BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

Almost all of the stronger candidates answered this question correctly. The weaker candidates found it more challenging with a fifth of them answering correctly. Over half of these responses incorrectly calculated that the white blood cells would be less than 1 m in diameter, which would be small for a prokaryotic cell.

Questions 2, 7, 24 and 28

Over four fifths of the stronger candidates and at least a third of the weaker candidates answered these correctly.

Questions 3, 4, 5, 13, 14, 19, 20 and 21

Over four fifths of the stronger candidates and two fifths of the weaker candidates answered these correctly.

Question 6

Nearly half of all candidates answered this correctly. Almost a quarter of the weaker candidates incorrectly suggested that none of the solutions would test positive for reducing sugars and three tenths of all candidates incorrectly selected that when testing the glucose solution, more glucose would be present when testing for non-reducing sugars than when testing for reducing sugars.

Question 8

Over nine tenths of the stronger candidates answered this correctly. Half of the weaker candidates incorrectly indicated that molecule Z contained more than two different fatty acids.

Question 9

Over nine tenths of the stronger candidates answered correctly, whilst nearly a third of the weaker candidates answered correctly.

Question 10

Almost all of the stronger candidates answered correctly, whilst approaching a quarter of the weaker candidates answered correctly.

Question 11

Over nine tenths of the stronger candidates answered correctly, whilst three quarters of the weaker candidates answered incorrectly.

Question 12

Over two thirds of all candidates knew that the *y*-axis should be absorbance, and approaching two fifths of all candidates knew that the calibration curve would produce a straight line.

Question 15

Two fifths of all candidates incorrectly suggested that facilitated diffusion requires ATP.

Question 16

Less than half of all candidates answered this correctly. Almost two fifths incorrectly selected option **C**, omitting to include that the solute could be removed from the cell by exocytosis.

Question 17

One third of all candidates answered this correctly. The block with one dimension smaller than any of the other blocks will change most quickly.

Question 18

Whilst most of the stronger candidates answered correctly, over half of the weaker candidates selected options including process 2. The repair of cell structures by protein synthesis does not require mitosis.

Question 22

Over half of the stronger candidates, and nearly a third of the weaker candidates answered correctly. Just over half of all candidates appreciated that after the first division in the culture medium containing ^{14}N, 100% of the molecules would contain one strand with ^{15}N and one strand with ^{14}N.

Question 23

Over three fifths of all candidates incorrectly selected option **A**. The total number of bases in the DNA molecule was 2   2 600 150, since the length of the molecule was given in base pairs.

Question 25

The majority of stronger candidates and almost three quarters of the weaker candidates were able to identify the non-transcribed strand, with almost three tenths selecting option **C** which shows two strands, not one.

Question 26

Whilst two thirds of all candidates correctly knew that suberin is found in the Casparian strip, only two fifths of all candidates correctly selected option **A**.

Question 27

This was answered correctly by four fifths of all candidates.

Question 29

Less than a quarter of all candidates answered this correctly. Statement 1 is incorrect as it is the energy released during the transport of protons through the co-transporter that drives the movement of sucrose. Statement 3 is incorrect as the sucrose moves into the phloem sieve tube elements through the plasmodesmata.

Question 30

Four fifths of all candidates answered this correctly.

Question 31

Over two thirds of the stronger candidates and approaching a fifth of the weaker candidates answered this correctly.

Question 32

Less than a third of all candidates answered this correctly. The atrioventricular valve closes at point 1 on the graph and opens at point 4, whilst the semilunar valves open at point 2 and close at point 3. Therefore, they are both closed between points 1 and 2 and points 3 and 4.

Question 33

Almost three quarters of the stronger candidates answered this correctly. In the capillaries surrounding the alveolus, haemoglobin needs to be free to become oxygenated and carbon dioxide needs to be released for gas exchange to occur.

Question 34

The majority of stronger candidates answered this correctly. Weaker candidates selected each option almost equally.

Question 35

Less than three tenths of all candidates answered this correctly. Over four fifths of the weaker candidates selected options containing the incorrect statement 1. The epithelial cells present in the photomicrograph are not squamous cells, which are present in the alveoli.

Question 36

A quarter of all candidates answered this correctly. Over half of the weaker candidates incorrectly selected options containing statement 1. However, there are no cilia in the alveoli. Over a third of all candidates incorrectly indicated that elastic fibres keep the alveoli open.

Question 37

Just over two fifths of all candidates knew that all three statements about antibiotics were correct.

Question 38

Half of all candidates were able to draw the correct conclusions from the information provided.

Question 39

Over half of all candidates were able to use the information to determine which blood groups could be given to a person with blood group AB.

Question 40

Over two fifths of all candidates answered this correctly.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 4, 5, 8, 17, 23, 24, 25, 26 and 36

Over four fifths of the stronger candidates and two fifths of the weaker candidates answered these correctly.

Question 2

Whilst over four fifths of all candidates realised that the magnification would be unchanged, less than a third appreciated that as the wavelength increased the resolution would decrease.

Question 3

Over nine tenths of the stronger candidates answered this correctly whilst the weaker candidates selected each option almost equally.

Questions 6, 9 and 40

Over four fifths of all candidates answered these correctly.

Question 7

Whilst almost all candidates knew that water has properties dependent on hydrogen bonds, approximately half of all respondents knew that this was also true for cellulose and haemoglobin.

Questions 10, 11, 16 and 37

At least three fifths of all candidates answered these correctly.

Question 12

Almost all of the stronger candidates and nearly a fifth of the weaker candidates answered correctly.

Question 13

Just over two fifths of all candidates answered correctly. Over half of the weaker candidates incorrectly selected options **A** or **B**.

Question 14

Approximately half of all candidates realised that the cells were placed in a salt solution to prevent the cells from taking in or losing water by osmosis.

Question 15

The majority of stronger candidates answered this correctly. Many weaker candidates incorrectly indicated that facilitated diffusion requires ATP and that phagocytosis does not require ATP.

Question 18

A quarter of all candidates incorrectly selected the statement that telomeres prevent all damage to DNA.

Question 19

Almost all of the stronger candidates answered correctly. Nearly half of the weaker candidates incorrectly selected options **A** or **B**. They needed to appreciate that DNA is replicated in the S phase.

Question 20

A third of all candidates incorrectly selected options that included centriole replication. This process occurs during interphase not prophase.

Question 21

A quarter of all candidates identified the correct description of ATP structure.

Question 22

Whilst the majority of stronger candidates answered correctly, almost three quarters of weaker candidates selected options including DNA replication. DNA replication requires DNA polymerase not RNA polymerase.

Question 27

About two fifths of all candidates answered this correctly. Suggestion 1 is valid since dissolved metal ions could follow this route. Suggestion 2 is also valid since transport of water and dissolved metal ions in the xylem is via the apoplastic pathway and transport across the endodermis is via the symplastic pathway. Suggestions 3 and 4 are not valid. In 3, there will be slower transpiration and so lower accumulation and for 4 the rate of transpiration is not altered by a slow transpiration stream.

Question 28

Two fifths of all candidates could identify movement of water through intercellular spaces as being the apoplast pathway.

Questions 29 and 34

The majority of stronger candidates answered these correctly and the weaker candidates selected each option almost equally.

Question 30

Over nine tenths of all candidates knew that ventricular pressure increases, and half of all candidates also realised that the aortic pressure would also increase to gain credit.

Question 31

Three fifths of the weaker candidates could not identify option **D** as a plan diagram of a major vein.

Question 32

Whilst three quarters of the stronger candidates answered correctly, approaching a fifth of the weaker candidates answered correctly.

Question 33

This question tested a new learning outcome on the syllabus and less than two fifths of all candidates answered this correctly. **B** is incorrect since a net hydrostatic pressure change is not clear enough, additionally the relative water potentials of the tissue fluid and plasma are important.

Question 35

One third of all candidates answered this correctly. Many candidates incorrectly indicated that the alveoli walls are made of cuboidal epithelium instead of squamous epithelium. Additionally almost a third incorrectly selected option **D**. Only the trachea has rings of cartilage; the cartilage in the bronchi occurs in irregular blocks.

Question 38

The majority of stronger candidates gained credit. Over two fifths of weaker candidates incorrectly thought statement 1 was correct and over three fifths of the weaker candidates incorrectly thought statement 3 was correct.

Question 39

Almost a third of the weaker candidates and two thirds of the stronger candidates were able to process the information and correctly select option **D**.

BIOLOGY

Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

The majority of stronger candidates answered this correctly, whilst half of the weaker candidates incorrectly selected option **C**.

Questions 2, 5, 15, 18, 20, 22 and 29

Whilst at least three fifths of the stronger candidates answered these correctly, the weaker candidates selected each option almost equally.

Question 3

Over two thirds of the stronger candidates and a tenth of the weaker candidates realised that the largest and heaviest cell structure would be the nucleus where mRNA production occurs.

Question 4

One third of all candidates answered this correctly, whilst over half of the weaker candidates incorrectly selected glucose.

Questions 6, 7, 16, 21, 31, 35 and 40

More than three fifths of all candidates answered these questions correctly.

Question 8

Almost four fifths of the weaker candidates were unable to identify the structure of fructose.

Question 9

Over seven tenths of the weaker candidates did not realise that trehalose would be formed by condensation of two α-glucose units so would have the formula $C_{12}H_{22}O_{11}$ and not $C_{12}H_{24}O_{12}$.

Question 10

Over four fifths of the stronger candidates and a quarter of weaker candidates answered correctly.

Question 11

Approaching three tenths of the weaker candidates correctly identified the molecule containing peptide bonds.

Question 12

Over three fifths of the weaker candidates incorrectly indicated that statement 2 was correct.

Question 13

Two fifths of all candidates answered this correctly.

Question 14

Whilst the majority of stronger candidates were able to evaluate the information provided correctly, over half of the weaker candidates incorrectly suggested hat water would enter the cells.

Question 17

Half of all candidates answered this correctly.

Question 19

Over two thirds of all candidates incorrectly suggested that statement 2 was correct. It is centromeres, not centrioles, that attach chromosomes to the spindle during metaphase of mitosis.

Question 23

Approaching half of all candidates answered correctly with over a fifth of weaker candidates incorrectly selecting the statement that RNA contains deoxyribose.

Question 24

Over three fifths of the stronger candidates were able to use the diagram to correctly establish that **D** was thymine.

Question 25

Over four fifths of all candidates answered this correctly.

Question 26

Most of the stronger candidates could identify the xylem in the diagram and a fifth of the weaker candidates answered correctly.

Question 27

Over a third of all candidates incorrectly indicated that the vascular bundle was from a root.

Questions 28 and 30

Over half of all candidates answered these correctly.

Question 32

Over four fifths of the stronger candidates and approaching a fifth of the weaker candidates correctly interpreted the graph.

Question 33

Over two fifths of all candidates incorrectly suggested that the muscle in ventricle walls relaxes during ventricular systole.

Question 34

Approaching three tenths of all candidates answered this correctly.

Question 36

Nearly one third of all candidates answered this correctly, with almost half of all candidates incorrectly identifying slide 1 as trachea. The trachea has C-shaped rings of cartilage.

Question 37

Over three quarters of the stronger candidates answered this correctly. The most common error amongst weaker candidates was to also select the term malarial parasite.

Question 38

Over three fifths of the stronger candidates were able to process the information supplied in order to correctly select option **D**.

Question 39

Almost two fifths of the weaker candidates and three quarters of the stronger candidates were able to interpret the information and correctly select option **B**.

BIOLOGY

Paper 9700/21
AS Level Structured Questions

Key messages

Care in the use of terminology is required when describing the events that occur between transcription and translation. For example, in **Question 6(b)(ii)**, the RNA molecule synthesised during the transcription of the DNA template strand should be termed the primary transcript, as this is comprised of both introns and exons. RNA splicing in post-transcriptional modification produces messenger RNA (mRNA), which is a molecule that consists of exons only, and is the molecule that exits the nucleus.

Candidates should note that when using data in support of an answer, all appropriate units should be included. For example, in **Questions 3(b)**, **3(c)(i)** and **3(c)(ii)**, the correct unit for ATP concentration is $\mu mol / dm^3$.

Candidates should use accurate and precise terminology when constructing responses, For example:

- a plateau in a graph may not mean this is the maximum value
- 'complementary shape' and 'same shape' have different meanings
- use of the term 'size' as a description of length, width, or diameter, for example, is not precise
- comparative language should be used where appropriate to describe changes or differences, such as higher/lower and increases/decreases.

General comments

Candidates should be reminded to make full use of all data and information provided in the question. For example, in **Question 6(c)**, as well as the information provided in the text, **Fig. 6.2** shows that a tRNA molecule has an amino acid attached, its identity, and gives further detail of the anticodon.

Question 3 provided information relating to the action of enzyme action and inhibition that candidates needed to assimilate. It is important that candidates take time to read the information carefully and to pay particular attention to the questions asked. For example, in **Question 3(b)**, **(c)(i)** and **(c)(ii)**, candidates were asked to refer to Fig. 3.2 and Fig. 3.3 to help construct their answer. Many referred only to Fig. 3.3, which prevented them from being able to gain full credit. In addition, for accuracy, the use of a ruler is recommended when reading graphical data, such as that in Fig. 3.2 and Fig. 3.3.

Candidates must make sure that they give precise answers to questions. For example:
In **Question 6(a)**, candidates were asked to name the four bases. This meant that abbreviations were not acceptable as an answer. Similarly, the words 'single' and 'double' are not numbers, so were not accepted.
In **Question 5(b)**, references to the size of the flagellum is insufficient when describing its length.
In **Question 2(c)** candidates should refer to antibodies being degraded or broken down, rather than antibodies disappearing.

It is good practice for candidates to use information provided elsewhere in a question to help them construct a response. However, copying the text and using it as the sole information given in an answer will not attract any credit. For example, in **Question 4(b)(ii)**, no credit can be given for explaining that triglycerides are unsuitable as a component of cell surface membranes because they are hydrophobic, as candidates were given this information in **Question 4(b)(i)**.

Comments on specific questions

Question 1

(a) Most candidates correctly identified tissue **D** as cartilage in **Fig. 1.1**. Although many were able to identify **A** as epithelial tissue, some did not state that it was ciliated. Some candidates could have improved their answer by using more precise terminology, for example by stating that tissue **A** was ciliated epithelial tissue rather than epithelial tissue and stating that tissue **B** is muscle tissue rather than smooth muscle. As the question asked for the names of the tissues, answers such as ciliated epithelial cell or smooth muscle cell were not credited.

(b) Many candidates were able to clearly describe the role of the mucus in maintaining the health of the gas exchange system and scored full credit. However, some referred to the mucus being secreted by goblet cells rather than focusing on the role of the mucous glands, or stated that ciliated epithelial cells, rather than cilia, move the mucus. A few candidates also understood that the layer of mucus acts as a barrier preventing pathogens reaching the epithelial cells.

(c) (i) Please note that, due to an issue with **Question 1(c)(i)**, all candidates were awarded full credit for this question, to make sure that no candidates were disadvantaged.

(ii) Some candidates showed an understanding that the higher saturation of haemoglobin in respiring tissues means that less oxygen will dissociate and therefore reduce the supply to the tissues. Others did not notice that the higher saturation of haemoglobin existed at partial pressures equivalent to those in the tissues and instead interpreted this as a higher saturation of haemoglobin arriving from the lungs. A common misconception was that the faster or deeper breathing that occurs in hyperventilation would result in haemoglobin being loaded with more oxygen. Some candidates described the graphs and needed to go on to use the data to show a difference in the saturation of haemoglobin, within the acceptable range of 2 – 6 kPa O_2 at the tissues.

Question 2

(a) (i) Many answers were seen that correctly identified the process of exocytosis occurring in **Fig. 2.1**. Common errors included endocytosis and phagocytosis.

(ii) Many candidates correctly identified structure **P** in **Fig. 2.1** as the nucleolus and gave a correct function. Common errors were to state that **P** is the nucleus or to give the function of the nucleolus as storing DNA. The question asked candidates to name cell structures, so the full name of the structure should be written out and abbreviations should not be used. In this question, credit was given for stating that **R** is rough endoplasmic reticulum. rather than rough ER or RER. The function of the mitochondrion should be stated as carrying out *aerobic* respiration, rather than respiration. Modification of polypeptides and the formation of vesicles occur in both the Golgi body and rough endoplasmic reticulum.

(b) There were many excellent answers seen describing the hybridoma method of producing monoclonal antibodies. Some candidates stated that the pathogen is injected into the small mammal, rather than the antigen being injected to stimulate an immune response. Some incorrectly suggested that antibodies were extracted and fused with myeloma cells. References to the mixing of plasma cells with myeloma cells were not credited.

(c) Most candidates explained that the use of injected antibodies in the treatment of disease is an example of passive immunity. As such, no immune response is initiated and memory cells are not produced. Only a few candidates explained that the immunity is only temporary because the antibodies are degraded. A common error was to refer to antibiotics rather than antibodies. Many gave detailed accounts of the events that occur in a secondary immune response, which was not required.

Question 3

(a) Most candidates were able to gain full credit for their descriptions of the active site having a shape that is complementary to the substrate, in this case being ATP or the intracellular protein.

(b) Many candidates recognised that the V_{max} of TKR with and without the drug GNF-5 is the same. Some candidates used terms such as ‘levelling up’ or plateau’ instead of ‘reaching maximum activity' or 'V_{max}'. Some were able to develop their answer by referring to the K_m being higher in the presence of GNF-5. Some excellent answers were seen which explained that the data in **Fig. 3.2** showed that the inhibition effect decreases as the substrate concentration increases. Candidates often used comparative data in support of their explanations, although many of these needed to include the units for the concentration of ATP ($\mu mol / dm^{-3}$) in their answers.

(c) (i) In this question, candidates were asked to refer to **Fig. 3.2** and **Fig. 3.3** to state how the activity of the mutant form, T315L, differs from TKR without the inhibitor. Many candidates gave answers comparing the effect on T315L activity with and without GNF-5 using **Fig. 3.3**. The stronger candidates were able to state that, unlike TKR, there is no activity at $0.1\,\mu mol / dm^{-3}$ ATP with T315L. One further difference that can be identified from the graphs is that the V_{max} for T315L is reached at a higher concentration of ATP. This involved candidates being aware of the log scale for ATP concentration on the horizontal axis. This also meant that the K_m for T315L is higher.

