BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

Most candidates found this question straightforward with more than half of all candidates answering correctly.

Question 2

Most candidates answered correctly. The most common incorrect answer was to select option **A**, with only a few selecting a sequence based on sizes.

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Question 3

Many candidates correctly calculated the distance as 1.0 μm. The most common incorrect response was option **C**, with only a few selecting options **A** and **B**.

Question 4

Whilst most candidates answered correctly, some incorrectly thought that function 1 was matched with appearance V. The mRNA passes through the nuclear membrane and this is described by appearance X.

Question 5

Many candidates found this difficult, with only the strongest candidates correctly realising that, with a decreased rate of ATP production, there would be reduced activation of RNA nucleotides resulting in reduced transcription of nuclear DNA.

Question 6

Many candidates answered correctly, with option **B**, the most common incorrect response.

Questions 7, 8, 9, 10, 12 and **14**

Most candidates found these questions straightforward and answered correctly.

Questions 11, 13 and **15**

Some candidates found these questions challenging, although those who performed well in their AS Level overall answered correctly.

Question 16

Half of all candidates answered this correctly. The most common incorrect response was to select option **D**.

Questions 17 and **18**

Most candidates found these questions straightforward and answered correctly.

Question 19

The majority of stronger candidates understood this topic well and answered correctly. The most common incorrect response was to choose option **B**.

Questions 20 and 21

Approximately half of all candidates answered these questions correctly.

Question 22

Some candidates found this question difficult, perhaps not realising that the question refers to the process of semi-conservative replication of DNA in a prokaryotic cell.

Question 23

Many candidates found this question difficult and incorrectly selected option **C**. This cannot be true because a mRNA codon cannot be CTC.

Questions 24, 27 and 28

The majority of candidates found these questions straightforward and answered correctly.

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Question 25 and **29**

Most candidates found these questions straightforward, with almost all of those who performed well in their AS Level overall answering correctly.

Question 26

Most candidates answered correctly. The most common incorrect response was to select option **A**.

Questions 30

Almost all candidates realised that the shift from X to Y is caused by an increased concentration of carbon dioxide (options **C** and **D**), but only the strongest candidates overall selected the correct answer, **D**.

Question 31

The majority of all candidates answered these questions correctly.

Question 32

Many candidates incorrectly selected options containing statement 1. If there was a hole in the wall separating the two ventricles blood would leak through, but mainly from left to right as the ventricles contract.

Question 33

The majority of those who performed well in their AS Level overall answered correctly. Weaker performing candidates selected each option almost equally.

Questions 34, 35, 36, 37and 39

The vast majority of all candidates found these questions straightforward and answered correctly.

Question 38

Some candidates found this question difficult, with the most common incorrect answer being option **D**.

Question 40

Almost all candidates found this question straightforward and answered correctly.

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Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

Nearly all candidates realised that statement 3 was correct. Only the stronger candidates correctly chose option **D**. The most common incorrect response was to select option **B**.

Questions 2 and 3

The majority of candidates answered these questions correctly.

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Question 4

This question proved to be straightforward for all abilities, with the vast majority of all candidates answering correctly.

Question 5

Most candidates who performed well overall answered correctly. Of the weaker candidates, many incorrectly selected options that identified centrioles as spherical rather than cylindrical.

Questions 6, **7** and **9**

Almost all the stronger performing candidates and many of the weaker candidates answered these questions correctly.

Question 8

Almost half of candidates answered correctly. The most common incorrect response was to select option **A**. Since the student was recording the time taken for the first appearance of a colour change, the 'the time the solutions are heated' is a variable that cannot be standardised.

Question 10

Almost all the stronger performing candidates were able to identify the molecules as glycerol and fatty acids, to conclude that the bonds were ester bonds (option **A**). Many of the weaker candidates also answered correctly. The most common incorrect response was to select option **B**.

Question 11

This question proved to be straightforward for all abilities, with most candidates answering correctly.

Question 12

Those candidates who performed well overall were able to answer correctly. The most common incorrect response was to select option **B**. The amino acids in a β-pleated sheet are not coiled and the quaternary structure does not always contain two types of polypeptide.

Questions 13, **15** and **16**

Most candidates found these questions straightforward. Almost all the stronger performing candidates and many of the weaker candidates answered correctly.

Question 14

Almost half of candidates answered correctly. The most common incorrect response was to select option **A**. Since induced fit can occur at an active site, the site does not have a fixed shape.

Question 17

Almost half of all candidates were able to process the information provided and then select the correct explanation. All other options were selected by at least some of the candidates.

Question 18

Most candidates realised that the space Y would be taken up by solution X and correctly selected option **C**.

Question 19, **20**, **26** and **36**

These questions were straightforward for all abilities and most candidates answered correctly.

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Question 21

Most of the stronger performing candidates realised that only statement 2 is a feature of nuclear division and so answered correctly. The weaker candidates selected across all options, with option **A** as the most common incorrect response.

Questions 22, **24**, **29**, **31** and **37**

Most candidates found these questions straightforward. Almost all the stronger performing candidates and many of the weaker candidates answered correctly.

Questions 23, **25**, **27**, **32, 34** and **35**

Almost all the stronger performing candidates and many of the weaker candidates answered these questions correctly.

Question 28

Almost all the stronger performing candidates correctly worked out the fifth event in the cardiac cycle and so answered correctly. The weaker candidates selected across all options, with some answering correctly.

Question 30

Some candidates found this question challenging, although most of the stronger performing candidates answered correctly. The weaker candidates selected across all options, with the most common incorrect response being option **B**.

Questions 38 and **39**

At least half of those who performed well overall answered correctly. Others found these questions more challenging and selected across all options.

Question 40

Almost all the stronger performing candidates and many of the weaker candidates answered these questions correctly.

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Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

Most candidates of all abilities knew that when plant cells are stained and viewed with a simple light microscope only nucleoli would be visible from the cell structures listed and so answered correctly.

Questions 2, 3, 4, 6, 7 and 8

These questions were straightforward for all abilities and most candidates answered correctly.

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Question 5

The majority of all candidates answered correctly. Some incorrectly thought that function 1 was matched with appearance V. The mRNA passes through the nuclear membrane, which is described by appearance X.

Questions 9 and **10**

These questions were straightforward for all abilities and most candidates answered correctly.

Question 11

Almost all the stronger candidates and most of the weaker performing candidates answered correctly. The most common incorrect response was to select option **B**.

Question 12

Almost all the stronger performing candidates answered correctly. The weaker candidates selected across all options, although many were able to identify the correct relationship between K_m and V_{max}. The most common incorrect response was to select option **B**.

Questions 13 and **15**

Almost all the stronger performing candidates and most of the weaker performing candidates answered correctly.

Question 14

Most candidates knew that the proteins and glycoproteins can allow cells to bond together to form tissues, so selected options containing statement 1. Most of the stronger performing candidates answered correctly, whilst many of the weaker candidates incorrectly selected option **D**.

Question 16

Most candidates answered correctly, with a few incorrectly selecting option **A**.

Question 17

This question performed well, with many candidates answering correctly. The weaker candidates selected answers across the options and, although most answered correctly, some selected option **A**.

Question 18

Many candidates were able to link knowledge of cancer cells having repeated continual cell division, which would only occur if the telomere length was kept the same. The most common incorrect response from the weaker candidates was to select option **B**, whilst the vast majority of stronger performing candidates answered correctly.

Question 19

Many candidates answered this question correctly. The weaker candidates selected answers across the options and, although most answered correctly, some selected option **C**.

Questions 20, **29**, **30**, **31 and 32**

Almost all the stronger performing candidates obtained the correct answer. Many of weaker performing candidates found these questions difficult and were unable to answer correctly.

Question 21

Many candidates answered correctly. The most common incorrect response was to select option **B**. Within the ribosome there are 6 exposed bases allowing two codon-anticodon interactions.

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Question 22

The majority of all candidates and almost all the stronger candidates answered correctly. Some candidates incorrectly thought that the percentage of hybrid DNA molecules was 50%, so selected options **A** or **B**.

Questions 23, **28**, **33 and 36**

The majority of candidates found these questions difficult and only those who performed the strongest overall answered correctly.

Questions 24 and **26**

These questions were straightforward for all abilities and most candidates answered correctly.

Question 25

Almost all the stronger performing candidates answered correctly. The weaker candidates selected across all options, with most selecting either option **A** or option **B**.

Question 27

Many candidates were able to correctly select the xerophytic adaptations that were able to reduce the water potential gradient. Most of the stronger performing candidates answered correctly. The weaker candidates selected answers from across the options.

Questions 34 and 3**5**

Almost all the stronger performing candidates obtained the correct answer. Many of weaker performing candidates found these questions difficult and selected across the options.

Question 37

Most candidates carried out the correct calculation for the answer. The most common error was to obtain the percentage increase by subtracting 0.2% from 1.5% (option **A**).

Questions 38 and 3**9**

Almost all the stronger performing candidates obtained the correct answer. Many of weaker performing candidates selected across the options.

Question 40

This question was straightforward for all abilities and most candidates answered correctly.

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Paper 9700/21
AS Level Structured Questions

Key messages

- Candidates should check the scaling used for axes carefully before extracting data from graphs. **Question 3(a)** required candidates to interpret a graph which had both positive and negative values on the *y*-axis. The strongest answers were able to describe the gain in mass at low concentrations of sucrose and the loss in mass at higher concentrations of sucrose in terms of water potential and osmosis. Weaker answers stated that the potato cylinder lost more mass as the concentration of sucrose increased whereas a careful check would have shown that this was not the case at every concentration.
- For **Question 6(a)**, many candidates were aware that DNA polymerase joins nucleotides forming the sugar phosphate backbone but did not demonstrate more detailed knowledge of the action of this enzyme. Candidates could have gained further credit by stating that this enzyme adds nucleotides to extend a polynucleotide and that it also has a role in proofreading and repair.
- Candidates should be able to name the species causing the diseases stated in Topic 10 of the syllabus. **Question 2(a)(i)** required the full binomial name for the bacterial pathogen causing tuberculosis and many candidates gave only the generic name.

General comments

Question 1(b)(iii) required candidates to apply their understanding of electron microscopy to suggest why there were very few mitochondria visible in the electron micrograph. Most found this very challenging with many suggesting that the cell did not need them. Candidates need to ensure that they make full use of the information provided in the question stem. The plasma cell in the electron micrograph was described as metabolically active, which should have allowed candidates to rule out the idea that mitochondria are not needed. Many also suggested that the magnification or resolution were not sufficient to see these structures. This did not gain credit as mitochondria can be seen using the electron microscope and some were visible in **Fig. 1.3**.

Question 3(b) was well answered, with many candidates giving considered responses outlining the process of osmosis and the resulting effects on the potato cells. Candidates should take care when describing osmosis to use the term water potential gradient rather than concentration gradient.

Question 5(c) illustrated the importance of reading the question carefully. Some candidates wrote answers outlining how monoclonal antibodies can be used in the diagnosis of disease rather than treatment. These answers were unable to gain credit.

Question 6(c)(ii) assessed the candidate's ability to recall how lung cancer may develop as a result of smoking tobacco. Many responses gained credit for making the link between carcinogens in the smoke and mutations, but few made specific reference to the type of cells that would be affected by these mutations.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to identify the two parts of the amino acid, although a small number of candidates confused the two parts. The most common incorrect answer for **A** was to refer to it as a nitrogen group. A small minority labelled **A** amino and **B** acid, this was insufficiently detailed to gain full credit as candidates were expected to recall that **B** was a carboxylic acid group.

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(ii) Many candidates were able to use **Fig. 1.2** effectively to show the removal of the hydrogen and oxygen atoms from the two amino acids and the resulting formation of water. The strongest answers also included a further diagram to show a peptide bond linking the amine group of one amino acid with the carboxyl group of another amino acid. A small minority were unable to recall that the peptide bond forms between these groups and attempted to draw diagrams linking two amine groups.

(b) (i) The majority of candidates who labelled **Fig. 1.3** were able to identify the nucleus. A few labelled mitochondria. Many candidates did not gain credit because they did not put a label on **Fig. 1.3**.

(ii) This was well answered. The majority of candidates made good use of the formula box provided in the answer space to write out the formula needed to perform the calculation. The most common error was to provide the answer to the calculation as a decimal. This was unable to gain full credit because the question asked for the answer to the nearest micrometre.

