BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 4, 7, 9, 13, 25, 28 and 35

The vast majority of candidates answered these questions correctly.

Question 2

Most candidates answered correctly with only some of the weaker candidates able to calculate the length of the eyepiece graticule scale as 13 mm.

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Question 5

Many candidates found this question difficult. Label 1 is to the inside of the rough endoplasmic reticulum, so cannot be correct. Transcription of DNA will be occurring in both the nucleus and the mitochondrion.

Question 10 and 12

These two questions both concerned the topic of proteins. In **Question 10,** most candidates answered correctly, although weaker candidates did not recognise that both sets of bonds were hydrogen bonds. In **Question 12**, the majority answered correctly although some candidates were unable to select the correct words.

Question 14

The stronger candidates found this question straightforward, with most answering correctly. The weaker candidates did not know that all four statements were correct.

Question 16

Although most candidates answered correctly, a minority of candidates did not link statement 1 with an increase in fluidity.

Question 19

The majority of candidates answered this question correctly, although some candidates selected answers which incorrectly included cytokinesis or interphase.

Question 22 and 23

The majority of the higher-performing candidates had no difficulty in answering these questions correctly. In **Question 22,** a minority showed a weak understanding of strands and molecules, and in **Question 23** some candidates worked out the codon but did not take their reasoning a step further to give the DNA template required.

Question 27

Whilst the majority of stronger candidates answered correctly, some candidates found this question difficult and were not able to identify the labelled cells.

Question 29 and 30

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

Question 33

The majority of the higher-performing candidates answered correctly, although many of the weaker candidates incorrectly gave the answer carbon monoxide instead of nicotine.

Question 34 and 38

Whilst most candidates found these two questions straightforward and answered correctly, a minority found them difficult.

Question 39

Almost half of candidates answered this question correctly. Most realised that option **A** is not correct, but many selected option **B** and **C**, suggesting that the majority did not know the structure and properties of antibody molecules.

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Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 4, 11, 14, 15, 17, 27, 35, 36 and 37

The vast majority candidates answered these correctly.

Question 3

Although many candidates answered correctly, some did not realise that the single membrane-bound structures would be secretory vesicles carrying mucus in the goblet cell.

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Question 5

Many candidates found this question difficult. Plasmodium is a eukaryote which contains all three structures in its cells.

Questions 8, 9 and 10

Whilst the higher performing candidates had no difficulty with these questions, the weaker candidates were less certain and selected all options almost equally.

Question 12

Many candidates found this question difficult. The fatty acids released when lipids are broken down will cause the enzyme to denature by changing the pH.

Question 13

The majority of candidates found this question very difficult. **A** is not correct because the lowest substrate concentration will occur at the optimum temperature. Either side of the optimum, the substrate concentration will be higher.

Questions 16, 18, 19, 20, 21, 22 and 23

Whilst most of the higher performing candidates answered these questions correctly, others were less certain and selected across all options.

Question 24

Over half of all candidates were able to correctly deduce that X was a five-carbon sugar.

Question 26

Whilst the majority of stronger candidates answered correctly, only a minority of weaker candidates were able to give the correct role of ATP in this context.

Question 29
Whilst the higher performing candidates had no difficulty with this question, the weaker candidates were less certain and selected all options almost equally.

Question 30

Although some candidates answered correctly, the function and location of the atrioventricular node was not well understood by many candidates.

Questions 32 and 33

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

Question 38

Many candidates found this question difficult. The typical Y-shaped antibody is formed from two heavy chains and two light chains. Each of the four chains has a variable region.

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Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

Many candidates found this question difficult. Statement 2 cannot be correct as it refers to the use of a ×4 objective lens rather than a ×10 objective lens.

Questions 3, 10, 25 and 36

The vast majority of candidates answered these questions correctly.

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Question 4

Many candidates answered this question correctly. However, some candidates did not realise that addition of carbohydrate to protein was the first step.

Question 5

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

Question 7

Although the stronger candidates found this question straightforward, some candidates incorrectly thought that, if the solution was green for both tests, this meant no glucose was present before testing.

Questions 8, 9, 19, 21, 22, 27 and 31

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

Question 11

Many candidates found this question difficult and only a minority of all candidates could identify the correct description for collagen.

Question 13

The majority of candidates found it difficult to process the information provided about two types of enzyme inhibitors.

Question 14

Although many candidates found this question difficult, the majority of strong candidates answered correctly.

Question 15

The majority of the stronger candidates understood the effect of enzymes in an enzyme-catalysed reaction.

Question 16

Whilst almost all of the stronger candidates answered correctly, a minority of the weaker candidates were able to identify the components that act as antigens in the cell surface membrane.

Question 18

Although the higher performing candidates answered correctly, many found this question difficult. Many of those who answered incorrectly thought that air is found at Z, rather than solution Y.

Question 20

The majority of candidates answered incorrectly because they confused the fact that one DNA molecule has two strands.

Question 23

Many candidates found this question difficult, with all options being chosen. Of those who answered correctly, most went on to perform well overall.

Question 26

Although many of the higher performing candidates answered correctly, many candidates overall found this difficult, with a minority able to select the appropriate statement about the photomicrograph.

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Question 32

Many candidates found this question difficult with only a minority able to explain how the maximum uptake of oxygen occurs as blood passes through the capillaries of the lungs.

Questions 33, 34, 35, 39 and 40

These questions were answered correctly by the majority of stronger candidates.

Question 38

Although many candidates answered correctly, not all realised that bacterial ribosomes have a different structure from human ribosomes.

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Paper 9700/21
AS Structured Questions

Key messages

Key events occurring in the immune response are the recognition by the immune system cells of the non-self (foreign) antigen and activation of specific lymphocytes. Some questions that are set for Topic 11, Immunity, are based on unfamiliar material and do not always identify the antigen for the candidate. When responding to questions such as this, a good introduction would be to identify the non-self antigen. In **Question 5(a)**, a simple statement identifying the non-self antigen, as the toxoid would set the correct scene for the rest of the response.

Candidates should be reminded to take care when describing transpiration. Transpiration is the loss of water vapour from the aerial parts of the plant, mainly through the leaves. Water evaporates from the surfaces of the mesophyll cells within the leaf and water vapour diffuses through open stomata or through the cuticle (cuticular transpiration). In **Question 6(b)**, candidates should not describe water as evaporating from the surface of the leaf or evaporating from guard cells or of evaporating through stomata.

Questions set on graphical data can vary in the command term used. In **Question 3(a)**, candidates were asked to compare the effects of temperature on the activity of immobilised sucrase with the activity of sucrase free in solution. This should have indicated to candidates that it was necessary for them state both similarities and differences in the results and that biological explanations of the similarities and differences were not required.

General comments

Many candidates were extremely well prepared for this exam and were able to deal competently with unfamiliar material in addition to showing an excellent grasp of syllabus knowledge. At every level of achievement there were candidates who could have improved one or more answers by reading through their response to check that they have not made a simple error that contradicts their answer. For example, in **Question 2(c)**, many candidates wrote that water moves through plasmodesmata by osmosis.

Parts **(a)** and **(b)** of **Question 3** involved graphical data and there were many good data quotes which were presented correctly with the appropriate units. In both, some points made by candidates implied that time was plotted on the horizontal axis. For example in **(a)**, the comparisons stated for the results shown in **Fig. 3.1** often referred to the activity of the enzymes increasing and decreasing *faster* and/or *slower*. Some candidates stated that the activity of the two forms of sucrase 'started at the same activity (76 per cent) '. Some explained the steep decline in the activity of free sucrase as showing that it is 'rapidly denatured '. A typical answer to part **(b)** was 'activity between pH 5.5 to pH 8.0 decreases over time until the enzyme completely denatures '.

In **Question 4**, many candidates illustrated their answer on the Bohr effect by choosing a particular value of partial pressure of oxygen. This was good use of the graph. Some candidates could have considered the approximate values of pO_2 found in respiring tissues as they chose a value of 6.0 kPa, which is too high.

Question 5(a) was a good example where many candidates were confident in their use of correct scientific terminology, for example clonal selection, clonal expansion and antigen presentation. Although this was generally a strongly answered question, some used the term antigen instead of antibody and a number incorrectly used the term receptor to mean the antigen binding site.

In **Question 2(c)**, the entry of sucrose into the sieve tube in the leaf was often correctly stated to cause a decrease in water potential. However, only a proportion went on to correctly describe the mechanism of

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entry of water into the sieve tube as osmosis or describe the movement as down the water potential gradient. It was quite common to see 'down the concentration gradient'. In this question and in **Question 6(b)**, some candidates confused water potential gradients, hydrostatic pressure gradients and concentration gradients.

Candidates should be aware that the use of the term 'affected' can be too vague to gain credit. For example, in **Question 3(b)**, statements such as 'sucrase immobilised in beads is not affected as much by the solution of high pH' required further qualification before credit could be given.

In **Question 6(d)**, it was acceptable for candidates to either state that energy was required for active transport or that ATP was required. However, candidates should be reminded that energy is not the same as ATP. In **Question 1(a)(ii)**, although 'mitochondria produce ATP ' was an acceptable alternative to 'provide, energy / ATP', it was not correct to state that mitochondria *produce* energy.

Comments on specific questions

Question 1

(a) (i) Many candidates identified the two sections of mitochondria shown in the electron micrograph as cut in different directions and some responses could be credited with a correct description of **A** as a transverse section and **B** as a longitudinal section. A few candidates accurately used the terms transverse and longitudinal. Some candidates stated this the wrong way round. Some noted that mitochondria are of different ages and needed to be more specific by referring to **A** and **B** in their answer. A common error was to describe mitochondria as cells, for example by describing them as being surrounded by cell membranes and dividing by mitosis. Many candidates related the difference in size to the difference in activity of the two structures although few seemed aware that mitochondria are flexible and can change shape.

(ii) Almost all candidates stated that mitochondria are the site of ATP production. A few did not gain credit as they stated that this organelle produces energy. Fewer went on to explain that there needs to be sufficient mitochondria for the two daughter cells following cytokinesis in the root tip cells. The best responses avoided reference to active uptake of ions and other cell activities that need energy, as this was not the focus of the question. Some candidates referred to mitochondria as the powerhouse of the cell, which did not gain credit. It was quite common for candidates to suggest that the process of division supplied the energy or ATP and that they used it to undertake mitosis themselves.

(b) There were many good drawings of the nuclear envelope and the nuclear pore visible in region **C** in **Fig. 1.1**. For full credit candidates needed to join together the two lines that represented the nuclear envelope to form the lining of the pore. Some candidates annotated their diagrams to show the communication that occurs through nuclear pores, including the movement of mRNA into the cytoplasm and the movement of nucleotides into the nucleus. Some misinterpreted what was required and drew detailed drawings of cell membrane structure, often leaving a large space labelled as nuclear pore protein. Others drew transport proteins in their membranes and labelled them as nuclear pores. These drawings only gained credit if they showed the two bilayers of the nuclear envelope. Some drew plasmodesmata through cell walls and labelled them as nuclear pores, which was not creditworthy and some candidates did not label their diagrams at all.

(c) Many candidates gained full credit. Candidates who simply stated that the nucleus controls the cell activities and listed some activities, such as metabolism and movement across membranes, did not gain any credit. Better answers referred to the genetic information stored within nuclei and led on to refer to transcription, the production of mRNA and thus the use of DNA in the synthesis of proteins. Good answers also explained that the nucleolus is the site of production of ribosomal sub-units, although it was more common to see production of ribosome, which was credited. Some candidates knew ribosomal RNA was synthesised. Some stated that the nucleus protects DNA but did not elaborate further by stating the nature of the threat, such as degradation by enzymes. Some candidates missed the reference to non-dividing cells in the question and wrote about DNA replication. Others described protein synthesis in detail, which could not be credited beyond mRNA production. A number of very vague responses were seen, such as the nucleus is the control centre or brain or library of the cell. Frequently candidates referred to DNA being used for protein synthesis but did not explain that it contains coded information for the sequence of amino acids in polypeptides.

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Question 2

(a) (i) Most candidates identified the subunits of sucrose correctly as glucose and fructose. Many stated that glucose is α-glucose. Some candidates incorrectly thought that fructose is a pentose.

(ii) Most candidates identified the glycosidic bond in sucrose.

(iii) Hydrolysis was given by most, with a minority incorrectly referring to the reaction as condensation.

(b) Most candidates stated that sucrose is a non-reducing sugar so does not give a colour change with Benedict's solution and some qualified this statement with details of acid hydrolysis.

(c) The best responses to **(c)** focused on the entry of sucrose into the phloem sieve tube and its subsequent transport to the root storage tissues. A lengthy description of the movement of sucrose into companion cells was not required as candidates had been asked to describe transport from the phloem. Many candidates did not appreciate that companion cells are part of phloem tissue. Good answers started by explaining the movement of sucrose into sieve tubes by diffusion from companion cells through plasmodesmata. The decrease in water potential, the osmotic movement of water into sieve tubes and increase in hydrostatic pressure were often included. Many candidates also stated that translocation occurs by mass flow, with fewer successfully describing the gradient in hydrostatic pressure from source to sink. Some were confused by the terms source and sink.

Question 3

(a) Candidates did not always identify the key aspects of the graph. Many identified the peak activity that occurred at 60°C and the effect of the highest temperature on the activity of both forms of the enzyme. The activity at 40°C was rarely mentioned and many stated that the activity of the free enzyme decreased faster after 60°C compared with the activity of the immobilised enzyme. However, the graph shows the effect of increasing temperature, with no indication of time, so answers with implications of time did not gain credit. Some could have extracted data more accurately from the graph, stating temperatures with correct units together with the corresponding percentage of maximum enzyme activity. Stating that the activity of the immobilised enzyme is higher at all temperatures is not supported by the data. Many did, however, make reference to the higher activity of immobilised enzymes between 40°C and 60°C. Good answers included reference to enzyme activity throughout their answer rather than making reference to the rate of reaction increasing or decreasing. Weaker answers included vague references to temperature, such as 'around 65°C'.

(b) There were many good answers to this question. Many mentioned the protective nature of the alginate beads so that sucrase molecules are not exposed to the buffer solutions. Many also referred to the stability of the enzyme molecule and its active site even though there is an increase in hydroxyl ions. Some candidates referred to hydrogen ions and the breakage of ionic bonds, assuming that the graph showed a *decrease* in pH rather than an increase. Many did not answer the question in terms of enzyme structure.

(c) Almost all candidates listed the concentration of substrate or enzyme as the variable and some suggested the volume of substrate solution and enzyme solution. The 'amount' of enzyme or substrate was not accepted as this is ambiguous in this context. Some candidates did not explain their answers in terms of enzyme action, as required by the question, instead, referring to the need for fair and accurate results. Better answers referred to collisions between enzymes and substrates and the formation of enzyme-substrate complexes. Very few stated that the method used to measure enzyme activity should be the same.

(d) Many candidates answered this question very well. Some candidates simply stated that using immobilised enzymes is cheaper, which was not creditworthy.

Question 4

(a) Many candidates gained full credit. The most common correct answer was tertiary structure for **B**. Incorrect answers included iron for **E**, pleated sheet for **F** and omitting 'structure' for **G** to **J**. The term helix for **F** without any qualification as an alpha (α) helix did not gain credit.

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(b) (i) Almost all candidates gave the correct percentage saturation of haemoglobin.