(ii) Candidates often stated that the drug GMF-5 acts as a non-competitive inhibitor of T315L and that the activity does not reach the V_{max} of TKR. For full credit, candidates needed to qualify their answer, stating that the V_{max} changes or was different.

Question 4

(a) (i) The majority of candidates were able to state that ester bonds are formed between glycerol and fatty acids. The most common incorrect answer was glycosidic bonds.

(ii) Most candidates were able to state that the type of reaction involved in forming a bond between glycerol and a fatty acid is a condensation reaction.

(iii) Most candidates were able to gain credit by stating that the three fatty acids differ in length. This could be gained by writing **Y** is the longest, or **Z** is the shortest. Some excellent answers were seen with references to the number of C=C or double bonds in each of the fatty acids, and where candidates identified **X** as a polyunsaturated and **Y** as a monosaturated fatty acid. Some candidates confused the term saturated with unsaturated and there were often references to the number of kinks in the hydrocarbon tails or the fluidity of each fatty acid, which were not credited.

(b) (i) Many candidates gave clear descriptions of hydrophobic molecules being non-polar, insoluble, and unable to form hydrogen bonds with water. References to these molecules as those that hate or repel water did not gain credit.

(ii) Many candidates stated that triglycerides are unable to form a bilayer. Stronger responses included more detailed explanations, such as triglycerides do not have a hydrophilic component and are therefore unable to interact or form hydrogen bonds with water. Some candidates approached this question by attempting to explain why phospholipids are a suitable component of cell surface membranes, rather than explaining why triglycerides are not.

Question 5

(a) To gain credit for this question, candidates needed to state that a transmissible disease is passed on to an uninfected person or to an uninfected organism. Answers referring to the spread of the disease were not credited.

(b) Many candidates stated that information on magnification is needed but did not specify that it is the magnification of the image or the electron micrograph in **Fig. 5.1** that is important. Some remembered to state that the measured length of the flagellum in the image is also required. Often candidates gained the mark by referring to the formula (actual length = measured length of the flagellum divided by the magnification). Some candidates incorrectly stated that the magnification of the microscope is required and explained how this could be determined from the eyepiece and objective lenses used.

(c) (i) Candidates frequently calculated the case-fatality rate / % for Yemen correctly and most of these gave their answer to the required format of one decimal place, as shown in the data for the other countries listed in **Table 5.1**.

(ii) Most candidates were able to many reasons to explain the large outbreaks of cholera in some countries, including the lack of uncontaminated drinking water, and untreated sewage. The lack of availability of vaccines, antibiotics and oral rehydration treatment were often stated as contributing to the outbreaks. Many also gave examples in their answers, such as crops being irrigated with contaminated water. Weaker answers were less specific in their references to poor sanitation, education and standards of hygiene. Some candidates confused cholera with malaria.

Question 6

(a) Candidates were asked to name the four bases in mRNA and DNA in **Table 6.1** and correct spellings of the bases were also required. The use of abbreviations A, T, G, C, and U in answers was ignored. Answers stating that single strands are found in mRNA and double strands in DNA were not credited, as candidates were asked for the number of strands.

(b) (i) Most candidates correctly identified stage 1 in **Fig. 6.1** as transcription. Some misinterpreted **Fig. 6.1** and referred to the DNA unwinding.

(ii) Answers to this question showed that candidates had a very good understanding of the events that occur in the synthesis of molecules of mRNA. Most chose to describe the removal of introns. Some of these could have improved their answer by including the fact the exons remaining are then joined together. Other candidates referred to the splicing of the primary transcript, which also gained credit. A number incorrectly described introns as being removed from the primary transcript and not from mRNA. Some described the process of transcription rather than the post-transcriptional modification of the primary transcript.

(c) (i) Many referred to the specificity of the amino acid attached to the tRNA shown in Fig. 6.2, its transport to the ribosome and the subsequent binding of the tRNA anticodon to the complementary mRNA codon. The best answers concentrated on the role of the transfer RNA, rather than describing the process of translation. A few candidates identified the amino acid shown in **Fig. 6.2** as glycine and described how it becomes attached to the tRNA molecule. Some showed an understanding that the main role of tRNA is to ensure that the specific amino acid it carries is placed into the correct position forming the primary structure of the cotransporter protein. A number also noted that the tRNA is reused, bringing its specific amino acid once more to the ribosome. Often, descriptions included subsequent events occurring, such as the formation of the tertiary structure or folding of the polypeptide. These events do not relate to the role played by tRNA, so were not required.

(ii) There were many correct descriptions of the proton pump operating to establish a gradient enabling the H^+ ions to diffuse through the cotransporter protein accompanied with sucrose. Stronger responses also showed an understanding that sucrose is moved against its concentration gradient and that the polar nature of the molecule required the presence of a transport protein. Some answers needed to be clearer that H+ and sucrose are moved from the cell wall into the companion cell. A number implied that the cotransport occurred between the companion cell into the phloem sieve tube element.

BIOLOGY

Paper 9700/22
AS Level Structured Questions

Key messages

Candidates should understand that the pool of stem cells in any one location in the body needs to be maintained so that differentiated cells can be supplied when required. This means that stem cells must be self-renewing as well as being able to form cells that can differentiate or begin to differentiate to form cells suited to a particular function. In **Question 1(d)**, some candidates implied that stem cells divide into differentiated cells, without showing an understanding of self-renewal.

Question 4(c) highlighted how accuracy and care in the use of terminology is required when describing the events that occur between transcription and translation. The RNA molecule synthesised during the transcription of the DNA template strand should be termed the primary transcript, as this is comprised of both introns and exons. RNA splicing in post-transcriptional modification produces messenger RNA (mRNA), which is a molecule that consists of exons only, and is the molecule that exits the nucleus.

In **Question 4(f)**, candidates were asked to describe the mechanism of action of acetazolamide as a reversible non-competitive inhibitor. Some attempted to give features related to both competitive inhibition and non-competitive inhibition and/or features of reversible and irreversible inhibition. By providing a choice, candidates prevented credit from being awarded, even if the correct responses were included.

General comments

Many candidates were well prepared and could bring together knowledge and understanding from throughout the syllabus to answer all of the questions. Some candidates who gave a generally good overall performance gave a weak response in **Question 4(c)**, which was based on material that has been introduced for the most recent syllabus. Although it is recognised that it is extremely helpful to candidates to practise past paper questions, they should also be aware of the newer areas of the syllabus and give equal attention to all learning outcomes.

The introduction to **Question 1** clearly stated that intestinal epithelial cells have cell structures known as microvilli. In **Question 1(c)(iii)** and **(d)**, many wrote about microvilli as if they were a type of cell, rather than cell structure. For example, in **(d)**, stem cells were described as dividing to form microvilli, rather than intestinal cells with microvilli.

Although many gave a sentence or bullet-pointed style answer to **Question 2(c)(ii)** that was creditworthy, some only wrote one word, for example ‘quick’, or ‘convenient’, as an advantage of using an RDT dipstick. These needed qualifying with a relevant statement.

It was noted that some candidates wrote about the Fehling’s test in **Question 3(a)**, whereas the required knowledge to satisfy the 9700 syllabus is the Benedict’s test for reducing sugars and the use of Benedict’s solution when testing for non-reducing sugars.

In **Question 4(d)**, candidates were asked to suggest a location in red blood cells for the two carbonic anhydrase isoforms. Many did not answer the question asked and gave locations such as lungs or blood plasma or suggested locations such as mitochondria and the nucleus. Candidates needed to apply their basic knowledge to an unfamiliar context.

Use of microscope slides and images is critical to improving knowledge and understanding of many areas of the AS syllabus. This was particularly highlighted in **Question 5**, which had questions based on a photomicrograph of a transverse section through part of a bronchus.

Syllabus Topic 7, Transport in plants, requires candidates to understand that mineral ions can be transported in plants dissolved in water. Only some candidates noted this when answering **Question 6(a)**.

Comments on specific questions

Question 1

(a) The difference between the appearance, 3D compared to 2D, was the most common correct reason candidates gave for identifying **Fig. 1.1A** as the scanning electron micrograph and **Fig. 1.1B** as the transmission electron micrograph. For those who referred to **Fig. 1.1** in their answer, it was sufficient to give a feature of either one. Some candidates gave a theoretical response and to gain credit were required to give a feature for both SEM and TEM. Incorrect statements suggested differences in resolution or magnification.

(b) Most were able to gain full credit with some very precise and detailed answers including the idea of measuring a number of microvilli in the image to calculate a mean length. Those gaining partial credit knew the formula to use but suggested an incorrect conversion factor for mm or cm measurements or did not state that the same units should be used.

(c) (i) Many candidates gave the use of ATP or energy and carrier proteins as features of active transport. These were not credited because they were given in the stem of the question. Although many gained credit for 'active transport is against the concentration gradient' or 'active transport is from low concentration to high concentration', some answers were better expressed and began with 'is the transport of substances…'. Some contradicted themselves, qualifying 'against the concentration gradient' with 'from high to low concentration'. It was far less common to see other features, such as the specificity of the carrier proteins and their binding sites, or the conformational change that occurs on binding. One error made by some candidates was to state that endocytosis or exocytosis involved active transport.

(ii) Many knew that glucose needed to be transported against its concentration gradient. Some gave more details, explaining the role of Na^+, and so completed the explanation to gain full credit. These candidates had successfully made the link with the cotransport of sucrose and hydrogen ions in companion cells. Some did not refer to Na^+ and cotransport in their response, instead explaining why carrier proteins are needed for hydrophilic substances to be transported across the cell surface membrane.

(iii) Almost all candidates knew that microvilli would provide a large surface area for efficient glucose uptake; far fewer completed their response by explaining that this allowed more cotransporters to be present to increase uptake.

(d) The quality of response for this extended answer was very varied. The strongest responses showed a clear understanding that stem cells produce genetically identical daughter cells and that these cells can remain as stem cells, in self-renewal, or go on to form differentiated cells. These answers referred to the context of intestinal cells and gave correct suggestions with concise explanations. Weaker responses often gave a general list of the importance of mitosis and if explanations were attempted, were not on topic, such as writing about blood cell types or ciliated epithelial cells rather than cells of the intestine.

Question 2

(a) (i) Concise and correct answers addressed only treatment for suspected cholera. Most of these realised that the main treatment for cholera, oral rehydration therapy, would also be used for other diarrhoeal diseases so would be a safe choice. Good answers explained that this was a solution of glucose and salts. Although antibiotics may not usually be given as a treatment until a more severe case of cholera is diagnosed, candidates were credited for applying knowledge of cholera and its treatment. Some candidates described preventive measures, such as vaccines, even though the introduction to the question noted that the people described were already experiencing diarrhoeal disease. Some answers were based on hygiene and sanitation, including sewage, rather than a treatment for disease.

(ii) The clearest answers considered the transmission of cholera and showed an understanding that an earlier recovery from cholera or a decrease in the quantity of contaminated diarrhoea being produced would reduce the potential of contaminated faeces being passed to the wider public. Some did not explain how early treatment would prevent an outbreak, but described and explained one or two preventive measures for cholera.

(b) (i) It was important in this question to provide the structural details of antibody molecules that allowed them to be specific for a particular antigen. Many used the correct terms and included 'antigen binding site(s)' and 'variable regions' in their response. The importance of having a complementary shape to the antigen was also known by some. Others gave a more general outline and could have improved their response by including structural features relating to binding to specific antigens. Information about the hinge region or constant regions of antibodies were not relevant to this question. There were many who used the term 'receptor' or 'active site' in their response, which was not relevant to the question.

(ii) Most candidates made a good attempt and were able to make the correct diagnoses from the results of the dipsticks for persons **A** and **B**, as well as explain how the band shown at control area 4 confirmed that the results were valid. Some went on to explain the results in terms of antigen-antibody complexes and gained full credit if they were precise in their descriptions. For example, stating that an antigen-antibody complex had formed for person **A** could not be credited unless it was clear that this was antigen-antibody complex O1. Much weaker answers gave confused responses and some suggested that the antigen-antibody complexes were forming inside the bodies of persons **A** and **B** or that the antibodies were obtained from within the body.

(c) (i) Many of those who did not arrive at the correct calculated value made the mistake of dividing the number of correct diagnosis positive test results (97) for the dipstick by the combined total of culture test results (102 + 54 = 156), instead of dividing only by the number of positive results (102). Others added together all the results for the correct diagnosis of the dipstick test (97 + 32 = 129) by the combined total.

(ii) Candidates were given some of the advantages of using a dipstick instead of culturing the pathogen to obtain a diagnosis and were asked to suggest another advantage. A wide range of good suggestions were given and the most common response was to state that a quicker diagnosis of disease would be obtained. A short statement was required, so an answer such as 'fast', was not sufficient. Other examples where credit was not given, included repeating in a different way one of the advantages already stated, or suggesting that the test was more accurate, despite being told that laboratory culturing represented an accurate identification.

Question 3

(a) Many gave two correct differences between sucrose and fructose. The terms disaccharide and monosaccharide were required and it was not sufficient to state that sucrose was composed of two monomers and fructose was a single monomer. Some attempted to name the monomers but did not get the detail correct, usually stating that sucrose was composed of two glucose monomers. Most knew that sucrose was a non-reducing sugar, so was not a reducing sugar like fructose. Others gained the credit by giving an outline of the Benedict's test. Knowledge of a glycosidic bond being present only in sucrose was also shown. Some misread the question and gave differences between sucrose and glucose.

(b) (i) There were many excellent responses, with some candidates paying good attention to the detail provided in **Fig. 3.2** to give comprehensive answers. Others concentrated only on the fatty acid residues and did not mention glycerol. Some weak answers stated glycine or glycogen for glycerol. Stating that oleate, as an unsaturated fatty acid, has a double bond, or that the saturated fatty acid palmitate does not have a double bond, was credited. However, stronger responses showed an understanding that fatty acids contain a double bond with the C=O of the carboxylic acid portion, and hence stated clearly that oleate has a carbon-carbon (C=C) bond.

(ii) The strongest responses were accurate in stating that, for migration, triglycerides could provide more energy per unit volume or that a lower mass of triglyceride is needed to supply the same energy as glycogen. Stating that more energy could be stored in triglycerides was not credited.

(c) The word 'closed' with 'double' (circulation) was required to gain credit.

(d) There were many acceptable ways to answer this question and the majority of candidates were able to gain full credit. Some could have improved their answer by focusing on one or more of the ideas given in the introduction of **Question 3** and used this as a basis for their response. This meant that some just gave features of needing a heart as part of a double circulation system, which produced a response that could also be applied to all mammals.

(e) The names of the blood vessels associated with the heart were generally well known. Candidates should use the correct spellings for the names of these blood vessels. Incorrect spellings of 'aorta', such as 'arota' and 'aota', were not accepted. Common incorrect spellings for 'pulmonary' were 'plumonary' and 'pulmonery'.

Question 4

(a) Many gave the correct name of **X** as carbonic acid and **Y** as hydrogencarbonate (ions), although a proportion got these the wrong way round and some gave **X** as hydrogencarbonate and **Y** as hydrogen carbonate ions. 'Carbonate' was not credited for **Y**.

(b) Many understood that even though the primary structures of different carbonic anhydrase enzymes may be different, as long as the active site was the same for these enzymes, they would still be able to accommodate the required substrates and catalyse the required reaction. Some described the induced fit mechanism, which was not needed, and did not explain that the active sites or tertiary structures of the enzymes would be the same (or similar).

(c) Some candidates had a good understanding of introns and exons and gave confident and concise answers. They were careful not to call them 'genes' but to explain that they were non-coding or coding sequences (as part of a gene). These good answers only introduced the term messenger RNA or mRNA when they were writing about the final RNA product that left the nucleus to go to the ribosome for translation, and they were clear that this contained exons that had been joined during splicing of the primary transcript. A few also knew that, although introns are removed from the primary RNA transcript, they could remain in the nucleus and have regulatory roles. Others had a general idea of the role of introns and exons, but were not precise in their terminology, while some had knowledge of what occurred but got it the wrong way round, stating that exons were the non-coding sequences. There were many other incorrect answers, such as suggesting that introns and exons were START and STOP codons, or that they were different types of genes, or that they were proteins involved somehow in transcription or translation.

(d) Most suggested the cytoplasm as a location for one or both isoforms to gain credit. Fewer explained that this was an ideal location to be close to haemoglobin molecules or showed an understanding that the cytoplasm or cytosol provided the aqueous medium for the reaction to occur. Most candidates remembered that red blood cells are full of haemoglobin molecules and so do not have cell structures such as nuclei and mitochondria. Many incorrectly stated that the enzymes would be part of, or within, a haemoglobin molecule. The reaction between carbon dioxide and water occurs without the enzyme, so it was also important in the explanation to emphasise that the products would be formed rapidly because of the presence of carbonic anhydrase. Some suggested that the enzyme would be part of the cell surface membrane to gain credit; it was not concise enough to suggest 'near the surface'.

(e) Most stated 'exocytosis' as the transport mechanism for secretion of CA6. The most common incorrect mechanism given was active transport.

(f) The mechanism of action of acetazolamide as a reversible non-competitive inhibitor was usually described well enough to gain full credit, with some of the best accounts noting that binding would result in a lack of product until the drug detached from the enzyme. Some could have improved their response by stating that the shape of the active site was changed, rather than the shape of the enzyme changing. The allosteric site was frequently spelled incorrectly, with some attempts being too erroneous to gain credit.

Question 5

(a) Statements about resolution and magnification were not required; to gain credit it only needed to be noted that the luminal surface was the location of the cilia (of the ciliated epithelial cells). Stronger candidates understood that if the luminal surface of the epithelium was visible, and that if the image in **Fig. 5.1** was described as being of a good resolution, it would not be correct to say that the resolution was not good enough to 'see' the cilia, or that cilia are 'too small to be seen'. Some incorrectly described the cilia as microvilli.