(iii) A small number of candidates were able to recognise that the electron micrograph was only a thin section of the plasma cell and therefore the mitochondria would be found in other sections. Common incorrect ideas included the suggestion that the plasma cell did not need energy and therefore did not need mitochondria. Candidates should be aware of the roles of ATP inside a cell including the need for ATP during metabolic reactions such as protein synthesis. A significant number of responses suggested that the magnification and/or the resolution was not sufficient to view mitochondria. This did not gain credit as there were a small number of mitochondria visible in **Fig. 1.3**.

(c) The importance of the lack of organelles to reduce the resistance to flow of phloem sap was recognised by many candidates. Weaker responses were unable to identify the phloem sap and referred instead to water or 'substances' moving in the sieve tube element. Some candidates recognised the role of the companion cell but very few successfully made the link between these cells and their role in carrying out the metabolic reactions for the sieve tube element.

Question 2

(a) (i) The strongest answers stated both names, correctly spelt and showed knowledge of the correct form by writing the generic name with a capital letter and the specific epithet with a lower-case letter. Some candidates omitted this question, suggesting a lack of familiarity with the binomial name for the pathogen that causes tuberculosis. The genus name was often incorrectly written as '*Microbacterium*'. Some candidates gave only one name for the pathogen, e.g. *Mycobacterium* without the specific epithet while others abbreviated the genus name, e.g. *M.bovis*. These answers lacked the required detail to gain credit. A few candidates gave two named organisms and these both needed to be correct to gain full credit.

(ii) This question was well answered and many candidates identified the type of immunity correctly. The most common incorrect answer was artificial passive immunity. Candidates who ticked more than one box in the table were unable to gain credit.

(b) (i) Many candidates correctly identified that the antibiotic was acting as a non-competitive inhibitor. The stronger answers went on to explain that due to the action of the antibiotic the active site of the enzyme changed shape and was no longer complementary to the substrate. The strongest responses were able to link this to a lack of production of mRNA. Candidates who were then able to apply their understanding of the process of protein synthesis gained further credit by relating this to the effects on translation.

(ii) This question was well answered by the majority of candidates. Most were able to describe the increase in number of cases between 2009 and 2013. The most successful answers also used data taken from **Fig. 2.2** to illustrate this increase. Many candidates were able to identify time periods during which the trend in the data changed, such as between 2010 and 2011, where there was very little increase in the number of cases of RR-TB and MDR-TB.

(iii) Descriptions of how drug resistance develops were variable, with many candidates writing only about the over use of antibiotics or about people not completing the course of antibiotics. Very few made reference to the significance of a reservoir of bacteria remaining in the body when a course of antibiotics is not completed. Weaker responses described people as becoming resistant to the antibiotics rather than bacteria. There were some knowledgeable responses describing the role of

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mutation and the importance of both horizontal and vertical gene transmission in the development of resistance. The strongest answers gained further credit for linking these ideas to an increase in the frequency of the resistance allele in the bacterial population.

Question 3

(a) Candidates had to apply their knowledge of water potential and osmosis in order to describe the trends within the data shown in **Fig 3.2**. Very few candidates identified that the *y*-axis had both positive and negative values. Many candidates tried to identify an overall trend in the data by stating that, as the concentration of sucrose increased, the mass of the potato decreased. This description was unable to gain credit because it was not correct for every concentration of sucrose on the graph. Many candidates were able to gain credit for using data quotes to support their description even when the description of the overall trend in the data was uncreditworthy. The highest achieving responses recognised that at 0.0 and 0.2 mol dm^{-3} the positive values for mean percentage change in mass showed that the potato had in fact gained mass. These answers went on to indicate that the potato in 0.2 mol dm^{-3} sucrose solution had gained less mass than that in 0.0 mol dm^{-3}.

(b) There were some very good answers to this question in which candidates applied knowledge of water potential and osmosis to the results for the potato cylinder in 0.6 mol dm^{-3} sucrose solution. Many candidates were able to identify that water was lost from the cylinder but some descriptions lacked reference to the cells of the potato, describing instead water loss from the potato cylinder as a whole. The best answers linked this water loss to the water potential gradient and the resulting effects of osmosis on the cells, such as plasmolysis.

Question 4

(a) This was a straightforward question for many candidates who correctly identified the two cells. The most common incorrect label for **A** was a red blood cell and a significant number of candidates identified **B** as a white blood cell which was insufficiently detailed. Some candidates confused the two cells, labelling **A** as a lymphocyte and **B** as the neutrophil.

(b) (i) This was answered well. The majority of candidates were able to apply their understanding of the circulatory system and identify that the concentration of oxygen in the lymph would be lower than the concentration of oxygen in the blood in the aorta. Most also recognised that the concentration of carbon dioxide would be higher. Weaker candidates suggested that the concentration of red blood cells would be the same in the lymph as it would be in the blood in the aorta. Some candidates confused the blood and the lymph and so were not able to gain credit.

(ii) To gain full credit for this question, candidates needed to consider the immune response that occurs as a result of the presence of a foreign pathogen in the body, so that they could then deduce why the protein concentration in the lymph increased. Many candidates successfully suggested that the increase in protein concentration was due to antibody synthesis and some went on to identify that these would be produced by plasma cells. A small number of candidates showed excellent application of their understanding of the immune response and made links to the production of cytokines. Weaker responses suggested that the enzymes produced by phagocytosis were causing the increase in protein concentration. This was unable to gain credit as these are intracellular enzymes and would not be found in lymph.

(c) (i) Most candidates gained partial credit by stating the role of the sinoatrial node (SAN) as the pacemaker of the heart. Fewer were able to expand their answer by describing how the SAN acts in this role. Weaker answers lacked appropriate terminology. These explanations included stating that the SAN sent a signal rather than a wave of depolarisation or that the signal spread across the heart muscle rather than across the atria. Some candidates confused the SAN and the atrioventricular node (AVN).

(ii) Candidates had to apply their understanding of how the contraction of the heart is coordinated to the unfamiliar example described in the question stem. Many answers showed a good understanding of the role of the AVN in delaying the impulse and therefore suggested that heart rate would increase. A number went on to link this to other possible outcomes, such as more impulses reaching the ventricle per unit time or ventricles contracting before they are full. Weaker responses described the effect on blood flow round the circulatory system, which was unable to gain credit as it did not answer the question asked.

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Question 5

(a) Most candidates were able to give a simple description of the immune response with reference to non-self or foreign antigens. A few linked the presence of foreign antigens to the action of lymphocytes. Those who did not gain credit needed to develop their simple ideas about protecting or defending the body to give more specific answers in greater depth.

(b) (i) Most of the candidates who gained credit were able to recall that an autoimmune disease occurs as a result of the immune system failing to distinguish between self and non-self. The strongest answers went on to recognise the importance of receptors complementary to cell signalling molecules in the cell surface membrane of effector cells. Some candidates suggested correctly that these receptors might be blocked by antibodies in order to disrupt cell signalling. Others suggested that the antibodies might bind to the cell signalling molecule to prevent it binding to the receptor. These candidates were able to gain credit for their creative thinking as specific knowledge of this cell signalling pathway is not required by the syllabus. Very few candidates developed their answers to describe the effects of this lack of binding to reactions inside the effector cells.

(ii) Many candidates wrote about the lock and key hypothesis rather than the induced fit hypothesis, describing the substrate and active site as complementary. Many who wrote about induced fit effectively described the active site moulding to fit the substrate, but few stated clearly that the active site is not complementary to the substrate at the start of the reaction. Weaker responses described the shape of the active site as similar to that of the substrate. There were many good descriptions of the formation of enzyme-substrate complexes and products leaving the active site so that the enzyme can be reused. Very few referred to the role of an enzyme in lowering the activation energy.

(c) The strongest answers recognised that monoclonal antibodies allow targeted treatment and made links to the targeting of CD20 in the cell surface membrane of B-lymphocytes. Descriptions of the uses of monoclonal antibodies in the diagnosis of disease were unable to gain credit. Weaker responses described how monoclonal antibodies are produced and made little or no reference to how they could be used in treatment of diseases.

Question 6

(a) Very few candidates were able to describe the action of DNA polymerase joining nucleotides to extend a polynucleotide. Most who gained credit referred to the formation of the sugar phosphate backbone and many were able to identify the bonds that formed as phosphodiester bonds. Weaker answers described synthesising a new strand of DNA without reference to specific roles of the enzyme.

(b) (i) This question was well answered by most candidates. Some were unable to gain credit because they stated that cancer results from uncontrolled division and did not link this to the treatment and the subsequent prevention of this uncontrolled division.

(ii) There were many good answers to this question. Most candidates recognised that transcription produces mRNA, which does not contain thymine. The weakest answers showed a lack of understanding of transcription, such as suggesting that nucleotides were not needed for the process.

(c) (i) Many candidates identified the stage of the cell cycle as cytokinesis. The most common incorrect answer was telophase.

(ii) Many candidates wrote excellent answers which included reference to carcinogens causing mutations and the resulting uncontrolled mitosis. Some knowledgeable answers referred correctly to proto-oncogenes and tumour suppressor genes. Very few candidates were able to identify the cells in which the cancer-causing mutations would occur.

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Paper 9700/22
AS Level Structured Questions

Key messages

- Candidates should check the scaling used for axes carefully before extracting data from graphs. **Question 2** included a bar chart comparing the content of three components in cigarette smoke. The *y*-axis value was 0.4 mg for each 2 mm square and the *y*-axis printed values were every 2 mg from 0 to 20. Some candidates incorrectly used one 2 mm square to equate to 0.2 mg. Using a ruler to check across from the *y*-axis would also have helped some candidates.
- For **Question 3(b)**, a number of candidates knew that mature red blood cells lack organelles to allow room for haemoglobin molecules but did not realise that these cells have cytoplasm. Candidates should be aware that the cytoplasm contains haemoglobin molecules and that these molecules require an aqueous environment to function in the carriage of oxygen and carbon dioxide.
- Candidates were generally more familiar with the concept of viral and bacterial diseases. Many did not appreciate in **Question 5** that malaria is a disease caused by a protoctist, and that protoctists are eukaryotic organisms.

General comments

Many candidates demonstrated that they were knowledgeable of the syllabus learning outcomes. Generally, responses contained separate clear sentences, each containing a correct idea pertinent to the question. Each response to each part-question contained enough different main points to cover the marks allocated to the question, and where there were extended responses, these appeared to be planned and laid out in a logical sequence to show the correct train of thought.

In questions such as **Question 1(a)**, where candidates were asked to identify with a label line a structure or region, a ruler should be used for the label line, and the end of the label line should clearly end at the structure or within the region.

In **Question 2(c)**, there was generally good understanding of the difference between the role of haemoglobin and red blood cells. However, for a number of weak responses, it was clear that the candidates thought that red blood cells and haemoglobin were the same, or that a red blood cell carried only one haemoglobin molecule. There were responses that described the binding of oxygen to a red blood cell, or stated that if carbon monoxide bound to a haemoglobin molecule, this meant that a red blood cell could not carry any oxygen.

Question 3(d) and **(e)** were based on a condition of red blood cells that was associated with the disease spherocytosis type 2. Even though this was clearly stated, a proportion of candidates focused their ideas and their written responses on sickle cell anaemia. Candidates should be prepared to come across unfamiliar material in questions.

In completing **Table 4.1** in **Question 4(a)**, there was a gap in knowledge for many candidates in relation to the name of the bond between the DNA nucleotide monomers. A higher proportion gave hydrogen bond as their answer rather than correctly stating phosphodiester bond.

Question 5(e) was about problems with developing a vaccine. A proportion answered this as problems with current vaccines and gave general ideas such as malnutrition giving a poor response, or inability to reach people to carry out a vaccination programme.

In **Question 6**, **Fig. 6.1** was a graph of substrate concentration against rate of reaction for an enzyme-catalysed reaction. Candidates were asked to explain the differences between the rates of reaction at a low substrate concentration compared to a high substrate concentration. Only some were aware that this meant

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that biological explanations were required and many gave only a description of the results at the two values stated.

There were some part-questions where candidates were required to make comparisons. Some were very accomplished in this, but others did not use comparative terms or make it clear to which side they were referring; this was particularly apparent in **Question 3(e)**, where it was not always clear if candidates were referring to normal red blood cells or spherocytosis type 2 red blood cells.

Comments on specific questions

Question 1

(a) Candidates were required to add a label line to **Fig. 1.1** to identify one area with phloem sieve tubes. Most chose an area within a vascular bundle, and many chose one of the larger bundles so that they could clearly label the area concerned. A good number added their line to the outer darker area of sclerenchyma, and some chose the inner xylem. Some ended their label line at the junction between the phloem sieve tubes and sclerenchyma and did not gain credit.