(ii) Explanations of the Bohr effect were very variable. Many thought that the carbon dioxide combining with haemoglobin made the oxygen saturation decrease. Most candidates used the graph in **Fig. 4.2** to support their answer, although those who gave a data quote without this description often chose a partial pressure of oxygen that is too high, such as 6.0 kPa. Many candidates began an explanation of the effect of carbon dioxide by referring to the role of carbonic anhydrase. It was important to state that there would be an *increase* in the production of carbonic acid and an *increase* in hydrogen ions so that the effect of pCO_2 10.7 kPa could be highlighted against pCO_2 5.3 kPa. At a high partial pressure of carbon dioxide there are *more* hydrogen ions to combine with haemoglobin to form haemoglobinic acid. A proportion of candidates knew that the effect is to decrease the affinity of haemoglobin for oxygen. Some thought that decreasing the percentage saturation of haemoglobin means *less* oxygen is delivered to actively respiring muscle tissue. A number of candidates incorrectly stated that muscle tissue respires anaerobically to release carbon dioxide. Weaker responses incorrectly referred to the formation of carboxyhaemoglobin.

Question 5

(a) Some candidates did not use the information provided in the question and wrote about an immune response to bacteria or to a pathogen. Many answers were very well organised descriptions of the stages of an immune response and frequently included details of the role of T-helper lymphocytes. Many candidates were unclear about the source of memory cells.

(b) (i) Almost all candidates stated that autoimmune diseases are the result of an inability to distinguish self from non-self. Some thought that these diseases are the result of the immune system attacking itself, for example making statements such as 'producing antibodies against the body's own natural defence mechanism'. Many knew that antibodies are produced by B-lymphocytes against receptors on the cell surface membranes of neurones or muscle cells. They also described the consequences of this in terms of poor transmission of impulses and muscle weakness. Weak answers described the action of the immune system as 'mounting an attack'. Some candidates thought that the antibodies are produced against acetylcholine instead of against the receptors for this neurotransmitter. Some gave incorrect details about T-lymphocytes, describing the cells as attacking and destroying muscle cells or receptors.

(ii) Some candidates gave correct suggestions. A few explained that the immune response to the receptors described in part **(b)(i)** would keep recurring because the receptor molecules would continue to be produced.

Question 6

(a) Many candidates correctly named cell **A** and pathway **B**. Incorrect answers for **A** included mesophyll cell, epidermis, epidermal cell, endothelial cell and companion cell.

(b) Candidates who scored well on this question began by describing the evaporation of water from the surfaces of mesophyll cells and diffusion of water vapour out of the leaves. This led them to mention transpiration pull and the cohesion between water molecules. Fewer gave a clear statement about the water potential gradient between xylem in the root and the surrounding cells as shown in **Fig. 6.1**. Some candidates referred to adhesion of water molecules without stating that it is to cellulose in the walls of xylem vessels. Many included references to root pressure, when this is not relevant. Many mentioned cohesion and adhesion but did not explain them or incorrectly stated that adhesion is the attraction between water molecules.

(c) Many candidates correctly referred to movement through the cell membranes, cytoplasm and vacuoles and a small proportion qualified this by stating that this gives a much higher resistance to the flow of water.

(d) There were many correct answers to this question and described differences. Some candidates referred to the roles of carrier proteins and channel proteins and those who stated that channel proteins are required for facilitated diffusion but not for active transport gained credit. However, some stated that channel proteins are used for facilitated diffusion and carrier proteins for active transport, which did not gain credit as carrier proteins are also used in facilitated diffusion.

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Paper 9700/22
AS Level Structured Questions

Key messages

Candidates should be reminded to take care when describing transpiration. Transpiration is the loss of water vapour from the aerial parts of the plant, mainly through the leaves. Water evaporates from the surfaces of the mesophyll cells within the leaf and water vapour diffuses through open stomata or through the cuticle (cuticular transpiration). In **Question 1(d)(iii)**, candidates should not describe water as evaporating from the surface of the leaf or evaporating from guard cells or as evaporating through stomata.

Key events occurring in the immune response are the recognition by the immune system cells of the non-self (foreign) antigen and activation of specific lymphocytes. Some questions that are set for Topic 11, Immunity, are based on unfamiliar material and do not always identify the antigen for the candidate. In **Question 3(c)(ii)**, the O antigen of *Escherichia coli* had been noted in the short introductory paragraph, and although the actual question only stated 'pathogenic strain', candidates take care in their response to show an understanding that the pathogen is the organism that has entered the body to cause an infection and the antigen of the pathogen is the molecule that provokes an immune response.

Questions set on graphical data can vary in the command term or terms used. In **Question 5(c)**, two command terms were used, describe and explain. This meant that credit was given for making relevant statements about what could be seen on the graph of **Fig. 5.2**, for the extraction or manipulation of numerical data and also for biological explanations. The question required candidates to consider the benefits of stopping smoking, so it should have been clear that differences were required and that it was not necessary to state any similarities.

General comments

In **Question 1(a)**, most responded as requested by using label lines and the letters given to them to identify three plant cell structures. A number of candidates wrote out the name of the structure, which was not penalised but would have wasted some time. Writing the label over the top of the structure is not good practice as it is not always clear which part is being labelled.

Question 1(d) highlighted the importance of reading the introductory information. This question focused on the movement of water within leaves only, yet a proportion of candidates wrote at length about movement of water in the roots (often mentioning the Casparian strip) or in the xylem as it moved up the stem.

Prompts within the answer lines are there to guide the candidate into setting out their response. The prompts for A, T, G, C were given on the four lines for the response in **Question 2(a)** and some candidates ignored this and wrote out the bases in a different order.

Question 3 was challenging for some candidates. This contained unfamiliar material and also required candidates to draw on knowledge and understanding from a number of different syllabus topics. **Fig. 3.1** contained information about the structure of the cell wall of *Escherichia coli*. A common error in part **(a)** was to think that the outer membrane was not part of the bacterial cell wall. The labelling on **Fig. 3.1** clearly showed the outer membrane as part of the cell wall, highlighting the need for candidates to study carefully the information provided in **Fig. 3.1**.

In **Question 4**, it was evident that many candidates have had the opportunity to view stages of mitosis in prepared slides and/or from photomicrographs and were able to identify cells in the different stages of mitosis and cells in interphase from descriptions of events that occur in these stages.

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Question 5(a) referred to the gross structure of the human gas exchange system. Some did not realise that the response should be limited to the structures seen with the naked eye and gave details of structures seen using the light microscope.

The importance of reading the question carefully was also highlighted in **Question 6(b)**. Here, there were many excellent accounts outlining the use of monoclonal antibodies in the diagnosis of disease or the steps in the production of monoclonal antibody, but these did not gain any credit as the question had asked about the use of monoclonal antibodies in the treatment of disease.

Comments on specific questions

Question 1

(a) This was an easy start for many candidates and there was evidence that most had experience of observing plant cells as seen using a light microscope or as seen in photomicrographs or drawings of photomicrographs. The least well-known structure was the tonoplast. Most realised that the chloroplasts were large organelles, and this was the most well-known cell structure.

(b) This question did not require candidates to carry out a calculation of the actual length of **X**–**Y**. Most knew that the measured value for **X**–**Y** would need to be divided by the magnification. Good responses made it clear that by measuring **X**–**Y** with a ruler, the measurement obtained would not be in the units required and that a conversion to micrometres was necessary. Some included a formula for magnification and this should have been rearranged to show that actual size = image length ÷ magnification. Where partial credit was gained, this was generally for thinking that a centimetre measurement would need to be multiplied by 1000, rather than 10 000. Some stated to measure in micrometres, which is not correct. Some candidates attempted to use standard form and got confused, for example stating that the measurement should be multiplied by 10^{-3} or 10^{-4}.

(c) As the mitochondria that were drawn in **Fig. 1.1** were not labelled, and as the light microscopes used by candidates would not reveal mitochondria and Golgi bodies, these two cell structures were credited in **(c)**. Many gained full marks. Prokaryotes have 70S ribosomes, so listing ribosomes could not gain credit without further detail such as 80S or larger. Weak responses listed two of the three labels given in **(a)** or structures such as the nucleus, cytoplasm and cell wall.

(d) (i) The best responses were concise statements explaining the meaning of the apoplastic pathway. Those stating movement from cell wall to cell wall and in the intercellular spaces gained full credit, while others stated a cell wall pathway and gave further correct detail such as movement that did not involve water crossing membranes. These answers avoided any detail of roots or of the symplastic pathway. This contrasted with some that extended the response incorrectly to describe how the water enters the spongy mesophyll cells or how water needed to enter the endodermal cells of the root. A fairly frequent error was to describe the movement of water in the apoplast pathway as osmosis. A common misconception was to state that plasmodesmata were involved, with some candidates visualising them as part of the cell wall pathway. Some candidates included the Casparian strip in their account of water movement in the leaf.

(ii) There were some knowledgeable responses that were careful to express properties of water in terms of water molecules. Hydrogen bonding was well known, with fewer explaining that water was a polar molecule or a molecule with a dipole. The most common error was to describe cohesion but use the term adhesion and vice versa. Thorough answers remembered to address the movement of water to the intercellular air spaces and here it was sufficient to state that water evaporated from the surfaces of the mesophyll cells. Some wrote about water as a solvent, but this was not needed for this question. Reference to the specific heat capacity, or latent heat of vaporisation, were not required.

(iii) Many were able to gain full credit, usually for explaining that transpiration was occurring and that stomata were open for gas exchange. Diffusion of water vapour from the intercellular air spaces out to the atmosphere was not usually well described, with many not stating ‘vapour’ and others stating ‘out of the cell’. A few explained that the movement was down a water potential gradient. Movement out down a concentration gradient was not credited as responses needed to be expressed in terms of water potential.

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Question 2

(a) (i) The four bases of DNA were well known and usually correctly spelled.

(a) (ii) Some very well-expressed answers were seen, giving step-by-step explanations of how the discovery made by Chargaff pointed to the concept of complementary base pairing and confirmed hydrogen bonding between purine-pyrimidine base pairs and the double-stranded nature of the molecule. Weaker accounts repeated the findings of Chargaff but did not continue to make a statement about complementary base pairing. Some wrote about DNA replication or the Meselson and Stahl experiment, which was not required.

(b) This was answered well. Some did not qualify their answer of pentose and so did not gain credit. Ribose was the most common incorrect answer.

(c) Many made the connection between the sequence of bases in DNA and the sequence of amino acids in proteins to gain some credit. Fewer realised that there are many different proteins, which would mean many different sequences. The fact that proteins contain 20 different amino acids was not often seen. Some wrote about the varied functions of proteins or stated that the different shapes of protein held the information, which were not required. Weak answers referred to proteins having nucleotides or bases, like DNA.

Question 3

(a) There were many concise, clear responses outlining how penicillin prevented the formation of cross-links by inhibiting bacterial transpeptidase. These also made one or more good suggestions as to how the more complex cell wall of Gram-negative bacteria could prevent penicillin from acting. Full credit could be gained without detailed knowledge of the role of autolysins in bacterial cell wall synthesis. Some candidates gave correct accounts of their involvement in the weakening of the cell wall by penicillin action. Others stated that penicillin created holes or that penicillin inhibited autolysins. It was common, but not relevant, to see considerable detail on the mechanism by which bacterial cells would lyse owing to a weakened cell wall. Some weak responses gave descriptions of penicillin as an antibody. Others did not know that penicillin acted on the bacterial cell wall and wrote about the entry of into the cell or the destruction of the cell surface membrane.

(b) (i) Most knew what was meant by passive. The most common incorrect answer was to state that it meant movement down the concentration gradient. Some incorrectly attempted explanations of passive immunity.

(ii) High quality answers considered all aspects of OmpF porin as a transport protein and avoided repeating information given to them in the introduction. Many used **Fig. 3.1** to identify OmpF porin as a channel protein and a high proportion explained how structure of the protein would allow the stated substances to pass across the membrane. Some realised that a channel protein would allow facilitated diffusion, but not active transport, to occur. Quaternary protein structure was noticed by a number of candidates, with fewer stating that it was a globular protein. A common misconception was that the protein was specific to a particular substance. Some stated that the protein was a channel or carrier protein or that the protein carried out facilitated diffusion or active transport.

(iii) It was important to realise that, because mRNA for the polypeptide of OmpF porin was still synthesised, the control in the production of OmpF porins in *E. coli* was at the translation level and not at the level of transcription. A number of candidates missed this point and suggested that a mutation had occurred or that transcription could not proceed. Although many suggested correctly that translation could not occur, not all realised the significance of micF binding to the START codon of mRNA rather than elsewhere on the molecule. Vague references to the ribosome being unable to 'read' the mRNA could not be credited. Some stated incorrectly that a protein with a different primary structure would be produced.

(c) (i) There was considerable variation in the quality of response, with some giving most or all of the expected points, while others gave insufficient detail to gain full credit. Some did not name the monomers as monosaccharides. The weakest responses muddled disaccharides and polysaccharides or gave mixed responses containing some detail of polypeptides.

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(ii) Many excellent answers were seen, showing a good understanding of the importance of immunological memory and the difference between a pathogen and an antigen. Some gave an account of the immune response to infection with one strain of *E. coli* and could have improved their answers by explaining the nature of the specificity and hence the reason for the lack of immunity to a different *E. coli* strain.

Question 4

(a) Most were able to make the link between cell **5** in **Fig. 4.1** and a high rate of transcription and translation and cell **4** with a reassembling nuclear envelope. Relating cell **3** to the formation of the spindle was more difficult for many, and cell **2** was a common incorrect choice. Not all realised that spindle formation must occur before metaphase so that the prophase chromosomes can be connected to the fibres and moved to the spindle equator.

(b) Concise answers gaining full credit outlined only the events occurring between the onset of anaphase and late anaphase and used the correct terminology. It was not necessary to describe the events occurring during the stage shown in cell **2**. Although the names of stages shown in cell **2** and cell **1** were not required, some found it helpful to name metaphase and anaphase to organise their response. Some could made it clearer that the two sister chromatids for each chromosome at the spindle equator were separated and were moved by the contraction of the spindle fibres to opposite poles. There were also some ambiguous responses describing chromosomes as forming two chromatids or as dividing into two chromatids, not showing an understanding that the chromosome already consisted of two sister chromatids at the onset of mitosis. Fewer wrote about the separation of the chromatids by the centromere dividing or the movement of the daughter chromosomes to the poles with the centromeres leading. Some confused centromeres with centrioles or with centrosomes. A few wrote about homologous chromosomes, chromatin strands or DNA.

(c) Some candidates had deduced that, as **Fig. 4.1** showed cells in all stages of the cell cycle, the apparently empty appearance of some of the cells could not be due to them being in interphase, where the chromosomal material is seen as chromatin, as many others had suggested. This led a proportion to state that these cells had not taken up the stain used. Some candidates may have carried out a root tip squash preparation and have experience of cells not being stained. Others made acceptable suggestions to gain credit.

Question 5

(a) Only structures of the gas exchange system seen with the naked eye needed to be described in this question. There was a wide range in quality of response. Many gave thorough accounts that included more than enough correct detail to gain full credit. Others included facts such as 'rings of cartilage' rather than C-shaped rings for the trachea, or confused the bronchioles for the bronchus. Some wrote about the role of the ciliated epithelium in the health of the gas exchange system or about the effects of smoking on the lungs, which was not relevant.

(b) Most gained at least one mark for this question. The most common points noted were decreased blood pressure and heart rate, and quite a few also wrote about decreased risk of blood clotting. A number of candidates gave details of how nicotine affects the cardiovascular system, which does not answer the question.