(b) Good answers included reference to both cell **D** and cell **L** and gave two or more correct explanations as to why there was a difference in appearance. A small proportion gained credit by stating that the bronchial epithelium consists of two different cell types, goblet cells and ciliated epithelial cells. Some candidates were not familiar with the histology of the bronchus and common incorrect ideas referred to cells containing goblet cells, describing dark and light regions, writing about blood vessels or suggesting differences in oxygen concentration within cells.

(c) Most answers gaining full credit were well organised, naming the tissue in box **A** as smooth muscle, accurately outlining the function of the tissue, and then comparing this to the function of **B**, cartilage. Contraction and relaxation of smooth muscle should not be described as stretching and recoiling, as this is a feature of elastic tissue. Some responses correctly identified smooth muscle for tissue **A**, and then introduced a contradiction by stating that it contained elastic tissue or mucous glands or goblet cells. Others suggested blood vessels for tissue **A**.

Question 6

(a) This question required candidates to work out the possible pathways that dissolved mineral ions could take once they had entered the xylem in the roots. Some showed an understanding that mineral ions could be transferred to sources where they could be used or could, at a later time, enter phloem to be transported to other areas of need. Most who gained full credit stated that the mineral ions would enter phloem sieve tubes when water entered from the xylem in preparation for mass flow down the hydrostatic pressure gradient. Those gaining partial credit tended only to explain how mineral ions are transported within phloem sieve tubes, and some of these included much detail of the mechanisms involved in the cotransport of sucrose, and details of the events leading to mass transport, which was not required. The weakest responses were very confused, with some writing about transport of ions within xylem or relating sources and sinks to xylem and not phloem.

(b) Most candidates knew that companion cells were adjacent to sieve tube elements. Fewer named sieve plates or gave another acceptable answer for the modified end walls or were able to correctly describe the location of phloem cytoplasm.

BIOLOGY

Paper 9700/23
AS Level Structured Questions

Key messages

Candidates should be familiar with the range of features that are found in the leaves of xerophytic plants and be able to identify and explain these features using images or prepared slides taken from a wide selection of xerophytic species. A number of candidates lacked confidence when attempting **Question 3(a)**, which presented candidates with a photomicrograph of a transverse section through part of a leaf of *Hakea laurina*.

In **Question 3(b)(i)**, candidates applied knowledge of stem cell features to meristem cells in plants. It was not well understood that the pool of stem cells in any one location in the body needs to be maintained so that differentiated cells can be supplied when required. Stem cells and meristem cells must be self-renewing as well as being able to form cells that can differentiate, or begin to differentiate, to form cells suited to a particular function. In this case it was to form the cells in a root cluster that would increase the uptake of mineral ions and water.

In **Question 4(e),** many incorrectly used the term 'receptor' to describe the antigen-binding site of an antibody molecule or used phrases such as 'the receptor of the antigen binding site'. The term 'receptor', in the context of B-lymphocytes, should be used if describing the membrane-bound immunoglobulin which is known as the B-cell receptor.

General comments

Well-prepared candidates were able to answer questions that required application of knowledge and understanding, as demonstrated in **Question 3(b)**, where an understanding of the features of stem cells, active transport and the principles involved in surface area were applied to the unfamiliar context of root clusters.

There were a number of questions where information was presented in diagrams and in photomicrographs. Those candidates who took time to assimilate the information provided were better prepared to answer the questions that followed. Some candidates' responses could have benefited from the help provided by the visual stimuli.

The use of microscope slides and of images is extremely important in improving knowledge and understanding of many areas of the AS syllabus. This was particularly highlighted in **Question 1(c)**, which was based on a photomicrograph of a transverse section through part of the trachea.

Question 2(b) included a label for **Fig. 2.1** that used the term 'water potential' and this term was repeated in the question. Some candidates instead wrote about 'water concentration' or 'the concentration of water molecules' within their answer. These terms should be avoided, particularly when questions include information about concentrations of solutions.

In **Question 3**, candidates were presented with terms that sounded very similar: roots, root clusters, rootlets, rootlet cells and root hair cells. Each had a different meaning and to gain full credit, it was important to use the correct term when answering the three different questions in **Question 3(b)**.

Responses to **Question 4(d)** showed that only some candidates had a good grasp of the differences between DNA transcription and DNA replication.

Candidates should check that they have answered all parts of all questions. There were a number, including higher performing candidates, who did not sketch a curve on **Fig. 5.2** in **Question 5(b)(ii)**.

Although many were familiar with the role of the atrioventricular node in **Question 6(c)**, only some showed an understanding that, because of the presence of a ring of non-conducting fibrous tissue, direct impulse conduction cannot occur between the walls of the atria and the walls of the ventricles.

Comments on specific questions

Question 1

(a) Either bronchus or bronchi was acceptable; most of those who did not gain credit incorrectly named the bronchioles or used a term part-way between the two.

(b) Well-constructed answers highlighted the differences between the two different arteries by giving concise statements about both blood vessels, or by using comparative terminology. For example, when writing about the arteries branching from the aorta, good answers gave 'higher pressure' rather than 'high pressure' and 'more oxygen' rather than 'transports oxygen'.

(c) (i) Stronger candidates who were familiar with images such as those in **Fig. 1.1** demonstrated good knowledge of this area of the syllabus and were able to produce complete responses that gave main structural features and further details. Generally, these candidates noted that they were only asked to describe structural features visible in the photomicrograph, so did not give detail of other cell structures they may have learned about. They also avoided explaining the function of the structures, which many other candidates did. Some responses incorrectly suggested that all cells have cilia instead of explaining that the epithelial lining is composed of non-ciliated goblet cells and ciliated epithelial cells. Some needed to make it clear that the cilia are only located on the luminal surface of the ciliated epithelial cells.

(ii) **Fig. 1.1** showed a mucous gland labelled so that candidates who looked carefully at the photomicrograph were able to see that structure **X** was not a mucous gland. A number identified **X** as a blood vessel or a correctly named blood vessel and had no problem giving correct features to support their choice. Others gave one of the other structures found in the gas exchange system, such as mucous gland, goblet cell, cartilage, smooth muscle or elastic tissue, with their justification not matching the features that could be seen on **Fig. 1.1**.

Question 2

(a) Candidates were required to compare a bacterial cell with a plant cell. Most knew 'ribosomes' for the second gap and 'vacuole' for the final gap; some found it difficult to recall 'murein' or 'peptidoglycan' as the component of bacterial cell walls and stated 'chitin' or a term that was related but not accurate enough to gain credit.

(b) Candidates were asked to explain why the protoplasts were kept in a solution that has the same water potential as the cell. Good responses stated bursting or shrinking as potential outcomes if the water potentials were not the same and then explained why in terms of water potential and/or movement of water by osmosis. Others only stated an outcome, without giving an explanation. Some wrote about water potential differences but then contradicted their response with an incorrect direction of movement of water or incorrect outcome to the protoplast.

(c) (i) To gain full credit, the response needed to address the structure of a cellulose molecule as well as a cellulose microfibril. Generally, candidates knew more about cellulose molecules. There were some strong answers describing the type of bond present and demonstrating knowledge that adjacent β-glucoses are rotated through 180°. Those who wrote correctly about microfibrils knew that the cellulose molecules were parallel and/or that hydrogen bonds were present, and a few answers went on to describe the staggered arrangement of molecules so that the beginning and end of the molecules were not all in the same place. Weak responses gave pieces of information that were correct but mixed with features of amylose or amylopectin, or described features of protein structure.

(ii) Most candidates who gained credit stated lignin or hemicellulose as an additional component of the plant cell wall. There were many incorrect suggestions of molecules found in plants such as sucrose, starch and β-glucose. Substances such as chitin, peptidoglycan and collagen were also seen.

(d) **Fig. 2.2** and the label concerning chloroplasts served as a clue for many candidates, who named a correct plant cell type for obtaining the protoplasts. Some were too vague and stated ‘leaf cell’, while a number suggested the name of a plant.

Question 3

(a) **Fig. 3.1** showed that leaves of *Hakea laurina* have a very thick waxy cuticle, and most candidates observed this. Fewer were able to give an accurate explanation of how this is an adaptation. The waxy cuticle found on non-xerophytic plants can be described as a waterproof feature. To gain credit, an explanation in terms of the increased thickness of the cuticle was required. Suggesting an increased diffusion distance needed to be related to water vapour and not to water as a liquid. A number of different descriptions were accepted for the location of the stoma in **Fig. 3.1**, although those describing it as being in the middle of the sub-stomatal air space did not gain credit. There were some good explanations in terms of decreasing the water potential gradient. Some of the weak responses chose to write about other xerophytic features.

(b) (i) The quality of response to this question varied greatly. Clear accounts introduced the idea that mitosis was occurring many times to form new cells, before explaining that the newly formed cells could then differentiate into the specialised cells found in a root cluster. Others described the meristem cell dividing into root hair cells or rootlet cells and did not show an understanding that differentiation occurred after cell division.

(ii) Candidates who realised that organic anions could be moved against the concentration gradient into the soil from the rootlet cells were able to apply knowledge of features of active transport to answer this question. Others incorrectly attempted to link outward movement of anions to movement of phosphate ions and/or water into the cells.

(iii) Those candidates who had referred back to the bullet-pointed list provided in the introduction to **Question 3(b)** were able to extract the information provided about the root cluster being composed of root hair cells and relate this to an increase in surface area for absorption.

Question 4

(a) Most candidates were able to complete **Fig. 4.2** to show a correct formula to calculate the actual width **X**–**Y**. The calculation itself proved to be straightforward for those who were able to convert the measured width to nanometres. Most followed the instruction to give the answer to the nearest 10 nm.

(b) Of those who did not know that ‘pathogen’ was the correct term to give, answers such as ‘disease-causing organism’, ‘bacteria’, ‘virus’ and ‘vector’ were seen, or some stated the name of the disease, ‘cholera’.

(c) Most responses showed an understanding of how *Vibrio cholerae* can be transmitted to an uninfected person. Some could have improved their answer by using the term ‘contaminated’ rather than ‘dirty’, ‘unclean’ or ‘polluted’ to describe drinking water containing the pathogen. A number incorrectly described *V. cholerae* as a virus.

(d) Many were able to give one correct suggestion as to why only one strand of the DNA in gene *ctxA* or *ctxB* is involved in the production of the relevant subunit, with most of these noting that messenger RNA (mRNA) is single-stranded. Fewer explained the difference between the template and non-template strands of the DNA comprising the genes or related a single strand of mRNA to the production of a single subunit (polypeptide).

(e) (i) To do well in this question, candidates needed to understand how the structure of an antibody molecule is related to its function. The idea of specificity was frequently seen and this needed to be qualified further by showing knowledge of how the structure of the antigen binding sites of the different monoclonal antibodies made them suitable to be able to bind to their particular antigens. It was not relevant to write about the hinge region or constant regions of the antibodies. In addition to using the term ‘receptor’ incorrectly, the term ‘active site’ was also seen for the antigen binding site, with some candidates confusing antibody action with enzyme action.

(ii) A large number of different ideas were acceptable discussion points for this question. As part of their answer, some candidates used the information given at the beginning of the question to explain why agglutination or the prevention of motility would help prevent illness. It was less common to see points relating to the different uses of the two specific monoclonal antibodies. Some could have improved their answer by considering a more varied approach, as they chose to focus on just one point and write at length about this, repeating the same idea in different ways. Care was needed when discussing the immune response. There were many clear explanations as to how agglutination would encourage phagocytosis. Some weaker responses wrote about the antibodies as being part of the immune response rather than explaining that they would be an early treatment that could be used before the immune response became effective, or that they could be used as an addition to an immune response.

Question 5

(a) It was helpful for candidates to be able to use the information provided to visualise enzymes of a pathway being organised within the internal cell membranes. Weak responses considered enzymes in membranes as only being located on the external surface of the cell surface membrane. This meant that they had difficulty suggesting a correct advantage to the cell of enzyme pathways being located in the membranes rather than the cytosol.

(b)(i) Most of those who sketched on **Fig. 5.2** gave a correct curve for the rate of reaction for COX-2 in the presence of a competitive inhibitor. Candidates should check that they have answered all parts of all questions. There were a number who left **Fig. 5.2** blank.

(ii) The candidates who had completed **Fig. 5.2** were more likely to be able to gain full credit here. They were able to use the completed graph to compare the two different curves and verify that, in the presence of a competitive inhibitor, V_{max} stays the same and K_m increases.

(c)(i) To give a complete response, candidates had to remember to refer to *PTGS2* when explaining what is meant by a gene, which many did. Enzyme COX-2 as an example of a polypeptide that is coded for by a gene was more frequently left out of the explanation. Stating that a gene is a sequence of nucleotides should also be qualified with the fact that a gene is part of a DNA molecule.

(ii) The introduction to **Question 5** explained that in some cells, the final products of the COX pathway could stimulate cell division. Some candidates understood that a mutation in *PTGS2* would increase the rate of cell division and so the chances of errors occurring during replication would increase. Others were not able to think through the steps involved and thought that a mutation in *PTGS2* would immediately cause a cell to become cancerous.

(d) Many candidates were able to identify arachidonic acid as an unsaturated fatty acid. Many included reference to the C=C double bonds shown in **Fig. 5.3** and then were able to give an acceptable description of how this would contribute to an increased fluidity of the membrane. Weaker candidates did not realise that the fatty acid would be incorporated into a phospholipid and thought that the molecule, with its partly circular shape, was a separate membrane component.

Question 6

(a) To gain credit, the wall of the right atrium needed to be identified as the location of the sinoatrial node. Many were not precise enough and stated 'right atrium' or 'in the right atrium'.

(b) Most correctly named atrial systole for the part of the cardiac cycle described.

(c) The role of the atrioventricular node in delaying the impulse initiated by the sinoatrial node was generally well known. Stronger responses also showed knowledge and understanding of the band of non-conducting fibre between the atria and ventricles. Some misunderstood the question and wrote about the opening and closing of valves and the direction of blood flow in the heart.

(d) Most gave 'semi-lunar' to gain credit. If this term was not given, both the aortic valve and the pulmonary valve needed to be named.

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.

When drawing bar charts, candidates should take care to draw separate bars of equal width with ruled vertical and horizontal lines joined precisely with accurate plots.

When viewing slides under a microscope, candidates should observe detail and include such detail when producing diagrams, such as the presence of large air spaces in plan diagrams and visible inclusions in cell diagrams.

General comments

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.

Comments on specific questions

Question 1

(a) (i) The majority of candidates were able to carry out a serial dilution of 10.0% molecule **R**, showing the correct concentration below each beaker (5.0%, 2.5%, 1.25% and 0.625%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water (**W**) to each beaker. A few candidates showed different volumes of 10.0% molecule **R** below each beaker made by proportional dilution.

(ii) The majority of candidates organised their results clearly by presenting a ruled table and including the heading for percentage concentration of molecule **R** and the heading for number of drops. The majority of candidates gained credit for recording the number of drops for all the concentrations of molecule **R** and the results showed that the number of drops for the highest concentration of molecule **R** was lower than the number of drops for the lowest concentration of molecule **R**. Most candidates recorded the results as whole numbers.

(iii) Most candidates correctly suggested that one source of error when measuring the dependent variable was the difficulty in identifying the end-point. Many candidates stated that counting the number of drops released was an error because the size of the drops varied. A few candidates identified difficulty in releasing just one drop from the syringe.

(iv) The majority of candidates who had suggested the difficulty in identifying the end-point in **Question 1(a)(iii)** correctly suggested using a colorimeter. Many candidates who had identified the variation in the size of the drops as an error or the difficulty in releasing one drop, suggested measuring the volume of molecule **R** used to reach the end-point as an alternative method.

(v) The majority of candidates correctly recorded the number of drops of **U** needed to reach the end-point.

(vi) The majority of candidates were able to correctly position the concentrations of molecule **R** made in **Question 1(a)(i)** on the scale in **Fig. 1.3**. Some candidates positioned the concentrations equidistant from each other along the scale which did not gain credit.

(vii) Most candidates were able to correctly estimate the concentration of **U** by correctly positioning the letter **U** on the scale in **Fig. 1.3**. The most common mistake was incorrectly reading the direction of the trend in the table when determining the concentration of **U**.

(b) (i) The majority of candidates correctly used the headings given in the table to label the *x*-axis (plant extract) and the *y*-axis (time / s). The majority of candidates also labelled each bar clearly and drew bars of equal width on the *x*-axis. Most candidates used a scale of 10 s to 2 cm for the *y*-axis and plotted each bar accurately. Many candidates drew ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely. The most common error was drawing bars that were joined and not separate.

(ii) The majority of candidates identified plant extract **F** as the plant extract that would contain the highest concentration of molecule **R**.

(c) (i) The majority of candidates read off the correct estimate of 22 g cm^{-3} for the plant extract resulting in an inhibition area of 92 mm^2.

(ii) The majority of candidates suggested that the molecule in the plant extract may inhibit growth by punching holes in the bacterial cell wall causing the cell to burst. Many candidates also suggested that the molecule might inhibit protein synthesis or DNA replication by inhibiting the action of enzymes.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole leaf. These candidates gained credit for drawing at least four layers of tissue and showing the correct shape of the leaf. Some candidates showed the detail of the stomata opening into large air spaces. Many candidates used a label line to correctly identify the epidermis.

(ii) Some candidates correctly observed the presence of a cuticle around the leaf or only a few stomata, adaptations which enable the leaf to survive at high altitude.

(iii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent epidermal cells, with each cell touching at least one of the other cells and with double lines representing the cell walls. The stronger candidates drew inclusions in each of the cells. Most candidates used a label line to show the cell wall of one cell. The most common errors were to draw cells with lines that did not meet up precisely and cells with no inclusions.

(b) The majority of candidates identified at least two observable differences between **J1** and **Fig. 2.1** using only observable differences. Most candidates stated that there were fewer stomata on **J1** and more in **Fig. 2.1** and that **J1** had more air spaces than in **Fig. 2.1**. Some candidates stated that **J1** was triangular in shape while **Fig. 2.1** was more of an oval shape.