(b) There were many good answers here. Stronger responses used the term photosynthates or assimilates or gave correct examples of assimilates, in particular sucrose and amino acids, rather than stating 'food', which did not earn credit. Stating that transport occurred from a source to a sink was commonly seen, with some also giving correct examples of sources and sinks. It is more accurate to state that transport is from the source to a sink, rather than to state that the assimilates are transported to a source to be taken to a sink. Weaker responses were too vague in describing the transport of assimilates to gain credit.

(c) (i) This was well known by many. Some did not follow the instruction to name the tissue and stated epidermal cell. Common errors were to state cuticle, endodermis or epithelial tissue.

(ii) To work out the correct proportions of tissues when viewing specimens using a microscope, it is only necessary to use an eyepiece graticule, which many candidates knew.

(d) Many candidates demonstrated very good drawing skills and there were some excellent diagrams drawn. The instruction was to label only those structures that are found only in plant cells and quite a few answers gained only partial credit as they also labelled those found in animal cells. In some diagrams, the large permanent vacuole was too small or missing and in others a double membrane was drawn for the tonoplast. Some did not draw in a cell wall. Very weak responses included structures within the cell that should not be there, such as drawing in a vascular bundle. A few drew sections through a leaf.

Question 2

(a) A very high proportion interpreted **Fig. 2.1** correctly and gave the two WHO regions required. There were some who only gave one region, SEARO, and some mistakenly gave AMRO instead of EMRO as the second region.

(b) Candidates needed to use their knowledge of the effects of each of the three components of cigarette smoke listed. Those who knew that nicotine increased the stickiness of platelets, and so increased the risk of blood clots, were able to compare the data for the AFRO and EURO regions to see that AFRO had the higher nicotine content. This was also supported with the correct comparative data taken from the graph. The reference in the key to (x10) by nicotine indicated that the value plotted was ten times larger than actual, but for the correct extraction of data, 9.2 compared to 7.7–7.9 mg per cigarette was acceptable. Many just stated tar, while some gave tar and nicotine as the two bars that were higher than those for EURO. Some weak responses included carbon monoxide, despite this being a higher value for EURO than AFRO.

(c) The quality of responses varied widely. There were two approaches that were acceptable for this question: carbon monoxide in cigarette smoke entering the blood stream leading to a decrease in available oxygen, and less oxygen entering the blood stream during gas exchange. The majority who gained credit concentrated on the effect of carbon monoxide. Some of the in-depth responses focusing only on carbon monoxide gave enough detail to gain full credit. It was important to explain

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in some way that the affinity of haemoglobin for carbon monoxide was (far) greater than for oxygen and to show understanding that, overall, the percentage saturation of haemoglobin would decrease, as there would be less haemoglobin available to bind oxygen. Many remembered the term carboxyhaemoglobin and quite a number noted that binding was more permanent or more stable than when oxygen binds to haemoglobin. Some candidates gave good accounts but lost a little credit by accidentally stating 'carbon dioxide' within their response. Some weak responses used 'red blood cell' instead of haemoglobin, a few of whom suggested oxygen was complementary to the biconcave shape of the red blood cell. Weaker responses that focused only on cigarette smoke in the airways tended not to note the introduction to the question about short-term effects and wrote about emphysema, or gave vague ideas suggesting that tar would block the airways. More thoughtful accounts that focused on cigarette smoke affecting the airways noted the accumulation of mucus and the decreased quantity of air containing oxygen that could reach the gas exchange surfaces.

Question 3

(a) The strongest responses gave comparative sentences to clearly show the advantages of the electron microscope over the light microscope. Some did not do this, stating only that electron microscopes have a high resolution. Quite a number repeated the information given to them about a higher magnification and this did not earn credit. The ability to see more detail needed to be supported by a correct example, such as being able to see ribosomes or details of the internal structure of mitochondria. It was not enough to say 'can see more detail in the cell'. Some confused values of wavelength with resolution or gave the incorrect units for the resolutions achieved, for example stating that the electron microscope, compared to the light microscope, could see structures smaller than 200 μm instead of 200 nm. Some gained credit for knowing that the electron microscope had a higher resolution but went on to contradict themselves by getting the values the wrong way around.

(b) Candidates were expected to use their knowledge of red blood cell structure to be able to make comparisons, using information about erythroblasts that could be taken from the text and from the image shown in **Fig. 3.1**. Many correctly noted the presence of the nucleus in an erythroblast cell and the difference in shape of the two cell types. A common error was to state that the red blood cell had a concave, rather than a biconcave shape. Some referred only to surface area without mentioning specific shapes. A number of candidates stated that the red blood cells had no cytoplasm, while others stated that the cells were hollow. Credit was awarded for a comparison with regard to haemoglobin: those who only stated that red blood cells have haemoglobin were not credited as this did not identify whether or not erythroblasts had haemoglobin. As candidates were not expected to know about the stages of development of red blood cells, stating that erythroblasts did not have any haemoglobin (whereas red blood cells do) was awarded credit. However, there were also some good answers explaining that the organelles were still present within the erythroblast for the synthesis of haemoglobin, so that there would be some, but less, haemoglobin than red blood cells. To achieve further credit, some candidates needed to give three differences to match the level of credit available for this question. Weaker candidates just repeated the information given, explaining that erythroblasts were in the bone marrow and red blood cells were in the circulation.

(c) (i) Many achieved full credit for completing **Table 3.1**. Some logically placed the organelles in sequence of the process of synthesis: nucleus, ribosome or rough endoplasmic reticulum and Golgi body. Those who suggested Golgi body but then incorrectly qualified with reference to packaging into Golgi vesicles or secreting proteins were not credited as the question asked only about protein synthesis and these stages occur after protein synthesis. Mitochondria providing ATP for synthesis needed to be qualified with more detail, such as the activation of amino acids to form aminoacyl tRNA. Some candidates did not give organelles so this column sometimes contained DNA, mRNA, rRNA or tRNA. Cytoplasm was a relatively common, incorrect, inclusion and a number confused the nucleus with the nucleolus.

(ii) Many candidates answered correctly. Most candidates recognised that they should name an enzyme but some gave terms related to the carriage of gases by haemoglobin, such as carbaminohaemoglobin. Others gave carbon anhydrase or just anhydrase and this did not gain credit. Carboxylase was also seen.

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(d) The two most popular ideas that gained candidates full credit were correct reference to the difference in surface area to volume ratios and the decreased ability for a spherical red blood cell to pass through capillaries. Many were able to gain some of the credit available. Very few responses noted that the shape of a biconcave cell rather than a spherical cell would be more advantageous in terms of distance for oxygen to travel to reach haemoglobin molecules and time taken to reach high levels of saturation of haemoglobin with oxygen.

(e) Stronger responses compared both cell types, worked sequentially through the scenario presented and used the correct terminology in their response to gain full credit. These responses made it clear as to whether they were referring to the normal red blood cell or the red blood cell with spherocytosis type 2. Others could have improved their response by explaining that osmosis occurred with water entering both cells (down the water potential gradient) and then comparing the effects of this in both cells rather than only writing about one cell type. Weak responses suggested that the mutation gave spherocytosis type 2 cells a stronger membrane, while quite a few attempted to explain how differences would affect the ability of the cells to take up oxygen.

Question 4

(a) Almost all candidates were able to gain some credit completing **Table 4.1**. The most well-known bonds were the glycosidic bonds between glucose monomers and the least well-known were the phosphodiester bonds between nucleotides. An error seen in a number of responses was to state protein as the monomer for collagen – some stated amino acids (protein) or protein (amino acids), but this did not gain credit.

(b) Most candidates gained some credit for their explanations of the different structures. Many knew that amylose has α-glucose monomers and cellulose has β-glucose monomers; details of the bonds were less well known. Stronger responses stated α-1,4 for amylose and β-1,4 for cellulose, but others only stated 1,4. It was quite common for candidates to suggest that cellulose has both α-1,4 and β-1,4 bonds. The descriptions varied greatly when candidates were explaining that only cellulose molecules had adjacent glucose monomers rotated through 180°.

(c) The description of semi-conservative replication of DNA was generally very well answered and many candidates gained full credit. A common error was to write about strands of DNA when referring to DNA molecules or the DNA double helix. Some candidates used the term ‘unzipping’ to mean unwinding, which was not credited. The idea of unzipping is related to the breaking of the hydrogen bonds between complementary bases on the two polynucleotide strands, and although this term is helpful in the explanation, it should always be qualified with reference to the breaking of hydrogen bonds. Some candidates could have made it clearer that the process is a sequential addition of activated nucleotides, that is, there is elongation of a growing polynucleotide chain. Some incorrectly stated that DNA ligase was the main enzyme for polymerisation. Fewer wrote about the idea of leading and lagging strands and the requirement of ligase to seal together (Okazaki) fragments.

Question 5

(a) Most candidates knew that the end result of the action of penicillin on bacterial cells was cell lysis. Quite a few understood that penicillin acted as an inhibitor of the transpeptidase enzyme and gave good accounts of how this would prevent cross-links forming between peptidoglycan chains. However, there was considerable confusion seen in many other accounts: some thought that penicillin was able to produce autolysin to make holes in the cell wall, or that penicillin made holes. Others believed that it prevented the formation of peptidoglycan molecules. The weakest responses suggested that it was involved in the immune response, with some describing penicillin as engulfing bacteria.

(b) The name of a species of *Plasmodium* was generally well known. Many, however, wrote the genus of the mosquito, Anopheles.

(c) A range of ideas were seen, and many candidates were able to give a reasonable suggestion to gain credit. Some knew that protein was used by females for some aspect of reproduction but did not mention egg development. There were vague accounts such as ‘only females reproduce’ or quite incorrect use of terminology ‘for females when they are pregnant’. Many incorrectly suggested females needed blood to feed to their larvae.

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(d) Suggesting explanations for the results in **Fig. 5.1** was a challenge for a number of candidates. However, there were quite a few who worked steadily through the information provided to understand well what the research showed. These candidates explained themselves accurately and could go on to make a valid comment as to the importance of the results for doctors.

Those who believed *Plasmodium* was a bacterium got very confused with the pathogen and the bacteria that live in the gut of *Anopheles*. Some thought the bacteria lived in the gut of humans rather than in the mosquito. Many answered in terms of antibiotic resistance, which was not applicable to this unfamiliar context. It was a difficult concept for some candidates to understand that: a blood meal containing antibiotics taken by *Anophleles* would only kill bacteria and not the protoctist *Plasmodium*; presence of bacteria in the gut of *Anopheles* would mean competition for *Plasmodium* and that this would decrease the chance of the pathogen establishing itself; that a reduced number of *Plasmodium* gave a greater chance of the immune system of the mosquito eliminating the pathogen.

(e) Many gave answers related to the problems experienced generally with vaccines that are being used, rather than about the difficulties researchers faced in developing a malaria vaccine. Knowledge that vaccines contain antigens to provoke an immune response was evident in a minority of answers. Of these, some could have improved their response by stating that different species have different antigens, rather than using the term 'strains' to mean species. Also, some wrote as if each species only had one antigen, rather than showing an understanding that, as eukaryotes, they would have many antigens. The term antigenic variation was not always used in context of the ability to change antigens in different stages of the life cycle, and here some thought that this was mutation (rather than differences in which antigens are expressed). Where credit was given, this was frequently for understanding that the pathogens spent stages of their life cycle within host cells so were not exposed to the immune system responses, or some valid reference to cost was stated.

Question 6

(a) Candidates who gained credit usually did so for showing understanding that telomeres prevent the loss of genes or genetic information. It was not sufficient to say that they prevent the loss of DNA or loss of genetic material as telomeres are lengths of DNA and are genetic material, and telomeres do shorten during replication of DNA. Fewer stated that telomeres allow continued replication of DNA.

(b) Candidates were asked about stem cells and cancer cells and so responses needed to indicate that they were referring to both types of cells. It was well understood that these cells carried out mitosis; stronger responses qualified this with knowledge that there was continuous replication or a higher rate of replication. Some made the mistake of stating that stem cells have uncontrolled mitosis but this is only true of cancer cells.

(c) The induced fit theory was well known. A few wrote 'induced fit lock and key' or gave one of the two in brackets, so could not be awarded credit.

(d) Many responses gave descriptions of the rates of reaction at the two different substrate concentrations. While these descriptions were correct, they did not answer the question, which required explanations of the differences between the two. Where explanations were given, there were generally correct references to the states of the active sites, enzyme-substrate complex formation and limiting factors. One common misunderstanding amongst some candidates was that at the lower substrate concentrations, because there was still an increase in rate of reaction as substrate concentration increased, there must be more enzyme-substrate complexes forming than at the higher substrate concentration. A number of weaker responses, instead of comparing the two points, attempted to describe the trend between the two.