(c) Many were confident describing and explaining how the results for the higher partial pressures of oxygen showed the benefits of stopping smoking. Fewer also considered the results at the lower partial pressures and those that did generally gained full credit. A good response quoted values to support points made and most were able to cope well with the fact that each small 2 mm square on the *y*-axis of **Fig. 5.2** equalled four per cent. A fairly common error with weaker responses was to confuse the effect of stopping smoking on gas exchange with the effect of stopping smoking on the percentage saturation of haemoglobin with oxygen. This meant that a number wrote about an increased ability to take in more oxygen in the lungs rather than a greater availability of haemoglobin molecules to bind to oxygen owing to the lack of carboxyhaemoglobin formation.

(d) A high proportion gained both marks here. Most concentrated on explaining non-infectious, but some also addressed what was meant by disease. Where only partial credit was gained, this was for ambiguous answers.

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Question 6

(a) The enzyme-catalysed reaction was not familiar to candidates and most did very well applying principles of enzyme action to the example given. Common errors were to state that mevinolin has the same structures as HMGCoA rather than the same shape or to state that the product of the reaction was cholesterol rather than mevalonic acid. The most common omission was to write about binding to the enzyme rather than to the active site of HMG CoA reductase. Some incorrectly described a mechanism that involved non-competitive inhibition despite being told otherwise in the question.

(b) **T**here was a very varied standard of response seen with this question. Some gave excellent outlines of the different uses of MABs, noting many of the expected points and some even naming specific MABs and the diseases that are treated. Others were very vague and although it was usually reasonably clear that MABs were introduced into the body of a person with a disease, there was little extra detail about how they acted. Apart from incorrectly writing about detecting or diagnosing disease, some gave an account of the production of monoclonal antibodies.

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Paper 9700/23
AS Level Structured Questions

Key messages

Key events occurring in the immune response are the recognition by the immune system cells of the non-self (foreign) antigen and activation of specific lymphocytes. Some questions that are set for Topic 11, Immunity, are based on unfamiliar material and do not always identify the antigen for the candidate. When responding to questions such as this, a good introduction would be to identify the non-self antigen. In **Question 3(e)(i)**, a simple statement identifying the non-self antigen as cyFBPase would set the correct scene for the rest of the response.

Candidates should be reminded to take care when describing transpiration. Transpiration is the loss of water vapour from the aerial parts of the plant, mainly through the leaves. Water evaporates from the surfaces of the mesophyll cells within the leaf and water vapour leaves through open stomata or through the cuticle (cuticular transpiration). In **Question 3(a)**, candidates should not describe water as evaporating from the surface of the leaf or evaporating from guard cells or of evaporating through stomata.

Questions set on graphical data can vary in the command term used. In **Question 5(a)**, candidates were asked to describe the differences between the activity of papain compared to the activity of ficin between 20 °C and 80 °C. This should have indicated to candidates that it was not necessary for them to describe similarities in the results, give a description of differences at 10 °C or to give explanations of the results.

General comments

The level of knowledge and understanding demonstrated by a good proportion of candidates was extremely high and frequently responses contained all or almost all the expected ideas for the particular question. Some of these were also very competent at handling information new to them.

In **Question 1**, it was evident that many candidates have had the opportunity to view stages of mitosis in prepared slides and/or from photomicrographs and many good answers were seen.

Question 2(a) assessed candidate ability to convert between mm and μm and understanding of how to do this was quite good. Most of **Question 2** assessed AO2 skills of handling information and some candidates were very adept at applying knowledge and understanding to cope with unfamiliar material.

The importance of reading the question carefully was highlighted in **Question 3(e)(i)** and **Question 4(a)**. In **Question 3(e)(i),** candidates were asked to describe events occurring within the body of the small mammal following inoculation with cyFBPase. This should have been the prompt for candidates to give details of an immune response. A number only focused on the last part of the question, for monoclonal antibody production and wrote about the hybridoma method for monoclonal antibody production. In **Question 4(a)**, it was only necessary to outline how oxygen passed from the alveolus to the blood stream. A large proportion described how oxygen enters red blood cells and is taken up by haemoglobin.

In **Question 5**, there was some evidence that a number of candidates did not understand the difference between immobilised enzymes and enzymes free in solution, with many implying that catalysis would be more accurately carried out if the enzyme ‘could not move’.

Many candidates did not know the differences between prokaryotes and eukaryotes in **Question 6(b)** and it was quite common for little credit to be awarded.

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Comments on specific questions

Question 1

(a) Many spotted the obvious difference between cell **D** and cell **E** that **D** has one nucleolus compared to the two nucleoli in **E**, but fewer knew that they were nucleoli. Although candidates were told that the cells were in the same stage of the cell cycle, some did not take note of this detail and suggested that the cells were in different stages.

(b) Most correctly identified cell **A** as being in prophase. Anaphase for cell **C** was also well known. A smaller proportion stated telophase but daughter chromosomes were clearly evident and there were no signs of nuclear envelopes. The stage in cell **B** was frequently misidentified as metaphase and it may be that some candidates lacked the confidence to state prophase again, despite being told that some cells were in the same stage of mitosis.

(c) The majority realised that they were being asked to describe telophase and many gave more than two correct events, the most popular being the formation of nuclear envelopes around each group of daughter chromosomes, the decondensing of the chromosomes and the reappearance of the nucleoli. Others named telophase as the stage, which was not required, but did not give correct details and described cytokinesis instead. Fewer described anaphase and some described all stages of mitosis.

Question 2

(a) To gain credit, some mathematical evidence was required to compare the two values in the same units. Most who did this converted 35 µm to mm and compared to the stated value of 0.05 mm. Some converted the 0.05 mm to µm and a few deciding to convert to metres to make a comparison. Many gained credit, but the quality of explanation varied. Where candidates thought that the person could see the adipocyte, this was because they were one or more decimal places out in their conversion. Weak responses did not attempt any conversions and either simply stated 'yes' or 'no' or gave a reason based on the image in **Fig. 2.1**, such 'yes' because the lipid droplet is large, or 'no' because a nucleus could not be seen.

(b) There were a number of well-expressed explanations that covered two or more of the expected points. Many of the better responses showed an understanding that the organelles were too small to interfere with light waves. Some thought that the wavelength of light was the same as resolution, so stated that the organelles were smaller than the light wavelength. Those that gained partial credit usually stated either that the organelles were too small or that the resolution of the light microscope was not high enough.

(c) (i) Ester bond was correctly named by candidates who tended to do well overall. Common incorrect bonds were hydrogen, glycosidic and peptide.

(ii) There were some very good answers that included all the expected points. More confused responses named facilitated diffusion and knew about protein channels but stated that the fatty acids were enclosed in vesicles and left through the channel by exocytosis. Others stated exocytosis as the mechanism but described facilitated diffusion. Some thought the ATP shown in **Fig. 2.2** was required for membrane transport and incorrectly deduced active transport. Some very weak responses described all the events shown in **Fig. 2.2**. Some responses could have been improved by noting that the hormone was the signalling molecule, and that the membrane protein was the receptor. Weaker responses thought that ATP became a second messenger molecule and that this second messenger molecule combined with an enzyme that acted as a receptor.

(d) Many candidates gained credit, with all the correct ideas seen and most of these stating that the cell lacked mitochondria or a nucleus. Some of the answers included further correct detail. Where no credit could be given, this was for responses that concentrated on haemoglobin and oxygen.

Question 3

(a) Explanations concerning the stomatal crypts were generally better than those for the multilayered epidermis. For the multilayered epidermis, better responses were accurate in their description of

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an increased diffusion distance and avoided statements such as 'more cells to go through'. Similarly, moist air, water vapour and high humidity were all acceptable descriptions for the stomatal crypts explanation, rather than expressions such as traps water and pockets of water. Common misconceptions were that water as a liquid needed to pass through the multi-layered epidermis, rather than water vapour. Some stated that the increase in number of layers would mean an increase in the thickness of the waxy cuticle on the epidermal surface. It is important for candidates to understand that transpiration is a consequence of gas exchange to obtain carbon dioxide for photosynthesis. Quite a few suggested incorrectly that the stomata were closed.

(b) Candidates were asked to name the *cells* specialised for transport so the correct answer was phloem sieve tube elements. It was not acceptable to simply state the tissue phloem, which is composed of more than one cell type, or to state sieve tubes, which are the structures formed from sieve tube elements.

(c) This was a straightforward question that was completed with a very varied quality of response. The best responses showed an understanding that the source is the area where assimilates are synthesised, rather than just state that it is where assimilates are loaded into phloem. Stating that the sink was a place where assimilates were used or were needed was not enough as all areas in a plant will use or will need assimilates. A number wrote about the transport of delivery of water and mineral ions.

(d) (i) Many candidates had learned the definition stated in the relevant learning outcome of the syllabus. Others gave a confused response and wrote about an altered sequence of amino acids in the gene rather than sequence of bases, or jumped one stage and stated that it meant an altered polypeptide. There were many who stated that the genetic coding changed.

(ii) Some candidates paid careful attention to the information provided in the question and realised that a correct suggestion should be based on the fact that cyFBPase could not be synthesised by plants with the mutation in the gene *cyFBP*. A larger proportion answered a question about preventing the functioning of cyFBPase rather than preventing the synthesis so responses about altered active sites or non-functioning proteins were not credited.

(e) (i) Some very comprehensive answers were seen, the best of which gave a sequential account that ended correctly with the formation of the plasma cells (B-lymphocytes) that synthesised antibody specific to cyFBase. It was not necessary to mention the formation of memory cells because these are not the cells required for monoclonal antibody production. A common error was to think that antibodies are removed from the mammal rather than cells. Some thought that T-lymphocytes produced antibody. Some gave accurate outlines of monoclonal antibody production and these could only gain some credit if detail of the events occurring within the small mammal were included.

(ii) This short question was challenging for many candidates. Some grasped the concept that anti-cyFBase would bind specifically to cyFBase and if a plant was not able to synthesise the enzyme because of the mutation in the gene coding for the protein, then the monoclonal antibody added to the extract would not have an antigen with which to bind. Most incorrect responses stated that sucrose was not synthesised.

(f) Most gained at least one mark with the suggestion that less sucrose would be synthesised or that less sucrose would be present. The suggestions that smaller plants would require less stored starch or that there would be less room for starch meant that the candidate had missed the part of the introduction where they were told that there was proportionately far less starch. The most common error was to think that starch was made from sucrose, although some of the better responses noted correctly that less sucrose meant less could be hydrolysed to release glucose for starch synthesis.

Question 4

(a) This was a straightforward question and many gained full marks with concise responses that did not continue beyond the transport of oxygen into the blood within the pulmonary capillary. Some candidates gave detailed answers describing the movement of oxygen from the blood into the red blood cell and uptake by haemoglobin and/or the circulation of blood from the lungs to the heart and rest of body. The movement of carbon dioxide into the alveolus from the blood was frequently described, which was also not necessary.

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(b) (i) Most candidates were able to extract the relevant values from **Fig. 4.1** and make the correct calculation. A small proportion incorrectly gave kPa as units.

(ii) The best answers used **Fig. 4.1** and considered the percentage saturation of haemoglobin at partial pressures found in the in the respiring tissues as well as in the lungs. Most concentrated only on explanations at higher partial pressures of oxygen. A common misconception was to think the question was about altitude and the disadvantages of being at high altitude.

(c) There was considerable flexibility allowed for the definition of the term disease and a wide range of ideas could gain credit. A high proportion of candidates did not realise that disease was a term used for both infectious and non-infectious conditions and consequently wrote only about infectious diseases.

(d) Many gained some credit for knowledge that the haemoglobin formed as a result of Hb^S expression would display impaired ability to bind oxygen. Further credit was usually gained with knowledge that there would be changes in the levels of protein structure. Some excellent responses gave details of the base substitution mutation and the consequential change to the mRNA codon. Good answers flowed with a sequential nature, beginning with the mutation and ending with the problems of oxygen carriage. Some candidates wrote about the genetics of sickle cell disease and a few stated the symptoms of the disease, neither of which was required.

Question 5

(a) (i) Most candidates saw that the percentage of maximum activity of 100 for papain occurred at a very different temperature to that of ficin on **Fig. 5.1**. It was less easy to gain marks for describing differences between the two enzymes when there was an increase or decrease in activity with changes in temperature. Accurately expressed responses used terms such as steeper increase or less sharp decrease and were careful to avoid references to time such as slower increase or faster drop. A few very good answers gave one of more of the other differences evident on **Fig. 5.1**. Most extracted correct data from **Fig. 5.1** to support their answers. Where errors occurred, this was usually from assuming that one small 2 mm square had a value on the *y*-axis of 2, rather than of 4. Some attempted to give explanations for the results shown, which was not required, and others gave similarities as well as differences.

(ii) Most realised that ficin would have the best activity in the temperatures found in the human body. There were quite a number who gave an incorrect human body temperature and the extreme examples of this were to choose papain as the treatment and explain that human body temperature was close to 60 °C.

(b) Most of the responses that gained credit stated that immobilised enzyme could be re-used. The most frequent incorrect suggestion was that an enzyme would be able to cleave antibodies more accurately if it was immobilised than if it were free in solution.

(c) (i) The term extracellular was generally correctly given by those candidates who performed well overall.

(ii) The most common correct answer given was collagen. Elastin was also an acceptable and fairly common response.

Question 6

(a) Answer **D** was generally well known, followed by answer **C**. For **B**, many thought that the causative organism of malaria was a prokaryote and for **A** measles was frequently not included in the list of viral diseases. Statements **A** and **B** were the most demanding as candidate needed to know the type of causative organism for all six listed diseases to gain full credit.

(b) The nuclear envelope was frequently incorrectly stated as the nuclear membrane or nucleolus. It was not sufficient to state 'not linear' when comparing DNA as candidates were expected to know that the DNA of prokaryotic cells is (usually) circular. 60S was frequently seen instead of 80S for the ribosomes of eukaryotic cells. Most gave one or two correct examples of a double membrane-bound organelle, but far fewer knew the cell wall material of prokaryotes and it was common to see cellulose or chitin as an answer.

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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 are assessed in this examination.

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

When drawing graphs, such as in **Question 1(c)(i)**, the points should be plotted accurately and the line should be clear, sharp and unbroken.

General comments

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

Comments on specific questions

Question 1

(a) (i) Many candidates were able to show how to carry out a proportional dilution within the requirements of the question. The most common error was not decreasing the concentration by 0.2% between each successive dilution.

(ii) The majority of candidates organised their results clearly by presenting a ruled table, with headings for percentage concentration of milk and colour. The results for most candidates showed the expected trend and were recorded correctly using only the standard colours shown in **Fig. 1.1**. The most common error was to use colours not shown in **Fig. 1.1**.

(iii) The majority of candidates recorded an appropriate colour for sample **U**.

(iv) The majority of candidates correctly stated the known concentrations of milk protein where the colour result for **U** is the same.

(v) Many candidates were able to suggest an improvement to the error provided. Some candidates were able to suggest another significant source of error and provide an appropriate improvement.

(b) (i) The majority of candidates organised their results clearly by presenting a ruled table, with the heading for the dependent variable being coagulation. The results of most candidates showed the expected trend and were recorded correctly using the key provided in **Fig. 1.2**. The most common error was not recording the coagulation for all of the concentrations made in **(a)(i)**.

(ii) The majority of candidates correctly used the key to record the result for **U**.

(iii) The majority of candidates correctly labelled the positions on **Fig. 1.3** of the percentage concentrations of milk decided in **Table 1.2**. Many added the label for **U** in a position that correctly corresponded to their results. The most common error was not showing all of the concentrations decided in **Table 1.2**.

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(c) (i) Most candidates correctly used the headings given in the table to label the *x*-axis and the *y*-axis. Most candidates used an appropriate scale labelled at least every two cm and plotted the graph accurately using a small cross or a dot in a circle. However, some candidates labelled the axes incorrectly or gave incomplete headings. The most common error was to draw a line which was too thick or not ruled to the centre of the cross or dot. Candidates should be reminded of the need to use a sharp pencil.

