not make reference to the darkness of the bands in the figure provided so did not gain credit here.

(d) (i) The majority of candidates knew that the florescence would indicate the position of SUT but many did not link this with the fact that the antibody would bind with the SUT. A few candidates incorrectly thought that the antibody would trigger an immune response. A small number of candidates mentioned that the tissue would be looked at with a microscope.

(ii) A few candidates gained both marks for this question. A good number of candidates made the link between the presence of SUT in the aleurone layer and the transport of sucrose from the aleurone layer to the endosperm, however only a minority of candidates mentioned that the products of the hydrolysis of starch did not include sucrose and in fact was maltose or eventually glucose.

(iii) Candidates tended to either know the whole outline of the process of translocation well or not at all. A number of candidates continued to write about the SUT from the previous question and did not access any credit. The most common answer was that the process was by mass flow and that water moves by osmosis into the sieve tube element. Some candidates knew that the active part of

the process is the pumping of H^+ ions out of the companion cell which led to the cotransport of sucrose back into the companion cell. Some also knew that the movement of water into the sieve tube increased the hydrostatic pressure but only a few recognised the hydrostatic pressure gradient as being responsible for the mass flow of the phloem sap. A common error was to write that water moves into the phloem rather than, more specifically, into the companion cell or sieve tube.

Question 5

(a) Few candidates could give a definition of the term biodiversity that was detailed enough for full credit. Many candidates wrote about diversity but did not include the word genetic.

(b) (i) The main ideas were realised by some candidates but were not always clearly expressed. Some candidates used the term interbreeding rather than inbreeding when describing the idea that there would be less choice of mates so more chance of inbreeding. Candidates realised that the gibbons would be more at risk from dangers from the outside, e.g. poachers.

(ii) This question was answered well. Candidates knew how Zoos could contribute to the conservation of gibbons. Some candidates wrote about captive breeding, which was not required.

Question 6

(a) Many candidates found this question difficult. Most recognised that ion channels may be affected by the toxin but did not go on to say that this prevented movement of Ca^{2+} or Na^+ ion into the neurone. Many candidates also said that ions would not move into the membrane, rather than the neurone itself. Some mentioned a lack of vesicles fusing with the membrane but did not say that the acetylcholine would not be released. Any references to there being no action potentials or depolarisation frequently did not state in which membrane or neurone.

Many realised that the toxin would act as an inhibitor to an enzyme but did not name the enzyme or that it binds to or blocks the acetylcholinesterase. Some candidates stated that it bound to acetylcholine. Many went onto say that the reaction would not take place but not the consequence of failure to recycle acetylcholine. Again there were references to continuous depolarisation or action potentials but not in the postsynaptic membrane or neurone.

(b) (i) Candidates wrote about receiving the stimulus and sometimes about the transmission of the impulse but rarely linked the two so could not gain credit.

(ii) Few correctly named receptor or generator potential. Common errors included action potential, resting potential or depolarisation.

(iii) This question was poorly answered. The idea that large stimuli meant greater frequency of action potentials was not mentioned by many candidates. Most thought that the larger the stimulus the greater the size of the action potential. A few wrote about the all or nothing law or the idea the all action potentials have the same amplitude which gained partial credit. Occasionally more receptors or more neurones were correctly mentioned.

Question 7

(a) (i) Many candidates answered this correctly stating carbon dioxide concentration or temperature but a significant number stated light intensity. Many lost credit by writing carbon dioxide but omitting concentration.

(ii) Many candidates obtained full credit, usually by stating leaf surface area, number of stomata or number of chloroplasts. Fewer referred to intercellular airspaces or rubisco concentration.

(iii) Very few candidates scored well here. Many mentioned low or no photosynthesis but did not acknowledge that respiration was taking place. Only more able candidates recognised that at **X** the rate of the two reactions were equal.

(b) (i) Many correctly stated RuBP, but there were a number who mentioned rubisco or another molecule in the light dependent or independent stage.

(ii) There were some very confused responses here. Many did not state that the grana are the site of light dependent reactions. Some stated that the grana have ATP or reduced NADP, but not that it produces them. There was a large number of candidates that mentioned that these were formed in the stroma.

(iii) Whilst some candidates stated that there was a lack of ATP and reduced NADP they did not link this to their use in the Calvin cycle, simply stating that a lack of these molecules meant that carbon dioxide could not combine with RuBP. More able candidates scored full credit by mentioning the reduction in the Calvin cycle, less RuBP regeneration and less conversion of GP to TP.

(c) Many candidates gained full credit. The most common error was to simply state chlorophyll rather than chlorophyll a. Thylakoids and reaction centre were often quoted and electron carriers or electron chains were accepted for ETC.

Question 8

(a) (i) Most candidates had difficulty choosing suitable symbols that followed convention. Thus a common error was to use an upper case letter with the wrong superscripts. Since this was codominance, it required the use of two different upper case superscripts. The question about alleles for horns was slightly better answered but many candidates had the answers reversed so did not realise that, in this case, the allele for horns is the recessive one.

(ii) Some candidates gained full credit. A common error was to omit one or other of the options for white, hornless cattle. Candidates who did not choose suitable symbols for part **(i)** were sometimes able to gain credit here by following through their answer using the correct convention.

(b) Many candidates were able to state that humans act as a selecting agent and that animals are crossed to provide benefit for humans. Fewer candidates went on to say that this would lead to a reduction in genetic variation, an increase in inbreeding depression and a loss of hybrid vigour.