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Paper 9700/23
AS Level Structured Questions

Key messages

- Candidates should understand the difference in scale between molecules and cells. In **Question 1**, some confused the molecule of haemoglobin with a red blood cell. In **Question 1(d)**, a number wrote about haemoglobin having a sickle-cell shape and in **Question 1(e)**, some wrote about the cytoplasm of haemoglobin.
- When describing changes in a factor or a parameter, candidates should state whether there is an increase or a decrease. The use of words such as 'change', 'alters' or 'affects' are too vague for credit to be awarded. Two common examples of this were 'microRNA could affect the start codon on the mRNA' in **Question 3(b)** and 'drugs affect neuraminidase' in **Question 5(b)**.
- Questions often ask candidates to give differences between structures or processes. In cases where the differences are not absolute differences they should use comparative adjectives, such as larger, smaller, slower, faster, etc. For example, the arteriole shown in **Fig. 4.1** in **Question 4** has a thicker wall than the capillary.
- It is important that candidates take care to structure their answers to match the question. In **Question 4(a)**, some candidates described the three layers that compose arterial walls and then wrote about the functions of arteries without relating each tissue to a specific function. In **Question 3(a)**, some candidates described the results shown in **Fig. 3.2**, **Fig. 3.3** and **Fig. 3.4**, but offered no explanations.
- Candidates should take care when reading questions to decide where in a process they should begin their answers. This would help to avoid long bodies of text being provided which are not relevant to the answer required. For example, in **Question 1(d)**, a proportion of candidates wrote about the changes to the base sequence of the gene *HBB* and the primary structure of β-globin, rather than the effects of these changes.

General comments

In general, candidates attempted answers to all the questions and none seemed to be short of time. Many candidates gave concise responses illustrated with appropriate factual details and clear descriptions and explanations of the data provided. Spelling of technical terms is important. Examples of poor spelling in answers included 'caspid' for capsid and 'carbominohaemoglobin' for 'carbaminohaemoglobin'.

Candidates should remember to include units when quoting data in their answers and to ensure that they transcribe units accurately. For example, in **Question 3(a)**, the unit for the transpiration rates is shown in **Fig. 3.3** as $\text{mmol}\,\text{m}^{-2}\,\text{s}^{-1}$. Many candidates often omitted 'mmol' from their answers.

Comments on specific questions

Question 1

(a) (i) Most candidates identified **A** in the diagram of haemoglobin as a haem group. Some were credited for stating that it is the prosthetic group in haemoglobin. Incorrect identifications included iron, histone, ribosome and β-globin.

(ii) Almost all candidates stated that the role of the haem group was to bind with oxygen. Some candidates stated that oxygen bonds with haemoglobin, which did not gain credit. Some answers referred to the correct number of oxygen molecules or atoms that bind to each haem group, which was not required.

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(b) There were many good answers explaining why haemoglobin is described as a globular protein. Many described the arrangement of the amino acids with hydrophilic R-groups on the outside of the molecule with the amino acids with hydrophobic R-groups arranged in the centre away from water. The three-dimensional nature of haemoglobin was not accepted as a suitable answer because all proteins, including fibrous proteins, have such a shape. A common error was to refer to 'hydrophobic tails of the protein facing inwards and hydrophilic heads pointing outwards'. Another common error was simply to describe the four levels of organisation shown by haemoglobin without explaining why the molecule is described as globular. Very few stated that haemoglobin has a metabolic or physiological role.

(c) Many candidates successfully explained why β-globin is described as a polymer. They often referred to the repeating monomers or sub-units and stated that these are amino acids. Some candidates stated that these monomers are joined by peptide bonds to form a large molecule but omitted to state that they are amino acids.

(d) A large number of candidates did not directly answer the question and instead wrote lengthy descriptions of the mutation that occurs in the gene *HBB*, rather than outlining the effects of the change in the primary structure of β-globin on the function of haemoglobin. Good answers started with the effect of the change from glutamic acid to valine and its effect on the solubility of haemoglobin and its ability to bind oxygen. Some candidates described the change to the haemoglobin molecule as making the molecules 'sticky' so that they become fibrous. However, they often became confused between the structure of haemoglobin and the shape of red blood cells and wrote statements referring to haemoglobin becoming sickle shaped. Other common errors included stating that haemoglobin loses its biconcave shape, becomes insoluble, or that it does not carry any oxygen at all.

(e) There were many thorough answers to this question. The most successful answers explained that carbon dioxide binds to haemoglobin to form carbaminohaemoglobin. Some candidates were confused with carbon monoxide and gave the compound as carboxyhaemoglobin. A few candidates stated that carbon dioxide reacts with the terminal amine groups on the polypeptides. Weaker answers stated that carbon dioxide binds with the haem groups in haemoglobin. However, many candidates also outlined the role of haemoglobin in binding hydrogen ions, relating this to the action of carbonic anhydrase and the formation of hydrogencarbonate ions. A few candidates included the detail that carbon dioxide remains bound to haemoglobin until it reaches the alveoli. Many candidates wrote their entire answer about the role of carbonic anhydrase. A common error was to state that carbonic anhydrase is an enzyme found 'in haemoglobin'. Hydrogen ions were often described as hydrogen atoms.

Question 2

(a) Most candidates gained full credit on this question. A common error was to identify cell **B** as showing telophase.

(b) Some candidates correctly calculated the percentage of cells in anaphase and the mean length of time in minutes for anaphase. Many did not calculate 29 as a percentage of 5000 to give 0.58% and, of those who did, some correctly calculated the time as 4 minutes. The most common incorrect answer for the time was 417.6 minutes. Candidates who rounded up the percentage to 0.6% and who expressed the time as 4.2, 4.18 or 4.176 minutes all gained credit.

(c) Most candidates gave an event that occurs during cytokinesis in plant cells. Typical correct answers referred to the formation of the cell plate, formation of the cell wall and division of the cytoplasm. Knowledgeable candidates described the collection of vesicles from the Golgi body at the centre of the cell. The most common incorrect answer was the formation of a cleavage furrow, which does not occur in cytokinesis in plant cells.

Question 3

(a) This question required candidates to analyse information in two bar charts and a line graph. Many candidates gave very detailed descriptions of the data, supporting their answers with figures, but did not offer any explanations of the differences between the results for the drought tolerant tomato plants and the non-drought tolerant plants. Stronger answers showed an understanding of the relationship between the size of the stomatal aperture and the quantity of water vapour lost through

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open stomata to give a correct explanation of the difference between the two plant types. Some also understood that less evaporation of water occurs from the surface of the cells in the mesophyll in the drought tolerant plants, owing to the smaller aperture size. Some responses incorrectly referred to the role of the roots in absorbing water, when **Fig. 3.4** shows results from potometers containing leafy shoots, not whole plants. Those who noticed this explained the difference between the shoots in terms of transpiration pull. Most candidates gave data quotes in support of their answers, but some did not give complete units so did not gain credit. Some answers included details of the many adaptations of xerophytes, although only those of leaves were relevant here.

(b) Candidates who realised that the microRNA must bind to mRNA explained the likely changes that would occur to prevent protein synthesis. Others needed to relate their answer to the function of mRNA in protein synthesis as suggested in the question. These responses tended to explain that microRNA brings about mutations in mRNA so that the start codon would not be recognised or that stop codons would be inserted into the mRNA. Some gave vague answers stating that microRNA would change the base sequence of the mRNA. Candidates who wrote about the inability of tRNA to bind to some regions of mRNA did not refer to codons and anticodons. Some also thought that microRNA may be a cell signalling molecule. A few candidates mentioned that microRNA might prevent mRNA leaving the nucleus.

Question 4

(a) Good responses described part of the arterial wall structure and related this to a function, before describing another part of the structure with its function. Some had organised the response so that the description began at the endothelium and ended up at the tunica externa, or vice versa. Other candidates often described the structure of artery walls in detail, giving the names of the three layers in addition to a description. To gain credit, responses needed to also include an accurate account of the roles of the structures that they had described. A common error was to state that the smooth muscle in artery walls pumps blood in a peristaltic fashion. Another common error was to state that arteries are lined by smooth muscle to reduce friction between blood and the wall of the artery. Many candidates referred to the cells lining the lumen of arteries as the 'epithelium' rather than the endothelium. Some discussed the size of the lumen and the absence of valves – neither of these features were required in this question.

(b) (i) Most candidates identified the cells in the lumen of the arteriole as red blood cells and stated that they were either biconcave discs or had no nucleus. Descriptions of the shape of red blood cells being concave were not credited, although 'the shape is concave on both sides' was accepted. Some candidates incorrectly stated that the cells were white blood cells or were more specific identifying them as monocytes or neutrophils, often giving comments on lobed nuclei as their reason.

(ii) Candidates were often more successful at describing the differences between the arteriole and the capillary shown in the electron micrographs than they were in answering **Question 4(a)**. Many commented on the differences in size, but some did not notice the magnifications and stated that the capillary was the larger vessel. Other candidates made correct references to the magnifications and some even used them to calculate the diameters of the two vessels. The best answers compared the ratio of wall thickness to lumen diameter for the two vessels. The question asked for the differences so it was important to give comparative words, such as 'thicker' rather than 'thick' to refer to the wall of the arteriole. Many noticed that the lumen of the arteriole carried more red blood cells than that of the capillary.

(c) (i) Some candidates wrote very detailed answers about the formation of tissue fluid, although many did not show an understanding of this topic. It was rare to find candidates referring to filtration of blood in the formation of tissue fluid. Some statements needed to be more precise, for example, 'gaps in capillaries' should have been stated as 'gaps in the walls of capillaries'. Many candidates stated that the contents of the plasma, such as water, glucose and salts, diffuse out to form tissue fluid and should have made a reference to the higher pressure of the blood arriving at the capillary network. Some also stated that 'blood leaks out of capillaries'.

(ii) Most candidates stated that the fluid in **X** is lymph. The most common incorrect answer was tissue fluid. Fewer candidates gave correct differences between lymph and blood plasma. Many showed poor understanding by stating that lymph does not have red blood cells. Candidates often gave protein content as a difference but did not state that these proteins are large or are plasma proteins.

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Question 5

(a) Many candidates gave at least one correct feature. Many stated that there is a protein coat or a capsid. As it is not possible to tell from the diagram whether the virus contains DNA or RNA, the only answers accepted were 'nucleic acid' and 'DNA or RNA'. Some candidates stated that viruses contain plasmids, which is incorrect since plasmids are a feature of bacteria and the diagram does not show any circular structures that resemble plasmids.

(b) Many **c**andidates were able to apply their knowledge of enzyme inhibition to this unfamiliar example. Many answers correctly explained that the drug binds either to the active site or to an allosteric site of neuraminidase, so that enzyme-substrate complexes do not form. Those who did not make the connection often assumed the drug was an antibody and some stated that it combines with the 'cell surface membrane of the virus'. There was some confusion regarding the actual substrate for neuraminidase as many thought it was haemagluttinin. Some suggested that the mechanism involved receptors and cell signalling.

(c) Many candidates wrote detailed answers that easily gained full credit. Some needed to be more precise when referring to cytokines, by stating that these are released by T-helper lymphocytes rather than just T-lymphocytes. Some candidates stated that T-cells mature into T-helper cells and T-killer cells during an immune response. These two categories of T-cells are present in the immune system from very early in the life of a mammal. They do not differentiate from precursor cells during primary immune responses. Some candidates also stated that 'plasma cells differentiate into immunoglobulins'. Some thought that plasma cells divide by mitosis to make more plasma cells and some could have improved their response by naming plasma cells as the cells releasing antibodies rather than just stating B-lymphocytes.

(d) (i) To gain full credit, candidates had to give at least one advantage of artificial passive immunity and one disadvantage. Some candidates were confused with active immunity and stated that people are vaccinated and show 'a fast immune response'. Most candidates gave two or more disadvantages.

(ii) Many candidates stated the two ways in which mammals can acquire natural passive immunity to infectious diseases. They referred to breast milk, mother's milk or colostrum, and antibodies crossing the placenta or travelling in the umbilical cord. Those who did not give the placental route stated that antibodies could be acquired by injection or by vaccination, catching influenza, by eating another mammal that has immunity or by eating fruits and vegetables. Some of these candidates may have been confusing antitoxins with antioxidants that are present in fruits and vegetables. References to maternal blood 'diffusing across the placenta' were seen occasionally and were not credited.