(c) The majority of candidates accurately measured the length of the scale bar with the appropriate units. The stronger candidates showed the division of the length of the scale bar by the actual length of the scale bar (950 m) and then showed the length of line **X–Y** divided by the answer. Some candidates recorded the correct width of the leaf with appropriate units.

BIOLOGY

Paper 9700/32
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 graphs, candidates should choose a scale where both axes use most of the grid available and allow the graph to be read easily to half a 2 mm square.

When viewing slides under a microscope, candidates should take care to observe fine detail and include such detail when producing diagrams, such as the position of vascular bundles in plan diagrams and the shape of xylem vessel elements in high power diagrams.

General comments

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.

Comments on specific questions

Question 1

(a) (i) The majority of candidates were able to carry out a serial dilution of 1 $mol\,dm^{-3}$ ascorbic acid, showing the correct concentration below each beaker (0.1 $mol\,dm^{-3}$, 0.01 $mol\,dm^{-3}$, 0.001 $mol\,dm^{-3}$ and 0.0001 $mol\,dm^{-3}$) and transferring 1 cm^3 of the previous concentration to the next beaker and adding 9 cm^3 of distilled water to each beaker. A few candidates showed different volumes of 1 $mol\,dm^{-3}$ ascorbic acid below each beaker made by proportional dilution.

(ii) The majority of candidates organised their results clearly by presenting a ruled table and included the heading for concentration of ascorbic acid (**A**) and $mol\,dm^{-3}$ and the heading for volume and cm^3. Most of the candidates gained credit for recording the initial volume and the final volume of gas in the syringe for all the concentrations of ascorbic acid and 0 $mol\,dm^{-3}$, and the results showed that the volume of gas produced was greater for the lower concentration of ascorbic acid than the volume of gas produced for the higher concentration of ascorbic acid. Many candidates recorded the results to 0.1 cm^3 and some candidates included the correct calculation of the total volume of gas produced. The most common error was adding the initial and final volumes together to record the total volume of gas produced.

(iii) Most of the candidates were able to identify the greatest volume of gas produced and correctly calculate the rate of gas production / $cm^3\,min^{-1}$.

(iv) Most candidates correctly suggested using a gas syringe as an improvement to the procedure that would make the measurements more accurate. Many candidates suggested a method to standardise the thickness of the potato cylinders and some candidates suggested using a thermostatically controlled water-bath to keep the temperature constant, or a way of stabilising the syringe in the water to prevent gas escaping.

(b) (i) The majority of candidates correctly recorded the temperature of the hydrogen peroxide before and after adding potato discs. Most candidates correctly calculated the change in temperature after two minutes.

(ii) Some candidates stated that temperature was a significant source of error in the investigation as an increase in temperature would increase the rate of reaction between catalase and hydrogen peroxide.

(c)(i) The majority of candidates drew the graph, using the headings given in the table to correctly label ascorbic acid daily dose / mg on the *x*-axis and maximum ascorbic acid concentration in blood plasma / mol dm^{-3} on the *y*-axis. Many candidates used scales of 200 mg to 2 cm for the *x*-axis and 20 mol dm^{-3} to 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting the points. The most common errors were using a non-linear scale for the *x*-axis.

(ii) Most candidates suggested that the ascorbic acid present in the blood plasma (6 mol dm^{-3}) when the daily dose was 0 mg was obtained from the food in the volunteer's normal diet. Some candidates explained that the maximum absorption of ascorbic acid occurred at a daily dose of 500 mg (75 mol dm^{-3}) and an increase in the daily dose to 1000 mg did not increase the concentration of ascorbic acid in the blood plasma.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. Most candidates gained credit for carefully following the instructions and drawing a section of the stem. The stronger candidates gained credit for drawing at least two layers of tissue and showing the correct position and arrangement of the vascular bundles and air spaces. Many candidates used a label line to correctly identify the epidermis.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. Most candidates were able to draw a group of four adjacent xylem vessel elements, with each xylem vessel element touching at least two of the other xylem vessel elements and with double lines representing the cell walls. The stronger candidates drew a different shape for each xylem vessel element. Some candidates used a label line to show the wall of one xylem vessel element. The most common errors were drawing lines that did not meet up precisely and drawing the same shape for all of the xylem vessel elements.

(b) (i) Some candidates correctly showed the division of one division on the stage micrometer by the number of eyepiece graticule units (17) present in one division of the stage micrometer. Many candidates correctly calculated the actual length of one eyepiece graticule unit with appropriate units to achieve the answer of 60 m.

(ii) Most candidates correctly measured the diameter of the stem in **Fig. 2.3** using the eyepiece graticule placed across the figure. The majority of candidates multiplied the number of eyepiece graticule units by the actual length of one eyepiece graticule unit calculated in **Question 2(b)(i)** to correctly calculate the actual diameter of the stem, 4440 m.

(iii) The majority of candidates identified at least two observable differences between **K1** and **Fig. 2.3** using only observable differences. Most candidates stated that there were more vascular bundles on **K1** and fewer in **Fig. 2.3** and that **K1** had more air spaces than in **Fig. 2.3**. Some candidates stated that the vascular bundles on **K1** were scattered over the whole section, whereas on **Fig. 2.3** they were arranged in a ring close to the epidermis.

BIOLOGY

Paper 9700/33
Advanced Practical Skills 1

Key messages

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

Candidates should be aware that the wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. In **Question 1(b)(v)**, where the question states 'explain the effect of increased temperature on the activity of enzyme **E**', the candidate needed to give reasons as to why something happens, such as referring to increased kinetic energy and that the molecules move faster.

General comments

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.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly explained that the discs rose to the surface because oxygen had been released as the enzyme catalysed the breakdown of hydrogen peroxide.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for pH of buffer and the heading for time with units (seconds). The majority of candidates gained credit for recording three times for each pH. Many candidates also recorded a mean time for each pH. The stronger candidates recorded the times in whole seconds.

(iii) The stronger respondents explained how the trend in their processed results provided evidence for their decision to support or not to support the suggested hypothesis.

(iv) Many candidates stated that the pH of the buffer was the independent variable.

(v) Some candidates correctly described that an appropriate control for the investigation was denaturing the enzyme by boiling or replacing the enzyme with water.

(vi) Many candidates correctly suggested that the reason why reusing the same hydrogen peroxide solution was a possible source of error was that the buffer on the disc or the enzyme from the previous experiment would contaminate the hydrogen peroxide solution.

Most answers correctly stated that using fresh hydrogen peroxide solution for each buffer would reduce this source of error.

(vii) A few candidates correctly described that they could modify the procedure by using narrower intervals of pH either side of the optimum pH according to their results in **Question 1(a)(ii)**.

(b) (i) The majority of candidates stated the room temperature with the appropriate units.

(ii) Many candidates correctly stated two temperatures between room temperature and 50 °C so that each temperature was separated by at least 5 °C.

(iii) Many candidates correctly stated that the mixture of buffer and **E** to use was the buffer that showed the shortest time for the disc to rise according to their results in **Question 1(a)(ii)**.

(iv) Many candidates correctly recorded their results for **T1** and **T2** and included the appropriate units.

(v) Many candidates explained the effect of increased temperature on the activity of the enzyme by referring to the increase in kinetic energy causing more successful collisions to occur and more enzyme-substrate complexes to be formed.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole section on **L1**. Many candidates gained credit for drawing at least three layers of tissue and showing the correct proportion of the vascular bundle in relation to the depth of the leaf. Most candidates used a label line to correctly identify a trichome.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw two cells from the upper epidermis and two cells from the layer below with each cell touching at least two of the other cells, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing chloroplasts in the appropriate cells. Most candidates used a label line to identify a chloroplast in one cell.

(b) (i) Many candidates measured the lengths of the epidermal cells correctly and showed the addition of these lengths and division by five.

(ii) Some candidates used the scale bar and the mean length of lines to calculate the mean actual length of the epidermal cells by dividing the length of the scale bar by 8 to calculate the magnification and showing the division of the mean length of lines by the value for magnification.

(c) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (percentage shade) and the *y*-axis (mean specific leaf area / $cm^2 g^{-1}$). Some candidates labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *x*-axis, used a scale of 20 to 2 cm and for the *y*-axis, used a scale of 20 to 2 cm with the origin labelled as 100 or 110. Many candidates plotted all the points accurately and joined the points with a thin line. The most common errors were not using the correct scale and drawing lines which were too thick.

(ii) The majority of candidates correctly described the trend in the mean specific leaf area by stating that as the percentage shade increased the mean specific leaf area also increased. Some candidates used the data to describe the trend.

(iii) The majority of candidates correctly stated the mean specific leaf area in 30% shade.

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 that the wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. In **Question 1(b)(ii)**, where the question states 'explain the difference in the change of mass between the potato pieces in the 0.4 mol dm^{-3} sucrose solution and the potato piece in the 1.0 mol dm^{-3} sucrose solution' the candidate needed to give reasons as to why something happens, such as referring to the movement of water between the cells and solutions in terms of water potential and explaining the different effects of the movement of water on plant cells.

General comments

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.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to carry out a serial dilution of 1% reducing sugar solution, showing the correct concentration below each beaker (0.5%, 0.25%, 0.125% and 0.0625%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of reducing sugar and the heading for time with units (seconds). Many candidates recorded times for all the concentrations with the highest concentration having the shortest time. The stronger candidates recorded the times in whole seconds.

(iii) The majority of candidates stated that one significant source of error when measuring the dependent variable was the difficulty in judging the time taken to the first appearance of a colour change.

(iv) Many candidates correctly suggested that the use of colour standards or a colorimeter to help identify the colours would reduce the error.

(v) The majority of candidates stated a time for **U** with the appropriate units.

(vi) Many candidates correctly estimated the concentration of reducing sugars in **U** using their results from **Question 1(a)(ii)** and **Question 1(a)(v)**. The stronger candidates correctly halved their value for **U** for the concentration of fructose in **U** and explained that sucrose was made up of glucose and fructose in equal proportion.

(b) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (concentration of sucrose solution / $mol\,dm^{-3}$) and the *y*-axis (change in mass / g). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *x*-axis, used a scale of 0.2 to 2 cm and for the *y*-axis, used a scale of 0.2 to 2 cm. Many candidates plotted all the points accurately and joined the points with a thin line. The most common errors were not using the correct scale and drawing lines which were too thick.

(ii) Many candidates correctly explained that the mass of the potato piece in 0.4 $mol\,dm^{-3}$ sucrose solution had not changed as the water potential in the cells of the potato piece was equal to the water potential of the sucrose solution and there was no net movement of water. The higher achieving candidates also stated that the potato piece in 1.0 $mol\,dm^{-3}$ sucrose solution had lost mass as the water potential in the cells of the potato piece was greater than the water potential of the sucrose solution and water moved out of the potato piece by osmosis.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the whole section on **M1**. Many candidates gained credit for drawing two layers around the vascular tissue. Most candidates used a label line to correctly identify the epidermis.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw a group of four adjacent cells with two cells from the epidermis and two cells from the layer below the epidermis with each cell touching at least two of the other cells and with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for drawing the correct proportion of the cells. Most candidates used a label line to identify the cell wall of one cell.

(b) Many candidates included only observable differences in **Table 2.1** and listed at least three observable differences between **M1** and **Fig. 2.1**, such as the epidermis was thinner on **M1** than in **Fig. 2.1**, the xylem vessels were smaller on **M1** than in **Fig. 2.1** and the endodermis was observable on **M1** but not in **Fig. 2.1**.

(c) (i) Many candidates correctly measured the line **X**–**Y** and the scale bar with the appropriate units. Some candidates showed the length of the scale bar divided by 3.4 mm to calculate the magnification and then divided the length of **X**–**Y** by the value for magnification.

(ii) Many candidates correctly calculated the area of the root section by showing the division of the actual diameter by two to find the radius and using the formula for calculating the area of the root section with the appropriate units.

(iii) Many candidates correctly suggested that the answer to **Question 2(c)(ii)** was an estimate of the area of the root section rather than the actual area since the root section was not a true circle.

(iv) Many candidates correctly suggested that a more accurate estimate of the area of the root section could be made by taking more measurements of the diameter at different points across the root and calculating the mean diameter.

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 that the wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. In **Question 1(b)(vi)**, where the question states 'explain how increasing the temperature by 10 °C above room temperature would affect the results you obtained' the candidate needed to give reasons as to why something happens, such as referring to increased kinetic energy and the formation of more enzyme-substrate complexes.

General comments

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.

Comments on specific questions

Question 1

(a) The majority of candidates correctly recorded the colour of the contents of each test-tube and recorded the colour red for 60 mmol dm^{-3} and blue for 0.6 mmol dm^{-3}.

(b) (i) Many candidates were able to carry out a serial dilution of 1% invertase solution, showing the correct concentration below each beaker (0.1%, 0.01%, 0.001% and 0.0001%) and transferring 1 cm^3 of the previous concentration to the next beaker and adding 9 cm^3 of distilled water to each beaker.

(ii) Most candidates recorded the room temperature with the appropriate units.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for concentration of invertase (%) and the heading for colour. Many candidates recorded a colour for each concentration of invertase. The stronger candidates recorded the colour red for the highest concentration and blue for the lowest concentration.

(iv) Many candidates correctly estimated the concentration of reducing sugar for the highest and lowest concentrations of invertase according to their results in **Question 1(a)** and **Question 1(b)(iii)**.

(v) The majority of candidates correctly stated that as invertase concentration increased the more reducing sugar was produced.

(vi) Many candidates correctly stated that as a result of increasing the temperature by 10 °C above room temperature, more results would show the presence of reducing sugar as the temperature became close to the optimum temperature for invertase and there was an increased rate of reaction with more successful collisions and more enzyme-substrate complexes formed.

Some candidates correctly stated that if the increased temperature was above the optimum temperature for invertase, the active sites of invertase would be changed causing the enzyme to be denatured and fewer enzyme-substrate complexes to be formed.

(vii) Some candidates correctly stated two significant sources of error, such as the difficulty of identifying the colours and that some concentrations of invertase and sucrose were left to react for more than three minutes. The stronger respondents correctly suggested how to improve the procedure to reduce the effect of these errors by suggesting the use of colour standards to help identify the colours and carrying out each test separately to ensure that the reaction time for each concentration of invertase was exactly three minutes.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the region of the stem on **N1**. Many candidates gained credit for drawing at least three layers of tissue and showed the correct distribution of tissues within the projection. Most candidates used a label line to correctly identify the epidermis.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw a group of four adjacent cells in the epidermis with each cell touching at least one other cell and with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for drawing the correct proportion of the cells. Most candidates used a label line to identify the cell wall of one cell.

(b) (i) Most candidates correctly circled 389 as the anomalous result.

(ii) Many candidates were able to calculate the mean distance travelled by the seeds of length 10.0 mm by showing the addition of the three distances, 212, 206 and 210, and division by three.

(iii) Most candidates used the headings given in the table to correctly label the *x*-axis (seed length / mm) and the *y*-axis (mean distance travelled / m). Some candidates labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *x*-axis, used a scale of 4 or 5 to 2 cm and for the *y*-axis, used a scale of 4 to 2 cm with the origin labelled as 200.

Many candidates plotted all the points accurately and joined the points with a thin line.

The most common errors were not using the correct scale and drawing lines which were too thick.

(c) Many candidates correctly measured the line **X–Y** drawn across the length of the seed and showed this length divided by 55. The stronger candidates showed their working and used appropriate units.

BIOLOGY

Paper 9700/41
A Level Structured Questions

Key messages

It is essential that candidates read each question carefully and apply their knowledge to the context of the question presented. Question **3(e)** and **Question 5(d)** required careful thought to work out the responses required. **Question 4(b)(ii)** was an example where some candidates gave answers from a learned list about the social implications of GMOs without engaging with the specific scenario in the question.

Candidates should be wary of learning lists from the mark schemes to previous papers without fully understanding and being able to express how the sequence of points links together, for example, in **Question 5(a)**.

Candidates should present differences as pairs of contrasting points, for example in **Question 3(e)** and **Question 10(a)**.

General comments

There was a wide range of marks with the strongest candidates scoring very high levels of credit. Most candidates showed a sound basis of knowledge of the syllabus. Candidates who did best had skills as well as knowledge. These stronger candidates made full use of the question stem material and showed flexibility of thought in being able to apply their knowledge to new contexts. There was evidence of weaker candidates having rote learned answers from previous mark schemes. While helpful for reinforcing key points, this approach leads to inflexibility and a lack of understanding of the logical links between the marking points. These candidates tended to give the same list of points in answers that did not match the new question context.

Responses showed some common misconceptions. The most significant of these were that:
- chloroplasts contain mitochondria
- chemiosmosis in chloroplasts does not make ATP
- ions such as calcium and hydrogen ions can enter into and be retained by the phospholipid bilayer of a membrane
- the natural selection process that results in adaptation is the same as genetic drift where random chance alters allele frequencies in a way that does not result in the population becoming more suited to its environment.

For **Question 2(a)** and **Question 3(e)**, candidates needed to be more confident in differentiating the parts of the granum as 'thylakoid membrane' and 'thylakoid space' (or thylakoid lumen).

Comments on specific questions

Question 1

(a) (i) The majority of candidates correctly identified the domain and kingdom to which the golden mantella belongs.

(ii) Candidates made a variety of acceptable suggestions about the benefit to the frog of being brightly coloured. The best suggestion based on the information given was that a bright colour warned predators of the frog's toxicity. Others made the reasonable suggestion that a bright colour could attract mates. Poor suggestions were that the colour would attract prey in order to poison it or that the bright colour provided camouflage, without giving a strong supporting argument such as being hard to see against yellow flowers.

(b) Many candidates correctly identified that the inhibition of the calcium ATPase pumps meant that calcium ions were not returned to the sarcoplasmic reticulum and therefore remained in the sarcoplasm. However, many went on to assume that there would be no calcium ions to bind to troponin and subsequently no muscle contraction. Full credit was gained by those who explained that the calcium ions remaining in the cytoplasm would remain bound to troponin, causing tropomyosin to be unable to return to cover the myosin head binding sites on actin and resulting in permanent contraction of the muscles of predators. Quite a few candidates mistakenly believed that the effect of the toxin was to the mantella frog, rather than to its predators.