Section B

Question 9

(a) Stronger candidates achieved full credit. Some appreciated that these pills contain synthetic hormones although few stated that they would act for longer in the body as they would not be broken down as fast as endogenous hormones. References to oestrogen or progesterone concentrations remaining high in the blood were comparatively rare. Some candidates commented that levels, rather than concentrations, would remain high or that concentrations would increase without further qualification. Many candidates recognised that there would be inhibition of LH and FSH secretion by the anterior pituitary gland although inhibition of GnRH release by the hypothalamus was rarely seen. Nevertheless, good candidates understood that a negative feedback mechanism would be involved. The effect of the pill in preventing ovulation was frequently mentioned, as was the secretion of thick cervical mucus to prevent the entry of sperm. However, there were fewer references to its effect on the endometrium or that it would prevent implantation.

(b) There were some comprehensive accounts seen, with many candidates listing the positive effects, including the regulation of the menstrual cycle, the reduced risk of ovarian cysts or uterine cancer, as well as the reduced risk of pelvic, or uterine, infections, often adding that this was due to the mucous plug in the cervix preventing the entry of bacteria. Many also listed the biological disadvantages of the pill, such as increasing blood pressure or susceptibility to thrombosis. There was also frequent mention of the increased risk of breast cancer and transmission of STDs.

The social and ethical issues were well-addressed by most candidates. Many commented that there would be reduction in unwanted pregnancies, or that couples would be able to plan their families more effectively. The importance of the pill in population control was mentioned. However, there were fewer references to women having control over their fertility although some candidates stated women would be able to choose when they conceive.

The negative social and ethical aspects of the pill attracted more comments, especially from less able candidates. Many candidates also stated that the pill could lead to an increase in promiscuity.

Question 10

(a) There were some excellent descriptions of the features of wind-pollinated plants with suitable explanations. Many candidates stated that the anthers hang out of the flower in order to facilitate wind pollination, often going on to add that the anthers are versatile, allowing them to sway in the wind to enhance the release of pollen grains. Similarly, many commented that the stigmas would also hang out of the flower to trap pollen, with better candidates recognising that feathery, or branched, stigmas would increase the chance of pollination. The majority of candidates understood that small, lightweight pollen grains would be produced in large quantities to enable them to be easily carried in the wind. However, some confused pollen with seeds, stating that feathery extensions would make them more aerodynamic. Many candidates also understood that wind-pollinated flowers would have either small petals or no petals at all, and that nectaries, nectar or scent would be absent as there would be no need to attract insects. However very few linked this to a reduction in energy expenditure by the plant.

(b) Only a few candidates achieved full credit for this question. Many appreciated that there would be an increase in both heterozygosity and genetic variation, but some simply stated that the genetic diversity or the gene pool would be maintained, rather than enhanced. Some referred to outbreeding reducing inbreeding depression and promoting hybrid vigour, often adding that this would then reduce the likelihood of harmful recessive alleles being expressed in the offspring and allow the species to adapt to changing environmental conditions. There was also occasional mention of increased resistance to pests or disease. Weaker candidates gave descriptions of cross-pollination giving rise to new species or outlined the benefit to farmers in producing better crops with greater yield.

BIOLOGY

Paper 9700/43
A2 Structured Questions

Key messages

- Candidates need be able to combine their own biological knowledge with new information and in new contexts. Many questions require the ability to handle information and solve problems.
- Sequences of events such as immune system activation (**Question 2**) and oogenesis (**Question 9**) involve both names and processes. Candidates need to know the names of the stages as well as the linking processes.
- Candidates need to be offered opportunities throughout the course to form opinions, weigh up data to come to a conclusion and make reasoned judgements, as in **Question 2(c)(ii)**.
- Candidates should use of terminology correctly. For example, in **Question 3**, **Question 4** and **Question 8**, the word allele is needed to convey specific meaning in preference to the more general term gene. Similarly, in **Question 7** and **Question 9**, candidates should be clear in their use of the word chlorophyll versus chloroplast.

General comments

Candidates found this an accessible paper with every question offering some opportunity to show their knowledge and understanding and to gain some marks. There were many high-performing candidates.

Generally candidates were most successful on **Question 1** (recall and understanding of respiration), **Question 5** (conservation), **Question 7** (photosynthesis) and **Question 9** (oogenesis and the menstrual cycle). The genetics problem on sex linkage was completed successfully by the majority. Questions using data sources such as graphs in **Question 2(c)** and **Question 3(b)**, tested the ability to recognise and clearly describe patterns and trends and to draw inferences from them. **Question 4** was poorly answered by many. This may reflect the difficulty candidates have in relating events at the molecular level to the larger physiological level and how this impacts on decisions of clinical significance.

Comments on specific questions

Question 1

(a) (i) Candidates applied their knowledge of anaerobic respiration to correctly identify compounds **W**, **X** and **Y** as ethanal, carbon dioxide and reduced NAD. The commonest errors were to give **Y** as reduced NADP, or as NAD alone without indicating that it carries hydrogens or is reduced at this point in the metabolic pathway.

(ii) Differences between anaerobic respiration in yeast cells and in human muscle cells were stated clearly, with the most common distinctions being between the end-products lactate and ethanol, or the point that the reaction in yeast contains two steps and is irreversible whereas this is not the case in human muscle cells. Some candidates named the two different dehydrogenase enzymes.

(b) Integrating new information (that dinitrophenol interferes with the proton gradient in mitochondria) with a basic understanding of chemiosmosis proved a challenge to candidates. Marks were scored more often for explaining observation one (fewer ATP molecules produced) and observation three (constant oxygen uptake) than for observation two (more heat energy released). Knowledgeable candidates related observation one to fewer protons passing through ATP synthetase stalked particles on the inner mitochondrial membrane. Constant oxygen uptake was correctly linked to

electron flow continuing and the role of oxygen as the final electron acceptor. Very few candidates linked the idea of energy released from the flow of electrons in the electron transport chain to the release of heat energy.