Question 6

(a) (i) Candidates gave either nanometres or micrometres as the unit that should be used. Micrometre was not accepted, but the accepted abbreviation for nanometre was credited. A few candidates gave 'Nm' or 'NM' and these were not credited as N m, for example, stands for Newton metre.

(ii) The outer surface of the membrane in diagrams is shown by the presence of the carbohydrate chains on glycoproteins and glycolipids. There were many correct answers to this question. 'Sugar chains' was accepted as were the presence of antigens and receptors. Some candidates referred to the glycocalyx in their answers. However, others stated that the sugar chains are part of glycogen or even of glucagon and so did not gain any credit. Some candidates referred to methods of viewing the membrane in electron microscopes, rather than the way to differentiate between the faces.

(b) There were many good answers identifying cholesterol and phospholipids as the components of the membrane. As the bracket in **Fig. 6.1** only indicated a single layer of phospholipids, the answer 'phospholipid bilayer' was not credited. Candidates did not gain credit for brief roles such as 'fluidity of membrane'. Some candidates described the structure of a phospholipid without stating any role. Others gave vague statements such as 'phospholipids maintain the structure of the cell'.

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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 can be applied to the requirements of the examination.

Candidates should be able to identify the significant sources of error in an investigation as any variable that could change during the recording of results and may make the results less accurate. Contamination is not considered a significant source of error since washing correctly should remove contamination.

General comments

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

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

The majority of centres provided all the materials required and the majority of candidates experienced no problems with materials or apparatus when completing the question paper.

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

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

Comments on specific questions

Question 1

(a) (i) Many candidates gained credit for showing the correct volumes of **A** and **W** to make at least three further concentrations of ethanol.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. Stronger responses included the heading for percentage concentration of ethanol (**A**) and the heading for colour intensity. The majority of candidates gained credit for recording the colour intensity for all the concentrations of ethanol. Many candidates recorded results which showed that the higher the percentage concentration of ethanol the higher the colour intensity. The stronger candidates also recorded using the scale.

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

(iv) Some candidates correctly explained that, at high concentrations of ethanol, the proteins in the membranes of the beetroot cells were denatured and phospholipids were disrupted, increasing the

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permeability of the membrane and leading to more diffusion of pigment out of the beetroot cells. A common error was to describe the results of the investigation rather than give an explanation.

(v) Many candidates correctly stated that one significant source of error was judging the exact colour when observing the colour of the liquid and then suggested the use of a colorimeter as an improvement. Some candidates stated that an error occurred when cutting the beetroot cylinders into 2 mm thick discs and suggested a more precise method of cutting the discs. Some candidates also correctly stated that putting the discs on a paper towel and blotting them to remove excess **W** was a source of error and suggested that an improvement would be to blot the discs for a set time.

(b) (i) The majority of candidates drew the graph correctly, with appropriate scales on the axes and accurately plotted the points. The most common errors were not including the correct label for each axis, omitting the units for the axes and not labelling the scale at least every 2 cm.

(ii) Most candidates answered correctly, using their graph to estimate the water potential of the potato tissue at 80 arbitrary units.

(iii) Some candidates correctly suggested a suitable improvement.

Question 2

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

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent cells from the central region, with each cell touching at least two of the other cells and double lines representing the walls. The most common error was to draw lines that did not meet up precisely enough. Most candidates used a label line to show the cell wall of one cell.

(b) (i) Some candidates correctly measured the three diameters of the stem shown by the lines **C**–**D**, **E**–**F** and **G**–**H** and correctly measured the depth of the outer layer in the six locations. Many candidates then showed the correct calculations of the means and some also gave their answers to the correct degree of accuracy.

(ii) Some candidates showed the correct simplest whole number ratio from their answers to **(b)(i)**, although a common error was to include units with the ratio.

(c) The best answers were organised into a table with three columns headed features, **J1** and **Fig. 2.2**. Many candidates listed at least three observable differences between **J1** and **Fig. 2.2**.

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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 consider the command word of the question before responding. For example, in **Question 1(b)(iii)**, candidates are asked to explain the shape of the graph, so the answer should include reasons for the shape, such as referring to increased kinetic energy and the formation of enzyme-substrate complexes between 5.5 °C and 36.0 °C, and the shape of the active site changing between 36 °C and 49.5 °C leading to the substrate being unable to bind and fewer enzyme-substrate complexes being formed.

General comments

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

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

The majority of centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

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

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

Comments on specific questions

Question 1

(a) (i) Many candidates correctly assessed the risk for **E** as medium or high, for **S** as low and for **C** as medium or high.

(ii) Many candidates answered correctly and completed **Fig. 1.1** with sufficient detail.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. Stronger responses included the heading for percentage concentration of copper sulfate solution and the heading for time with units (seconds). Most candidates gained credit for recording the times for at least five concentrations of copper sulfate. Many candidates correctly recorded results which showed that the higher the percentage concentration of copper sulfate the longer the time the iodine remained yellow. The stronger candidates also recorded the times in whole seconds.

(iv) The majority of candidates correctly recorded the time for **U** in seconds.

(v) The majority of candidates correctly estimated the concentration of copper sulfate in **U**.

(vi) Many candidates correctly stated that a significant source of error was judging the exact time of the colour change. Some candidates also correctly stated that using a glass rod caused drop sizes to be unequal.

(vii) The best answers suggested using concentrations of copper sulfate close to the concentration of copper sulfate in **U**.

(viii) Many candidates suggested suitable improvements, with stronger responses suggesting the use of a colorimeter or colour standards.

(b) (i) The majority of candidates drew the graph correctly, with appropriate scales on the axes and accurately plotted the points. The most common errors were not including the correct label for each axis, omitting the units for the axes and not labelling the scale at least every 2 cm.

(ii) Most candidates answered correctly, using their graph to find the rate of reaction when the temperature was 37.5 °C.

(iii) Some candidates suggested suitable explanations for the shape of the graph at the stated temperatures. A common error was to describe the graph rather than explaining why it was that shape.

Question 2

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

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent epidermal cells with each cell touching one of the other cells and double lines representing the walls. The most common error was to draw lines that did not meet up precisely enough. Most candidates used a label line to show the cell wall of one cell.

(b) (i) Some candidates correctly measured the thickness of the leaf shown by line **X**-**Y** and then showed the correct calculation of the actual thickness of the leaf and used appropriate units. The most common error was the omission of units.

(ii) Many candidates showed the addition of the lengths of the five cells and division by five.

(iii) The best answers were organised into a table with three columns headed features, **K1** and **Fig. 2.1**. Many candidates listed at least three observable differences between **K1** and **Fig. 2.1**.

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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 can be applied to the requirements of the examination.

Candidates should consider the wording of questions to ensure that they identify and address the requirements. For example, when instructed to show working, all steps in a calculation should be clearly displayed.

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

General comments

In general, candidates demonstrated a very good understanding of the skills required. Most candidates showed they were familiar with the microscope and demonstrated good drawing skills.

Comments on specific questions

Question 1

(a) (i) The majority of candidates recorded measurements within the correct range and gained credit for this. A common error was to include units in the body of the table.

(ii) Most candidates stated that all the potato cylinders should be cut to the same length and were credited. The stronger candidates stated the apparatus they would use to ensure the cylinders were all the same length.

(iii) The majority of candidates gained credit for stating a volume of buffer within a suitable range.

(iv) The majority of candidates organised their results clearly by presenting a ruled table. Stronger responses included the heading for pH and the heading for colour intensity. The majority of candidates gained credit for recording the results for at least five different pH values. Most gained credit for their results showing the correct trend and also for using the scale provided to record their results.

(v) The majority of candidates gained credit for recording the results for **PU** using the key provided in **Fig. 1.2**.

(vi) Most candidates correctly estimated the pH of **PU** from their results.

(vii) Many candidates gained credit for identifying that a colorimeter could be used to make a more accurate estimate of the pH of **PU**.

(viii) Most candidates were able to describe a suitable modification to the procedure. The majority of candidates gained credit for stating five different temperatures and, in order to achieve these temperatures, that they would use a thermostatically controlled water-bath.

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(b) (i) Most candidates drew the graph correctly, with appropriate scales and labels on the axes and plotting the points accurately. Some candidates labelled the axes incorrectly or gave incomplete headings. The strongest responses plotted the points precisely using a small cross or dot in a circle and accurately connected the points with a ruled line. The most common error was drawing lines which were not ruled to the centre of each plot.

(ii) The majority of candidates described the correct trend and illustrated this trend with correct data from their graph.

(iii) Many candidates identified that a low pH may cause the proteins in the cell surface membrane to denature and gained credit for this. Some candidates suggested that this would reduce the absorption of minerals by active transport. Descriptions of the denaturing of enzymes were not required here.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The higher achieving candidates gained credit for carefully following the instructions and drawing the correct part of the leaf section. Many candidates gained credit for drawing at least three layers of tissue and for drawing the correct proportion of the vascular tissue in relation to the other tissues. Most candidates used a label line to correctly identify the lower epidermis.

(ii) Credit was awarded to candidates whose drawings were made using lines which joined up precisely and used most of the space provided. Most candidates followed the instructions and drew four cells, each cell touching at least one other cell. The most common error was to draw lines that did not meet up precisely enough. Many candidates were credited for drawing the correct shape of the cells. Most candidates used a label line to identify the cell wall of one cell.

(b) The majority of candidates identified a correct observable feature that identified the cells as being xylem, for example thick cell walls. A common error was to describe the colours of the staining of the cell walls or to describe features which were not observable.

(c) (i) The majority of candidates correctly measured the length of line **L** and used appropriate units (cm or mm). Many candidates recorded the number of eyepiece graticule units within the correct range. Most responses were credited for showing all of their workings and calculating the correct answer using appropriate units.

(ii) The majority of candidates demonstrated the correct calculation using their answer to **Question 2(c)(i)**.

(iii) Many candidates answered correctly and annotated **Fig. 2.3** with three observable differences between **Fig. 2.3** and **M1**.

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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.

Candidates should be familiar with the mathematical requirements of the syllabus, for example being able to calculate areas of triangles, circumferences and areas of circles and rectangles, surface areas and volumes of cylinders and rectangular blocks.

Candidates should carefully consider the wording of questions to ensure that they identify and address the requirements. For example, when instructed to show working, all steps in a calculation should be clearly displayed.

General comments

In general, candidates demonstrated a very good understanding of the skills required to be successful. Most candidates showed they were familiar with the microscope and demonstrated good drawing skills.

Comments on specific questions

Question 1

(a) (i) The majority of candidates gained credit for identifying the need for four more cube sizes. Many candidates were able to calculate the surface area, volume and the ratio of surface area:volume correctly. The most common error was to state dimensions which did not produce cubes, with the measurements of the sides being of unequal length.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading surface area:volume and the heading for time with the appropriate units. Most candidates gained credit for recording the results for at least four different size cubes as whole seconds.

(iii) The majority of candidates described the correct trend for their results.

(iv) Many candidates stated that repeating the experiment at least twice more would improve the confidence in their results. A common error was to just state 'repeat', which was not sufficient. Repeating the experiment just once would not allow anomalous results to be ruled out so would not improve the confidence in the results.

(v) Many candidates suggested a suitable control for this investigation.

(vi) The stronger responses gained credit for suggesting that the diffusion distance would be longer and that this would prevent substances such as oxygen reaching the centre of the organism efficiently and therefore limit the activity of the organism. A common error was to state that diffusion would be slower. Descriptions of the exchange of gases in the lungs of an organism were not relevant to this question.

(b) (i) The best responses correctly identified the type of error along with the correct effect on the trend. Many candidates were able to identify the errors correctly, then described an incorrect effect on the

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trend. Some candidates stated errors which were not systematic or random, as required by the question.

(ii) Most candidates stated an appropriately sized cube.

(iii) Most candidates described a suitable modification to the procedure. The majority of candidates stated five different concentrations of ascorbic acid and the method by which they would make these concentrations.

(c) (i) The majority of candidates answered correctly.

(ii) Most candidates drew the graph correctly, with appropriate scales and labels on the axes. Some candidates labelled the axes incorrectly or gave incomplete headings. Most candidates drew bars of equal width and distance apart on the *x*-axis and plotted each bar accurately. The strongest responses drew ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely. The most common error was drawing lines which were not ruled. Another common error was to plot the number of drops of iodine solution instead of ascorbic acid concentration or to plot ascorbic acid concentration against the number of drops of iodine solution as a line graph.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The higher achieving candidates gained credit for following the instructions and drawing the whole of the section. Many candidates drew at least four layers of tissue. Many candidates gained credit for drawing the correct proportion of the vascular tissue in relation to the other tissues. Most candidates used a label line to correctly identify the epidermis.