(c) Many candidates scored full credit for their description of calcium ion channels opening to allow calcium ions to enter the synaptic knob, causing the movement of acetylcholine-containing vesicles and the subsequent exocytosis of acetylcholine into the synaptic cleft. These candidates noted the word 'cholinergic' in the question and did not make the error of just writing 'neurotransmitter' or 'ACh' in their answer. Most candidates correctly specified the presynaptic membrane in their response, but some made the mistake of stating that Ca^{2+} ions move into the membrane itself rather than through it into the cytoplasm of the synaptic knob. Mistakes in the use of terminology included referring to the 'pre-synaptic knob' and the 'post-synaptic knob'. The swelling at the end of a pre-synaptic neurone is referred to simply as the synaptic knob or terminal bouton. Some candidates wrongly described the exocytosis of vesicles rather than the exocytosis of acetylcholine. A few candidates missed the reference to the cholinergic synapse and continued to discuss the neuromuscular junction from **Question 1(b)**.

Question 2

(a) Most candidates understood the idea of naming a structure and explaining its function, but some responded with little reference to specific sub-structures within the chloroplast organelle. The most common correct responses stated that thylakoids are the site of the light dependent reaction and the stroma is the site of the light independent reaction and contains rubisco. Many candidates did not refer specifically to the thylakoid membranes as the location of the photosystems, electron transport chain proteins and ATP synthase. Many candidates mentioned the presence of DNA and 70S ribosomes but did not make it clear that these make some of the chloroplast's proteins. Some candidates mentioned the chloroplast envelope but did not state its function of compartmentalising the reactions of photosynthesis from the rest of the cell. A large number of candidates wrongly suggested that chloroplasts contained mitochondria and some thought that the inner membrane of the chloroplast envelope was folded. Some wrongly referred to the stroma as 'cytoplasm'.

(b) Candidates showed a good recall of cyclic photophosphorylation. Most stated that cyclic photophosphorylation only involves photosystem I and accurately described photoactivation, the movement of electrons along the electron transport chain and the subsequent return of the electrons to their original location. A few candidates did not link these events to their purpose of ATP production.

(c) Candidates found the absorption spectrum graph showing the three pigments in a red alga challenging to interpret. Most worked logically through each pigment, describing the peak wavelengths of absorption of each, or the range of wavelengths absorbed. Many were also able correctly to identify the colours represented by the wavelengths. A few candidates lost credit here either by being imprecise when stating data from the graph, not using the correct units in their data quotes, or by using poor terminology to describe the role of the pigment in absorbing light. Some candidates showed little understanding of why the three pigments were present; some suggested the algae used the organic material present in the water as a food source, implying they were heterotrophic and did not need photosynthetic pigments. Many did not use the information given in the question about deep water lacking red and blue wavelengths of light. The strongest answers stated clearly that the green and yellow wavelengths present in deep water that cannot be absorbed by chlorophyll a can be absorbed by the accessory pigments, giving a higher rate of the light dependent stage of photosynthesis leading to more algal growth.

Question 3

(a) This was well answered with most candidates stating a correct term such as polymerisation, anabolic or condensation for the type of reaction where larger complex biological molecules are built from smaller ones.

(b) Most fully correct responses stated that ATP is needed in the first part of glycolysis to phosphorylate glucose to make fructose 1,6 bisphosphate. Other creditworthy reasons for the phosphorylation included to make glucose more reactive and to prevent it from leaving the cell. Some answers showed imprecise use of the terminology used to describe energy changes in chemical reactions. Some mistakenly stated that the phosphorylation decreased the 'activation energy of glucose'. Candidates should be aware that activation energy refers to the energy needed for a reaction to occur and that it is not appropriate to refer to the 'activation energy' of one reactant molecule. Similarly, a few candidates referred to increasing the 'energy level' of glucose. An acceptable wording of this difficult idea was to state that phosphorylation activates the glucose or makes it less stable (i.e. fructose bisphosphate is less stable than glucose and less activation energy will be needed for the reaction that splits it into two triose phosphate molecules).

(c) The main error in naming the locations of substrate-linked phosphorylation was to name just one instead of the two correct locations, which were the cytoplasm and mitochondrial matrix. Some candidates just referred to the processes (glycolysis and Krebs cycle) rather than to the locations within the cell.

(d) Candidates showed good recall of the link reaction. The terms decarboxylation and dehydrogenation were frequently used. A few candidates contradicted themselves by correctly referring to the loss of carbon dioxide but calling it carboxylation. The reaction of acetyl with co-enzyme A was frequently mentioned but some only named 'co-A' instead of giving the full name of the co-enzyme. Some candidates thought that pyruvate rather than the two-carbon acetyl fragment combined with coenzyme A.

(e) This was a challenging question requiring candidates to identify differences in how chemiosmosis operates in mitochondria and in chloroplasts. Candidates knew the process in mitochondria better and sometimes just described this, gaining no credit. The most significant weakness in candidates' understanding of chemiosmosis in chloroplasts was not knowing that the protons are pumped across the thylakoid membrane from the stroma to the thylakoid lumen (due to the action of the electron transport chain) and that these protons then diffuse back through ATP synthase in the thylakoid membrane in the opposite direction, from the lumen to the stroma. Few were aware of the final electron acceptor or the end-product in both. Credit was not given for comparisons that just stated a negative for one of the processes, such as 'chemiosmosis in mitochondria makes water but in chloroplasts it does not'. Candidates needed to sift their knowledge to identify the end-product in both (water in mitochondria and reduced NADP in photosynthesis). One misconception that occurred was thinking that in mitochondria chemiosmosis makes ATP (true) but that in chloroplasts it does not make ATP (untrue).

Question 4

(a) All candidates attempted this question and the majority gained some credit, with many earning all or nearly all of the credit available. The box most commonly left unticked was the box stating that gene editing can produce a transgenic organism.

(b) (i) Many candidates correctly identified tree **A** as the wild type orange tree (as it showed the largest area of leaf with canker disease).

(ii) The overwhelming majority of candidates recognised that giving orange trees resistance to citrus canker bacteria would result in a greater healthy leaf area for the orange trees and therefore a higher yield of orange fruits. Many also identified the increased profit for the farmer and the cheaper price of the fruit as a result of higher yields. Candidates frequently wrote that the farmer would not have to treat their trees with chemicals to kill bacteria, but some misnamed these bactericidal chemicals as insecticides or herbicides. A significant number of candidates did not use the question context by referring to the specific example of oranges, and instead relied on recalled facts that were not applied to this scenario. Some candidates wrote about an improved yield of trees rather than fruit, and some weaker responses suggested that the bacterium that causes canker on citrus tree leaves could harm human health.

Question 5

(a) Most candidates were able to explain at least in part how the ice sheet led to allopatric speciation. Many answers relied on rote learning of the principles of allopatric speciation from previous mark schemes and many candidates did not fully understand these and misinterpreted some ideas. The commonest errors were to wrongly imply that the different mutations in the two areas were not random ('there were different selection pressures and so different mutations occurred') and to equate natural selection with genetic drift ('different selection pressures led to genetic drift'), when in fact these are two different mechanisms that change allele frequencies.

(b) (i) There was a great deal of confusion between natural selection and genetic drift in both parts of **Question 5(b)**. The difference in fur colour was clearly adaptive and so could be explained in terms of a selective advantage in each subspecies, adapting it for its environment (natural selection). Some candidates claimed that this also showed genetic drift and lost the credit they might have gained for natural selection as they contradicted their argument.

(ii) Few candidates understood that the size difference was not obviously adaptive; in fact, it is the opposite of what would be expected if the subspecies were adapted to their environments in terms of thermoregulation. Since the difference cannot be explained by natural selection, possible explanations are genetic drift or that the phenotypic difference seen is not genetic but is a result of food shortage in the tundra and plentiful food supply in the south. Very few candidates grasped these ideas. Most tried to explain the size difference as adaptive, often giving contradictory arguments about size, surface area and heat loss in the process. Endothermic animals, such as mammals, at higher latitudes should be larger (not smaller, as is the case with *Rangifer tarandus groenlandicus*), with a smaller surface area to volume ratio to minimise heat loss.

,

(c) Most gave good answers stating that hybridisation would increase genetic variation and hence the ability to adapt to future change. The question was comparative but some candidates did not give a comparative answer stating, for example, that 'the hybrids can adapt to climate change' instead of 'the hybrids will be more able to adapt to climate change'. Some wrongly argued that hybridisation between subspecies was negative since it would lead to 'inbreeding depression' and 'sterility'. Some candidates took a limited short-term view, e.g. that two parents would breed to give a hybrid offspring that would immediately have an advantage and survive. Candidates needed to take the whole gene pool and long-term view of what range of alleles was present and which alleles at some future date might allow some individuals to survive and carry the population forward. Some candidates confused the idea of a species being well-adapted now with the potential to adapt in the future.

(d) Candidates struggled to bring their knowledge of practical techniques to the question of how to test the hypothesis that migratory behaviour is genetic. Relevant techniques that could be used to compare the genes in the reindeer sub-species included PCR, electrophoresis, DNA sequencing and bioinformatics. Some candidates mentioned these and explained how they could be used to compare the genomes of reindeer of the two sub-species. Microarray analysis to compare gene expression was a frequent answer that was not creditworthy since the question needed candidates to suggest ways of finding differences in the alleles present in the different reindeer gene pools, not temporary differences in expression of the same genes. Many candidates only considered ecological survey techniques rather than gene technology techniques, and the commonest wrong answer was a detailed description of the mark-release-recapture protocol to calculate the size of a population of mobile animals using the Lincoln index. The implausible means of counting large mammals by using quadrats was suggested by some.

Question 6

(a) Most candidates knew that blood glucose concentrations are maintained by homeostasis or negative feedback. A few candidates misinterpreted the word 'mechanism' and wrote 'glycogenesis' or 'glycogenolysis'.

(b) (i) Most candidates stated that glucagon, as a hormone, travels through the blood. Common mistakes were mentioning 'diffusion' or writing 'binds to receptors'.

(ii) Most candidates had learned the second messenger mechanism and were able to identify adenylyl cyclase and cAMP.

(iii) Many candidates were unable to describe the role of enzyme cascades as signal amplification. Instead they described aspects of glycogenolysis such as the activation of glycogen phosphorylase.

(iv) The majority of candidates knew that glycogen phosphorylase breaks down glycogen into glucose. Some mentioned the production of glucose without referring to glycogen and some contradicted their correct idea by writing 'gluconeogenesis' as well.

(c) Many candidates were well prepared for this recall question and most named glucose oxidase as the enzyme in the biosensor. Not all stated that it is responsible for the formation of both gluconic acid and hydrogen peroxide although many candidates mentioned one of these. Some responses gave the incorrect name 'glutamic acid' instead of gluconic acid or gluconolactone. Many candidates knew that the sensor generates a current (rather than a current being imposed by the sensor), which was expressed in many ways such as 'electron flow' or 'transfer of electrons'. Some candidates confused a colour-changing test strip with the biosensor.

Question 7

(a) Most candidates gained credit for giving the definitions of gene and allele. Answers that did not gain credit included those that omitted the word DNA from the definition of a gene and those that described an allele as a type of gene or stated a version of a gene without using the word 'different'.

(b) The majority of candidates were able to work out the genotypes and phenotypes in the genetic cross. Errors included adding a zero for white-eyed flies in the ratio, despite this phenotype not appearing in the cross, and not matching the genotypes to the phenotypes and the numbers in the ratio to the correct phenotypes.

(c) Most candidates described crossing the red-eyed fly with a fly of homozygous recessive genotype but not all stated that it must be a white-eyed fly. Many candidates worked out that if all the offspring were red-eyed then the genotype must be homozygous dominant. A common omission was to write that the presence of a non-red eye colour in the offspring indicated a 'heterozygous genotype' without specifying the colour of the eyes and linking this to the precise genotype of the red-eyed parent.

Question 8

(a) (i) Candidates scored well on this question, showing awareness of the impact of humans on biodiversity through the destruction of habitats for agriculture and development and through hunting, over-fishing or over-exploitation of wild species. As it was a 'suggest' question, pollution and climate change were allowed as answers, although in fact there are no documented examples of any species going extinct between 1800 and 2000 due to anthropogenic climate change. Some candidates just described the trends in the graph without suggesting reasons for these trends.

(ii) Many candidates successfully calculated the rate of species extinction over the last fifty years of the graph. The main errors were reading the graph incorrectly, either using the human population line instead of the number of species line or reading figures from the wrong axis scale.

(b) Responses varied in that some candidates were very well prepared with a list of reasons why biodiversity should be maintained, while others had few strong reasons to offer. Candidates showed appropriate knowledge in mentioning useful resources we obtain from other species, such as medicines, food and wood, and also when describing the role of biodiversity in science, education and tourism. Some candidates showed understanding of the interconnectedness of the biosphere in terms of the stability of food webs and mineral cycling and the role of vegetation in preventing soil erosion and maintaining climate stability.

While those candidates who correctly used the words 'ethical' and 'aesthetic' gained credit, few showed understanding of what these words mean in terms of reasons for maintaining biodiversity. Candidates' comments showed short-term thinking about protecting every individual of a species, whereas conservation is a long-term project of managing resources to maintain viable populations into the future. Pest species, those that spread human diseases and those which overproduce where only a limited area of suitable habitat is available, may have to have their population sizes controlled by humans, but without driving them to extinction.

Many candidates mentioned 'aesthetic' arguments, but many had little idea what the aesthetic argument for conserving biodiversity is – that nature is beautiful and people enjoy this beauty and that time spent 'in nature' contributes to physical and mental well-being.

Question 9

(a) Most candidates were able to identify that the structure made of cellulose was the inner cell wall of the guard cell, **D**. Fewer could identify the location of the Calvin cycle as the chloroplasts in the guard cells, **B**.

(b) Candidates recalled steps in the mechanism that opens stomata but weaker responses omitted key details. A common error was to write 'cell' or 'stoma' instead of specifying that guard cells were the location of the events described. Other areas of confusion were mixing up the directions in which the two ions travelled and the mechanisms by which they moved (active transport for H^+ versus facilitated diffusion for K^+).

Question 10

(a) Few candidates were able to fully contrast the structure and function of the two types of neurone. Often one neurone was correctly described without the contrasting description for the other neurone. Common errors were to describe the sensory neurone cell body as being in the middle of the axon rather than being situated between the axon and dendron in the neurone, and to suggest that motor neurones have dendrons. The question command to 'contrast' meant that writing similarities such as 'both have…' could not gain credit.

(b) Most candidates were able to use the data in the table to describe the relationships between myelination and impulse transmission speed and axon diameter and impulse transmission speed, often supporting their conclusions with correct paired data from the table. Some omitted reference to 'speed' which was essential to the answer.

(c) Many candidates made insufficient use of the graph to explain why further action potentials were not possible. Many candidates did not mention the letters **A**, **B** and **C** at all, or combined **A** and **B** together in their answer, as though the ion channels opening and closing during **A** (depolarisation) were the same as those that open and close during **B** (repolarisation). The commonest correct answer was reference to hyperpolarisation at **C**.

BIOLOGY

Paper 9700/42
A Level Structured Questions

Key messages

- Candidates should read the question carefully and answer with precision, paying particular attention to the command words such as describe, explain, suggest and outline.
- Candidates need to take care to spell technical terms correctly.

General comments

A wide range of credit was awarded throughout the ability range, with a good spread either side of the mean. Most candidates made an attempt to answer most questions. **Questions 1** and **2** proved to score well as did **Question 10**. Many candidates found **Questions 5**, **6** and **7** to be challenging.

Comments on specific questions

Question 1

(a) (i) This was generally answered correctly, with most candidates stating melanin, DOPA or dopaquinone. The most common incorrect answer was tyrosinase, while a few candidates confused names and gave myosin.

(ii) Most answers correctly stated cyclic AMP or calcium ions. Incorrect answers included adenylyl cyclase, G-proteins and mRNA.

(iii) While most candidates correctly stated that the person would have albinism, and described some of the features of this condition, some did not demonstrate that they understood the term ‘phenotype’. A few needed to read the question more carefully as they made comments about spots on jaguars.

(b) Most responses correctly showed a monohybrid cross and gained full credit. Where this was not the case, the errors were generally where candidates needed to state that their symbols represented alleles, or to make clear which genotypes in the offspring produced which colours. A small minority tried to do a dihybrid cross or sex linkage and a few crossed a black animal with a brown animal.

Question 2

(a) (i) Candidates were asked to explain why light intensity can be a limiting factor. Many misinterpreted the question and defined what a limiting factor is. Very few attained full credit and those who gained some credit commented on variations of the importance of the light-dependent stage. Very few identified light energy as the factor that limits the light-dependent stage. References to the products of the light-dependent stage were rarely seen as was any reference to the impact of light on stomatal opening. Some candidates incorrectly wrote reduced NAD or NADP as a product.

(ii) Candidates were asked to complete the figure by sketching lines for RuBP and TP when the concentration of carbon dioxide is reduced. Generally, this was well answered, with many responses accurately drawing lines that demonstrated a solid understanding of the Calvin cycle and gained full credit. A minority incorrectly showed RuBP as a horizontal line or following the other two lines decreasing. A significant number of candidates needed to read this question more carefully as they left the graph blank.

(iii) Most candidates were able to explain that under very dry conditions, less carbon dioxide would be able to enter the leaf. Very few gained the credit, however, as they needed to give the specific part of the leaf or cell where carbon dioxide would have been destined to end up for photosynthesis, e.g. air spaces, palisade cells, mesophyll cells, stroma, chloroplasts. The most common creditworthy point was that stomata would close. A significant minority also recognised the synoptic link that this would be a stress response involving ABA.

(b) (i) Candidates were required to read data from the graph and calculate a percentage change in mean plant biomass. This calculation was carried out successfully by the majority of candidates. Some candidates managed to read the graph adequately but then used the wrong equation to calculate percentage change. Quite a few could have gained more credit by correctly rounding the final answer. The most common error was to divide by the final total instead of the starting total.