(ii) Many candidates were able to explain that, as the temperature increased, the enzyme and substrate gained kinetic energy and that above 41 °C the enzyme became denatured. A common error was not using the data in the graph and table.

(iii) Many candidates stated the pH values and gave a description of how to change the pH, but did not always include the use of a buffer.

Question 2

(a) (i) The drawings of many candidates were of an appropriate size and did not include any cells. Stronger candidates drew the vascular bundle in the correct proportion to the depth of the midrib and showed that it was subdivided into at least two layers. Many candidates correctly identified the vascular bundle using a ruled label line and label.

(ii) Most candidates drew the required number of whole cells. Many used a sharp pencil to draw clear, thin lines that were continuous. The most common error was to draw cells that were too small or with lines that were not continuous.

(iii) The majority of candidates suggested one observable feature and appropriate explanation. The most common error was to restate the question instead of providing an explanation.

(b) (i) Many candidates were able to complete **Fig 2.2** correctly. A common error was to miscount the number of graticule divisions.

(ii) Many candidates correctly counted the number of eyepiece graticule units and gained credit for this. Some candidates showed the multiplication of this measurement by the answer from **2(b)(i)**.

(iii) The stronger candidates correctly annotated **Fig. 2.5** to show two observable differences between **J1** and **Fig. 2.1**. The most common error was to show more than two observable differences or to label a feature present only on **Fig 2.5** rather than show a comparison with **J1**.

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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.

Within an investigation, candidates should be able to calculate the correct answer to an appropriate number of significant figures, using quantitative results or data provided. For example, in **Question 2(a)(vii)**, candidates needed to calculate the rate of diffusion using 1 / time from their own data.

Candidates should be able to measure area using a grid, counting those squares more than half filled within the grid as one whole square and not counting those squares that were less than half a square. When calculating the total surface area of a leaf, such as in **Question 2(b)(i)** and **2(b)(ii)**, it is helpful to indicate on the grid each of the 1 cm × 1 cm squares included in the calculation.

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

Section A

Question 1

(a) (i) The majority of candidates were able to record three times for the cubes to reach the end-point. Many candidates recorded the times as whole seconds.

(ii) Many candidates calculated the mean time taken for the cubes to reach end-point with the appropriate units (seconds). The most common error was to omit the units.

(iii) The stronger candidates identified one significant source of error as the difference in the sizes of the cubes, although other valid answers were credited.

(iv) Most candidates correctly stated two variables that needed to be standardised as the volume of hydrochloric acid and the temperature of the acid.

(v) The majority of candidates correctly completed **Table 1.2** showing how to prepare four further concentrations hydrochloric acid.

(vi) The majority of candidates organised their results clearly by presenting a ruled table. Those achieving higher credit included the heading for concentration of hydrochloric acid / mol dm^{-3} and the heading for time / seconds. The majority of candidates gained credit for recording the mean times for at least four concentrations of hydrochloric acid. Many recorded results which showed that the higher the concentration of acid took the shorter the time to reach the end-point. The stronger candidates recorded the time in whole seconds.

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(vii) Some candidates correctly calculated the rate of diffusion for 1.0 mol dm^{-3} hydrochloric acid and in the lowest concentration of hydrochloric acid tested by using 1 divided by time.

(viii) Many candidates stated whether the hypothesis was supported or rejected and explained how the results provided evidence for this. The most common error was not stating how the results justified the decision.

(ix) Many candidates suggested the concentration of hydrochloric acid that should be used and gave a reason. The most common error was stating that 1.0 mol dm^{-3} hydrochloric acid should be used as it was ready to use.

(x) Many candidates stated that different sizes of cubes should be used and the better responses stated that at least five different sizes should be used. The stronger candidates stated how changing the size of the cubes affected the surface area to volume ratio.

(b) (i) Most candidates used the headings given in the table to correctly label the *x*-axis and the *y*-axis. However, some candidates labelled the axes incorrectly or gave incomplete headings. The stronger candidates used a scale of 5 to 2 cm for the *y*-axis. Most candidates drew each bar separated for each type of pathogenic bacterium and all the bars were of even width. Many candidates plotted the horizontal line at the top of each bar precisely and with a thin line. The most common errors were not including a full axis label for each axis, omitting the units for the *y*-axis, not labelling the scale every 2 cm and drawing lines which were too thick.

(ii) Many candidates correctly identified **Q** as the type of bacterium to be used and gave correct reasoning to support their choice.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the shaded area in **Fig. 2.1**. Many candidates gained credit for drawing at least four layers of tissue. Credit was given to those candidates who showed subdivision of the vascular bundles and used a ruled label line and label (**X**) to identify a region containing xylem tissue.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce lines which were continuous and used most of the space provided. Many candidates were able to draw the three cells required by the question and also gained credit for drawing each cell touching at least one of the other cells. Credit was also gained by those who drew an inclusion within the palisade cell or the epidermal cell. Most candidates used a ruled label line and label (**P**) to identify a chloroplast.

(b) (i) Many candidates correctly described how to use the grid by counting the number of squares that are completely filled and those that are more than half-filled.

(ii) The majority of candidates correctly recorded the total area of the part of the leaf shown in **Fig. 2.2** and the area of the leaf section occupied by **V**. Most recorded the areas as whole numbers.

(iii) Most candidates correctly calculated the percentage of the part of the leaf shown in **Fig. 2.2** that was occupied by **V**. Most candidates recorded the answer to the correct degree of accuracy.

(iv) Many candidates correctly suggested that using a grid with smaller squares would give a more accurate estimate of the area of the leaf.

(c) The stronger candidates listed at least three observable differences between **M1** and **Fig. 2.2**, such as **M1** had few trichomes and the leaf shown in **Fig. 2.2** had many trichomes.

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Paper 9700/33
Advanced Practical Skills 1

Key messages

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

Candidates should be able to draw a graph with axes, with the independent variable on the *x*-axis clearly labelled with units where appropriate, and the dependent variable on the *y*-axis labelled with units where appropriate. Candidates should be able to select a scale where both axes should use most or all of the grid available and allow the graph to be read easily to within half a 2 mm square, such as 1, 2, or 5 units to a maximum of 20 mm. Candidates should be able to plot all the points accurately and all the plotted points should be connected with a clear, sharp and unbroken line, either as a line of best fit or as a smooth curve or as a set of ruled straight lines to join the points.

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

Section A

Question 1

(a) (i) The majority of candidates were able to complete **Table 1.2** to prepare the three sucrose concentrations, **S4**, **S3** and **S2**.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of sucrose and the heading for time with units (seconds). The majority of candidates gained credit for recording the times for all four concentrations of sucrose. Many candidates recorded results which showed that the higher the concentration the shorter the time for the appearance of a colour change. The stronger candidates recorded times as whole seconds.

(iii) Many candidates stated a time for sample **U** and correctly completed **Fig. 1.1** to show the estimate of the percentage concentration of sucrose solution in the sample.

(iv) The stronger candidates used a scale of 1 to 2 cm for the *x*-axis, labelling the scale every 2 cm. Some candidates selected a suitable scale for the *y*-axis so that the results recorded in Question **1(a)(ii)** could be plotted. Many candidates drew a thin line to each plot. The most common errors were choosing an inappropriate scale for the *y*-axis and drawing lines which were too thick.

(v) Many candidates were able to use the graph and the time stated in Question 1**(a)(iii)** to correctly estimate the percentage concentration of sucrose in **U**.

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(vi) The stronger candidates identified one significant source of error as the difficulty of identifying the appearance of the first colour change.

(vii) Many candidates correctly suggested that increasing the number of sucrose concentrations below 2.0% would improve the procedure to obtain a more accurate estimate of the percentage concentration of sucrose solution in the fruit extract. The stronger candidates stated that at least five concentrations below 2.0% should be used and the difference between the concentrations should be as small as possible.

(b) (i) Most candidates clearly showed the addition as required and correctly completed the calculation, giving the percentage of the fruit that was made up of sugars. Most candidates gave the answer to no more than two decimal places.

(ii) Most candidates used the headings given in the table to correctly label the *x*-axis and the *y*-axis. Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates used a scale of 2 to 2 cm for the *y*-axis. Many candidates plotted the horizontal line at the top of each bar precisely and with a thin line. The most common errors were not including a full axis label for each axis, omitting the units for the *y*-axis, not labelling the scale every 2 cm and drawing lines which were too thick.

(iii) Many candidates correctly named a source of sucrose in the plant as the leaves and named the process used for loading the sucrose into the phloem tissue as active transport.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the epidermis and the vascular bundles in the stem. Many candidates gained credit for drawing one outer vascular bundle and three inner vascular bundles. Credit was also given to those candidates who showed subdivision of the vascular bundles and used a ruled label line and label to identify the cortex.

(ii) The majority of candidates used the eyepiece graticule in the microscope to measure the total length of the four cells (**L**) and the depth of one of the cells (**D**) and recorded the number of eyepiece graticule units as whole numbers.

(iii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce lines which were continuous and used most of the space provided. Many candidates were able to draw four cells from around the air spaces. Many candidates were credited for showing each cell touching at least one of the other cells. Credit was also given to those candidates who drew the correct shape for these cells. Most candidates used a ruled label line and label to identify the cell wall of one cell.

(iv) Many candidates correctly suggested that **K1** might grow in an aquatic habitat.

(b) Many candidates correctly measured the width of the stem as shown by the line **X–Y**. To calculate the actual width of the stem the stronger candidates showed the multiplication of the number of eyepiece graticule units by 29.5. Most candidates gave the answer to no more than two decimal places with the appropriate units (μm). The most common errors were to omit the units and not show all of the steps in the calculation.

(c) The stronger candidates used label lines to show three features in **Fig. 2.3** and described next to each line how each feature was different from the specimen on **K1**. Many candidates stated three observable differences between **Fig. 2.3** and **K1**, e.g. **K1** had vascular bundles touching while in **Fig. 2.3** the vascular bundles were separated from each other.

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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 are assessed in this examination.

When drawing graphs, such as in **Question 1(b)(i)**, the points should be plotted accurately and the line should be clear, sharp and unbroken.

General comments

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

Comments on specific questions

Question 1

(a) (i) The majority of candidates correctly labelled an appropriate number of beakers with the correct concentrations. Most candidates showed the transfer of 20 cm^3 from the each beaker to the next one and added the correct volume of water to each beaker. The most common error was to make a total volume of 20 cm^3 instead of the required 40 cm^3.

(ii) The majority of candidates organised their results clearly by presenting a ruled table, with headings for percentage concentration of ethanol, pH and colour. The results for most candidates showed the expected trend and were recorded correctly for a sufficient number of different concentrations of ethanol.

(iii) Some candidates correctly labelled the positions on **Fig. 1.2** of the percentage concentrations of ethanol solutions. Many added the label for **U** in a position that correctly corresponded to their results. The most common error was not showing all of the concentrations on the scale.

(iv) Some candidates were able explain correctly why they supported or rejected the hypothesis. Many did not recognise that a decrease in pH corresponded with production of CO_2, indicating that the yeast is not killed. The most common error was not including any reference to the candidate's own results.

(v) Many candidates recognised that matching the colour to the pH was difficult.

(b) (i) Most candidates correctly used the headings given in the table to label the *x*-axis and the *y*-axis. Most candidates also used an appropriate scale labelled at least every two cm and plotted the graph accurately using a small cross or a dot in a circle. However, some candidates labelled the axes incorrectly or gave incomplete headings. The most common error was to draw a line which was too thick or not ruled to the centre of the plot. Candidates should be reminded of the need to use a sharp pencil.

(ii) Many candidates showed on the graph how they obtained the volume of CO_2 at both points then showed the correct calculation for obtaining the rate.

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(iii) Many candidates correctly stated that you could use a thermostatically controlled water-bath to obtain different temperatures and some candidates stated at least five different temperatures.

Question 2

(a) (i),(ii),(iii)
Most candidates followed the instructions by drawing the required number of cells in each box, showing the differences in size and shape.

(iv) Some candidates correctly annotated the drawings to show an observable difference between **Y** and **M,** and also between **I** and **Y.** The most common error was to only mention **M** and **I** and not **Y.** Another common error was to refer to differences that were not observable.

(b) Most candidates followed the instructions by drawing the required number of whole cells. Many candidates used a sharp pencil to draw clear, thin lines that were continuous. The most common error was to draw cells which were too small or to draw lines that were not continuous.

(c) (i) Many of the drawings were of an appropriate size and did not include any cells. Stronger candidates also drew the layers in the correct proportions and shape.

(ii) The majority of candidates annotated the drawing correctly. The most common error was to show fewer than three observable differences.

(iii) The majority of candidates answered correctly with an appropriate reason.

(iv) Most candidates correctly measured the length of the scale bar in mm and showed appropriate units for this measurement. Many candidates showed the conversion to μm. Some candidates were able to use the scale bar to correctly calculate the magnification.

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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.

Within an investigation, candidates should be able to calculate the correct answer to an appropriate number of significant figures, using quantitative results or data provided. For example, in **Question 1(a)(iii)**, candidates needed to calculate the rate of enzyme activity using 1 / time from their own data.

When the question asks candidate to 'explain the effect…' , such as in **Question 1(b)(ii)**, the answer needs to include why something happens, such as referring to the binding of the substrates to the active sites of enzymes and the formation of 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

Section A

Question 1

(a) (i) Many candidates were able to complete **Fig. 1.1** with the required detail.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of sucrose and the heading for time with units (seconds). The majority of candidates gained credit for recording raw and processed times for each concentration of sucrose. Many candidates gained credit for recording results which showed that the higher the concentration the shorter the time for the appearance of a colour change. The stronger candidates recorded the time in whole seconds.

(iii) Some candidates calculated the rate of enzyme activity in 10% sucrose solution using 1 divided by time and expressed the answer in standard form.

(iv) Many candidates were able to state that the same concentration of substrate should be used. The stronger candidates stated that at least five different pH values should be used and these could be maintained using buffers.

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

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(ii) Many candidates correctly explained the effect of increasing the substrate concentration on the rate of enzyme activity by stating that the rate of enzyme activity increases as more enzyme–substrate complexes form. The stronger candidates explained that inhibitors were also binding to the active site. The most common error was just describing the trend shown by the graph.

(iii) Many candidates correctly stated that the type of inhibitor present was a competitive inhibitor.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the epidermis and three vascular bundles in the stem. Credit was given to those candidates who showed subdivision of the vascular bundles and drew the vascular bundle and the other tissues in the correct proportion. The stronger candidates also correctly identified the phloem using a ruled label line and label.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce lines which were continuous and used most of the space provided. Many candidates were able to draw four cells from within the cap and showed each cell touching at least two of the other cells. Credit was also given to those who drew the correct shape for these cells. Most candidates used a ruled label line and label to identify the cell wall of one cell.

(b) The stronger candidates used label lines to three features in **Fig. 2.2** and described next to each line how each feature was different from the specimen on **L1**. Many candidates stated three observable differences between **Fig. 2.2** and **L1**, e.g. **L1** had vascular bundles in a ring while in **Fig. 2.2** the vascular bundles were arranged in two rings.

(c) (i) Many candidates correctly showed 0.01 multiplied by 1000 with the appropriate units (μm).

(ii) Many candidates correctly measured the length of the line **X**–**Y** in eyepiece graticule divisions. The stronger candidates showed the length of **X**–**Y** multiplied by 10 μm. The most common errors were to omit the units and not show all of the steps in the calculation.