Question 2

(a) Candidates' knowledge of the immune system was variable. Some answers were very good and clearly described the sequence of events resulting in antibody formation after vaccination with NicVAX. Clonal selection and clonal expansion were stated or described as well as correct accounts of how B-lymphocytes mature and differentiate to become plasma cells. The role of T-helper cells was described by some candidates. Weaker candidates made little distinction between different types of lymphocytes and showed little understanding of the key processes occurring in an immune response.

(b) Most candidates could describe how hybridoma cells are formed. Details such as the extraction of plasma B lymphocytes from the spleen of a small mammal and the fusion with myeloma cells were well-known. Few mentioned the use of a fusogen such as PEG to accomplish this step. Many answers stopped short of explaining how the specific hybridoma cells that produce anti-nicotine antibody are identified and some references to culturing the cells did not state that mass production would ensue.

(c) (i) Most candidates used the graph to correctly describe an increase in nicotine concentration from 0-30 minutes, but few went on to summarise the subsequent decrease and gradual increase. Poorer answers did not describe the results for nicotine only and referred to other data for nicotine + Nic311 or Nic-IgG antibodies.

(ii) This question required candidates to evaluate the extent to which the data supported the founding hypothesis of the experiment. This is a skill that candidates find difficult. It was important that candidates used the graph in Fig. 2.1, referring to the results from the two different anti-nicotine antibodies for example, rather than just referring to the effects of NicVAX in general. The commonest comments to earn credit were accurate comparisons of figures read from the graph with all supporting units and *x*- and *y*-coordinates, with the general trend described as both antibodies causing lower nicotine concentration in the fetal circulation. Many candidates noticed that Nic-IgG was more effective than Nic311. The rarest marks scored were those involving a reasoned judgement or conclusion, such as that the lower nicotine concentration meant fewer side effects on the fetus, or that the presence of the antibodies did not eliminate nicotine from the fetal bloodstream entirely.

(d) Most candidates gave answers that were creditworthy.

Question 3

(a) (i) Few candidates appreciated that the salmon would be deliberately exposed to the viral disease in order for artificial selection to proceed. Knowledge of humans selecting the surviving or healthiest salmon stock for breeding was good however. Better candidates explained the need for these two processes to be repeated over many generations.

(ii) The problems arising from artificial selection were well-known, with terms like inbreeding depression and loss of hybrid vigour scoring most often. Some candidates did not fully describe the concept of harmful recessive alleles being more likely to be expressed in the phenotypes of offspring in an artificially selected population.

(b) (i) This question gave candidates an opportunity to show their skills in describing data from a graph. It was important that candidates followed the instruction to focus on groups **A** and **B** only and not spend time on group **C**. The quality of descriptive answers was high. Candidates had less to say in explanation of the trends, though most realised it was to do with resistance. Answers referring to 'immunity' in this context were penalised.

(ii) Candidates needed to use the details given at the beginning of the question and most did not understand the significance of the question about fish in group **C**. These were a control group of fish to show the baseline death rate of fish kept under the carefully controlled conditions inside the laboratory where the investigation was carried out. Candidates who did not appreciate that the investigation took place inside cited predators and lack of food as reasons for mortality in group **C**.

Pollution was a possibility since chemicals present on the skin of researchers such as sun cream can enter water and harm fish.

Question 4

(a) Candidates struggled with this question mainly due to not using the information given that haemophilia A is a sex-linked condition. Too many recited answers appropriate to screening both parents for an autosomal recessive condition such as cystic fibrosis, rather than realising that there is no need to screen for affected males, but only for carrier females. Candidates often did not use terminology accurately, such as referring to a haemophilia gene rather than, more accurately, a haemophilia allele.

(b) (i) Many candidates incorrectly thought that the removal of the faulty allele from millions of cells in a living human is possible. Gene therapy introduces a dominant allele to work alongside the existing faulty allele. While gene editing and RNA interference techniques exist they do not comprise part of a standard gene therapy augmentation protocol. Answers lacked detail, so that even those who stated a functional allele would be introduced did not link this to production of a functioning protein, to reducing symptoms, or to improving quality of life or lifespan.

(ii) Many candidates who scored poorly in previous sections did succeed here in saying that haemophilia A is caused by a recessive allele. Rarely candidates also said that the serious nature of the disorder merited it as a target for gene therapy treatment.

(c) (i) The greater success of gene therapy using gene *F9* was correctly related to the shorter length of *F9* by most candidates. A few thought that the 'greater than' symbol for *F8* meant that the size of the gene was unknown. Very few appreciated the importance of the small size of the gene for insertion into a vector and in improving the chance of it entering the nucleus of a target cell and integrating into the genome. Candidates mostly just said that the small size made gene therapy easier, which was not credited.

(ii) Candidates tended to repeat the table without offering any new interpretation of what they had read. Most realised that a DNA genome was an advantage for the adenovirus but could not say why, often focusing on its being double-stranded and therefore the same as existing DNA in target cells. Few saw that this saves the step of having to provide reverse transciptase to convert the RNA genome of the retrovirus into functional DNA. Most also realised that high gene expression is an advantage, but did not go on to link this to expression and the production of more of the therapeutic protein. Some considered the high host immune response was an advantage, whereas in fact it is disadvantageous due to the possibility of side-effects and the removal of viral vectors before they reach their target cells.