(ii) Candidates were given information about how Sox4 plants had been genetically modified and were asked to explain why these plants have a different mean plant biomass compared to wild type plants. Candidates rarely mentioned that an additional copy of the SBPase gene would be present and that would mean increased transcription/expression would occur. The majority received credit for recognising there would be increased regeneration of RuBP and consequently increased carbon fixation. Many candidates listed the resulting products but often missed the credit available for stating their use in the plant and thus the link to biomass and the resulting growth as biomass increased. A few candidates incorrectly suggested they had more biomass because they were better looked after, and some answers consisted of more general statements about the use of gene technology.

(iii) Many candidates recognised that a nitrate deficiency would limit the number of amino acids that could be made and that they are needed for protein synthesis of SBPase. Some candidates mentioned nitrates being a requirement for protein synthesis. To gain further credit, they needed to add that amino acids are the constituent part of the protein that require nitrogen in their formation. A few able candidates recognised that nucleotides would be limited but often did not give a correct reason for their use. Some mentioned transcription, but not nucleotides. Other incorrect uses of nitrates given included ATP and chlorophyll.

Question 3

(a) There were some very good answers to this question, and also answers where candidates clearly did not understand the process. Good responses highlighted the conversion of pyruvate to acetyl CoA as the starting point. The majority of candidates recognised oxygen as a final electron acceptor and this was the most commonly awarded point. Credit was also often obtained from correctly identifying the role of NAD in various parts of the process. A small number of stronger candidates clearly showed that they understood the role of NAD as a hydrogen carrier or electron carrier, being involved in the link reaction by removing hydrogen and carrying hydrogen to the ETC where it would be used in oxidative phosphorylation. Without oxygen as the final electron acceptor, the ETC would stop, and reduced NAD would not be oxidised and able to go back for more link reactions.

There was some confusion about reduced NAD oxidation. Some candidates wrote about Krebs cycle in more detail than the link reaction. Many commented on FAD, with confusion between whether the NAD was for the link reaction or Krebs cycle. A few responses focused on glycolysis or Krebs cycle and these candidates needed to more carefully interpret what was required of the question in order to gain credit. Several candidates incorrectly wrote about oxygen being directly involved in the link reaction and necessary to convert pyruvate to acetyl CoA or to make carbon dioxide. Some answers suggested that since oxidative phosphorylation or Krebs cycle could not happen, then the link reaction was not 'needed'. A significant number of candidates showed a notable misconception that NAD carries hydrogen ions, so demonstrating a lack of understanding of redox reactions involving loss and gain of electrons.

(b) The vast majority of candidates identified glycolysis as the process of aerobic respiration that takes place in the cytoplasm and were able to describe one or two steps correctly to gain credit for this question. Many candidates received full credit as they also correctly stated the products of glycolysis, although a significant minority missed these points by not stating the correct number of molecules produced (net 2 ATP and 2 reduced NAD). The omissions were usually not mentioning phosphorylation of glucose or triose phosphate oxidation to pyruvate. The main error included not naming the correct intermediate.

Question 4

(a) This question was matching factual statements with the processes of genetic engineering using a plasmid and gene editing. Many candidates were able to match these statements well to demonstrate some understanding of the differences between the two techniques. Common misconceptions included finding the statement with respect to CRISPR difficult to distinguish, and not recognising that both genetic engineering techniques can produce a different protein.

(b) (i) Candidates generally identified the wild type plant as **C** by correctly interpreting the graph. They realised that higher levels of the precursor shikimate would be found as the levels of glyphosate increased. The most common incorrect answer was **A**.

(ii) This was answered reasonably well, with candidates demonstrating their knowledge of how an increase in yield would help to resolve food shortages and the economic benefits that would follow on from this. One common misconception was that less weed killer would be needed; incorrect considering that this example of gene editing is designed to permit the use of herbicide, as the desired crops would now become resistant to its use. Although the question asked about the social benefits, several candidates confused this with ethical implications with respect to gene editing and food and impact on biodiversity. Some candidates gave generic contexts (e.g. therapeutic approaches) that could not gain credit.

Question 5

(a) Most correctly referred to geographical isolation and allopatric speciation. Errors included using the term allotropic instead of allopatric and stating that the separation itself was allopatric speciation. Some wrongly referred to the two separated groups as 'the two species' rather than groups or populations.

Most referred to a lack of gene flow between the two populations, and different selection pressures for the two groups, and also that different random mutations might happen. Quite a few, however, wrongly suggested that the mutations would occur because of the selection pressures.

There were references to alleles being selected for, but sometimes candidates needed to add that these were different alleles; also when referring to changes in allele frequency, which needed to be different for the two groups.

It was important to make the point that many generations, or a long time, had to pass before the two groups became reproductively isolated.

A very frequent and widespread misconception was that genetic drift is something that happens as a result of natural selection. Many candidates used the term to describe the resulting changes in genomes that happened as a result of the selection that they had just been describing. This misconception was also apparent in many answers to **Question 5(b)**.

A small minority of candidates misunderstood the information and suggested that some bison lived in forests and some lived in the sea.

(b) This was a challenging question, requiring candidates to apply their knowledge and understanding of natural selection and genetic drift to a set of unfamiliar data. These data did not provide enough information for any strong conclusions to be made, and credit was given to any candidates who clearly stated this. Many candidates correctly suggested that natural selection could have resulted in the differences in height or mass and outlined how these differences could give an advantage when feeding on the two different food sources. A few noticed that the height difference was not significant. Credit was also given for suggesting that non-genetic factors might be responsible for the differences in mass or height, such as the quantity or quality of the food supply.

Very few responses showed understanding of the term 'genetic drift' by suggesting how it might have caused any of the differences.

Most candidates could have gained further credit by discussing more than just one idea, such as the role of natural selection.

Some candidates wrote general answers about natural selection and genetic drift, without any reference to the data, which gained no credit.

(c) This question was also quite challenging. Candidates needed to read and understand the information about the similarities of the nuclear and mitochondrial genomes, and then consider how this might be used to infer the possible evolutionary histories of the European bison. Some correctly suggested that the European bison has a (relatively recent) common ancestor with *Bos*, to which it is more closely related than to the American bison. Some also explained that the mitochondrial genome is inherited through the female line. A very few suggested how these similarities may have come about, perhaps through breeding between European bison and *Bos*.

(d) The expected answer to this question was an outline of a variety of practical techniques that could be used to determine the degree of relationship between farmed cattle and European bison.

Some candidates correctly stated that DNA should be obtained from both species and went on to outline processes such as electrophoresis or the use of a microarray to determine the degree of similarity between the base sequences of the DNA samples. A common error was to refer to extracting mRNA and using this to generate cDNA for use in a microarray, which would provide information about similarities in gene expression, not in the DNA base sequences. Many candidates made appropriate references to databases (bioinformatics).

The ability to outline a process as required by the question, by summarising the main points, was not always apparent. Many candidates selected one process, such as gel electrophoresis or the use of a microarray, and described it in great detail.

Some candidates were able to state clearly that the degree of similarity between DNA base sequences, or amino acid sequences in a protein, would indicate the closeness of a relationship between the two species. A few also suggested breeding the two species together – although they often referred to the production of 'fertile' offspring, which would indicate that the animals belong to the same species.

A small minority were confused by the term 'practical techniques' and wrote about quadrats, random sampling and mark-release-recapture. A smaller number were also triggered inappropriately by the term 'hypothesis' and described statistical analyses or calculation of Simpson's index of diversity.

Question 6

(a) Many candidates were able to draw a correct arrow for the movement of gibberellin from the embryo to the aleurone layer, and another for the movement of amylase from the aleurone layer to the endosperm. A number of responses showed incorrect arrows, for example, the arrow for gibberellin going to the endosperm, the arrows for gibberellin or amylase either starting or ending in the testa, or the arrows remaining entirely within the endosperm. Weaker candidates did not attempt this question part.

(b) Nearly all candidates were able to describe the role of amylase in seed germination. Most understood that amylase hydrolyses starch in the endosperm into maltose, which is further hydrolysed to glucose. More able candidates then explained that glucose could be used by the embryo in respiration to provide energy for plumule or radicle growth. Weaker responses did not identify where hydrolysis would take place or suggested incorrect products, such as fructose. Occasionally, candidates went into considerable detail about the mechanisms involved in amylase synthesis, which was not required.

(c) The graph of the percentage germination of seeds with or without gibberellin treatment was well described by the more able candidates. Many began by stating that the maximum percentage germination was highest in group **C**, which had received the largest concentration of gibberellin, followed by group **B** with half the concentration, and lastly the control group with distilled water showed the lowest percentage germination. The most common error was where candidates did not identify the final percentage germination or misquoted the relevant figures. Many appreciated that the rate of germination was also highest in group **C**, or vice versa for **A**, although no reference to the figures for rate were seen. Candidates struggled to describe the start of the germination accurately for any group, with many commenting that germination of groups **B** and **C** began on day 1, rather than after it, while that of group **A** began on day 5. Some avoided the problem by stating that group **A** germinated four days after groups **B** and **C**.

Question 7

(a) Most candidates were able to draw the correct positions of the RNA polymerase bound to the promoter, and repressor molecule detached from the lac operon, when lactose is present. In many cases this also included lactose bound to the repressor. Weaker candidates most frequently made a mistake with the RNA polymerase, placing it over the operator (O) or halfway between the promotor (P) and O. Several candidates made no response to this question.

(b) (i) This question was directly testing recall of the learning outcome from the syllabus 'to describe the difference between a structural and regulatory gene'. Incorrect answers were frequently given, some stating the type of gene product (e.g. enzyme) or naming the protein produced by the expression of *lacY* – lactose permease.

(ii) Candidates often only named the protein product as 'permease'. Permease refers to any protein that facilitates movement across a cellular membrane, thus specificity was required by stating the molecule lactose. Candidates lost credit for trying to name the product as β–galactosid*ase* permease – a hybrid of two enzyme names. Candidates were often too informal in their descriptions of 'make the cell more permeable', indicating a general lack of awareness of the fundamental role of the cell (surface) membrane. Candidates must take care not to refer to the cell in a way that suggests this term is acceptable as homologous to cell (surface) membrane. Frequent incorrect responses included describing the protein as responsible for breaking down lactose.

(c) This question had two aspects, describe and explain, and answering both command words was required for full credit. Descriptions related to the sequence of increase/constant/increase/constant for the graph of the growth of *E.coli*, needed references to the shape of the population growth curve for credit. Weaker candidates wrote in general terms about an increase in growth over time, with unclear references to the plateaus.

The second part of this question was 'suggest explanations', where weaker candidates were unable to demonstrate an understanding of the basis of the question; that the *E.coli* would metabolise and respire glucose first, then the glucose/galactose derived from the hydrolysis of lactose. Some stronger candidates lost credit by describing glucose as being a limiting factor – i.e. 'still available', instead of having run out.

Question 8

(a) The majority of candidates correctly gave microvilli. The acceptable alternative of brush border was not seen. Common incorrect answers included papillae, villi, cilia, receptors and binding sites.

(b) Answers for this 'suggest' question were often poorly expressed and very few candidates were able to use the information in the stem of the question to gain credit. Common suggestions that could not gain credit included: to prevent leakage of substances, to prevent the impulse from escaping, to ensure that an impulse was generated and to hold the cells together.

(c) Most candidates were able to score the majority of the credit here and there were some excellent responses which included many more of the creditworthy points than the minimum for full credit. In general, understanding was good. Answers that did not score highly generally lacked the precision required.

Responses that did not reference the cell surface membrane/membrane (alone) could not access several of the marking points – e.g. 'depolarisation' needed 'of the cell surface membrane'; 'the neurotransmitter binds to a receptor on **B**' required mention of the receptor being present on the membrane. Regarding the movement of ions, the most common errors were inappropriate references – to Na^+/K^+ pumps; to voltage-gated channels rather than ligand-gated channels; to Ca^+ rather than Ca^{2+} ions/channels; to outward movement of Na^+ ions. Some candidates needed to be careful with their choice of the words 'fuse' and 'bind'. Answers which suggested that vesicles 'bind' to the cell surface membrane of **A** or that the neurotransmitter 'fuses' with the receptor in **B** did not gain credit. Credit for a 'receptor potential' being established in **A** could sometimes not be given due to the subsequent reference (when threshold exceeded) to it then 'becoming an action potential'. Understanding of the process of exocytosis was often poor with frequent references to the vesicles themselves passing from the cell in this way. Some candidates focused entirely on the events in neurone **B** (and further, in terms of the impulse passing on to the CNS) so that very little credit could be accessed.

Question 9

(a) Most candidates found this question very challenging and many scored little or no credit. Many responses incorrectly used comparative words suggesting that blood pressure would be 'higher' or 'increased'. Some referred to pressure and needed to qualify this with 'blood' or 'hydrostatic'. Others suggested that the different diameters in some way 'accommodated' the high pressure of blood coming from the heart and so prevented possible rupturing of vessel walls. Some stated that the differences could be explained entirely on the basis of the volume of blood being far less as it left through the efferent vessel.

Some candidates correctly described the force or push required and needed to go on to link this with a fluid being moved. Commonly, candidates instead named specific molecules/ions without appreciating that they would simply be moving within the forced fluid. A few mistakenly believed that blood in its entirety was pushed through. It was necessary to state where the fluid was passing through or into and a minority did not do this. Incorrect use of terms describing a passive movement, such as diffusion, appeared fairly frequently.

(b) (i) This part was well answered with many candidates being awarded full credit. Responses which did not gain credit included 'basal membrane' for **A** and 'endothelium' for **B**.

(ii) Most candidates achieved some credit in this question. Candidates who tried to cover a range of molecules, ions and blood cells, rather than just referring to one suitable example, struggled to gain credit. By incorrectly including red blood cells in a long list of substances referred to as 'molecules' they were unable to score. Most who quoted a molecular size of molecules that can pass through the basement membrane knew a correct value but a few needed to qualify the stated figure with, e.g. (R)MM.

Most were able to correctly describe an appropriate feature relating to **B**. A few appreciated that the pores allowed bulk movement of 'fluid' of some description into the capsule. Most referred to substances or named molecules without understanding that they would be carried through only because they were dissolved in the fluid.

Question 10

(a) Many candidates were able to suggest at least one assumption that must be made for the mark-release-recapture method to be valid, most notably for appreciating that there should be no migration of the population or alternatively, no births or deaths within the period of study. Many also commented that the mark should not harm the penguin or affect its survival. Fewer appreciated that time should be left for marked birds to reintegrate into the population or that penguins must be mobile for this to happen. Numerous answers indicated confusion with the assumptions associated with use of the Hardy-Weinberg equations.

(b) The vast majority of candidates were able to offer at least one reason why the African penguin has become endangered, usually for a comment on habitat loss. Many went on to gain full credit by mentioning global warming or climate change, and direct threats to the population such as predation, poaching, loss of food supply or competition for other resources. There were a few references to pollution and disease although the latter was only credited if the disease was new, rather than existing.

(c) Many candidates struggled with this calculation of the mean yearly decrease in population size from 1900 to 2000. It required the subtraction of 200 000 from 1.5 million and division by 100. Common mistakes were trying to calculate the percentage decrease per year, not dividing their figure by 100 or using data from the wrong columns. There were few correct answers of 13 000 (per year).

(d) Many candidates were able to give three characteristic features of the animal kingdom, with most of these referring to the possession of eukaryotic cells. Although a significant number of candidates limited their answer to a detailed description of the features of eukaryotic cells, many also mentioned that animals are all multicellular, with specialised cells that form tissues and organs, and that animals are heterotrophic. Other correct answers included reference to cilia or flagella, a nervous system and motility. Credit was more likely to be attained by referring to positive features (that is, features that animals possess), rather than negative ones (that is, features that they do not possess, such as the absence of a cell wall).

There were numerous answers suggesting that candidates equated the Kingdom Animalia with mammals or vertebrates. These listed features such as a vertebral column, lungs or hair.

BIOLOGY

Paper 9700/43
A Level Structured Questions

Key messages

- Candidates should take care when answering questions that require comparisons to be made, so that they refer to both of the features they are comparing in answers. This was evident in **Question 1(a)(iii)**, **Question 2(a)(i)** and **2(b)(ii)**, and **Question 9(b).**
- When asked to describe and explain data, as in **Question 2(b)(i)**, candidates should describe data in words first and then give evidence for their description with a paired data quote which includes the correct units.

General comments

Candidates found some questions more challenging than others, for example: **Question 3(c)**, **Question 4**, **Question 5(b) and 5(c)(ii)**, **Question 6(b)**, **Question 9(b)** and **Question 10(a)(ii)**.

Comments on specific questions

Question 1

(a) (i) Candidates were asked to name the parts of a nephron that were located in the medulla. Stronger candidates correctly stated the loop of Henle and the collecting duct. Weaker answers named other parts of the nephron or kidney, whilst a few left this question blank.

(ii) ADH or vasopressin was correctly named as the hormone involved in osmoregulation whilst some answers incorrectly referred to other hormones such as insulin and adrenalin.

(iii) Candidates were required to describe the relationship between the RMT and the urine concentration by referencing a given table of data. Good answers noted that as the RMT increased so did the urine concentration. Candidates found it more challenging to then explain the differences between the beaver and the kangaroo rat. The strongest responses used the data in the table and stated that as the kangaroo rat lived in the desert, there would be little water and so the rat's loop of Henle would be long, resulting in more water reabsorption in the kidney, producing more concentrated urine. Many weaker candidates were able to access some of the credit available. The weakest responses were very muddled and showed little evidence that these candidates had used the information from the table.

(b) Only the strongest candidates were able to access credit for this question. The most common answer given was that there is water in food. Few candidates mentioned water from the respiration of glucose or that there would be behavioural adaptations such as staying out of the heat or being active at dawn or dusk.