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Paper 9700/41
A Level Structured Questions

Key messages

Candidates should set out their working clearly and fully when required, such as for the calculations in **Question 1(a)(ii)** and **(iii)**, the Hardy-Weinberg calculation in **Question 2(c)(i)** and the genetics crosses in **Question 4(b)**. Numerical calculation may be accompanied by written explanation to illustrate the logic of manipulating the numbers in the way shown.

Candidates should avoid including material that is not relevant in their answers, e.g. writing about aerobic respiration when the question referred only to anaerobic respiration. It was also common to find answers that simply repeated the information in the question, which gains no credit.

Candidates should use comparative terms in their answers where required, e.g. when comparing two elements at the same time or when there is a change over time, such as before and after an intervention.

General comments

Responses often showed evidence of detailed learning, careful reading of the question and fluency in communicating biological concepts. Candidates performed best on questions that required recall of remembered facts, such as **Questions 6**, **7**, **8** and the ***Section B*** questions.

It was often evident that candidates knew relevant facts but found it more challenging when required to make use of their knowledge in the context of the data, graphs or information presented in the question, for example in **Questions 1**, **2** and **3**.

In **Question 4,** the genetics problems involving a dominance hierarchy of alleles of a single gene, required careful reading and logical processing, and full setting-out of all alternative crosses separately.

Question 5 provided the greatest challenge, although strong candidates readily assimilated and made use of the new information and showed they could comment on ethical, economic and social issues as well as compare techniques and evaluate controversial statements. Candidates should give both sides of the argument when asked to discuss an issue.

The candidates who performed best were able to keep their answers strictly relevant to the question and could use the information given in the questions, in conjunction with their understanding of the material, to help them construct their answer.

Comments on specific questions

Question 1

(a) (i) Most candidates used the data in **Table 1.1** to describe a relationship between increasing or decreasing the area of forest and the effect this would have on the number of orangutans. A few responses correctly noted that the relationship was a positive correlation, but it could not be concluded from the data that the two variables were directly proportional.

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(ii) Many candidates calculated the decrease in orangutan numbers and the number of years between 1985 and 2016 and used these figures to work out the mean annual decrease. The most common error was not giving the final answer to the nearest whole number as requested. A few candidates wrongly calculated a percentage decrease.

(iii) Candidates were not always successful in using their answer to **Question 1(a)(ii)** for this question**,** which was to estimate the number of years it would take for the orangutan to become extinct.

(b) Few candidates were able to give more than one reason for the decrease in orangutan numbers. The most common reason given was the presence or introduction of disease. Many responses mentioned hunting by man but did not consider why orangutans might be hunted, such as for live trade as pets, for use in traditional medicine or for crop protection. Errors included considering habitat loss, even though this was already precluded in the question stem, and providing learnt statements without applying knowledge to the specific situation of the orangutan.

(c) The roles played by zoos in the protection of the orangutans were well-known, particularly the goals of captive breeding and subsequent re-introduction into the wild. Some responses concentrated too much on the details of breeding programmes and so limited the credit available. The strongest responses also referred to education or raising public awareness, but answers that mentioned the opportunity zoos provide to conduct research into orangutans often did not consider what knowledge would be most useful for future conservation work, e.g. relating to diet, breeding habits, behaviour and genetic diversity.

Question 2

(a) Candidates described the process of evolution by natural selection in varying degrees of detail and with considerable variation in the accuracy of their use of scientific terminology. Strong answers mentioned the existence of selection pressures, survival of the fittest individuals who pass on an advantageous allele and the subsequent increase in frequency of the advantageous allele. A few candidates referred to genetic variation within species and the occurrence of random mutations. Those who mentioned fitter individuals reproducing often did not make this comparative by stating that they reproduce more than less fit individuals.

Some terms were wrongly used or erroneous included, such as selective pressure (which is not an acceptable alternative to selection pressure) and genetic drift. The term gene was often used for allele and was not credited. Rather than referring to natural selection as acting within a population of one species, many candidates incorrectly described natural selection as acting upon two separate species, with one species having the better allele and surviving and one becoming extinct as a result of having a disadvantageous allele.

(b) (i) Candidates sometimes had problems interpreting the bar chart and misunderstood the idea of clutch size. However, most gained credit for identifying five as the peak clutch size. A few candidates attempted to describe the small numbers of clutches seen at the extremes of clutch size, but did not gain the credit by only referring to one extreme instead of both low and high clutch sizes. Very few candidates described the pattern shown by the data as a normal distribution.

(ii) Candidates found this question difficult. Weaker responses simply stated that the selection factors did not vary over the sixty years so the pattern seen in clutch size stayed the same. A few candidates mentioned stabilising selection and explained it correctly by saying that the average clutch size has a selective advantage over the extremes. Very few candidates were able to engage with the question context and to make points relating to the ecological factors that might cause high and low clutch sizes to be at a selective disadvantage.

(c) (i) Some candidates had no problems in carrying out the mathematical and logical processes necessary to calculate the number of heterozygous individuals in a population of budgerigars, but many lost credit for various errors in thinking. The main types of error were:

- not taking the population size (86) into account and finding the proportion of blue budgerigars as a proportion of 86, i.e. 0.198.
- taking the number of blue budgerigars as equal to q, the frequency of the recessive allele, rather than q^2, representing those individuals who are homozygous for the recessive allele.

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- not converting a correct calculated value of *2pq* to the number of heterozygous individuals in the population by multiplying by 86.

(ii) Most candidates knew two conditions when the Hardy-Weinberg principle cannot be applied. The most frequent answers were the existence of selection and non-random mating (which is not the same as 'no random mating'), followed by small population size and migration.

Question 3

(a) (i) Many candidates correctly identified the sections of the lac operon in order as the promoter, operator, *lac Z* and *lac Y*. Some candidates confused the terms operator and operon and a significant number wrote the correct names, but in the wrong order. Where candidates knew the names of the products of the structural genes *lac Z* and *lac Y* rather than the names of the genes, they needed to state 'gene' to gain the credit, e.g. β-galactosidase gene.

(ii) This question was very well answered, with the vast majority of candidates recognising that β-galactosidase was responsible for hydrolysing lactose to glucose and galactose (although a few candidates did not complete the reaction, stating only that lactose was hydrolysed). The role of *lactose permease* was usually correctly described, except when stated as changing the permeability of lactose itself or changing the property of a cell wall rather than the cell surface membrane.

(b) (i) This question tested knowledge of section 16.3 of the syllabus. However, few candidates understood the word *constitutive*.

(ii) Candidates generally answered this question well, although some did not gain credit as their answers described the effect of the presence of lactose rather than the effect of its absence. Many candidates were able to state that a repressor protein, in the absence of lactose, bound to the operator thereby blocking RNA polymerase from binding to the promoter. However, some candidates confused the operator and promoter regions for the binding locations of both these molecules. Some candidates showed that they had memorised the process, but could not reverse their answer to take into account the missing component (lactose).

(iii) Many candidates realised than a non-functional repressor protein would mean that the genes would remain permanently switched on, but did not relate this to the question asked regarding the effect this would have on this strain of *E.coli*. Strong answers progressed to considering the impact on the bacterium of unnecessary protein synthesis in terms of a waste of ATP or amino acids.

Question 4

(a) Most candidates gave the correct genotype for the badgerface goat. Weaker answers missed out one or more of the possible genotypes for a white goat. Most answers used the correct symbols for the alleles and showed the genotypes as diploid, but some gave tetraploid combinations.

(b) Most candidates could state the two possible genotypes of a grey goat, but many only showed one of these possibilities being crossed with the white goat genotype ***Aa*** derived from the parental cross described. A significant number of candidates included the grey badgerface genotype or wrong white genotypes in a large selection of crosses.

Crosses were frequently poorly laid out and thus the candidates' thinking was often unclear. Those who placed the parents' gametes, offspring genotypes and offspring phenotypes in a Punnett square were more likely to score highly. Some candidates lost credit by not linking offspring genotypes to offspring phenotypes.

(c) The majority of candidates realised that the goat with genotype **aa** would be black. This was correctly explained in most answers in terms of the melanocortin 1 receptor not being blocked by a protein product. Errors included references to the **a** allele possibly fitting into or not fitting into the receptor, instead of it not producing a functional protein, i.e. the DNA was confused with the protein product. Most did correctly describe MSH binding to the receptor triggering production of melanin in the **aa** goat.

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Question 5

(a) (i) Many candidates simply restated the information provided in the question, that the presence of human growth hormone in the pigs made them grow larger and heavier. Few candidates successfully drew on their knowledge of how growth proceeds in a mammal to suggest reasons such as increased mitosis, altered gene expression or production of more structural components like bone or muscle. Few also considered how the hGH might work for longer or be broken down less quickly, leading to a greater additive effect of both hormones enhancing pig growth.

(ii) Many candidates recognised the mouse DNA as the promoter, although this was occasionally incorrectly referred to as the 'promoter gene'. Candidates did not gain credit for repeating question stem information. Strong responses referred to RNA polymerase binding to the mouse promoter to stimulate either gene expression or mRNA production or to control transcription. Explanations of the role of metal ions often did not show a realisation that these could be added when needed to control when hGH was made. A significant number of candidates made the error of writing DNA polymerase instead of RNA polymerase when describing transcription.

(b) (i) This was answered well, with most candidates giving two reasons why the transgenic pigs did not have economic value in the long term, due to the lack of offspring and limited passing on of the transgene. Many also referred to the expense of having to engineer new transgenic pigs or treat stomach ulcers. Some candidates related their answer to expense or the economy.

(ii) Most candidates made reference to ethics or related terms such as right or wrong, just or unjust, showing they understood the meaning of ethical or unethical. Candidates who gained full credit mostly stated that producing transgenic pigs of this type was unethical because the pigs suffered illness and could not carry out normal behaviour.

(c) (i) This was poorly answered as candidates tended to compare applications of the techniques, not the relative merits of the fundamental techniques themselves. Candidates who scored stated that the gene editing technique had a greater success rate while some noted that a specific gene was targeted and contrasted this with the unpredictable effects of random insertion of a transgene. Most responses, however, did not address the question asked but discussed the advantages of the second application for the welfare of the pigs.

(ii) The scientist's statement had two components, relating to the new technique being a form of selective breeding but not genetic engineering. To discuss the truth of the statement, candidates had to identify which part of the statement they were in agreement or disagreement with and give a reason why. Few could explain that this was not selective breeding due to the manipulation of a gene, use of IVF or lack of repeated crossing and selection. Many candidates incorrectly indicated that the gene editing technique that caused a deletion in a gene was genetic engineering. Most candidates gained credit for predicting that the technique would be more socially acceptable due usually to the advantage of reducing disease in pigs.

Question 6

(a) Most candidates were able to identify where each of the compounds or structures were found in the mitochondrion. Some candidates used the names of the parts of the mitochondrion, rather than using the letters **P** and **Q** as requested.

(b) (i) The majority of candidates could calculate the mean number of mitochondria and express their answers in standard form to match the other figures in the same column of the table, but all correct representations of the right number were accepted.

(ii) Candidates did not always explain the reasons for the difference in mean number of mitochondria between the two types of cell clearly enough. Often, statements were not comparative in terms of greater activity or the need for more energy or ATP in the heart cell. Those who stated that the heart muscle cell contracts gained credit, but heart cells 'pump blood around the body' was not credited as this described the function of the whole organ rather than that of the cell.

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(iii) Few candidates realised that mitochondria themselves vary in size and in the surface area of their cristae. The calculation of the mean number of mitochondria per unit volume (μm^3) in the table meant that differences in cell size could not be a factor.

Question 7

(a) (i) Many candidates knew that non-cyclic photophosphorylation occurred at thylakoid membranes or a lamella or granum. It was not correct to specify a sub-part such as a named photosystem alone since this contains the light-harvesting pigments but not all the components of the electron transport chain or ATP synthase which are also necessary to complete the process.

(ii) Candidates more often correctly identified **A** as photolysis than **B** as chemiosmosis or photophosphorylation. The commonest error was to name **B** as either oxidative phosphorylation or ATP synthesis.

(iii) Many understood that the oxygen produced in process **B** diffused out through the stomata or is used in respiration. Responses referring to it as a waste gas without further detail were not credited.

(iv) Many candidates correctly named the primary pigment in photosystems I and II as chlorophyll a. Common errors were the use of a capital A or an alpha symbol or giving two contradictory answers.

(v) Most candidates correctly named the two compounds used in converting GP to TP in the Calvin cycle as ATP and reduced NADP. The most common mistakes were to omit either the word 'reduced' from NADP or the H from NADPH, or to omit the P and to write just 'reduced NAD'.

(b) Many candidates showed familiarity with a long list of biomolecules that could be synthesised from a starting point of triose phosphate. To achieve full credit they needed to think more widely and to suggest the use of TP in regenerating RuBP or the use of TP or one of its products in respiration.

Question 8

(a) Candidates generally knew the differences between the nervous and endocrine systems. Responses sometimes confused rate (how fast or slow something is) with duration of effect (long or short timespan).

(b) Many candidates could interpret the graph and gain full credit for matching the patterns of hormone secretion to the statements.

(c) The biological basis of the action of contraceptive pills was generally well understood. Most realised that FSH and LH secretion would stop and many gave further detail of the involvement of the anterior pituitary gland and negative feedback. The effect of lack of these hormones was also usually correctly described, with follicle maturation and ovulation stopping. Further detail of the effects on cervical mucus and the endometrium were also stated in the stronger responses. Some candidates gave more emphasis to the social aspects of contraceptive pill use instead of explaining the biological basis.

Question 9

(a) Good responses described a number of features that make ATP a universal energy currency. Universal means that all (not just some) cells or organisms use ATP. There is a common misconception that being small or water soluble enables ATP to move around the body, in the blood or across cell membranes. It should be emphasised that ATP is generated and used within each cell and only moves within that cell. Some candidates made the fundamental error of referring to energy being produced, rather than being released. A few candidates gained credit by including uses of ATP. The abbreviation 'rNAD' should be explained as meaning 'reduced NAD' when first introduced. It should not be assumed that rNAD is a standard abbreviation.

(b) Many candidates were able to supply a complete account of respiration in anaerobic conditions. There was sometimes too much detail of glycolysis leading to the production of pyruvate, which is a feature of any respiration in any condition. Candidates needed to concentrate more on the

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pathway taken by pyruvate when conditions are anaerobic. Some candidates wrote lactase or lactose instead of lactate and some did not name lactate dehydrogenase as the enzyme involved in the conversion to lactate. The differences between respiration in anaerobic conditions in mammals and yeast were often well described, with the clearest presentations being in a table format.

Question 10

(a) A diagram was often used to show the structure of a sensory neurone, but some drew a motor neurone with the cell body at one end, meaning credit could only be gained for features common to both neurones. Candidates most commonly scored for describing Schwann cells and nodes of Ranvier, and for stating that the cell body was the location of the nucleus. Fewer mentioned the presence of many mitochondria and many ribosomes or much RER in the cell body.

Some candidates were unfamiliar with the impulse travelling a considerable distance along a dendron towards the cell body, followed by a shorter distance along the axon in a sensory neurone. These terms are preferred since they highlight key structural features of a sensory neurone and help to differentiate its structure from that of a motor neurone. Many candidates misused the term 'dendrites' when referring to the structures occurring at either end, rather than just at the end closest to the stimulus or the post-synaptic end in a relay or motor neurone.