Question 5

(a) (i) Very few candidates gained full marks on this question. Some responses correctly referred to the genetic diversity within a species but it was not clear that the diversity of habitats or of ecosystems was also important, along with the number of different species present. Many candidates did not refer to species at all.

(ii) The importance of maintaining biodiversity was generally well explained, with many candidates gaining full credit. Most responses referred to its value in the maintenance of food chains, as human resources or to attract eco-tourists. Additional marks were gained by reference to the maintenance of genetic variation, nutrient cycles or climate stability.

(b) (i) Many candidates had difficulty with the first part of this question. A clear description of the general trends shown by the graphs was required for each of the habitats. An inadequate description of how the figures varied from year to year was frequently given. When candidates did describe the trends, some good responses noted the exceptions in particular years that did not fit the overall trends. Candidates were better able to describe the relationship for the period 1990 to 2005, with most realising that for both habitats the relationship was the same.

(ii) Only a few gained full credit, although some candidates did realise that it was difficult to set boundaries to the marine areas or that marine animals moved from place to place, but it was rare to see references to the problem that international ownership complicates organisation of marine reserves or that the public shows less interest in the marine habitat.

Question 6

(a) Most candidates recognised were **C**, where aquaporins and glucose transport proteins are present in tubule wall cells, along with **B**, where tubule wall cells are modified to produce filtration slits. Less well known were **G**, where no aquaporins are present in the tubule wall cells or **J**, where aquaporins are always present in the tubule wall cells but no glucose transport proteins are present.

(b) (i) This calculation proved difficult for many candidates. Many did not realise that, having calculated the difference in the urea concentration between the two diets, it was then necessary to divide by the low protein diet concentration to calculate the percentage increase.

(ii) Some candidates were able to explain how a higher quantity of protein in the diet leads to an increase in the concentration of urea in the urine. A significant number incorrectly described proteins themselves being directly deaminated, instead of the amino acids. Few responses explained that the increased amount of urea in the blood would be filtered into the nephron.

Question 7

(a) (i) Many candidates understood that more light was absorbed by chlorophyll at peak **X** leading to a greater rate of photosynthesis. A few responses also explained that this difference in rate was due to the shorter wavelengths of light having more energy.

(ii) While most candidates correctly explained that most plants appear green because green wavelengths of light are reflected rather than being absorbed, not all the responses referred to the involvement of chlorophyll in this process.

(iii) The role of accessory pigments in the light-dependent stage of photosynthesis was frequently well described as passing energy to the primary pigment or reaction centre. Fewer candidates referred to these accessory pigments being able to absorb wavelengths or colours of light that are not absorbed by the primary pigments.

(b) Many candidates gained maximum credit. Most included enzyme denaturation, an increase in transpiration, stomatal closure and photorespiration, all leading to a decrease in the rate of photosynthesis. Less carbon dioxide fixation, loss of turgor, the involvement of ABA and a reduction in carbon dioxide uptake were other correct ideas quite commonly seen.

(c) Rubisco was recognised by most candidates as the enzyme in the stroma, in addition to the thylakoids as the fluid-filled sacs. Only a few responses were unable to name the circular DNA or the ribosomes that make the chloroplast proteins.

Question 8

(a) The possible genotypes of normal-winged, grey-bodied fruit flies were correctly stated by the majority of candidates.

(b) Candidates who understood the principles of a test cross usually gained maximum credit for crossing the unknown genotype fly with a vestigial wing and ebony body fly and describing the possible outcomes. Most realised that if all offspring show the dominant traits the unknown genotype must be homozygous and if some offspring showed recessive traits the unknown genotype must be heterozygous. The most common omission was not naming the process as a ‘test cross’.

(c) Many candidates gained maximum credit. Essential to this was the recognition that the eye colour alleles must be written as superscripts and that X and Y chromosomes must be shown at all stages. The most common error was the offspring genotypes not being clearly linked to their phenotypes and a significant number of candidates did not include X and Y chromosomes at all. Candidates needed to use the symbols given in the question, so answers involving symbols invented by the candidate were not credited.

Question 9

(a) There were many very good answers for part **(a)** gaining full marks. However, some candidates had memorised the names of the cells involved, but could not explain the processes linking the different stages in oogenesis. There were also problems in the use of correct biological terms, such as the word 'egg' rather than 'ovum'. Generally known facts included that the first part of oogenesis occurs before birth and later stages after puberty. Candidates who knew that the primary oocyte gives rise to the secondary oocyte at ovulation often forgot to mention that a polar body is also produced. Some candidates gave creditworthy detail about the early stages of oogenesis, but then described hormonal changes and unnecessary detail about follicular cells and events of the menstrual cycle, rather than the later stages of oogenesis.

(b) Candidates could summarise the menstrual cycle in general but did not always focus on changes in the uterus. These wrote more about FSH and LH than about oestrogen and progesterone. They also gave little consideration to increases and decreases in concentration of the hormones in the blood. The most common error was to confuse the terms uterus wall (i.e. the muscular myometrium) and uterus lining (endometrium). Some mis-named the endometrium as endothelium. Others said that oestrogen and progesterone are produced without saying that they are then secreted into the bloodstream in order to take effect. Another common error was to state that both oestrogen and progesterone build up the endometrium, rather than oestrogen causing the thickening stage and progesterone maintaining the thickness.