Question 2

(a) (i) One successful strategy to answer this question was to divide the answer space into two columns, one for each type of photophosphorylation. When candidates wrote in continuous prose, it was a common occurrence that the same point was not compared so the credit could not be awarded. Most candidates were able to correctly identify at least one similarity. The most common answer was either that ATP was produced in both processes or that both involved an ETC. A smaller number of candidates identified that both involved the photoactivation of chlorophyll. The most common difference to be highlighted was that only photosystem I was involved in cyclic photophosphorylation whereas both photosystem I and photosystem II were involved in non-cyclic photophosphorylation. Occasionally candidates suggested that it was only photosystem II involved in cyclic photophosphorylation. Other frequently given differences were that no reduced NADP or oxygen are produced or that there was no photolysis in cyclic photophosphorylation.

(ii) Candidates were asked to explain why carbohydrates were not produced if either photophosphorylation were prevented. Many candidates did not make the connection that the products from photophosphorylation were used in the Calvin cycle. Some made the link and stated what would happen if photophosphorylation occurred. For credit, they needed to go on to explain that there would be no ATP and reduced NADP made so there would be no Calvin cycle and no regeneration of RuBP. There were a minority of candidates who wrote reduced NAD instead of reduced NADP.

(b) (i) Candidates were asked to use the data from a graph to describe and explain the results shown by the wild type data only. Many candidates made comparisons between both data lines, often gaining no credit. A significant number of candidates did not describe the data line in words and instead gave data quotes, which did not describe the trend of the line. A good strategy to describe the trends on a graph is to use the axis labels, e.g. when the CO_2 concentration increases, the CO_2 fixation increases, and then to support this statement by quoting suitable figures with units. It was clear that many candidates understood that they needed to describe the line and found it difficult to access credit without such a strategy. Many candidates who had successfully described the trend needed to go on to explain why the data line had occurred in the way they described. A good number of candidates were able to give correct units when they made a paired data quote.

(ii) This question was well answered. The majority of candidates were able to describe that the Sox4 line had a higher rate of fixation of CO_2 compared to the wild type and went on to give a paired data quote with units of the highest CO_2 fixation rate for each. Most candidates were able to offer a good explanation for the difference caused by the introduced *SBPase* gene which allows the plant to have a faster regeneration of RuBP allowing more RuBP to react with CO_2.

Question 3

(a) Most candidates correctly answered this question with substrate-linked and oxidative phosphorylation. Weaker answers named the stages of aerobic respiration instead of the correct processes and the site of the reactions, for instance, the ETC. A minority also confused respiration and photosynthesis and so gave cyclic and non-cyclic photophosphorylation as their answers.

(b) Candidates across the range of ability found this question challenging. The most common points to be awarded credit were that reduced coenzymes delivered hydrogen, which split into protons and electrons, to the ETC for oxidative phosphorylation which meant that ATP was made. A significant number of candidates also recognised the role of recycling of NAD and FAD between the different stages of respiration and oxidative phosphorylation. Many candidates demonstrated a misconception which limited the credit they could access: NAD and FAD are hydrogen carriers or carriers of electrons, they are not carrying a proton or a hydrogen ion or a hydrogen molecule. When NAD or FAD become reduced, they gain electrons and a proton has no electrons. Some candidates attempted to describe the redox reactions that occur during the stages of glycolysis, the link reaction and the Krebs cycle. They mostly gained credit from explaining that the coenzyme became reduced. Some weaker candidates stated that both NAD and FAD were reduced in glycolysis and the link reaction, so did not gain credit. Only a minority of candidates described and explained the role of the oxidation reaction of the substrate in each of the stages of aerobic respiration.

(c) This question provided a novel context by giving an unfamiliar detail of the link reaction and the inhibition of a specific enzyme involved in the link reaction. Candidates had to suggest the importance of this inhibition. A small number of the strongest candidates were able to gain full credit. The most common answer was an explanation that the inhibition made it possible to control the rate of the link reaction because as the ratio of acetyl coenzyme A to coenzyme A changed, the level of inhibition would also change. Few candidates went on to explain the subsequent effect of this which allowed any excess build-up of acetyl CoA to be used in the Krebs cycle and to allow more coenzyme A to return to the link reaction.

Question 4

(a) A minority of candidates gained full credit. Most candidates gained an intermediate level of credit for correct responses throughout the statements in **Table 4.1**, suggesting there were no specific areas of strength or weakness.

(b) (i) Candidates were provided with information about a plant that had been part of a gene editing experiment and a graph was given to compare the gene edited plants with the wild type plant. More of the stronger candidates and some of the weaker candidates correctly selected type **A** for the wild type plant.

(ii) Candidates across the ability range found this question difficult. The most common answers identified that this crop could be grown in harsh environments, such as areas of water shortage. Some candidates mentioned an economic benefit but few highlighted that with longer storage times it would result in less food waste and that this crop would help to solve the global demand for food.

Question 5

(a) Candidates answered this question well, secure in their knowledge of how evolution occurs by natural selection. They successfully applied their knowledge to the information given that showed this was allopatric speciation, as the map provided showed a geographical isolation. Weaker candidates found it more difficult to explain clearly that once a population was isolated from another population, the selection pressures, mutations and selection of alleles would be different for each isolated population. Instead, they listed these processes for one population and needed to emphasise that they would be different in another population. A minority of candidates also suggested incorrectly that a change in environment would cause mutations.

(b) Candidates found this question challenging and only the strongest were able to achieve full credit. The most common correct answers included that DNA or a blood sample would be required. Many also knew that the DNA would be amplified by PCR. Few candidates were able to clearly express that the samples should be from different pumas at a variety of the different locations so as to compare the different sub-species. Of those who mentioned using a microarray, some were unable to select the correct type of microarray that would test for genome similarity as opposed to gene expression. A good number of candidates correctly referenced the use of bioinformatics.

(c) (i) It was clear that many candidates did not fully understand what continuous or discontinuous variation was, so did not score any credit. Of those who did, they were able to correctly explain that the feature was either present or absent, was categoric and gave qualitative data.

(ii) Candidates found this question very challenging. Few recognised that as this was a small population (30 individuals), that the effects of genetic drift would be more significant. Also, that with so few individuals present, inbreeding would take place, increasing homozygosity, bringing recessive alleles together. Since these forms were normally rare, some candidates were able to deduce that they were likely due to a recessive allele and so the effects of these rare variants would then be shown with the increased frequency of homozygous recessive individuals.

(iii) Most candidates recognised from the map that Texas is closest to Florida and would share similar types of climate or environmental conditions. A few added that the pumas would also be most genetically similar.

Question 6

(a) A minority of candidates were able to identify the structures in region **Y** as microvilli. Some realised that they would provide a large surface area and a small number went on to say that this would enable more sodium ions to enter the cell.

(b) This question tested the candidate's knowledge about how a receptor cell detects a stimulus and goes on to stimulate the transmission of an action potential in the sensory neurone. Even though the diagram presented a novel situation to the candidates, this question simply asked for an account of part of synaptic transmission. Many good attempts did not gain credit as they needed to use more precise terminology when making points. The most common error was in identifying cell membranes; some did not mention the membrane at all. It is expected that candidates use the term 'cell surface' membrane or to identify the precise membrane, e.g. presynaptic or post synaptic membrane.

The most common errors were:

- Describing exocytosis as vesicles binding, instead of fusing, with the presynaptic membrane.
- Describing the vesicles as being released by exocytosis instead of the neurotransmitter.
- Referring to the cell being depolarised rather than the membrane.
- Describing the sodium ion channels on the post synaptic membrane as voltage-gated, rather than ligand-gated.
- Describing ions as entering the membrane, rather than entering the neurone.

Question 7

(a) Stronger candidates were able to gain credit for correct definitions of these terms, using clear and precise descriptions. A lack of precision caused potentially good answers to gain no credit. For example, genes are lengths of DNA that code for a polypeptide, not a phenotype and a locus is the position of a gene on a chromosome and not just an area on a chromosome.

(b) Good genetic diagram skills were displayed here. Many candidates scored well, particularly with regard to parental phenotypes and genotypes and the offspring genotypes. The most successful candidates used the space well and drew a Punnett square with gametes, leaving enough space in each box to write the genotype and phenotype together. The majority of candidates, of all abilities, achieved full credit with a small number achieving most of the credit available. The most common errors were not linking the offspring phenotypes to the genotypes and not being precise about the ratio.

(c) The majority of candidates explained that the result of the mutation may be no tyrosinase being made so no enzyme is present to convert tyrosine to DOPA or on to dopaquinone and so melanin would not be formed. A small number of candidates explained that the type of mutation, possibly a substitution or frameshift, would result in a change in the tertiary structure of the protein and some also mentioned the possibility of a STOP codon causing no tyrosinase to be made. Weaker candidates struggled to gain credit on this question and only the strongest candidates were able to secure full credit.

Question 8

(a) Many candidates showed a secure knowledge of the syllabus learning outcomes and gave reasons such as climate change, a qualified reference to competition relevant to the example given, and loss of habitat. A large proportion also recognised that disease would play a role and could have gained credit if they had made it clear that it would be a new disease that would cause a recent decline in numbers of tapir. Strong responses used other ideas from this topic area to suggest reasons. For instance, a small number of candidates suggested that alien species could have been responsible as they might have been a predator to the Malayan tapir or that they might have brought with them a new disease.

(b) A minority of candidates were able to access full credit for this question. Many candidates confused the roles of zoos and conserved areas with the role of CITES. The most likely answers to be awarded credit were that CITES would make a list of species that are rare or endangered and that some species would have a trade ban imposed. Very few candidates also mentioned that for some species not yet at risk of extinction, trade restrictions may be imposed by way of permits required to be able to trade them. A good number of candidates recognised that border checks and a punishment system would be required to enforce the trading restrictions. A few candidates showed awareness that CITES encourages governments to join CITES and to abide by their regulations.

(c) This question was well answered across the range of abilities, resulting in many responses that showed a good knowledge base and achieved full credit.

Question 9

(a) Most candidates were able to name **A** as the axon and some could identify **B** as the nucleus of the Schwann cell.

(b) Strong responses stated that myelinated neurones had a faster speed of transmission due to long local circuits and saltatory conduction. These went on to explain that this was due to sodium ion channels only being effective at the nodes of Ranvier where there would be depolarisation of the membrane. A minority of candidates recognised that in a non-myelinated neurone, the depolarisation occurs along the whole length of the neurone because the sodium ion channels are present along the whole length of the neurone, which would mean local circuits would be short.

Question 10

(a) (i) A large number of candidates found giving a description difficult and instead gave data quotes, which did not show the relationship between both lines on the graph. More successful responses provided a description in words first and then supported this with a paired data quote with correct units. Some candidates were able to give a description and a data quote but used the wrong axis for the data quote for blood insulin concentration. The most able candidates were able to explain that the relationship showed that the process of negative feedback was occurring and that an increase in blood glucose concentration caused the release of insulin from the pancreas, which then caused cells to respond by increasing their permeability to glucose and condensing glucose to glycogen by glycogenesis. Few candidates linked the decrease of blood glucose concentration back to set point as being caused by insulin.

(ii) A very small number of candidates achieved higher levels of credit on this question. These candidates recognised that time would be needed to hydrolyse the starch into glucose. Few candidates were able to correctly comment on how the lines for both blood glucose concentration and blood insulin concentration would change, and only focused on one molecule. It was clear that some understood that there would be a delay in the concentrations increasing and that both peaks would be lower, but these answers were often not precise enough to be awarded credit. Very few recognised that both curves would take longer to decrease.

(b) This question was well answered and many responses demonstrated that candidates had a good knowledge base of this area of the syllabus. Some candidates were able to write a sequence of events that included all the creditworthy points available. A small number made mistakes in their answers when describing the process of glycogenolysis or gluconeogenesis, either with their use of the term or their description of how it occurred. A few candidates described events to the point where glucose was made available in the cell and needed to go on to outline how it is released back into the blood to be awarded full credit.

BIOLOGY

Paper 9700/51
Planning, Analysis and Evaluation

Key messages

Candidates should read all parts of the question carefully and be prepared to critically evaluate unfamiliar scientific data in tabular and graphical forms. To access the highest grades, sound knowledge needs to be applied when suggesting conclusions in novel scenarios.

When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow.

When planning such investigations, candidates should read the instructions carefully and avoid repeating details from previous questions, especially when advised not to, as no credit will be awarded for this.

General comments

The responses covered the full range of credit and there was no evidence that candidates were short of time on this paper. Weaker candidates were challenged most with providing sufficient detail in their descriptions of the practical plan in **Question 1(a)(iv)** and with misconceptions of the statistical meaning of $p < 0.05$ in **Question 2(c)(iii)**.

Comments on specific questions

Question 1

(a) (i) Most candidates were able to identify the independent and dependent variables correctly. Vague responses for the independent variable, such as ‘area’, did not gain credit. ‘Species of plant’ could not gain credit for the independent variable, as this would alter the focus of the investigation.

(ii) The majority of candidates correctly identified that the number of stomata should be measured. It was important for candidates to remember that ‘area of the field of view’ is not measured directly; they therefore needed to measure the diameter or radius (of the field of view) to achieve credit. When referencing πr^2, candidates should include a description of the meaning of the formula symbols.

(iii) Many candidates correctly calculated the stomatal density by dividing the number of stomata counted in **Fig. 1.2** by the area of the field of view to give a value in the range 0.014–0.019. A few candidates misinterpreted stomatal density by attempting to use the formula mass / volume and were unable to gain credit. Some candidates achieved partial credit for stating the correct number of stomata or, less often, the area, in their working.

(iv) Many candidates were familiar with this style of question and were able to give detailed answers, incorporating all of the main elements of a biological investigation. Those who were less familiar with the ecological focus of this investigation were unable to access the higher levels of credit. Candidates first needed to address how they would collect the leaves to be used in the investigation. Many collected at least the minimum of 5 leaves from each habitat. Fewer candidates considered that they should be comparing the same species of plant across both habitats to obtain data that was comparable. Valid control variables included the age of the leaf or the position on the plant that the leaf was taken from. The age of the plant was not a valid control variable, as old plants will have young leaves. It would not be possible to standardise the size of leaves growing in the different habitats, so this did not gain credit. Some candidates suggested collecting leaves using random sampling; this gained credit when a suitable method was explained, such as using a random number generator to find coordinates for leaf collection. Systematic sampling methods, such as collecting leaves at regular intervals along a line, also gained credit, but were rarely seen.

The rest of the investigation was laboratory based, although as instructed in the question, candidates were not expected to repeat details of the method for making leaf impressions. Several candidates attempted to control variables such as temperature, light intensity and pH; this was not necessary. Instead, candidates should control the leaf surface viewed and the magnification of the microscope. Very low and very high magnifications would not work, as there would be either too many or too few stomata visible within the field of view. Credit was given to many candidates for actively counting the stomata viewed using the microscope; a few gained additional credit for a method of systematic counting such as only counting whole stomata. Most candidates successfully suggested repeating the experiment in each habitat at least twice and calculating a mean. The majority of candidates used the correct scientific terminology in this context, using 'mean' not 'average'.

No investigation is totally without risk, so stating that this investigation involved no risks or needed no precautions did not gain credit. 'Low risk' alone did not gain credit; candidates needed to outline the hazard, risk, and appropriate mitigation. For example, plants may cause allergies, so therefore wear gloves/mask; animals in the habitat may be dangerous, so stay in a group with an expert.

(b) (i) Candidates needed to read the question carefully and give their answer to the nearest whole number to gain credit. Most candidates correctly calculated the percentage decrease as 73(%).

(ii) This question proved challenging to candidates. The tabulated data and suggested conclusion needed to be read very carefully. The command word 'evaluate' was used by some candidates to good effect; these candidates stated reasons 'to support' and 'not support' the conclusion. Some candidates restricted their answers to only support or not support the conclusion; this meant their answers were unable to achieve full credit. Several candidates referred to the number of stomata on the surfaces of leaves; such references were not specific to the conclusion presented.

Candidates were expected to use the data in **Table 1.1** to calculate the stomatal density of the leaf surfaces by dividing the number of stomata by the leaf area. Correct calculations of stomatal density could then be used to evaluate the conclusion; credit was given for this, provided candidates noted that the number of stomata was given as $\times 10^3$. To support the conclusion, a clear statement that stomatal density on the upper surface is higher in plants grown in high light intensity gained credit. Some candidates also noted that the stomatal density on the lower surface was similar in both light intensities. Many candidates realised that the stomatal density on the lower surface was also higher in plants grown in high light intensity, therefore not supporting the conclusion. This gained credit only if candidates referred to the 'mean stomatal density'. Several candidates correctly noted that no statistical test had been carried out. The fact that the data was only for one species rather than all plants was noted by fewer candidates. Those candidates who clearly made 'for' and 'against' statements as part of their evaluation were most successful.

Question 2

(a) (i) Antibodies would be present in both plasma and faecal samples, therefore candidates who suggested plasma samples might not be effective did not gain credit. Many candidates recognised that faecal samples would be easier to collect from chimpanzees than plasma samples; however, to obtain credit candidates needed to develop this line of thought. Most candidates did so and mentioned collecting faecal samples is non-invasive or would not harm either the chimpanzees or the investigators.

(ii) Many candidates correctly suggested adding water to the faecal samples to form a solution. Some candidates then went on to suggest filtering the sample and therefore gained full credit. Using a centrifuge was suggested by a minority of candidates. Responses that described washing the faecal samples to remove bacteria or various aspects of aseptic technique did not gain credit, as this risk assessment was not the focus of the question.

(iii) Distinguishing between individual chimpanzees requires a comparison of their DNA; gel electrophoresis was the most common correct answer. DNA sequencing was also suggested by some candidates. Protein electrophoresis or protein sequencing would not be appropriate, so this did not gain credit. PCR and bioinformatics alone would not be sufficient, so these techniques did not gain credit. Many candidates mentioned microarrays, however as microarrays compare gene expression, they would not be suitable, and this suggestion was not creditworthy.