(b) Some candidates were able to describe in detail how ion movement is involved in setting up and maintaining a resting potential in a myelinated neurone. Moving the ions by active transport via a sodium-potassium pump was usually described clearly, with only a few answers reversing the direction of movement of the two ions. Some responses also mentioned movement through ion channels, but this was not always identified as being by diffusion. Strong answers included the idea that the membrane was more permeable to potassium ions, resulting in its polarisation with the inside of the membrane becoming more negative than the outside. Most included the figure of -70 mV for the resting potential.

Common mistakes were to confuse resting potential with threshold potential and answers that described depolarisation in detail. Very few candidates mentioned that the movements of ions to establish and maintain resting potential only occur at the nodes of Ranvier.

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Paper 9700/42
A Level Structured Questions

Key messages

Candidates need to demonstrate an understanding of biological terms and use them in the correct context, such as in **Question 1(b)**, **Question 4(a)** and **(b)**, where terminology needed to be precise.

Question 5(c) tested the ability to evaluate – that is, to select appropriate information and data in order to support their argument. This is a high order thinking skill and candidates found demonstrating clear and logical thinking challenging in this context.

General comments

Many candidates were able to display their knowledge and understanding effectively throughout the paper.

Question 5 proved to be challenging for many candidates.

Comments on specific questions

Section A

Question 1

(a) Most candidates gained all of the credit available, being fully aware that hunting for a variety of reasons, destruction of habitat and food shortages were the major causes. The occurrence of disease and difficulty in finding a mate were given to a lesser extent in answers. Good awareness was shown of this important issue and the underlying reasons for it.

(b) Almost all candidates understood that moving the tigers from one zoo to another was important in maintaining or increasing the gene pool of the tigers. Many were also aware that it increased heterozygosity and prevented inbreeding depression. Producing hybrid vigour was given less frequently.

(c) IVF and artificial insemination were the most common answers given by the majority of candidates. Many candidates were also aware of embryo transfer and surrogacy as other possible methods of assisted reproduction.

Question 2

(a) Although the majority of candidates made a good attempt to explain *linkage*, many were confusing the terms gene and allele and so did not gain the credit. Few realised that they also needed to explain the term *autosomal*. Many candidates repeated the terms given in the question. Others clearly knew it was two different genes but did not say that they are on the same chromosome or did not specify that these alleles were inherited together. Weaker candidates added that the genes were at the same locus, or that more than one allele was on a chromosome.

(b) (i) Many completed genetic diagrams with correctly identified parents, some showing crosses from the first parents. However, the majority of students completed the diagram as a dihybrid cross rather than a linked cross, even though the question indicated the genes were closely linked. These gave four gametes rather than two and went on to draw a Punnett square with a 9:3:3:1 ratio, which

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limited the credit that could be awarded. Although many responses had offspring genotypes and phenotypes, they were often not matched together, so full credit could not be achieved. Most responses had ratios quoted although this was not a requirement. Even though the genotypes were provided in the question, a minority of candidates made up their own combination of different letters.

(ii) Many candidates did not perform well on this question, stating that this was a 9:3:3:1 ratio. Some stated a different ratio but did not specify that it was not 9:3:3:1. Of those candidates who did understand, some still did not gain credit as they only stated that there were more of the homozygous dominant phenotype rather than both homozygous phenotypes.

(c) (i) This was a straightforward question and the majority of candidates responded correctly, even if they did not score well on the previous questions.

(ii) A significant number of candidates were unable to carry out the calculation. Many did not identify which phenotypes denoted crossover having occurred and so a wide range of combinations of figures were used in the calculations. Many candidates did correctly identify the appropriate phenotypes as recombinant, however many of these did not round up appropriately.

(iii) Many candidates stated only that genes were close rather than linking it to the crossover value. Others tried to explain the significance of the COV they obtained in **Question 2(c)(ii)**, rather than relate COVs to the distance that the genes are apart.

Question 3

(a) (i) Most candidates answered this well, relating a correct sequence of events during prophase I and using correct terms. A minority of candidates incorrectly mentioned the nuclear membrane dissolving or the nucleus breaking down. Relatively few mentioned that chromosomes became visible, and a significant number wrongly indicated that centrosomes migrated to opposite poles. Some candidates focused only on genetic variation and so did not gain other available credit.

(ii) The majority of candidates did not perform well on this question. Many candidates wrote about independent assortment rather than random alignment so many responses scored no credit. As in **Question 2(a)**, the terms gene, allele and chromosome were not always used accurately. Some mentioned new combinations of alleles without reference to parents. Many candidates repeated the information given in the question, and did not explain what 'independent' meant in this context. There were answers which incorrectly described chromatids randomly pairing up.

(b) (i) The majority of responses recognised that the protoctist feeding on nutrients linked to infected chickens either being unable to feed or having impaired absorption. Some linked this to its effect on body mass of the chicken, whilst a minority of answers made reference to the immune response. Weaker candidates mentioned food rather than nutrients. Some candidates incorrectly stated that the protoctist affected gene expression or the synthesis of enzymes.

(ii) Most candidates found this question difficult, with few candidates gaining credit. Some stated that soil availability and other external environmental factors affected the growth and reproduction of *Eimeria,* and had not taken into account that the protoctist was a parasite and lived inside the body of the chicken. Very few candidates linked temperature to the inside of the chicken and a high number stated availability of food. A minority of candidates correctly stated that there would be other microbes within the gut of the chicken that would cause competition for resources and a few responses indicated that there may be drugs or medications used to treat infected chickens.

(c) (i) Most candidates recognised that the correct test is the *t*-test, although there were a range of other statistical tests incorrectly given.

(ii) A wide variety of graphs were produced. Those candidates who drew two bell-shaped curves almost always labelled them appropriately. Sketches showing the high dose curve as narrower and higher than the low dose curve were rarely seen. A very few candidates did not label the curves. Of those candidates who did not draw a bell-shaped curve, many incorrectly drew the low dose curve to the left of the high dose curve.

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Question 4

(a) The majority of candidates linked an initial mutation to the development of resistance, although often the mutation was not described as random or spontaneous. A few candidates explained the consequences of the mutation in terms of producing an allele coding for an enzyme that gave resistance. Many correctly identified the toxin as the selection pressure; some incorrectly giving this as the reason for the mutation. The features of the flies possessing the advantageous mutation in terms of selective advantage, survival, passing on the advantageous allele with its subsequent increase in frequency was largely understood. However, many candidates were unsure of the difference between a gene and its allele, alternating between the two in their answers.

(b) Most candidates explained that a geographical barrier was responsible for separating the two populations, which were subjected to different selection pressures or environmental conditions resulting in allopatric speciation. Genetic drift was the only effect resulting from the formation of new alleles that was occasionally given in answers.

(c) The use of bioinformatics in comparing the data of the two populations in terms of DNA sequences or amino acid sequences was largely understood by many candidates, as was the importance of mitochondrial DNA. Fewer candidates went beyond the comparison of sequences to explain how this information was used to estimate the length of time that *D.yakuba* had been living on Mayotte, in terms of calculating the percentage of bases or amino acids changed, or by using mutation rate to estimate time.

Question 5

(a) (i) Most candidates were able to state that gene therapy is the delivery of an allele (or corrected gene) into a patient. However, only a small number of responses identified the correct context for this by stating that it is used to override recessive genetic diseases, and very few answers provided an example of a suitable genetic disease that can be treated by gene therapy.

(ii) This was answered well, with most candidates understanding the role of enzymes in the production of recombinant DNA. The most common errors included stating that mRNA itself is turned into DNA rather than being used as a template, or confusing the role of these enzymes with restriction enzymes used to cleave DNA.

(iii) Candidates had to use their knowledge of the challenges in using appropriate vectors to identify why the AAV viral vector used should not be able to replicate. The majority of credited answers stated that a vector which was unable to replicate itself was used in order to reduce side effects or to limit the chance of cancer developing. Few answers suggested the idea of preventing the virus spreading to other cells. Some incorrectly stated that this would prevent the intended target cells from being infected by the virus, which would make this method of delivery ineffective.

(b) (i) Of the two separate concepts that could have been used to answer this question, very few candidates realised that Group **C** was an untreated control used to compare the effect of the hG-CSF therapy versus no therapy, to show if the therapy gave improved outcomes. Instead, the idea of the GFP gene as a marker was more commonly developed, with candidates giving suggestions about the gene being traceable within certain cells in the mouse. There were, however, some incorrect ideas about fluorescent mice and the GFP just showing that the mice had received the AAV vector containing GFP, rather than using it to identify that it reaches the intended target cells.

(ii) Many candidates merely stated that Group **D** mice were a control group, which was insufficient here, rather than being used as a comparison group to show the scale between normal mice and mice with a stroke, and how quickly treated mice could return to normal by providing a baseline set of readings in the different measurements. Very few stated the ideas of making the experiment valid, e.g. by showing that treated mice do not give readings that are better than a healthy mouse.

(c) This question proved to be very challenging. Answers clearly discriminated between across the range of abilities to evaluate data and draw conclusions from the information provided. Many answers only provided lists of unconnected and unexplained data. The clearest answers explained that the gene therapy would improve survival. Other parameters were generally less well

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described. Many answers quoted figures but did not consolidate these with a clear explanation of which groups of mice they were discussing. Many answers simply referred to groups by letter without mentioning which gene therapy (or not) they had received. Some candidates did not appreciate the roles of the two control groups, Groups **C** and **D**, referring to them as if they were being tested as therapies, for example, describing the healthy mice as being the best treatment for stroke, or suggesting that the empty AAV vector caused the poor results in mice with a stroke, rather than to test the effectiveness of the actual therapies. Few candidates commented about the likely effectiveness in humans, given that these results were in mice, to suggest that the hG-CSF gene therapy is promising and could be effective in humans, with the caveat that sufficient differences exist that would require further testing. Several answers were also incorrectly written as if this data had been obtained in humans.

Question 6

(a) All candidates had sufficient understanding of aerobic respiration to gain some credit, and many achieved the maximum available for this question. The most common errors were due to a lack of specificity by omitting terms such as 'substrate-linked' from substrate-linked phosphorylation, by missing out either 'matrix' or 'mitochondria' from matrix of mitochondria, or missing out one of the two steps where decarboxylation occurs in the Krebs cycle. Errors included incorrect locations (e.g. membrane, rather than matrix, of mitochondria), oxidative phosphorylation rather than substrate-linked phosphorylation, or confusing NAD with either NADP or reduced NADP, which was separate on the diagram provided.

(b)

Some candidates found understanding the context of this question challenging and referred to the production of ATP in **step 3** of **Fig. 6.1,** instead of linking the fact that the 5-carbon intermediate compound derived from glutamine could be used as a 5-carbon intermediate compound as shown in **Fig. 6.1**. However, candidates who made this link were able to access full credit. More commonly, candidates suggested that oxidative phosphorylation was involved, but often did not mention that reduced NAD or reduced FAD produced in conversion of the 5-carbon intermediate would deliver the proton and electron for employment of the ETC, so achieved only partial credit.

Question 7

(a) Most candidates placed all three compounds into the correct location in **Table 7.1**. The most common error was to state that RuBP and rubisco are found in the cells labelled **A**. A small minority of candidates put two answers in one box, thereby not obtaining the credit.

(b) This question was answered well. Most candidates clearly stated that this arrangement prevents oxygen (or air) coming into contact with the cells labelled **B** and that this avoids photorespiration.

(c) This question required both a description and an explanation. For the description, not all candidates clearly described differences, but simply described one curve and then the other. Most were able to quote data to support the difference they mentioned, and the majority of these remembered that they needed to quote the full coordinates – that is, the values from both axes, with units. It was also important to make these data quotes fully comparative by comparing activity at the same temperature, or temperature at the same activity.

Explanations were generally less successful than descriptions, although many answers correctly stated that C4 plants were adapted for survival in hot climates, and a few responses also explained that the data suggested that the C4 enzyme was more thermostable than the C3 enzyme. Some candidates tried to identify the enzymes as rubisco and PEP carboxylase, despite the question clearly stating that the data applied to one enzyme.

Question 8

(a) The events occurring after an action potential arrives at a presynaptic neurone were generally well known. However, few candidates mentioned depolarisation and, when this was given, it often wrongly referred to depolarisation of the neurone rather than of the membrane. Most candidates were able to describe opening of calcium ion channels and the subsequent entry of calcium ions into the neurone, although some wrongly said that the ions moved into the membrane. Descriptions of the effect of the calcium ions on the movement of vesicles containing acetylcholine

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towards the cell surface membrane, their fusion with the membrane and the release of acetylcholine, were generally clear and correct. A common error was to suggest that the vesicles bind to the membrane, or that it is the vesicles themselves that leave the cell. Many candidates described what happens after the acetylcholine is released from the cell, which was not relevant and so gained no credit.

(b) The majority of candidates were successful in making two correct points here. However, some candidates wrongly stated that the sodium ions could not move into the membrane, rather than into the cell. Some candidates did not qualify the idea of depolarisation being of the membrane.

(c) (i) The myelin sheath and mitochondria were well known. Few candidates were able to identify the sarcolemma.

(ii) This was very well known. Most answers correctly stated that the myelin sheath speeds up transmission of the nerve impulse, and also mentioned or described saltatory conduction.

(iii) Most responses gained some credit for this question, although few candidates were able to apply their knowledge of what happens at a neuromuscular junction widely enough to gain all of the available credit. Most correctly stated that these structures make ATP, and then proceeded to give some examples of processes that require ATP. Active transport was frequently mentioned, although sometimes in an incorrect context, such as the movement of calcium ions into the presynaptic neurone. Some also mentioned movement of the vesicles or exocytosis. Less common was a statement about the need for energy to synthesise or recycle (rather than to break down) acetylcholine. Many answers gave some detail about muscle contraction, which is not a function of the mitochondria at the neuromuscular junction.

Section B

Question 9

(a) Candidates choosing this question frequently scored well with a good account of the structure of a member of the Archaea. Most responses appreciated that the cell would not contain a nucleus, nuclear membrane or any membrane-bound organelles, although 70S ribosomes would be found. Many went on to describe the presence of circular DNA, often then referring to its association with histone proteins. Some references to a cell wall were seen and a few stated that it would not be composed of peptidoglycan. However, some responses commented on the unicellular nature of members of the Archaea and that they would replicate by binary fission. Occasionally, candidates gave examples of where these prokaryotes would be found, such as hot springs or hydrothermal vents. No references to the composition of the cell membrane differing from those of either Bacteria or Eukarya were seen.

(b) Responses to this question were generally weaker. Credit was most frequently awarded for reference to the seed bank housing a collection or variety of seeds which could be used to repopulate a species in the event of extinction or a natural disaster. Many also appreciated the importance of seed banks in maintaining the genetic diversity of a species but only rarely was there a comment on the maintenance of biodiversity as a whole. Most answers mentioned their importance for research and education. Some referred to the long term storage of seeds, occasionally stating the conditions required, such as frozen or dried. However, very few candidates added that these conditions were necessary to maintain dormancy or to prevent germination. Stronger candidates mentioned that seeds should be germinated regularly to test their viability, allowing fresh seeds to be collected and stored.

Question 10

(a) There were some excellent accounts of the mechanism of selective reabsorption in the proximal convoluted tubule. Candidates frequently began by stating that sodium ions would be pumped out of the epithelial cells of the proximal convoluted tubule, resulting in a sodium ion concentration gradient between the filtrate in the lumen and the cytoplasm of the cells. Many stated that sodium ions would then diffuse from the lumen into the cells, although relatively few mentioned facilitated diffusion or the use of a carrier protein. Nevertheless, most appreciated that glucose or amino acids would also enter the cells with sodium ions by co-transport or via a co-transporter or symporter protein. Few references to water entering the cells from the lumen down a water

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potential gradient were seen although many commented that water would re-enter the bloodstream. Almost all candidates were able to name at least one modification of the proximal convoluted tubule cells, most notably the presence of microvilli on the luminal surface. Most understood that there would be many mitochondria within the cells, often explaining why, and that they are held together by tight junctions. Fewer commented on the presence of many transport proteins, or suitable equivalents, or the folded basal membrane.