(ii) Credit was awarded to candidates whose drawings were made using lines which joined up precisely and used most of the space provided. Many candidates drew one large xylem vessel and three adjacent touching vessels, with two lines for the walls of the cells. The most common error was to draw lines that did not meet up precisely enough. Many candidates were credited for showing at least one cell which had at least five sides. Most candidates used a label line to identify the lumen of a cell.

(b) (i) Many candidates correctly identified the stage of mitosis as anaphase. Some candidates stated that the chromatids had separated and moved towards the poles. A common error was to omit reference to the poles of the cell.

(ii) Many candidates answered correctly. A common error was to include cells in the telophase stage of mitosis.

(iii) The majority of candidates gained credit for correctly measuring and displaying the length of line **R** using the appropriate units (cm or mm). Most candidates also showed all the steps in their workings and many gained credit for the correct answer.

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Paper 9700/36
Advanced Practical Skills 2

Key messages

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

Candidates should be able to identify the significant sources of error in an investigation as any variable that could change during the recording of results and may make the results less accurate. Contamination is not considered a significant source of error since washing correctly should remove contamination.

General comments

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

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

The majority of centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

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

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

Comments on specific questions

Question 1

(a) (i) Many candidates correctly assessed the risk for **H** as medium or high, for **W** as low and for **P** as medium or high.

(ii) Many candidates gained credit for showing the correct volumes of **P** and **W** to make at least four further concentrations of **P**. The most common error was describe a preparation that did not make up total volumes of 10 cm^3.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. Stronger responses included the heading for the independent variable (percentage concentration of plant extract) and the dependent variable (time / seconds). The most common errors were to omit the heading for the independent variable or to include 'seconds' in the body of the table. Most candidates gained credit for recording the times as whole numbers. Stronger candidates also recorded longer times for the disc to reach the surface with decreasing concentration of plant extract.

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(iv) Most candidates answered correctly.

(v) Some candidates correctly identified that one source of error was that the same hydrogen peroxide solution was used for each test, which decreased the concentration of hydrogen peroxide and then suggested the use of fresh hydrogen peroxide each time as an improvement. Some correctly observed that each paper disc had a different volume of plant extract on it, so suggested putting a set volume of plant extract onto each disc. Some candidates also correctly suggested that blotting each disc for the same time would standardise the volume of plant extract on each disc.

(b) (i) Most candidates answered to the correct degree of accuracy but had also included the anomalous value for test 2 in their calculation. Only a few candidates correctly calculated the mean value and gained full credit.

(ii) The majority of candidates drew the graph correctly, with appropriate scales on the axes and accurately plotted the points. The most common errors were not including the correct label for each axis, omitting the units for the axes and not labelling the scale at least every 2 cm.

(iii) Most candidates clearly used their graph and answered correctly.

(iv) The best answers explained that there were more substrate molecules so there more successful collisions and more enzyme-substrate complexes formed.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the correct sector of the stem. Many candidates gained credit for drawing at least two layers of tissue, at least two vascular bundles and showing the proportion of the vascular bundle in relation to the depth of the stem. Most candidates used a label line to correctly identify the xylem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent xylem vessels with each vessel touching at least two other cells and double lines representing the walls. The most common error was to draw lines that did not meet up precisely enough. Most candidates used a label line to show the cell wall of one vessel.

(b) (i) The stronger candidates correctly counted and recorded the number of eyepiece graticule divisions to measure line **X**-**Y**. Many candidates then showed the correct calculation of the actual width of the vascular tissue and used the appropriate units.

(ii) The best answers were organise into a table into three column headed features, **N1** and **Fig. 2.2**. Many candidates listed at least three observable differences between **N1** and **Fig. 2.2**.

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Paper 9700/41
A Level Structured Questions

Key messages

- Candidates should check the command words given in questions carefully, particularly with reference to 'describe' or 'explain'. Candidates should avoid giving detailed descriptions for questions that require an explanation.
- Candidates should take great care with the spelling of biological terms to maximise the credit available.

General comments

Many candidates found questions on gene technology and speciation more challenging, particularly **Questions 3(b)(ii)**, **Question 3(d)** and **Question 6**.

The question paper discriminated well and candidates obtained a range of scores, including many with high levels of credit.

Comments on specific questions

Section A

Question 1

(a) (i) Many candidates stated that a decrease in the water potential of the blood would lead to the release of ADH. Other correct changes in the internal environment that would also stimulate ADH release included an increase in blood glucose or ion concentration or a lower blood volume, although the latter was rarely seen. References to dehydration or low water potential were not credited as they did not constitute a change.

(ii) The majority of responses correctly identified the posterior pituitary gland as the body part that releases ADH into the blood. Several candidates missed out on the credit as they stated pituitary gland or incorrectly stated the anterior pituitary gland. Other responses included hypothalamus, kidney, liver and endocrine system.

(b) The membrane protein **A** and structure **B** were, in general, correctly named with a large proportion of candidates gaining full credit. **A** was identified as a receptor, ADH receptor, receptor protein and G-protein coupled receptor. Incorrect answers referred to **A** as a channel protein or in some cases glycogen phosphorylase or glycoprotein portion. For **B** the most common response was vesicle with aquaporins or simply vesicle. There were many responses stating aquaporin alone which were not credited. Some obscure responses were also seen including glucose and mitochondria.

(c) There was a good spread of credit here with some excellent accounts outlining the response of structure **B** to stimulation by phosphorylase enzyme and the consequences of this. Most responses started out with the movement of vesicles towards, or fusion with, the cell surface membrane. The consequences were also well understood by stronger candidates who commented that the increase in aquaporins in the cell surface membrane would increase its permeability, increasing the reabsorption of water by osmosis from the collecting duct into the cell and thence the tissue fluid and blood. Many continued to add that the water potential in the blood would

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increase to the norm and that a smaller volume of more concentrated urine would be excreted. However, while weaker candidates understood that water would return to the blood, they needed to mention that it would leave the collecting duct and explain the effect on the urine concentration or volume.

Question 2

(a) Many candidates understood that discontinuous variation, demonstrated by the stickleback fish phenotypes in the scenario provided, had discrete categories, with various forms of wording to that effect. Further explanation was often omitted, with fewer candidates explaining that there were no intermediates or that the environment had no effect or that there was only a single gene involved. There were a significant number of incorrect references to the environment affecting the phenotype in the different water conditions seen, or the phenotype being affected by genes (plural, rather than singular).

(b) Many incorrect responses referred to protection from humans (rather than predators) or suggested that these fish had evolved from saltwater rather than recently migrated. However, all three potential options were given in responses by stronger candidates.

(c) This question on natural selection was generally well interpreted in the scenario. At a basic level, responses linked the complete armour phenotype to a selective disadvantage, and therefore stickleback fish with this phenotype have reduced survival and reproduction. More extended answers then described that the low armour allele was preferentially passed on and therefore increased in allelic frequency. Good answers further explained that this is an example of directional selection or provided valid suggestions as to why the complete armour phenotype could be at a selective disadvantage. Partial credit was often due to a lack of clarity, for example not being clear which phenotype was at a selective advantage, which allele was being passed on, or allele frequencies changing without stating a direction. Some candidates discussed genes rather than alleles.

Question 3

(a) The advantages of producing human therapeutic proteins by recombinant DNA technology were well understood. Many candidates appreciated that the therapeutic protein would be identical to human insulin, so therefore would not stimulate an immune response or allergic reaction and would elicit a faster response than animal insulin. Most recognised that large scale production would be possible, at lower cost. There was also frequent mention of no risk of transmission of infection as well as no religious or ethical objections. However, few remarked that there would be no development of tolerance. References to less immune response or less risk of disease transmission were not credited as there would be none using recombinant DNA technology. Some candidates described the method of extracting and inserting the human insulin gene into plasmids, which was not required.

(b) (i) Most candidates provided a correct calculation of the percentage sequence similarity of human and salmon calcitonin. An incorrect calculation was usually due to miscounting of the number of identical amino acids in the two sequences.

(ii) There was some confusion about the use of bioinformatics, with some candidates referring to the use of electrophoresis or microarrays to identify sequence similarity rather than to accessing existing databases containing base/amino acid sequences and then using the available software to carry out comparisons or computer modelling of protein structure. Of those candidates who did identify this as being an electronic source of sequence data, several omitted to state the type of sequence. Despite this a good number of candidates scored credit here.

(c) (i) The majority of candidates knew that the enzymes that cut plasmid DNA are restriction endonucleases and some could name specific enzymes. Almost all candidates also knew that ligase enzymes are used in forming recombinant plasmids to join the DNA. Incorrect answers included recombinant enzyme or reverse transcriptase instead of restriction enzyme and DNA polymerase instead of DNA ligase. Very occasionally the answers would be the wrong way around.

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(ii) The identification of the properties of plasmids that allow them to be used as vectors in gene cloning was straightforward for most candidates but explaining them proved to be more problematic. The most common response was a statement that plasmids are small, or have a low molecular mass, so can easily be taken up by cells or bacteria. There were frequent references to plasmids having restriction sites which could be cut by restriction enzymes in order to insert a gene, although mention of polylinkers to allow cutting by different restriction enzymes was rare. Many commented that plasmids have circular DNA, but this was seldom linked to stability. Some understood that plasmids would have marker genes or gave examples, such as the gene for antibiotic resistance, but stated that this would be to recognise the plasmid rather than the transformed cell. While some appreciated that plasmids can replicate independently as they have an origin of replication, this was only occasionally qualified by stating that many plasmids could be produced. Very few candidates suggested features without explanations.

(d) Most candidates found this question difficult and were unable to provide good explanations as to the differences in control of gene expression in prokaryotes and eukaryotes or why expression vector plasmids must contain a prokaryotic promotor. Very few referred to the differences in eukaryotic and prokaryotic promoter sequences or RNA polymerases. A few understood that prokaryotic RNA polymerase could not recognise a eukaryotic promoter so would only bind to a prokaryotic one. However, many candidates gained credit for appreciating that, in the absence of binding, no transcription or gene expression would occur, or vice versa. Very occasionally, candidates noted that the transcription factors required to bind eukaryotic promoters would be absent in prokaryotic cells.

Question 4

(a) (i) The majority of candidates found it difficult to complete **Table 4.1** correctly, although most achieved at least two correct rows. Several answers selected where a process did happen but left other boxes blank. Candidates should follow the clear instructions in the question, which required a definitive positive or negative response in each box of the table.

(ii) The comparison of meiosis in gametogenesis in production of sperm in humans and production of pollen grains in flowering plants was challenging for many candidates. It was clear that, whilst most candidates had some knowledge of the processes in each, responses frequently did not make direct comparisons between the two processes, as was required by the question. In particular, candidates often described features of one process, then described features of the second process, but omitted to directly compare where they were similar or different. Aspects of spermatogenesis were generally better described than pollen grain formation. Very few candidates made reference to genetic variation, which is one of the key aspects of gamete formation.

(b) (i) This question was generally answered well. The first two genotypes posed little difficulty. Responses for the third genotype often did not allow for the absence of the allele for pigment production in petals. The fourth genotype occasionally yielded answers where petal colour was omitted rather than given as white.

(ii) Stronger responses described that the mutation would cause a change in primary and tertiary structures, and some extended to the potential type of mutation involved and its effects on the gene. However, some answers simply described the role of dominant and recessive alleles, rather than how the mutation itself would cause the lack of pigment production. Few described the outcome of the mutation in the gene product in the biosynthetic pathway itself. Some weaker candidates omitted the word ‘base’ from substitution, addition or deletion.

(iii) Despite being given the information in the question stem that one known mutation does not occur in the protein-coding region of DNA, several responses described features of genes that encode proteins, such as transcription factors or start codons. Of the correct options, named features were more generally seen such as promoters or stop codons. Occasionally promoters were only described, but this could still be credited where they were described as regulatory regions or binding sites for proteins that regulate transcription.

Question 5

(a) (i) Most candidates knew where light absorption in chloroplasts takes place. Answers included in the thylakoid, thylakoid membranes, grana, granum with a few referring to the lamella. Other answers

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included in the photosystems, accessory pigments and the chlorophyll in the thylakoid membrane, although references to photosystems or pigments alone were not credited. Some candidates stated that this happens within the stroma.

(ii) The majority of candidates gained credit here. Reduced NADP, oxygen and ATP were stated with similar frequency. Incorrect answers included water, NADP, reduced NAD and hydrogen ions with some also indicating that rubisco or carbon dioxide is a product.