(b) Candidates often noted that the lines/bands on **Fig. 2.2** were matching for HIV+ and SIV+ individuals; however, a clear statement that three lines matched was required to gain credit. A few candidates incorrectly assumed that the lines indicated matching genes or DNA. Several candidates were able to gain credit by noting that SIV antibodies (from the infected chimpanzees) could bind to HIV antigens. It was important to use the correct biological terminology of 'antibodies' and 'antigens' in this question. Additional credit could be gained by noting that therefore the HIV antibodies and SIV antibodies must have similar protein structures. The idea that HIV– or SIV– individuals do not contain antibodies for the HIV antigens was also creditworthy. It was not correct to state that these individuals have no antibodies present, or that they have no antigens. Some candidates noted that all the tests had a line present in the control region; candidates gained credit when they also stated that the test must be valid or had worked correctly.

(c) (i) Several candidates correctly identified that the original number of chimpanzees in the two populations (SIV+ and SIV–) were different. To gain credit, candidates needed to clearly state that the original or initial numbers were different. Candidates often stated that calculating the percentage of chimpanzees surviving made comparisons easier or more accurate; this was not creditworthy. Those candidates who suggested that the comparisons would be valid or fair were able to gain credit.

(ii) Many candidates showed a good understanding of the null hypothesis, stating that there is no difference between the life expectancy or death age of chimpanzees that are SIV+ and SIV–. Candidates should consider first whether the data being compared is continuous or categorical to determine the correct wording of the null hypothesis. A few candidates stated an alternative hypothesis rather than the null hypothesis. Candidates who discussed the number of chimpanzees that died did not gain credit, as this did not match the investigation. Careful reading of the information provided was required to avoid such errors.

(iii) Great precision with statistical terminology was required, and consequently very few candidates gained full credit. There were some good answers here, gaining credit for stating that there was less than 0.05/5% probability that the result occurred by chance. Less successful responses were either too vague to gain full credit or used incorrect terminology such as 'chance' or 'sure' instead of 'probability'. Candidates could extend their answers by stating that $p < 0.05$ is the probability where the null hypothesis is rejected or where critical values are chosen. However, it is incorrect to state that 0.05 is the critical value.

(iv) Many candidates were able to give a reason why the data in **Fig. 2.3** may not be an accurate representation of the effect of SIV infection on the life expectancy of chimpanzees. Candidates who noted that the death of chimpanzees may not be due SIV gained credit; giving specific examples for death such as hunting, predation or malnutrition gained further credit. It was also valid to note that some of the results in **Fig. 2.3** were due to the disappearance of chimpanzees rather than their death. Several candidates also gained credit by mentioning that the ages of the chimpanzees were estimated. A few candidates noted that chimpanzees might become infected with SIV during the investigation, or that the gender of chimpanzees might affect their life expectancy. Stating that the investigation only used a small number of chimpanzees, only lasted for 9 years, or only considered chimpanzees from one area (Gabon) did not gain credit. These issues would not reduce the accuracy of the investigation, but instead reflect some of the limitations of studying an endangered species.

BIOLOGY

Paper 9700/52
Planning, Analysis and Evaluation

Key messages

Candidates are advised to read the whole paper thoroughly before attempting any answers. Full consideration of all the information provided is essential for candidates to identify the areas of the syllabus being tested and to enable them to gauge the scientific terminology and the level of detail required.

In addition to planning, analysis and evaluation, candidates are expected to write clearly and concisely. Many responses demonstrated these skills across all question types.

General comments

Candidates were able to attempt all questions and the full range of credit was awarded throughout the cohort. Very few candidates left answers blank.

Comments on specific questions

Question 1

(a) (i) Many candidates gained credit by correctly identifying the measurable feature as the dependent variable. Some responses referred to the rate of diffusion of calcium hypochlorite as the dependent variable, which was incorrect. Candidates who gave two alternatives were unable to gain credit.

(ii) The strongest responses identified the surface area to volume ratio as the independent variable and labelled the *x*-axis accordingly and their sketch graph was well drawn with either a straight line or a smooth curve indicating a negative correlation. Weaker responses had only 'width' as the label on the *x*-axis or the line drawn extended beyond the axes. Occasionally, candidates attempted to add units to the surface area to volume ratios.

(b) (i) Many responses were clear, logical and detailed, demonstrating a sound understanding of practical procedures, equipment use, the control of variables and the precautions required to minimise any risks. The highest scoring accounts made good use of the information provided and produced plans that could be followed with ease. Weaker responses gave lengthy descriptions of how to cut the cubes, which were unnecessary, and some descriptions would not have produced a cube shape. It was not necessary to repeat the details provided in the question such as the concentration of calcium hypochlorite.

Many candidates suggested five as a sensible number of different sized cubes, and widths that could be cut using centimetres within the range 0.5–5 cm. Equipment used to prepare and measure the cubes was correctly identified by many of the candidates. Some referred to inappropriate equipment, for example, using a meter rule to measure the cubes. Good responses demonstrated an understanding that the cubes needed to be fully submerged in the calcium hypochlorite for a fixed time period and kept in a thermostatically controlled water-bath to maintain a constant temperature.

High-scoring responses described the variables that were controlled within their accounts, demonstrating a full understanding of the need to standardise variables and the methods by which this could be achieved. Candidates needed to understand the impact of the variables on the data collected and be able to describe how the variables could be controlled. This was not always possible when the variables were presented in the form of a list which did not refer to how the control of the variable was to be achieved.

Correct scientific terminology was important, and necessary, in a plan designed to be followed by another person. Stating that the surface area to volume ratio should be found lacked the method required to find the ratio. When the experiment is to be repeated to enable a mean to be calculated, the number of repetitions is important; there should be at least 3 repeats. The term 'average' is not accepted as an alternative to mean. Weaker responses often muddled the various measurements such as width, area and volume.

To gain credit for precautions, candidates needed to identify the hazard, the specific risk, e.g. irritant, allergy, cuts to the skin, and the precaution required to avoid the specified risk. Many candidates identified calcium hypochlorite as an irritant and stated that gloves should be worn to avoid irritation of the skin. Weaker responses gave incomplete answers such as 'taking care when using a scalpel', which were insufficient.

(ii) This question asked for a method for calculating a percentage change in volume. There were many clear responses that gained full credit by providing a detailed equation or a clear description of the mathematical steps and measurements to be taken. These descriptions needed to include the mathematical processes of subtraction, division and multiplication. Weaker responses had long descriptions which lacked clarity about where the measurements were taken from. Many responses made no reference to multiplying by 100, which is needed to calculate the percentage.

(c) (i) Almost all candidates gained full credit on this question. The identification of the anomaly could be achieved by reviewing the data provided and many circled the correct figure. Many candidates correctly calculated the mean and displayed their answer to the same level of precision as the other means.

(ii) The question asked how the method described could be improved to gain better repeatability, to enable each of the four candidates to obtain the same or very similar results. This did not require candidates to produce a new method but to add specific details that would improve consistency when carrying out the practical. Good responses identified the need to standardise the cube size, the volume of water, and the use of a thermostatically controlled water-bath to maintain a constant temperature. Many weaker responses suggested repeating the experiment more times but without any changes being made. Candidates should be aware that by repeating a process the outcome is not necessarily improved.

(iii) This question had two parts; stating the effect and the biological explanation of that effect. It was expected that the explanation would relate to the change in membrane permeability due to increasing temperatures. Weaker responses mentioned an increase in the rate of diffusion caused by the increase in kinetic energy of betalain molecules. Candidates had been told that betalain molecules are too large to diffuse through the cell membrane; this information was provided at the very beginning of the question. Although an understanding of the link between a reduction in light transmission and more betalain being present in the water was shown by many candidates, this did not form part of the answer to the question.

Question 2

(a) This question required candidates to apply their knowledge of estimating the size of animal populations to estimating what percentage of the badger population was infected. A calculation was needed and could have been stated as an equation or a full description. The clearest responses presented a straightforward equation showing how to calculate the percentage of infected badgers. These responses also made clear statements about catching a large sample followed by counting, testing and recording the numbers of infected and not infected. Many responses began with an account of the mark-release-recapture process without reference to testing and counting the infected badgers; in the context of this question this was only a partial answer. Careful reading of the information given was essential for candidates to ensure the focus of their responses was specific to this question.

(b)(i) A clear understanding that population density refers to the numbers of a single species per unit area was needed to gain full credit. The wording needs to be quite precise to avoid confusion. Many candidates copied the information from the stem of the question which refers to the

population density of infected cows and infected badgers. These responses lacked understanding of the term 'population' and that the numbers of cows and badgers could not be combined.
The second mark point rewarded any awareness that the use of population density will allow valid comparisons to be made. Many responses were vague, referring only to 'making the data easier to analyse' or 'needed because large numbers were being dealt with'.

(ii) The variables required to gain credit had to relate to the investigation outlined in the question. When conducting ecological studies, it is often impossible to standardise all variables. For example, the precise numbers of cows and badgers in each area sampled, the sex of the cows and badgers and the specific abiotic factors found at each site. This question asked for three variables. When considering a finite number of responses, candidates would be advised to begin with those responses that they are most confident in. Many candidates gained full credit by focusing on what could be standardised; the method of testing for TB, year and the time of year in which the counts were made. Weaker responses often gave a long list of variables that were uncontrollable and with a valid response only at the very end.

(c) (i) When writing a null hypothesis, it is important to be clear about what is being compared, in this case the number of infections in badgers and the number of infections in cows. Most responses only stated 'no correlation between the infected badgers and infected cows'. The information provided in the question included the phrase 'scientists investigated the correlation…', therefore a null hypothesis which referred to 'no significant difference' was incorrect.

(ii) Evaluation questions require candidates to identify both the data that can support and the data that does not support a hypothesis. The responses that evaluated both sides with supporting comments and observations of the data were able to gain full credit. In high-scoring responses, candidates reviewed the data overall using **Fig. 2.2** and **Table 2.2**. Many candidates recognised the flaws in the data and demonstrated an understanding that correlation does not mean causation. Weaker responses focused on specific areas sampled rather than the data sets. Positive and negative correlations were identified correctly by many candidates. Fewer were able to apply the significance to the correlation. The significance was often applied to the data.

Careful planning of responses to this type of question should be encouraged. The question asked candidates to use both **Fig. 2.2** and **Table 2.2**; the stronger responses made it clear if their comments related to the table or the graph. Weaker responses lacked this clarity so that it was difficult to distinguish between statements relating to the individual data sets and statements relating to the combined data sets.

BIOLOGY

Paper 9700/53
Planning, Analysis and Evaluation

Key messages

Candidates should read the whole of each question prior to answering.

When planning an investigation, it is important to be clear about the investigation being asked and to set out the work in a logical way.

When describing such investigations, candidates should read the instructions carefully, and avoid repeating details from previous questions, as no credit will be awarded for this.

General comments

Question 1

The common theme in this question was based around determining the water potential of potato tissue. In the first part, the candidates were introduced to a method involving coloured sucrose drops and asked to identify the independent variable and predict and explain the results of part of this investigation. This was followed by candidates being introduced to a second method involving mass gain or loss of the potato. After being asked to describe how to dilute a stock solution and assess the risk, many candidates confidently designed an effective experimental method to determine the sucrose concentration in the potato tissue. The final part of **Question 1** tested candidates' understanding of statistical analysis and the conclusions to be drawn from the data from this second investigation.

Question 2

This question tested candidates' understanding of the use of a respirometer to determine the RQ of blowfly larvae. Many candidates were familiar with this and followed through clear predictions, descriptions, and explanations of the use of the equipment introduced. Less successful candidates were not able to suggest variables requiring to be standardised or the reasons for an anomalous result. The manipulation of data for the calculation of the volume of oxygen and RQ were well answered by the majority, showing good mathematical skill.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly identified the independent variable as the concentration or water potential of the sucrose solution. A few responses confused the dependent and independent variables or only stated the aim of the investigation, which was to estimate the water potential of potato tissue.

(ii) Candidates were asked to predict the result if the water potential of the potato tissue was higher than the surrounding sucrose solution. For credit, they either needed to state that the coloured sucrose drop would sink or identify outcome 3 as the result. Responses that gave correct explanations about what would happen in terms of osmosis but without a prediction did not gain credit.

(iii) To gain full credit for this question, candidates needed to give two explanations for their prediction in **Question 1(a)(ii)**. Many responses correctly stated that water would leave the potato by osmosis. A few candidates incorrectly stated that sucrose would move. The strongest candidates developed their answers further, stating that the sucrose solution would therefore become less dense. Candidates who gave references to water potential alone needed to develop their answers further and include an explanation to gain credit.

(b) (i) Candidates were asked to describe the method necessary to produce 20 cm^3 of 0.4 $mol\,dm^{-3}$ sucrose solution, adding 8 cm^3 of stock solution to 12 cm^3 water. Common incorrect responses were to make general statements like 'by proportional dilution' or 'diluting the stock solution', without stating the volumes.

(ii) Several candidates stated that the investigation did not involve hazards such as fire or dangerous chemicals. However, the safety issues discussed should be specific to this investigation. Credit was given to responses which correctly identified that some people could be allergic to potatoes or that using a knife might cause injuries. Stating that sucrose or potatoes cause irritation did not gain credit, as these substances are not harmful to most people.

(iii) There were many well-planned responses. Candidates were often familiar with this investigation and with this style of question. Some responses needed to focus on the use of mass rather than the methylene blue technique to determine the equivalent sucrose concentration to achieve high levels of credit.

Several candidates gained credit by suggesting at least five different concentrations of sucrose solution to use, rather than just using the 1.0 $mol\,dm^{-3}$ and 0.4 $mol\,dm^{-3}$ sucrose solutions from **Question 1(b)(i)**. A few candidates refined the method so that once the approximate equivalent sucrose concentration was identified, further concentrations at small intervals around this point were investigated; this also gained credit.

Pieces of potato should be cut to the same dimensions; vague references to using the same size of potato did not gain credit. A few stronger candidates gave a method for creating potato pieces with the same dimensions, such as using a knife or cork-borer, and a ruler. The age or type of potato needed to be standardised and for these aspects, use of the words 'use the same….' is to be encouraged. Credit was also given for the use of a water-bath or temperature-controlled room to standardise the temperature. References to standardising the volume of sucrose solution did not gain credit; for this investigation it is more important that the potato pieces are fully covered by the solutions.

Most candidates measured the mass of the potato pieces before and after placing them in the sucrose solutions. The time the potato pieces spend in the sucrose solution should be standardised; any time less than 15 minutes did not gain credit as this is insufficient time for osmosis to change the mass of the potato pieces. Some candidates gave a method, such as using a paper towel, to dry the potato pieces before measuring their final mass. The majority of candidates suggested repeating the procedure a sufficient number of times and calculating a mean. The term 'average' should not be used in a scientific context.

A risk assessment was not required, so this did not gain credit.

(c) Most candidates correctly stated that the water potential of the potato tissue was –1.15 (MPa). Answers within the range of –1.11 to –1.19 (MPa) were also acceptable. To avoid error, candidates should use a ruled guideline and take care when reading the scale. As this is a measurement of water potential, the negative sign must be included.

(d) (i) Of those candidates who gained credit, the majority referred to the data being continuous or the data showing a normal distribution. A few candidates contradicted themselves by also stating that the data was discrete or discontinuous so were unable to gain credit. The conditions of the data for the *t*-test proved to be an area for improvement for many candidates.

(ii) The majority of candidates were able to give the correct null hypothesis, stating there was no difference between the water potential of the two types of potato. The most common error was to state that there was no correlation rather than no difference. A few gave the alternative hypothesis.

(iii) The majority of candidates were able to correctly calculate 38 as the number of degrees of freedom.

(iv) Many candidates gained full credit for this question, showing a good ability to analyse statistical data. Most responses correctly stated that the critical value was 2.024 (at 38 degrees of freedom and $p = 0.05$). Therefore, the null hypothesis is accepted as the calculated *t*-value is lower than this. Having accepted the null hypothesis, candidates were then able to conclude that there is no significant difference between the water potential of the two types of potato. A few candidates chose to reject the null hypothesis and therefore could not achieve full credit.

Question 2

(a) Most candidates stated that substance **X** absorbed carbon dioxide. Credit was given if candidates also stated that this carbon dioxide was produced by the blowfly larvae.

(b) The majority of candidates correctly identified that the meniscus in the manometer would move up. For credit to be awarded, a suitable explanation was also required. Creditworthy responses needed to go beyond stating that oxygen was taken in by the blowfly larvae for respiration, to provide an explanation that this would cause the volume or pressure of gas in the test-tube to decrease.

(c) Several candidates gained credit by suggesting that substance **X** should be removed in order to measure the carbon dioxide produced. Candidates should read the question strand carefully to construct their responses; those who referred to measuring the mass of substance **X** did not gain credit, as this would not be a modification of the apparatus. Few candidates considered replacing substance **X** with glass beads or other inert material.

(d) Candidates were asked to state two variables that should be standardised during the experiments. Temperature and the mass of substance **X** were often correctly identified. The number, mass and age of the blowfly larvae could also be standardised. 'Species of larvae' did not gain credit, as this had already been stated in the information given in the question. References to standardising the 'time for the experiment' were not given credit; it is the 'time to equilibrate' or the 'time for measurement (of the meniscus)' that should be standardised.

(e) Few candidates noted that the oxygen uptake for replicate 1 was much lower than the other replicates, therefore the blowfly larvae may not have been fully equilibrated for this first measurement. The blowfly larvae being at a lower temperature and reduced activity of the larvae were other possible causes for this anomaly. Several candidates suggested leaks in the apparatus, human error, or dead blowfly larvae as causes for the anomaly; these suggestions were not creditworthy. Stating that the temperature might be different for replicate 1 was not sufficient to gain credit, as this response does not explain why the oxygen uptake is lower.

(f) Many candidates were able to correctly calculate the volume of oxygen taken up by the blowfly larvae as $5.34\,mm^3\,min^{-1}$ for replicate 5. The cross-sectional area of the manometer tube should be calculated using πr^2; this is then multiplied by 68 (the distance moved by the manometer fluid) and divided by 10 (as the distance moved was measured after 10 minutes). Candidates should remember to show their working for all calculation questions, as some credit may be awarded for correct working even if the final answer is incorrect.

(g) Most candidates could calculate the respiratory quotient (RQ) for replicate 5 by dividing the volume of carbon dioxide produced by the volume of oxygen taken up, giving an answer of 0.56. No units should be given as RQ is a ratio.