(b) Many candidates scored almost full credit for recognising that the osmoreceptors in the hypothalamus would detect a decrease in the water potential of the blood and then stimulate the posterior pituitary gland to secrete antidiuretic hormone (ADH) into the bloodstream. They often continued to give detailed accounts of the action of ADH on the walls of the collecting duct and distal convoluted tubule before stating that the water potential in the blood would increase, or return to the set point. Some candidates also added that this constituted a negative feedback mechanism. There were very few references to neurosecretion or that the axons of the neurosecretory cells extend into the posterior pituitary gland. However, some candidates appreciated that the synthesis of ADH occurred in the hypothalamus.

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Paper 9700/43
A Level Structured Questions

Key messages

When asked to comment on data, as in **Question 1(a)(ii)**, candidates should look for patterns or trends and make comparisons as necessary, rather than simply writing out the data in a different format.

General comments

This paper was very accessible for most candidates.

Comments on specific questions

Section A

(a) (i) Most candidates were able to correctly calculate the number of macaques per km^2 to be 0.03. It is important to note that answers should be given to an appropriate number of decimal places. Unless instructed otherwise, this should be in alignment with the number of decimal places of the data given in the table, in this case two decimal places.

(ii) While some candidates simply copied out some of the data from the table, many were able to show that there was an inverse relationship between number of humans and number of macaques. Most were then able to suggest two reasons for this, such as hunting and habitat destruction.

(b) A majority of candidates correctly listed ways of protecting the Sulawesi macaque. The most common answers were to ban hunting or trade in the animals, to create reserves for them and to use assisted reproduction methods during captive breeding. A large number of candidates achieved full credit.

Question 2

(a) (i) This was a very accessible question to most candidates who achieved full credit by recognising the expected 9:3:3:1 F2 ratio and calculating the expected numbers of individuals correctly.

(ii) There were well-structured answers given with clear genetic diagrams for this straightforward cross. Most candidates clearly linked the offspring genotypes to offspring phenotypes and a majority of candidates achieved full credit.

(b) (i) The majority of candidates correctly identified prophase I as the phase when recombinants are produced and that it occurred by crossing over. A minority of candidates were not precise enough when identifying the stage by not indicating that it was in meiosis I.

(ii) Many candidates found this difficult and did not recognise that autosomal linkage was the explanation for the different results. Of those candidates who did recognise that autosomal linkage was the cause, fewer answers explained that the results were different due to the genes being on the same chromosome and this therefore meant that there was no independent assortment of homologous chromosomes.

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Question 3

(a) This question was a good discriminator across all ability levels. The most common answers identified that meiosis I halves the number of chromosomes to make haploid gametes. A significant number of candidates recognised that gametes were being made but did not specify that they were haploid and so did not score. Many candidates explained that haploid gametes were needed at fertilisation to restore the diploid number and that this maintained a constant chromosome number.

(b) (i) This was a challenging question that required candidates to use the information given as guidance, then name two different examples of environmental conditions that can affect plant phenotype. The most common answer was the effect of light, but very few candidates wrote light intensity, so even with a good description of how it affects the phenotype by changing the size of the plant, they did not gain credit. A small number of candidates gave good examples of other environmental conditions, for example: waterlogged soil, wind speed and pH. However, very few candidates then described the effect on the phenotype and so did not gain credit for this question.

(ii) Most candidates achieved full credit here. Many recognised that mutation caused genetic variation or new alleles and a few candidates went on to link this with a new phenotype being made. More candidates stated that the mutation caused an individual to have a selective advantage and therefore be more likely to survive the selection pressure.

(c) Many candidates made good comparative descriptions and went on to quote data from **Fig. 3.1** to support their answer, thus achieving all full credit. Some candidates did use the data from **Fig. 3.1** but were not comparative with their descriptions and looked at each population separately and each soil type separately, and therefore did not gain any credit.

(d) (i) Most candidates scored fully on this question and many achieved credit for working if a mistake was made in their calculation. Some candidates did not answer to an appropriate number of significant figures based on the data provided and thus awardable credit was limited.

(ii) Few candidates achieved full credit on this question. The majority of candidates correctly identified that the null hypothesis should be rejected but found it challenging to explain why they should reject the null hypothesis. Where credit was awarded it was for recognising that the value of *t* was higher than the critical value, but very few candidates went on to explain that this indicates there is a significant difference between the means given in **Fig. 3.2.**

Question 4

(a) Most candidates recognised that this was a familiar natural selection question and correctly referred to a spontaneous mutation occurring which gave plants a selective advantage, meaning they survived or reproduced to pass on this allele, which increased in frequency. Few candidates recognised that the insects were the selection pressure and very few that the mutation produced an allele which coded for the insect deterring chemicals. Some candidates incorrectly referred to the chemicals causing the mutation and others to genes rather than alleles. There were more candidate responses, however, which qualified mutation by being random or spontaneous.

(b) (i) The majority of candidates knew that a change in the mean indicated this was directional selection.

(ii) Most candidates knew that the flowering period being kept the same was due to stabilising selection. A minority of responses confused the two terms for **Question 4 (b)(i)** and **Question 4(b)(ii)** or did not know these terms.

(c) Many candidates found this challenging. It was clear that many understood the random nature of genetic drift but often did not quite explain that, in this context, it would mean that the results would therefore show no trend.

Question 5

(a) (i) Some candidates achieved full credit for this question with well-sequenced accounts of obtaining the dominant *APP* allele. These responses often described the use of probes and restriction

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enzymes, and a vector to add the gene to a zygote. Other methods were also described, such as the use of a gene gun or microinjection, and that promoters and marker genes would be needed alongside the added gene. Most candidates remembered the use of a restriction enzyme and plasmid as a vector but were unable to add more detail.

(ii) Most candidates correctly suggested that the use of an animal model would avoid the harming of humans while testing the treatments.

(b) Most candidates found the context of this DNA microarray analysis question very challenging and some did not attempt an answer. Only the higher ability level candidates were able to access all of the credit available. When credit was given, it was for stating that this microarray identified expressed genes, which showed up as fluorescent spots, which were recorded by a laser, and that the intensity of the fluorescence was proportional to gene expression. Very few candidates linked gene transcription to the production of mRNA or how cDNA would bind to the complementary single stranded probes, bound at known positions on the chip, or that each known position would be identified with a named gene.

(c) (i) A minority of candidates achieved full credit for this question. The majority did not subtract 28 from 932 to exclude mice that had not received training. The other figure needed for the calculation was the total number of mouse genes, 33 696, as given in the information given at the beginning of **Question 5(b)**. However, many candidates did not use this and only used data from the table.

(ii) Candidates of all ability levels were able to recognise the relationship between training and gene expression.

(d) (i) Most candidates knew that the name given to this type of treatment is gene therapy.

(ii) This was a challenging question, which required candidates to apply their knowledge of gene expression and of gene coding for a transcription factor within the correct context. Only very few candidates recognised that this gene being overexpressed would mean the transcription factor it codes for would be overproduced and that this would be responsible for switching on genes needed for forming memories or synapses. Some candidates suggested this would allow better learning and reduce the symptoms of Alzheimer's disease.

Question 6

(a) (i) Many candidates were able to mention glycolysis, the link reaction and Krebs cycle as sources of reduced NAD.

(ii) Some candidates were unclear about the precise role of the carriers and just described oxidative phosphorylation. More successful candidates stated that the carriers would split hydrogen from the reduced NAD into electrons and hydrogen ions as shown in the diagram. Higher ability candidates then stated that movement of electrons along the ETC provided energy. The highest scoring responses then went on to explain that this energy was used for the pumping of hydrogen ions into the intermembrane space.

(iii) This question was well answered with most correctly giving oxygen and ATP synthase.

(b) Whilst most candidates realised that a folded inner membrane would give a larger surface area, fewer were able to say what the benefits of this would be, namely to have more carriers or ATP synthase and therefore more ATP would be produced.

Question 7

(a) This question discriminated well across the ability range.

(b) (i) There were many confused responses to this question. Candidates were asked to explain the results for a tube containing chloroplast suspension and DCPIP and placed in the light. To gain full credit, candidates needed to say that this showed that the light dependent stage of photosynthesis was taking place and that the hydrogen produced would reduce DCPIP, causing the colour change. A wide range of correct and incorrect answers were given. A common incorrect answer was that hydrogen ions were released to cause the reduction of DCPIP.

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(ii) Most were able to explain the inclusion of the control in the investigation by stating that it set a baseline to compare with the other tubes or that any colour change in the other tubes was due to chloroplasts.

(iii) This question was answered well by a small majority of candidates. Some responses showed confusion and stated that the chloroplasts would either swell or shrink. In addition, some did not score credit because they referred to water concentration rather than water potential.

(c) Most were able to correctly state that carbon dioxide concentration would have no effect on the reducing ability of the chloroplast suspension, though some did not include the word concentration. Only the stronger candidates then went on to say that the reason for this was that it was not involved in the light dependent reaction.

Question 8

(a) Despite many candidates writing some irrelevant information, most were able to gain full credit for this question by listing at least three structural features for each.

(b) It was evident that many candidates had learnt this section of the syllabus well and consequently they scored highly.

(c) While many candidates could describe anaerobic respiration in muscle cells, fewer were able to state why this was important, namely that it enabled glycolysis to continue and produce ATP, although in small amounts.

Section B

Question 9

(a) Most candidates listed a good number of the characteristic features of the domain Eukarya. One of the more difficult points to achieve was to list all of the formations of cells, being unicellular, colonial and multicellular.

(b) Many candidates focused on a few types of assisted reproduction and simply described them without linking their role to conservation of endangered mammal species. Some candidates did, however, recognise that some species have difficulty reproducing, with the Giant Panda often being cited. IVF, surrogacy and artificial insemination were common examples of assisted reproduction. Incorrect answers such as zygotes being inserted in the uterus were common.

Question 10

(a) This question was answered well overall. Most candidates had learnt the effects of ADH on the kidney and wrote clear answers. Some lost credit by not referring to the cell *surface* membrane as the location of ADH receptors.

(b) This section of the syllabus was well remembered by many candidates but, as with **Question 10(a)**, credit was lost by not referring to the cell *surface* membrane as the location of receptors, this time for glucagon.

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Paper 9700/51
Planning, Analysis and Evaluation

Key messages

- When analysing data, candidates should look for trends. Data can be used to support an analysis but should not just quote raw data in isolation. Candidates should avoid simply rewriting the question and only giving descriptive answers.
- Candidates should have practice in describing tabulated data from unfamiliar material.

General comments

There was a wide range of responses and the paper differentiated well. Candidates seemed to have sufficient time to complete the paper.

Comments on specific questions

Question 1

(a) (i) There were many good responses to this question. The dependent variable is what was actually measured in the investigation, so this is the time for the discs to rise to the surface, not rate of photosynthesis. Some responses were too general and just mentioned 'time to rise' without mentioning the discs or that they rise to the surface. A few candidates had the variables the wrong way around.

(ii) The critical step in this experiment was that the timing of the discs should start when the discs reached the bottom of the beaker after being put in. Good responses realised this and set out the plan of investigation in a series of logical steps. It should always be the aim that the candidate's response could be used as a set of laboratory instructions.

Various approaches were described. Most candidates either placed a set of each type of leaf disc in separate beakers of sodium hydrogen carbonate solution or did a series of individual discs of each type in each solution, both of which were appropriate. Weaker responses suggested putting all the discs of each type together in one beaker or did not make it clear that the different types needed to be done separately to make the investigation practicable.
A good starting statement would be to use four beakers, each filled with the same volume of sodium hydrogen carbonate solution. Weaker responses sometimes also stated that whole leaves were put in rather than discs.

Other impractical suggestions were to carry out the investigation in the Petri dish rather than in a beaker, or placing the whole Petri dish into the beaker. Surprisingly few gave the critical step of timing from when the discs reached the bottom. As the dependent variable is the time to rise from the bottom to the surface, as shown in **Fig. 1.1**, this is important. The standardising variables were often well covered, provided the idea of keeping something the same was clear. Thus, there were good statements of the same number and size of discs, the same temperature and light intensity and the same concentration and volume of sodium hydrogen carbonate solution. Some quoted volumes that were not suitable, e.g. 10 cm^3 which, even in the smallest of beakers, would not provide enough depth to record a meaningful time for the disc to rise to the surface.
In general, many candidates were precise in stating exact figures for variables. Some weaker responses tended to have a heading 'Controlled Variables' and then a list of factors such as light or temperature with no reference to keeping them the same or how that would be achieved as appropriate. The risks in this investigation are low. Allergy to leaves was often mentioned and

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credited if a suitable precaution was linked to it. Carrying out a suitable number of replicates and calculating a mean was generally well covered.

(b) (i) Many candidates knew that rate is the inverse of time and that 1 is divided by the times given in the table. However, some responses stated that rate is simply the time for the discs to reach the surface. Other responses were in terms of the volume of oxygen released, which is not correct.

(ii) Candidates generally found this question difficult. Many responses partially explained why the conclusion may not have been valid, without the detail needed for full credit. Some tried to link all three conclusions just to the cuticle information in **(a)** and ignored the material in **(b)**. Candidates needed to link some synoptic knowledge of leaf anatomy to the material in the question in both sections **(a)** and **(b)**.

For conclusion 1, the best responses that gained credit were:

- as the cuticle is transparent there should be no reason for it to reduce light absorption
- spiderwort had a thin cuticle and sorghum a thick one but the rate of rise is similar
- the thicker cuticle would add to the weight thus slowing the rise of the discs.

For conclusion 2, acceptable ideas centred around the pigment content of the leaves, such as:

- the chlorophyll content may be similar to other leaves but is more concentrated in the green parts or it is hidden by the purple pigments in the purple stripes
- the purple pigments may also be light absorbing for photosynthesis
- the rate for spiderwort is close to that of sorghum and is faster than ivy, neither of which have purple stripes.

For conclusion 3, candidates needed to appreciate that C4 plants are only more effective at photosynthesis at relatively high temperatures. At the relatively low temperature of 20 °C they do not show increased photosynthesis relative to C3 plants. Candidates quite often mentioned aspects of C4 physiology and higher temperatures but did not always link it to the lower temperatures at which the investigation was carried out.

(c) (i) A significant number of responses used leaf discs rather than chlorophyll extract in the colorimeter. Credit was allowed for the correct use of red light and the recording of absorbance for the different leaf types.

(ii) The standard solution should be the extraction solvent from **(c)(i)**, where the most common solvent was water, which was accepted. Some incorrectly suggested that the chlorophyll could be removed from the chlorophyll extract.

(d) Many responses showed that candidates had a good understanding of the *t*-test. These appreciated that spiderwort was being compared with each of the other leaves so three tests were needed. Those who were less clear on the statistics suggested four tests on the basis that there were four species involved, or six tests on basis that each type was also compared with itself. Many candidates gave suitable explanations in their answers. Weaker responses used the various terms in the wrong context. A common error was to suggest that 0.05 is the critical *t* value.

Question 2

(a) (i) The data in the table was quite complex and some candidates were confused between whether the trees influenced the squirrels or the squirrels influenced the trees. It was important for candidates to indicate that a positive percentage change indicated an increase in that particular tree type or species and a negative percentage change indicated a decrease. The stronger candidates linked the suitability of species of tree for species of squirrel to whether that type of tree had increased or decreased.