(iii) There were some excellent descriptions of the reactions in the stroma that lead to the production of polysaccharides, such as alginate. Many candidates began by stating that rubisco would catalyse the fixation of carbon dioxide to RuBP leading to the production of an unstable six carbon compound which would then split to yield two molecules of glycerate-3-phosphate (GP). While most appreciated that GP would be metabolised to triose phosphate (TP), they did not add that this would be a reduction reaction: however, many understood that both ATP and reduced NADP from the light dependent reaction would be necessary for this step. The synthesis of glucose from TP was poorly explained, with weaker candidates commenting that TP would be converted to glucose or omitting glucose altogether and simply stating that it would form polysaccharides. Few mentioned that condensation reactions, or the formation of glycosidic bonds, would be involved. Weaker candidates did not identify the six-carbon compound as unstable or suggested that rubisco catalysed the formation of glycerate-3-phosphate. Although some recognised that GP would be reduced to TP, only the use of reduced NADP was mentioned.

(b) (i) Many candidates described rather than explained the difference in the rate of photosynthesis at low and high carbon dioxide concentrations. Nevertheless, some candidates went on to state that more carbon dioxide would be fixed at the higher concentration, resulting in an increase in the Calvin cycle or the enhanced production of glycerate-3-phosphate or triose phosphate.

(ii) Candidates found describing and explaining the effect of increasing daylength on the rate of photosynthesis at high concentration of carbon dioxide more straightforward. Most were able to state the relationship and quote appropriate figures from the table to support their answer. Stronger candidates recognised that the increase in daylength would allow more light to be absorbed by chlorophyll, or other suitable alternatives, and the consequential increase in the light dependant reaction and its products. Some candidates incorrectly suggested that higher light intensity would cause the stomata to open more widely, allowing greater uptake of carbon dioxide for the light independent reaction.

(c) (i) The effect of increasing pH from 8.1 to 8.4 on the rate of photosynthesis was described rather than explained in most responses, although some candidates appreciated that pH 8.4 would be closer to, or at, the optimum for the enzymes involved in the light dependent or independent reactions. Few candidates mentioned the effect of fewer protons on enzyme activity.

(ii) Few candidates were able to suggest why the data in **Fig. 5.2** did not fully support the idea that seaweeds could help to reduce ocean acidification. Many described the difference in the rate of photosynthesis between pH 8.1 and 7.8, while stronger candidates made the connection between a lower rate at lower pH and a reduction in the rate of carbon dioxide absorption or fixation, often adding that this would lead to a greater concentration of the acidic gas remaining in the ocean.

Question 6

(a) (i) Candidates found this question challenging and few responses gave any reasoning to their answer and were limited to the prediction only. Only a minority of answers referred to the involvement of homologous chromosomes pairing up or the formation of bivalents during a successful meiosis. Some gave numerical answers, which had no justification here without any prior knowledge.

(ii) Where credit was awarded for this question, it was predominantly for a statement of reproductive isolation and a statement of sympatric speciation. Some answers attempted to describe the lack of gene flow with the original parent species, but this was often limited to a repetition of part of the question (lack of mating) and so did not gain credit. Despite the evidence being for a behavioural effect, some answers incorrectly described incompatibility with parents, or migration of the hybrids and allopatric speciation. Mutations were often mentioned in answers but they were not specified as different mutations. Maintenance of the gene pool and a pre-zygotic isolating mechanism were rarely included in responses.

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(b) Most responses correctly identified from the information provided that the hybrid butterflies would be at a selective disadvantage due to their lack of distinctive coloration and would therefore be predated. Further explanation was rarely provided, whilst some responses suggested that future hybrid offspring would be sterile, despite being informed in the question stem that the hybrids are fertile. Other creditworthy points in terms of the hybrid pool decreasing, the parents being better adapted or that there was disruptive selection were rarely seen.

Question 7

(a) Comments regarding the low mineral content of the soil in the wetlands were rare, although some recognised that the soil would not be able to provide sufficient minerals to satisfy the needs of the Venus fly trap. While candidates frequently went on to state that the digestion of trapped insects would supplement the mineral demand of the plant, this was not always linked to growth. Weaker responses simply referred to nutrients.

(b) (i) The majority of candidates stated that the hairs would detect the stimulus, although there were other suggestions, like stomata, spikes or even cilia.

(ii) Explanations as to how the plant does not waste energy by closing unnecessarily were sometimes vague but stronger candidates understood that either one hair would need to be stimulated twice in close succession or, alternatively, two or more hairs had to be stimulated simultaneously or within 35 seconds.

(c) Descriptions of the differences between the action potential of a Venus fly trap and a human were often inaccurate, particularly when quoting figures, with candidates concentrating on changes in electrical potential rather than the duration of the phases. Many gained credit for stating that the resting potential of the Venus fly trap was 0 mV whereas that of a human was 70 mV. Stronger candidates noted that the duration of the refractory period and hyperpolarisation were longer in the plant whereas the duration of the action potential, depolarisation and repolarisation were shorter. Few commented that there was a smaller change in membrane potential in the Venus fly trap.

(d) There were some very detailed accounts of the mechanism of leaf closure following the production of an action potential. Stronger candidates began by stating that the action potential would spread to the lobes, triggering the hinge or midrib cells to pump hydrogen ions into the cell walls. The breaking of cross linkages resulting in the loosening of the cell walls was less frequently mentioned although some referred to the release of elastic tension. Many commented that calcium pectate in the middle lamella would dissolve and calcium ions would enter the hinge cells, lowering the water potential so that water would follow by osmosis, making them turgid. Many also appreciated that the lobes would become concave as a result, thereby trapping the insect although there was occasionally confusion between concave and convex. Weaker candidates offered descriptions of neurochemical transmission, how enzymes would be secreted to digest the insect or how the insect would be prevented from escaping. Some stated that the calcium pectate would act as a glue necessary to stick the insect to the leaf.

Question 8

The stages involved in oxidative phosphorylation were largely well known, with the majority of candidates obtaining high levels of credit for this question. Mistakes were generally due to imprecise answers rather than lack of knowledge.

Section B

Question 9

(a) Most candidates gained some credit for accounts of the similarities and differences between members of the two kingdoms. Many presented their responses in the form of a table. The features of kingdom Fungi were, on the whole, better described than those of kingdom Animalia. Most candidates appreciated that many fungi are unicellular, often giving yeast as an example,

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although some, for example mushrooms, can be multicellular. Many stated that fungi consist of hyphae, have a cell wall composed of chitin and reproduce by means of spores. For kingdom Animalia, many candidates commented on the multicellular nature of these organisms and that most would be motile. References to specialised cells differentiated into tissues were less frequent, as was the mention of the presence of cilia or flagella on some cells. The most common shared characteristics included linear DNA associated with histones, membrane bound organelles, which were often listed, and 80s ribosomes. Although many recognised that both kingdoms belong to the domain Eukarya, few mentioned that they are composed of eukaryotic cells. Some candidates stated that both have heterotrophic nutrition although others believed that fungi are autotrophic. No references to glycogen were seen. Weaker candidates confused fungi with bacteria so achieved no credit for either the common features of the two kingdoms or those of fungi alone.

(b) There were many comprehensive discussions of the methods used in breeding programmes for endangered mammal species. Most candidates understood the importance of sperm banks, or frozen zoos, and assisted reproduction in increasing the captive population. Many named both *in vitro* fertilisation and artificial insemination, often giving considerable detail of each procedure. The use of surrogate mothers was frequently mentioned although few stated that the health of the mother and development of the foetus could be monitored. Comments on the provision of an environment resembling their natural habitat as far as possible were rare, as were the keeping of genetic records or stud books. However, some candidates briefly mentioned international cooperation between zoos, mostly in the context of exchanging animals in breeding programmes to prevent inbreeding depression. The difficulties associated with captive breeding, such as the stress experienced by the animals leading to the rejection of a potential mate, were recognised by a number of candidates although comments on the disruption of the reproductive cycle were less common. Many also appreciated that problems might arise once the captively bred animals were released back into the wild, most notably their inability to find food, escape predators, or greater susceptibility to disease. However, some also mentioned their failure to integrate into social groups or their lack of fear of humans. Some candidates did not address the question and instead described the role of zoos in caring for and protecting the animals, educating the public, and how research programmes could be established to study their dietary requirements or behaviour.

Question 10

(a) Candidates generally made good attempts at describing the features of the ATP molecule that make it suitable for its role. Nearly all candidates described the molecule as small, although references to its solubility were more vague, and there were many descriptions of ATP being passed from cell to cell rather than between organelles and structures within the cell. References to ATP as an energy source generally described the breakdown of ATP to ADP and inorganic phosphate releasing energy with more developed answers referencing the specific amount of energy released per phosphate, and the reversibility of ATP breakdown. Only good answers approaching full credit referred to ATP being an intermediate between energy yielding and energy requiring reactions, and the high turnover rate of ATP. Weaker responses frequently described the production of ATP during respiration, or reactions/processes in which ATP plays a role, rather than describing the molecular features of ATP itself.

(b) Candidates predominantly achieved credit on generic aspects of experimental investigations, such as using a water-bath to control temperature, assessing over a suitable temperature range, performing repeats and calculating means. However, the specifics of this investigation were frequently lacking in candidate responses. Whilst some candidates understood that methylene blue (or DCPIP) turns colourless during the investigations, and more specifically when reduced, few responses effectively described the assay setup, such as providing glucose as a respiratory substrate, the yeast needing to be in suspension, or how anaerobic conditions would be achieved. In some cases, candidates who suggested temperatures to test often did not give a minimum range of five reasonable temperatures. Weaker responses used the term average rather than mean, and a large number did not show how to calculate rate of respiration. Some candidates also incorrectly referred to the methylene blue changing colour rather than turning colourless. A number of responses confused this investigation with that of aerobic respiration and/or photosynthesis (e.g. use of an absorbent to remove carbon dioxide or measuring volume of gas produced). Some answers also merely described the molecular steps in anaerobic respiration, rather than the experimental investigation.

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Paper 9700/42
A Level Structured Questions

Key messages

- Candidates should check the command words given in questions carefully, particularly with reference to 'describe' or 'explain'. Candidates should avoid giving detailed descriptions for questions that require an explanation.
- Candidates should take great care with the spelling of biological terms to maximise the credit available.

General comments

Many candidates found questions on gene technology and speciation more challenging, particularly **Questions 3(b)(ii)**, **Question 3(d)** and **Question 6**.

The question paper discriminated well and candidates obtained a range of scores, including many with high levels of credit.

Comments on specific questions

Section A

Question 1

(a) (i) Many candidates stated that a decrease in the water potential of the blood would lead to the release of ADH. Other correct changes in the internal environment that would also stimulate ADH release included an increase in blood glucose or ion concentration or a lower blood volume, although the latter was rarely seen. References to dehydration or low water potential were not credited as they did not constitute a change.

(ii) The majority of responses correctly identified the posterior pituitary gland as the body part that releases ADH into the blood. Several candidates missed out on the credit as they stated pituitary gland or incorrectly stated the anterior pituitary gland. Other responses included hypothalamus, kidney, liver and endocrine system.

(b) The membrane protein **A** and structure **B** were, in general, correctly named with a large proportion of candidates gaining full credit. **A** was identified as a receptor, ADH receptor, receptor protein and G-protein coupled receptor. Incorrect answers referred to **A** as a channel protein or in some cases glycogen phosphorylase or glycoprotein portion. For **B** the most common response was vesicle with aquaporins or simply vesicle. There were many responses stating aquaporin alone which were not credited. Some obscure responses were also seen including glucose and mitochondria.

(c) There was a good spread of credit here with some excellent accounts outlining the response of structure **B** to stimulation by phosphorylase enzyme and the consequences of this. Most responses started out with the movement of vesicles towards, or fusion with, the cell surface membrane. The consequences were also well understood by stronger candidates who commented that the increase in aquaporins in the cell surface membrane would increase its permeability, increasing the reabsorption of water by osmosis from the collecting duct into the cell and thence the tissue fluid and blood. Many continued to add that the water potential in the blood would

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increase to the norm and that a smaller volume of more concentrated urine would be excreted. However, while weaker candidates understood that water would return to the blood, they needed to mention that it would leave the collecting duct and explain the effect on the urine concentration or volume.

Question 2

(a) Many candidates understood that discontinuous variation, demonstrated by the stickleback fish phenotypes in the scenario provided, had discrete categories, with various forms of wording to that effect. Further explanation was often omitted, with fewer candidates explaining that there were no intermediates or that the environment had no effect or that there was only a single gene involved. There were a significant number of incorrect references to the environment affecting the phenotype in the different water conditions seen, or the phenotype being affected by genes (plural, rather than singular).