Question 10

(a) Most candidates found this difficult and gave very little specific detail of how wild grass species hybridised in the past and the principles illustrated by these events. Most included vague references to crossing between two plants, two types, or two crops rather than two species. A number of candidates did realise that this initial cross would mean that homologous chromosomes would not pair up and a few responses referred to chromosome doubling or non-disjunction solving this problem and restoring fertility. It was rare to see any attempt at describing the repetition of the hybridisation and chromosome doubling stages to produce a hexaploid. A few references were seen to a second hybridisation but this needed to be linked to a further doubling of chromosome number to gain credit. The marks most frequently gained related to the benefits of hybrid crops having increased yield and showing hybrid vigour. While a few mentioned that new combinations of desired characteristics could result, this was very rarely linked to the idea of the parent species being the source of these characteristics and that a beneficial mixing could occur.

(b) Very few candidates scored well on this section. They tended to write in vague terms about the production of 'superweeds' without considering the various ways in which these could arise. Candidates often focussed on the transfer of pollen or resistance genes from the GM plants but this needed to be more precisely described as being the transfer to either non-GM crop plants (of the same species) or to wild relatives (i.e. related species) to gain credit. Candidates who described the hypothetical possibility of unwanted transfer of the transgene are ignoring the real problem associated with growing herbicide-resistant crops, which is the evolution of herbicide resistance in more than a hundred weed species worldwide due to spontaneous resistance mutations being selected for by the intensive use of one herbicide.

A few responses did gain credit for referring to the GM rape itself possibly behaving as a weed or that hybrids formed might also be invasive leading to environmental problems. Candidates often referred to the potential for adverse effects of herbicide use, but rarely gained credit as this was not usually linked to an environmental or an economic problem. Some candidates described the potential benefits instead of the detrimental effects.

The most common correct point was for the high cost of GM seeds or plants. Some references to human health issues were stated but usually there was no link to a detrimental economic effect.

BIOLOGY

Paper 9700/51
Planning, Analysis and Evaluation

Key messages.

- Planning a method for an investigation is an integral part of this paper so it is important that candidates understand what is required. There are two main issues. Firstly, the method should be workable and give results which are valid and reproducible. Secondly the instructions need to be clear and with enough practical detail for another person to carry out the experiment.
- When evaluating conclusions based on experimental data candidates need to make sure that the experimental data or given information matches the conclusions.
- When analysing data, candidates should look for broad trends and patterns and not just quote individual pieces of unprocessed data.

General comments

Candidates had sufficient time to complete the examination paper. All questions were accessible, although evaluating experimental results and understanding how they can be used to support conclusions, such as in **Question 1(c)** and **Question 2(c)**, caused some problems to candidates.

The standard of answers varied greatly, particularly for **Question 1(b)** where many candidates simply copied the information in the summary of the investigation in the question, while others were able to describe a suitable method. There were also many examples of imprecise language, such as 'about the same' and 'a few drops'.

Comments on specific questions

Question 1

Careful reading of all the information about the mode of action of the described enzymes and the outline of the procedure is essential before starting to answer this type of question.

(a) (i) Most candidates correctly identified the dependent variable. Weaker answers were vague and included concentration of the enzyme, the effect of enzyme, or time.

(ii) The better answers identified all three variables with appropriate methods of control. Weaker answers often included time as a variable, which was not accepted, rather than time interval (between samples). Incorrect answers included variables that had not been controlled.

(iii) Very few candidates gave a clear answer to this question. In many cases terminology was used inaccurately, e.g. chromatography, chromatograms and chromatographs were all used, often within the same answer, to describe the position of products of hydrolysis. Only the best answers showed the understanding that the position of the products of hydrolysis would remain in the same place on successive chromatograms. Some candidates did not gain credit as their answer was about a single chromatogram. Common misconceptions were that the 'spots' would disappear once hydrolysis was complete and that testing with biuret reagent would give a negative result.

(b) Some candidates restricted their answer to a description of chromatography, as required and gained maximum credit. The majority, however, described a method for hydrolysing the proteins, including a lot of detail about controlling variables. Some weaker answers also described using different dilutions of the enzymes and protein solutions. The majority of candidates showed little

evidence in their answers of any practical experience of chromatography. Candidates who had knowledge of this technique gained some credit for describing how to draw a line of origin and how to place the chromatography paper into a solvent.

The best answers included relevant practical details. Many answers also referred to using dye to locate the products of hydrolysis, but very few mentioned that the chromatogram must be dried first. A critical variable, the distance moved by the solvent front, was often omitted.

In general, candidates did not evaluate which were the important variables needing to be controlled for chromatography. There were often long descriptions of cutting paper to exactly the same size, using the same volume of solvent and dye, none of which are likely to have an impact on the validity of the results. Some candidates referred to R_f values, which was not credited unless the formula that included measuring the distance was included in the answer. Weaker answers tended to be imprecise, for example the line of origin was often referred to as the solvent front, samples were applied as lines using a paint brush and the chromatogram allowed to run for inappropriate times, such as 30 seconds, 'about' 15 minutes or left until they ran off the end. In many cases it was not clear that samples from both types of enzyme were being used and that it was necessary to observe or to measure the location of the products of hydrolysis. Only the best answers made a clear statement about which chromatograms should be compared.

The majority of candidates who described how to improve reliability tended to say 'repeat three times and take a mean'. For this investigation it is not appropriate. Candidates needed to make it clear that there should be a minimum of three samples for each enzyme at each time interval. Some credit was allowed for a minimum of three replicates if it was clear that both enzymes had been used. It was also necessary that the taking of a mean was qualified in terms of the distance travelled by the products or their R_f values.

Although many candidates recognised that this was a medium risk experiment, the majority thought it was a low risk. Credit was allowed for those candidates who knew that the solvent used might be flammable and should not be used near open flames. Credit was also allowed for suggesting that the solvent or the dye might be irritant or toxic so that protective gloves should be used. Candidates who had not limited their method to chromatography almost always answered in relation to making enzyme solutions. These answers were not credited.