(ii) Candidates needed to relate the habitat changes described in **(a)(i)** to the decline in red squirrels. Thus, a drop in suitable habitat was creditworthy, as was less food related to the reduction in habitat or competition from grey squirrels. A number of responses mentioned competition for food in a rather general sense without saying that the result would be less food for red squirrels. Some candidates successfully included points on reduced habitat to shelter from predators whilst others mentioned the possibility of disease.

(b) (i) This question was generally answered well. The commonest error was to mention spacing of traps, which is not the same as density. Some responses mentioned ‘same number’ without qualifying it as same number per given area.

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(ii) This was answered well by most candidates, who realised that the percentage testing positive dropped over time. An equally valid approach was to note that in 2010 the percentage testing positive was much lower than the control group. Weaker responses tried to compare raw numbers of squirrels tested, which was not appropriate.

(iii) Two successful approaches were used to answer this question and they were expressed in a wide range of ways. Many candidates assumed that the original culls had been equally successful on both the island and the mainland and that immigration would subsequently be less likely in the island as it is more isolated. The other approach was to suggest that the cull was less successful on the mainland for a variety of reasons, such as the mainland is larger habitat, has more habitats and has more squirrels and so a breeding nucleus was readily available.

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Paper 9700/52
Planning, Analysis and Evaluation

Key messages

Candidates should:

- Describe experimental procedures in a logical sequence, giving clear instructions on how to do the experiment. The procedure should be suitable for producing valid results.
- Look for trends when analysing or evaluating data and summarise what it shows, taking care to relate to the context of the data.

General comments

There was a wide range of responses and the paper differentiated well. Some responses were excellent and showed a good understanding of experimental design and data interpretation. Others were poorly presented and showed little understanding of how to evaluate or analyse data. Some responses did not answer the question sufficiently, for example in question **1(d)(ii)**, some described experimental details of counting bubbles from pondweed instead of adapting the given method, and in **2(a)**, some described capture, mark, recapture for estimating the size of a population instead of how to use random selection to find study areas.

Understanding of statistics was good in many cases, although there is still some confusion about the meaning of the different types of bars that can be drawn on graphs to show variation in the data, such as standard error, standard deviation and range,.

Comments on specific questions

Question 1

(a) Many candidates gave a suitable answer, commonly a reference to the absence of numerical data.

(b) The majority of candidates found difficult to give a clear answer this question. There was a great deal of confusion between controls, control experiments and control variables. The most common answers were comments about each of the three tubes. In these cases, candidates were expected to make a statement about the purpose of each tube in relation to the dependent variable, in this case the colour change of DCPIP. The answer needed to be about a colour change, otherwise credit was not given. Many candidates answered in terms finding out whether or not the light dependent reaction was occurring or whether DCPIP was being reduced, which were not credited. Credit was also given for a more general answer identifying the tubes as controls that showed that light, chloroplasts and DCPIP were required for a colour change to occur.

(c) Very few candidates gave a correct answer. The most common answers were related to either diffusing the light to give even illumination, focusing the light onto the test-tube or absorbing different wavelengths of light.

(d) (i) Almost all candidates identified the independent variable. The dependent variable is what was actually measured in the investigation, so it was the time for the DCPIP to decolourise rather than the rate of photosynthesis. Credit was allowed for the time taken for the green colour to appear, but answers more often stated that the solution or suspension became colourless. A few candidates had the variables the wrong way around.

(ii) Candidates are expected to produce a workable method that could be used to obtain valid results. Candidates who have sufficient experience of practical work are more likely to understand the

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information given in the question and to use this to give answers that are logical, coherent and complete. There were many candidates who simply listed variables without any indication of how the variables will be changed, measured or standardised.

The critical step was deciding that a timer must be started as soon as the chloroplast suspension was exposed to light. Candidates who did not make this clear could not gain maximum credit. There were some good answers to this question in which candidates gave five suitable distances for the lamp, set up test-tubes with the same volumes of both the chloroplast suspension and DCPIP and measured the time for DPIP to decolourise using a colour comparison tube of chloroplast suspension. These answers also referred to a suitable safety concern and to repeating the experiment at least two more times to obtain a mean. The term 'average' was not credited in this context as this syllabus requires candidate to distinguish between the different types of average, mean, mode and median. Weaker answers often omitted the critical stage, describing timing until the mixture became colourless and did not specify how many repeats should be carried out. The weakest answers also gave unsuitable distances or too few distances from the lamp, showed little understanding of how to standardise the contents of the tube or how the measure the dependant variable. Candidate's should be aware that a minimum of 5 values for the independent variable is standard practice and as such should be including this routinely in their methods. Many of these answers showed little understanding that, to compare rates, each distance should be timed to a set point. A common answer was to put the tubes at the various distances, leave for 10 minutes and then compare the colours. Answers that repeated the experiment described in the question paper were also common.

Weaker answers also often used imprecise language, for example referring to amounts rather than volumes and not making a clear distinction between the volumes of the chloroplast suspension and the DCPIP solution. Some candidates referred to 'known volumes' which is not the equivalent to 'the same volume'. If candidates quote specific volumes, they should be appropriate to the apparatus and to the experiment.

A number of candidates did not make any reference to safety or made general comments about standard good practice such as tying back hair, not running, not using electrical equipment with wet hands. Safety issues should be specific to the practical or an assessment made of the risk.

(e) Most candidates gave a correct answer. Candidates who converted centimetres to metres were credited for a correct calculation.

(f) (i) Most candidates found this question difficult. Knowledge of how a colorimeter works was not required for candidates to interpret the graph from the information given. As the data is collected at intervals of one minute, the apparent end is at eight minutes, but there is no evidence about the reaction between seven and eight minutes. The most common answer was that the reaction was still occurring as there was still some absorbance. The majority of candidates did not appear to have applied their knowledge from the previous questions that in a chloroplast suspension exposed to light, DCPIP decolourises with time. As a result, absorption will change until all the DCPIP is colourless. However, as the suspension is green it will continue to absorb some light. This absorbance will not change, as the colour is unchanged once all the DCPIP has decolourised.

(ii) The majority of candidates drew a correct tangent and were able to calculate the rate of change. The most common error was to draw a tangent passing through another time in addition to six minutes, usually five minutes. A few candidates drew tangents at incorrect times but error carried forward was allowed for a correct calculation from this tangent.

(iii) Good answers showed an understanding that at low light intensity the DCPIP would decolourise more slowly but eventually reach the same end point. Some weaker answers were credited if the curve levelled above the curve on the graph instead of merging with it at a later point in time. The most common error was for the curve to start at an incorrect time, usually at 2 minutes. A great many candidates drew a curve to the left of the curve on the graph, suggesting some confusion in drawing a curve with a decreasing gradient.

(g) (i) The understanding and use of statistics was quite good, although some candidates found it difficult to state a null hypothesis. For the *t*-test the assumption is always there is no significant difference. The most common error was to omit 'absorbance' from the hypothesis.

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(ii) The majority of candidates gave a correct answer, commonly continuous data or data with a normal distribution. A few candidates referred to comparing means, which was stated in the question.

(iii) Many candidates found this question difficult. Common incorrect answers were 23, 22, and 6. Most candidates knew the correct formula to calculate degrees of freedom but gave the wrong value, either because they forgot to subtract one from each set of data, calculated for only one set of data, or divided the correct value by two.

(iv) The majority of candidates gave a correct answer. Weaker answers tended to state that **X** was greater than 0.05 and **Y** was less than 0.05, suggesting uncertainty about how to interpret the table.

Question 2

(a) Candidates familiar with random selection gave clear accounts of using a random number generator to generate coordinates for study sites. Some less good answers used a random number generator but were uncertain about what to do with the numbers. Any suitable method of randomising was accepted, for example, candidates who had done field studies commonly described making a numbered grid on a map or at the site and then using random numbers from a mobile phone app or numbers from a hat to select the grids for the study plots. Weaker answers were often too imprecise for maximum credit, for example, using 'a random number generator to choose position of plots' does not state how the numbers are used to position the plots. It was also clear that some candidates did not appreciate the size of the study plots and stated that they would throw the quadrats randomly. As a safety concern, throwing quadrats or stones to find a random site is not appropriate. A minority of candidates described capture, mark and recapture of deer and sheep.

(b) Most candidates made a suitable suggestion, commonly that the number of dung piles does not necessarily equal the number of animals or that sheep and deer dung may be difficult to distinguish.

(c) This question was answered well. Almost all candidates gave two correct answers. A few candidates described what should have been standardised, such as the number of deer and the species of plants.

(d) Most candidates found this question difficult. Very few candidates gained full credit. In general candidates did not know how to evaluate the data and did not realise that the data collected by the study did not support the idea that sheep grazing with deer reduces the need to cull deer. Almost all candidates assumed that number of plant species is the same as species diversity, when it can also include species abundance as well. A number of candidates noted that **Fig.2.2** showed a correlation between the number of plant species and the mean dung count, but very few went on the say that this did not necessarily mean a cause and effect. Weaker answers reversed the correlation and stated that the number of plants affected the number of deer. Most candidates also assumed that the range bars were either standard deviations or error bars and wrote extensively about overlap between the data in **Fig.2.3** and whether the results were significant or reliable. Candidates need to understand the difference between a range, standard deviation and standard error, all of which may be shown on graphs by means of vertical bars. Candidates who knew that range bars show the maximum and minimum values and realised that the longer the range the more variable the results, gained some credit. Similarly, the few candidates who realised that there was no separate sheep data for comparison also gained credit.

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BIOLOGY

Paper 9700/53
Planning, Analysis and Evaluation

Key messages

Candidates should be aware that:

- Experimental procedures should have logical sequence, give clear instructions on how to do an experiment and give valid results.
-]When analysing or evaluating data, candidates should look for and summarise the trends shown. Candidates should avoid simply rewriting the question and only giving descriptive answers.

General comments

There was a wide range of responses and the paper differentiated well, spreading over most of the mark range. The best answers understood experimental design and were able to adapt this to answer questions. The weakest answers were poorly presented, showing little understanding of how to evaluate or analyse data. Some answers were difficult to read where one answer had been crossed out then overwritten.

Comments on specific questions

Question 1

(a) Almost all candidates gave a correct answer.

(b) Some candidates used their knowledge of practical work using enzymes immobilised in alginate and were able to explain how to immobilise algae. Others gave very vague answers about pouring algae into circular moulds containing jelly or agar.

(c) (i) Almost all candidates correctly identified both the independent variable and dependent variable. A few answers incorrectly gave the rate of photosynthesis as the dependent variable. Rate is a calculated value and cannot be measured directly.

(ii) Good responses described a workable method that could be used to obtain valid results. These candidates used the information given and produced a logical and complete procedure. Some simply wrote a list of variables without describing any procedure to vary, measure or standardise the variables. This gained limited credit.

The critical step was in deciding to expose the algal balls to light for a specific time, measured with a timer, and to record the colour of the indicator. There were some good answers to this question in which candidates gave five suitable distances for the lamp, set up containers with the same number of algal balls and the same volume of hydrogencarbonate indicator, which were kept in covered until timing was started. These also described a suitable control, included a suitable safety concern and referred to repeating the experiment at least two more times to obtain a mean. The term ‘average’ was not credited in this context as this syllabus requires candidate to distinguish between the different types of average, mean, mode and median. Weaker answers often omitted the critical stage, did not keep the algal balls covered before timing and did not specify how many repeats should be carried out.

Some answers also gave unsuitable distances or too few distances from the lamp and showed little understanding of how to standardise the contents of the tube. A minimum of 5 values for the independent variable is standard practice and so this should be included routinely in methods. Many of these answers showed little understanding that to compare rates, each distance should be timed to a set point, which could be achieved by timing for the same time or choosing a specific

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colour standard and timing until this was reached. A common error was to state the concentration of oxygen was measured.

Some candidates used imprecise language, for example, referring to amounts rather than volumes or mass, which limited the credit awarded. Some referred to 'known volumes' and 'known masses' which is not the equivalent to the same volume or same mass. If candidates quote specific volumes they should be appropriate to the apparatus and to the experiment, for example some candidates added 'a litre' of hydrogen carbonate, others 1 cm^3.

A minority of candidates made a reference to safety, with most making only general comments about standard good practice such as tying back hair, not running, not using electrical equipment with wet hands. Safety issues should be specific to the practical or an assessment made of the risk. In this case, the practical had medium risk as sodium hydrogen carbonate is harmful and alginate may be an allergen for some people.

(iii) Many candidates suggested a suitable method of reducing heat, commonly a beaker of water between the light and the glass container or using light that do not emit much heat, such as LED. A sheet of glass was not credited as glass allows heat energy to pass through.

(d) Most candidates gave a correct answer. Candidates who converted centimetres to metres were credited for a correct calculation.

(e) (i) Stronger answers to this question were related to the subjective judgement of colour or that pH meters gave a precise numerical value. Weaker answers were too vague for credit stating only that a pH meter would give better or more reliable results.

(ii) The majority of candidates were able to draw a suitable curve. Good answers showed an understanding that at low light intensity the pH would decolourise more slowly but eventually reach the same end point. Some less good answers were credited if the curve levelled below the curve on the graph instead of merging with it at a later point in time. A common error was to draw a linear curve that ended at 10 minutes.

(iii) Many candidates did not answer the question and wrote about other factors they thought were limiting, for example the pH becoming too high, too much oxygen present and the wavelength of light. Very few candidates stated that hydrogencarbonate in the indicator solution is a source of carbon dioxide.

(f) (i) There were many candidates who found it difficult to state a null hypothesis. A null hypothesis always relates to what is being measured, in this case pH, between different experimental situations, in this case distilled water and weed killer **A**. For the *t*-test, two means are compared and the assumption is always there is no significant difference. The most common error was to omit pH from the hypothesis. Weak answers were often a statement either that weed killer would affect the light dependent process of photosynthesis, or that weed killer has no effect on the light dependent process of photosynthesis.

(ii) The majority of candidates gave a correct answer, commonly continuous data or data with a normal distribution. A few candidates referred to comparing means, which was stated in the question.

(iii) Many candidates found this question difficult. Common incorrect answers were 16, 9, 8 and 7. Most candidates knew the correct formula to calculate degrees of freedom but gave the wrong value, either because they forgot to subtract one from each set of data, calculated for only one set of data, or assumed there were the same number of replicates in each treatment.

(iv) Many candidates found it difficult to express their answers clearly. Better answers identified that results for weed killers **A** and **C** supported the conclusion and then linked this to the probability of the result being due to change being less than 0.05. The best answers also commented that the results for weed killer **B** was not significant as the probability was greater than 0.05, so the results were due to chance. Very few candidates commented that the probability value for weed killer **A** indicated it was most effective. Weaker answers showed confusion in interpreting the probability values and often reversed the meaning. Others stated that the smallest probability value of weed killer **A** supported the conclusion while the largest probabilities for weed killer **C** did not support the conclusion.

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Question 2

(a) Almost all candidates gave a correct answer. A small number misplaced a decimal point.

(b) (i) Almost all candidates gave a correct answer, commonly the set distance of the transect or the direction taken.

(ii) This question was answered well. Almost all candidates identified that the fall in the lionfish population after 2008 supported the conclusion. Better answers noted that the confidence intervals overlapped so that the difference in population was not significant. Some of the best answers commented on the decrease in population growth between 2007 and 2008 could mean that catching and eating lionfish could have started earlier than 2008.

(c) A few candidates calculated standard deviation correctly. Many candidates did know how to use a confidence interval find S_M. The most common error was to calculate using 35, which is half the 95% value for the confidence interval, instead of halving this to get the value of S_M. Error carried forward was applied in these cases.

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