Almost all candidates described a version of ascending paper chromatography although all the points were equally valid for thin layer, gel or column chromatography. A few candidates confused chromatography and electrophoresis. Some credit was given for common aspects of the two techniques. Weak answers showed little understanding of the principles of chromatography, commonly using the enzyme protein mixture as the solvent and adding dye to the chromatography paper.

Many candidates did not follow the context of the question and incorrectly listed the enzyme as the independent variable, then described how to make an enzyme protease mixture. Similarly, the R_f value was listed as the dependent variable or the stained products, without any indication of what was to be measured. Candidates should be able to write a method that is effectively a practical schedule that could be followed by another person to produce valid results.

(c) Very few candidates gained maximum credit for this question. In some cases this appeared to be the result of misinterpreting the information about how exopeptidases function. In other cases it was related to the candidate's understanding of how chromatography separates the components of a mixture. Many candidates gained credit for their answer for conclusion 1. Better answers also gained credit for their answer to conclusion 2. A few good answers gained credit for conclusion 3 but answers for conclusion 4 were rarely correct. Weaker answers repeated the conclusions given in the question.

Most candidates who gained credit for evaluating conclusion 1 did so for a correct comparison of the time taken for complete digestion. Better answers linked the number of products to the number of bonds broken. For conclusion 2, very few candidates realised that the exopeptidase removed amino acids one at a time from the terminal end of each peptide, but would leave a dipeptide that could not be hydrolysed, making the conclusion invalid. Some answers showed a partial understanding by stating that the enzyme needed three amino acids to function, but this was insufficient to gain credit. Many candidates stated that the 'spots' nearer the origin must be large peptides, suggesting a misconception about the way in which chromatography separates

molecules by solubility, which is not always directly proportional to molecular size. With conclusion 3, answers usually gained credit for a reference to chromatography depending on solubility and not charge. To evaluate conclusion 4 candidates needed to interpret the information about the action of the enzymes and realise that the four products from the endopeptidase would result in additional 'ends' for the exopeptidase to hydrolyse, i.e. provide extra substrate, thus increasing the rate of reaction. Some candidates appreciated that the enzymes might work together, but rarely explained clearly enough to gain credit.

(d) (i) Almost all candidates gave a correct answer.

(ii) Most candidates gave a correct answer. Weaker answers simply stated that the chromatograms looked the same apart from the circled spot or that the 'spots' were in different places. A number of candidates described the mutation of the sickle cell gene and the change in the amino acid from glutamic acid to valine.

Question 2

(a) (i) Most candidates were able to identify the dependent variable. The only common error was to state the side of the leaf sprayed.

(ii) Very few candidates suggested a suitable control. The most common incorrect answer was water. Candidates need to understand that a control should include all aspects of the experimental conditions, except the factor being tested. Most candidates appeared to understand that the test factor was the insecticide, but did not realise that the solvent, in this case the oily liquid, needed to be used as a control.

(b) (i) Candidates who had learned a definition of standard error (S_M) gained credit. There were, however, many candidates showing confusion between standard error and systematic or random error. Others confused standard deviation and standard error.

(ii) Many candidates quoted only one set of data, even though the question asks for results. Candidates were expected to use the data for the control and experimental leaves to find results where the number of aphids differed and the S_M values did not overlap. Many candidates identified group **B** at 24 hours, but did not include the results for group **B** at 48 and 72 hours. Credit was allowed if candidates compared the results of experimental group **A** with experimental group **B**, rather than group **B** experimental compared to the control. The most common reason given was because the numbers have dropped significantly, which does not explain why the values may be significant.

(c) Most candidates were able to comment that spraying the underside of leaves was more effective than spraying the upper surface. Better answers also appreciated that the values for both controls and the group **A** treated leaves had increased in value over the 72 hours. The best answers also noted that after 48 hours for group **B** treated leaves the number of aphids stayed low. Weaker answers tended to compare the control and group **A** treated leaves but to omit group **B**. Weaker answers often stated the number of aphids did not change over time. Many candidates continued to write about what the standard errors showed about the results, which was not required.

(d) (i) Many candidates gave a correct answer. The most common error was a reference to comparing sets of data, rather than comparing the means of two sets of data.

(ii) Although a high proportion of candidates gave a correct response a great many lost credit by, for example, omitting the word 'significant' from the answer or referring to 'the data' rather than the number of aphids. Weaker answers gave an experimental hypothesis. Candidates should be encourage to think of a null hypothesis as having three components: a reference to 'no significant difference', linked to the 'dependent variable being measured' (in this case the number of aphids), which is then linked to the 'two experimental conditions' being tested (in this case the different sides of the leaf sprayed with insecticide).

(iii) Most candidates have a correct answer. The most common errors were to use 5 instead of 25 as the value of n, or give a general formula without giving the value of n.

BIOLOGY

Paper 9700/52
Planning, Analysis and Evaluation

Key messages.

- Planning a method for an investigation is an integral part of this paper so it is important that candidates understand what is required. There are two main issues. Firstly, the method should be workable and give results which are valid and reproducible. Secondly the instructions need to be clear and with enough practical detail for another person to carry out the experiment.
- When evaluating conclusions based on experimental data candidates need to make sure that the experimental data or given information matches the conclusions.
- When analysing data, candidates should look for broad trends and patterns and not just quote individual pieces of unprocessed data.

General comments

Candidates had sufficient time to complete the examination paper. All questions were accessible, although evaluating experimental results and understanding how they can be used to support conclusions, such as in **Question 1(c)** and **Question 2(c)**, caused some problems to candidates.

The standard of answers varied greatly, particularly for **Question 1(b)** where many candidates simply copied the information in the summary of the investigation in the question, while others were able to describe a suitable method. There were also many examples of imprecise language, such as 'about the same' and 'a few drops'.

Comments on specific questions

Question 1

Careful reading of all the information about the mode of action of the described enzymes and the outline of the procedure is essential before starting to answer this type of question.

(a) (i) Most candidates correctly identified the dependent variable. Weaker answers were vague and included concentration of the enzyme, the effect of enzyme, or time.

(ii) The better answers identified all three variables with appropriate methods of control. Weaker answers often included time as a variable, which was not accepted, rather than time interval (between samples). Incorrect answers included variables that had not been controlled.

(iii) Very few candidates gave a clear answer to this question. In many cases terminology was used inaccurately, e.g. chromatography, chromatograms and chromatographs were all used, often within the same answer, to describe the position of products of hydrolysis. Only the best answers showed the understanding that the position of the products of hydrolysis would remain in the same place on successive chromatograms. Some candidates did not gain credit as their answer was about a single chromatogram. Common misconceptions were that the 'spots' would disappear once hydrolysis was complete and that testing with biuret reagent would give a negative result.

(b) Some candidates restricted their answer to a description of chromatography, as required and gained maximum credit. The majority, however, described a method for hydrolysing the proteins, including a lot of detail about controlling variables. Some weaker answers also described using different dilutions of the enzymes and protein solutions. The majority of candidates showed little

evidence in their answers of any practical experience of chromatography. Candidates who had knowledge of this technique gained some credit for describing how to draw a line of origin and how to place the chromatography paper into a solvent.

The best answers included relevant practical details. Many answers also referred to using dye to locate the products of hydrolysis, but very few mentioned that the chromatogram must be dried first. A critical variable, the distance moved by the solvent front, was often omitted.

In general, candidates did not evaluate which were the important variables needing to be controlled for chromatography. There were often long descriptions of cutting paper to exactly the same size, using the same volume of solvent and dye, none of which are likely to have an impact on the validity of the results. Some candidates referred to R_f values, which was not credited unless the formula that included measuring the distance was included in the answer. Weaker answers tended to be imprecise, for example the line of origin was often referred to as the solvent front, samples were applied as lines using a paint brush and the chromatogram allowed to run for inappropriate times, such as 30 seconds, 'about' 15 minutes or left until they ran off the end. In many cases it was not clear that samples from both types of enzyme were being used and that it was necessary to observe or to measure the location of the products of hydrolysis. Only the best answers made a clear statement about which chromatograms should be compared.

The majority of candidates who described how to improve reliability tended to say 'repeat three times and take a mean'. For this investigation it is not appropriate. Candidates needed to make it clear that there should be a minimum of three samples for each enzyme at each time interval. Some credit was allowed for a minimum of three replicates if it was clear that both enzymes had been used. It was also necessary that the taking of a mean was qualified in terms of the distance travelled by the products or their R_f values.

Although many candidates recognised that this was a medium risk experiment, the majority thought it was a low risk. Credit was allowed for those candidates who knew that the solvent used might be flammable and should not be used near open flames. Credit was also allowed for suggesting that the solvent or the dye might be irritant or toxic so that protective gloves should be used. Candidates who had not limited their method to chromatography almost always answered in relation to making enzyme solutions. These answers were not credited.

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(c) Very few candidates gained maximum credit for this question. In some cases this appeared to be the result of misinterpreting the information about how exopeptidases function. In other cases it was related to the candidate's understanding of how chromatography separates the components of a mixture. Many candidates gained credit for their answer for conclusion 1. Better answers also gained credit for their answer to conclusion 2. A few good answers gained credit for conclusion 3 but answers for conclusion 4 were rarely correct. Weaker answers repeated the conclusions given in the question.

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Question 2

(a) (i) Most candidates were able to identify the dependent variable. The only common error was to state the side of the leaf sprayed.

(ii) Very few candidates suggested a suitable control. The most common incorrect answer was water. Candidates need to understand that a control should include all aspects of the experimental conditions, except the factor being tested. Most candidates appeared to understand that the test factor was the insecticide, but did not realise that the solvent, in this case the oily liquid, needed to be used as a control.

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(ii) Although a high proportion of candidates gave a correct response a great many lost credit by, for example, omitting the word 'significant' from the answer or referring to 'the data' rather than the number of aphids. Weaker answers gave an experimental hypothesis. Candidates should be encourage to think of a null hypothesis as having three components: a reference to 'no significant difference', linked to the 'dependent variable being measured' (in this case the number of aphids), which is then linked to the 'two experimental conditions' being tested (in this case the different sides of the leaf sprayed with insecticide).

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Paper 9700/53
Planning, Analysis and Evaluation

Key Messages

- Planning a method for an investigation is an integral part of this paper so it is important that candidates understand what is required. Firstly, the method should be workable and give results which are valid and reproducible. Secondly the instructions need to be clear and with enough practical detail for another person to carry out the experiment.

- When analysing data, as in **Question 2(c)**, candidates should look for broad trends and patterns and not just quote individual pieces of unprocessed data.

General Comments

There were many good responses and no evidence that candidates ran out of time. All the questions were accessible. A significant number of candidates found the statistical questions difficult.

Comments on Specific Questions

Question 1

(a) (i) The majority of candidates correctly identified the type of amylase as the independent variable. The commonest errors were to suggest pH, temperature or enzyme concentrations.

(ii) There were many good responses, although some candidates listed only two variables. Some simply gave the figures for temperature or pH rather than how the temperature or pH was kept at the required value.

(iii) Many candidates suggested a suitable control, such as replacing the enzyme with water or with either boiled enzyme or denatured enzyme. A few candidates suggested heating the mixture of starch plus enzyme to denature the enzyme, which would not work as the reaction would occur until the enzyme denatured. Some candidates gave examples of variables that had been standardised in the investigation. Others removed the starch leaving the enzyme plus water or suggested just water alone.

(b) There were a number of comprehensive accounts seen. Many referred to the products as being naturally coloured, presumably from candidates' practical experience of separating the coloured pigments from leaf extracts, when in fact the information in the question made it clear that a dye needed to be used. Many answers described the hydrolysis procedure, which was not required.

There was some confusion as to what was actually spotted on the three chromatograms, with each of the enzyme mixtures being a common response. There was some credit given for any account which suggested that chromatography was carried out on a solution resulting from the use of each enzyme. Most commonly 3 separate chromatograms were run but it would be acceptable to run all three separately on one larger chromatogram. An important variable to standardise was that the number of applications applied to the origin was the same. Having run the chromatograms, the candidates should then make it clear that they would either observe or count the number of spots or measure the distance moved by each spot. Throughout the account a variety of ways of describing the spots were creditworthy. Candidates needed to include a clear instruction to compare the products. Clear responses also stated what the solvent front was and answered in terms of the solvent front reaching near the end, or reaching a pre-decided point. Some candidates

described letting them run until the spots reach the top, which was not creditworthy as the chromatogram would have over-run.

The key points in the procedure were to have an origin line drawn on the chromatogram near the base and then apply the extract using a piece of apparatus suitable for producing a small dot, such as capillary tubes. Use of a brush or pipette was credited only if qualified as being fine or small. Credit was given for a method of concentrating the product, either by evaporating the original product down or by drying between applications. Many candidates realised that the chromatogram needed to be dipped into the solvent so that the solvent did not reach the origin line. Sealing the chromatogram in some form of container was often mentioned but without explaining that this prevented evaporation or allowed the air inside to become saturated with solvent vapour. Fewer mentioned spraying with dye after the chromatogram had run and many of those who did left out the essential step of drying before spraying.

The majority of candidates who described how to improve reliability tended to say 'repeat three times and take a mean'. However, here it needed to be clear that the repeats were of the particular chromatograms for each hydrolysis product. Since a large number of candidates included all the detail of hydrolysis, this did not often gain credit as it included repeating the actual hydrolysis as well. It was also necessary that the taking of a mean was qualified in terms of the distance travelled by the products or their R_f values.

Many candidates thought this was a low risk investigation, when in fact the solvents used in this type of chromatography are often flammable and both the solvents and dyes are likely to be toxic or at least irritants or allergens. To gain credit, ideas on these areas together with appropriate precautions were needed.

The majority of candidates described paper chromatography, but all the points could be applied equally well to thin layer or gel chromatography which a very small number of candidates described. A few confused chromatography with electrophoresis.

In the weaker responses there were various confused ideas such as adding the enzyme and starch mixture to the chromatography paper before hydrolysis had occurred or floating the whole chromatogram in a trough of solvent.

(c) (i)(ii) The majority of candidates identified chromatogram **B** as alpha amylase and were able to explain this in terms of the number of different products produced by hydrolysis of starch. A significant number of candidates had chromatograms **A** and **C** the wrong way round.

Question 2

(a) (i) The majority of candidates identified the number of rootworms as the dependent variable.

(ii) The majority of candidates selected appropriate features of the experimental design and described them accurately. In some cases the responses were too general to gain full credit. For example four plots were used for each treatment and this needed to be stated rather than just 'several'. The general term 'large sample' unqualified was not credited as it was not clear what was being referred to. Likewise statements such as 'five random plants were chosen' did not gain credit unless further qualified with a way of randomising where the soil samples were collected, or with the idea of randomising the five samples per plot. Some candidates suggested what they would plan to do to ensure reliability rather than selecting from the information given. This resulted in lists of what had not been standardised such as light intensity, mineral availability, temperature or the pH of the soil.

(b)(i)(ii) Most candidates identified the NBt plots as the control and then provided an appropriate way in which the results from the control plot could be used to analyse the data from the other two plots. At the most basic level this was to allow a comparison with the experimental plots, and good responses took this further by suggesting either subtracting the two sets of data or looking at the comparisons in terms of allowing an estimation of the relative effectiveness of the different treatments.

(c) Although there was a tendency on occasions to simply quote raw data for individual days, there were also many instances where the candidates appreciated the overall trends. There was credit for both seeing the overall changes with time where the numbers of rootworms in both treatments

decreased over the two year period, and also for seeing that overall the numbers of rootworms were lower in the Bt plots than in the non BT plots plus insecticide, suggesting the Bt treatment was more effective. Other creditworthy points were that the root worms in the control plots decreased, but not as much as the treatments and in all cases the numbers fluctuated.

(d) (i) In general, candidates found this difficult. Whilst many realised that a null hypothesis means that there is no significant difference, they then chose the wrong parameter to compare and stated that there was no significant difference between the two treatments.

(ii) Very few candidates gained full credit. Some tried to find the degrees of freedom between all three pairs of conditions, which is not statistically valid. Many stated the formula as $(n - 1) + (n - 1)$ which gained some credit, but did not realise that $n = 20$ (5 samples from each of 4 plots).

(e) The majority of candidates realised that not significant meant that the results were due to chance. A few stated that not significant meant that it was not due to chance. The understanding of p was often confused. At the value given, it means that there is a greater that 95% chance (probability) that the results are due to chance. Many responses stated that it meant there was a more than 5% chance (probability) that it was due to chance, which was not credited.