(b) Many incorrect responses referred to protection from humans (rather than predators) or suggested that these fish had evolved from saltwater rather than recently migrated. However, all three potential options were given in responses by stronger candidates.

(c) This question on natural selection was generally well interpreted in the scenario. At a basic level, responses linked the complete armour phenotype to a selective disadvantage, and therefore stickleback fish with this phenotype have reduced survival and reproduction. More extended answers then described that the low armour allele was preferentially passed on and therefore increased in allelic frequency. Good answers further explained that this is an example of directional selection or provided valid suggestions as to why the complete armour phenotype could be at a selective disadvantage. Partial credit was often due to a lack of clarity, for example not being clear which phenotype was at a selective advantage, which allele was being passed on, or allele frequencies changing without stating a direction. Some candidates discussed genes rather than alleles.

Question 3

(a) The advantages of producing human therapeutic proteins by recombinant DNA technology were well understood. Many candidates appreciated that the therapeutic protein would be identical to human insulin, so therefore would not stimulate an immune response or allergic reaction and would elicit a faster response than animal insulin. Most recognised that large scale production would be possible, at lower cost. There was also frequent mention of no risk of transmission of infection as well as no religious or ethical objections. However, few remarked that there would be no development of tolerance. References to less immune response or less risk of disease transmission were not credited as there would be none using recombinant DNA technology. Some candidates described the method of extracting and inserting the human insulin gene into plasmids, which was not required.

(b) (i) Most candidates provided a correct calculation of the percentage sequence similarity of human and salmon calcitonin. An incorrect calculation was usually due to miscounting of the number of identical amino acids in the two sequences.

(ii) There was some confusion about the use of bioinformatics, with some candidates referring to the use of electrophoresis or microarrays to identify sequence similarity rather than to accessing existing databases containing base/amino acid sequences and then using the available software to carry out comparisons or computer modelling of protein structure. Of those candidates who did identify this as being an electronic source of sequence data, several omitted to state the type of sequence. Despite this a good number of candidates scored credit here.

(c) (i) The majority of candidates knew that the enzymes that cut plasmid DNA are restriction endonucleases and some could name specific enzymes. Almost all candidates also knew that ligase enzymes are used in forming recombinant plasmids to join the DNA. Incorrect answers included recombinant enzyme or reverse transcriptase instead of restriction enzyme and DNA polymerase instead of DNA ligase. Very occasionally the answers would be the wrong way around.

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(ii) The identification of the properties of plasmids that allow them to be used as vectors in gene cloning was straightforward for most candidates but explaining them proved to be more problematic. The most common response was a statement that plasmids are small, or have a low molecular mass, so can easily be taken up by cells or bacteria. There were frequent references to plasmids having restriction sites which could be cut by restriction enzymes in order to insert a gene, although mention of polylinkers to allow cutting by different restriction enzymes was rare. Many commented that plasmids have circular DNA, but this was seldom linked to stability. Some understood that plasmids would have marker genes or gave examples, such as the gene for antibiotic resistance, but stated that this would be to recognise the plasmid rather than the transformed cell. While some appreciated that plasmids can replicate independently as they have an origin of replication, this was only occasionally qualified by stating that many plasmids could be produced. Very few candidates suggested features without explanations.

(d) Most candidates found this question difficult and were unable to provide good explanations as to the differences in control of gene expression in prokaryotes and eukaryotes or why expression vector plasmids must contain a prokaryotic promotor. Very few referred to the differences in eukaryotic and prokaryotic promoter sequences or RNA polymerases. A few understood that prokaryotic RNA polymerase could not recognise a eukaryotic promoter so would only bind to a prokaryotic one. However, many candidates gained credit for appreciating that, in the absence of binding, no transcription or gene expression would occur, or vice versa. Very occasionally, candidates noted that the transcription factors required to bind eukaryotic promoters would be absent in prokaryotic cells.

Question 4

(a) (i) The majority of candidates found it difficult to complete **Table 4.1** correctly, although most achieved at least two correct rows. Several answers selected where a process did happen but left other boxes blank. Candidates should follow the clear instructions in the question, which required a definitive positive or negative response in each box of the table.

(ii) The comparison of meiosis in gametogenesis in production of sperm in humans and production of pollen grains in flowering plants was challenging for many candidates. It was clear that, whilst most candidates had some knowledge of the processes in each, responses frequently did not make direct comparisons between the two processes, as was required by the question. In particular, candidates often described features of one process, then described features of the second process, but omitted to directly compare where they were similar or different. Aspects of spermatogenesis were generally better described than pollen grain formation. Very few candidates made reference to genetic variation, which is one of the key aspects of gamete formation.

(b) (i) This question was generally answered well. The first two genotypes posed little difficulty. Responses for the third genotype often did not allow for the absence of the allele for pigment production in petals. The fourth genotype occasionally yielded answers where petal colour was omitted rather than given as white.

(ii) Stronger responses described that the mutation would cause a change in primary and tertiary structures, and some extended to the potential type of mutation involved and its effects on the gene. However, some answers simply described the role of dominant and recessive alleles, rather than how the mutation itself would cause the lack of pigment production. Few described the outcome of the mutation in the gene product in the biosynthetic pathway itself. Some weaker candidates omitted the word ‘base’ from substitution, addition or deletion.

(iii) Despite being given the information in the question stem that one known mutation does not occur in the protein-coding region of DNA, several responses described features of genes that encode proteins, such as transcription factors or start codons. Of the correct options, named features were more generally seen such as promoters or stop codons. Occasionally promoters were only described, but this could still be credited where they were described as regulatory regions or binding sites for proteins that regulate transcription.

Question 5

(a) (i) Most candidates knew where light absorption in chloroplasts takes place. Answers included in the thylakoid, thylakoid membranes, grana, granum with a few referring to the lamella. Other answers

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included in the photosystems, accessory pigments and the chlorophyll in the thylakoid membrane, although references to photosystems or pigments alone were not credited. Some candidates stated that this happens within the stroma.

(ii) The majority of candidates gained credit here. Reduced NADP, oxygen and ATP were stated with similar frequency. Incorrect answers included water, NADP, reduced NAD and hydrogen ions with some also indicating that rubisco or carbon dioxide is a product.

(iii) There were some excellent descriptions of the reactions in the stroma that lead to the production of polysaccharides, such as alginate. Many candidates began by stating that rubisco would catalyse the fixation of carbon dioxide to RuBP leading to the production of an unstable six carbon compound which would then split to yield two molecules of glycerate-3-phosphate (GP). While most appreciated that GP would be metabolised to triose phosphate (TP), they did not add that this would be a reduction reaction: however, many understood that both ATP and reduced NADP from the light dependent reaction would be necessary for this step. The synthesis of glucose from TP was poorly explained, with weaker candidates commenting that TP would be converted to glucose or omitting glucose altogether and simply stating that it would form polysaccharides. Few mentioned that condensation reactions, or the formation of glycosidic bonds, would be involved. Weaker candidates did not identify the six-carbon compound as unstable or suggested that rubisco catalysed the formation of glycerate-3-phosphate. Although some recognised that GP would be reduced to TP, only the use of reduced NADP was mentioned.

(b) (i) Many candidates described rather than explained the difference in the rate of photosynthesis at low and high carbon dioxide concentrations. Nevertheless, some candidates went on to state that more carbon dioxide would be fixed at the higher concentration, resulting in an increase in the Calvin cycle or the enhanced production of glycerate-3-phosphate or triose phosphate.

(ii) Candidates found describing and explaining the effect of increasing daylength on the rate of photosynthesis at high concentration of carbon dioxide more straightforward. Most were able to state the relationship and quote appropriate figures from the table to support their answer. Stronger candidates recognised that the increase in daylength would allow more light to be absorbed by chlorophyll, or other suitable alternatives, and the consequential increase in the light dependant reaction and its products. Some candidates incorrectly suggested that higher light intensity would cause the stomata to open more widely, allowing greater uptake of carbon dioxide for the light independent reaction.

(c) (i) The effect of increasing pH from 8.1 to 8.4 on the rate of photosynthesis was described rather than explained in most responses, although some candidates appreciated that pH 8.4 would be closer to, or at, the optimum for the enzymes involved in the light dependent or independent reactions. Few candidates mentioned the effect of fewer protons on enzyme activity.

(ii) Few candidates were able to suggest why the data in **Fig. 5.2** did not fully support the idea that seaweeds could help to reduce ocean acidification. Many described the difference in the rate of photosynthesis between pH 8.1 and 7.8, while stronger candidates made the connection between a lower rate at lower pH and a reduction in the rate of carbon dioxide absorption or fixation, often adding that this would lead to a greater concentration of the acidic gas remaining in the ocean.

Question 6

(a) (i) Candidates found this question challenging and few responses gave any reasoning to their answer and were limited to the prediction only. Only a minority of answers referred to the involvement of homologous chromosomes pairing up or the formation of bivalents during a successful meiosis. Some gave numerical answers, which had no justification here without any prior knowledge.

(ii) Where credit was awarded for this question, it was predominantly for a statement of reproductive isolation and a statement of sympatric speciation. Some answers attempted to describe the lack of gene flow with the original parent species, but this was often limited to a repetition of part of the question (lack of mating) and so did not gain credit. Despite the evidence being for a behavioural effect, some answers incorrectly described incompatibility with parents, or migration of the hybrids and allopatric speciation. Mutations were often mentioned in answers but they were not specified as different mutations. Maintenance of the gene pool and a pre-zygotic isolating mechanism were rarely included in responses.

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(b) Most responses correctly identified from the information provided that the hybrid butterflies would be at a selective disadvantage due to their lack of distinctive coloration and would therefore be predated. Further explanation was rarely provided, whilst some responses suggested that future hybrid offspring would be sterile, despite being informed in the question stem that the hybrids are fertile. Other creditworthy points in terms of the hybrid pool decreasing, the parents being better adapted or that there was disruptive selection were rarely seen.

Question 7

(a) Comments regarding the low mineral content of the soil in the wetlands were rare, although some recognised that the soil would not be able to provide sufficient minerals to satisfy the needs of the Venus fly trap. While candidates frequently went on to state that the digestion of trapped insects would supplement the mineral demand of the plant, this was not always linked to growth. Weaker responses simply referred to nutrients.

(b) (i) The majority of candidates stated that the hairs would detect the stimulus, although there were other suggestions, like stomata, spikes or even cilia.

(ii) Explanations as to how the plant does not waste energy by closing unnecessarily were sometimes vague but stronger candidates understood that either one hair would need to be stimulated twice in close succession or, alternatively, two or more hairs had to be stimulated simultaneously or within 35 seconds.

(c) Descriptions of the differences between the action potential of a Venus fly trap and a human were often inaccurate, particularly when quoting figures, with candidates concentrating on changes in electrical potential rather than the duration of the phases. Many gained credit for stating that the resting potential of the Venus fly trap was 0 mV whereas that of a human was 70 mV. Stronger candidates noted that the duration of the refractory period and hyperpolarisation were longer in the plant whereas the duration of the action potential, depolarisation and repolarisation were shorter. Few commented that there was a smaller change in membrane potential in the Venus fly trap.

(d) There were some very detailed accounts of the mechanism of leaf closure following the production of an action potential. Stronger candidates began by stating that the action potential would spread to the lobes, triggering the hinge or midrib cells to pump hydrogen ions into the cell walls. The breaking of cross linkages resulting in the loosening of the cell walls was less frequently mentioned although some referred to the release of elastic tension. Many commented that calcium pectate in the middle lamella would dissolve and calcium ions would enter the hinge cells, lowering the water potential so that water would follow by osmosis, making them turgid. Many also appreciated that the lobes would become concave as a result, thereby trapping the insect although there was occasionally confusion between concave and convex. Weaker candidates offered descriptions of neurochemical transmission, how enzymes would be secreted to digest the insect or how the insect would be prevented from escaping. Some stated that the calcium pectate would act as a glue necessary to stick the insect to the leaf.

Question 8

The stages involved in oxidative phosphorylation were largely well known, with the majority of candidates obtaining high levels of credit for this question. Mistakes were generally due to imprecise answers rather than lack of knowledge.

Section B

Question 9

(a) Most candidates gained some credit for accounts of the similarities and differences between members of the two kingdoms. Many presented their responses in the form of a table. The features of kingdom Fungi were, on the whole, better described than those of kingdom Animalia. Most candidates appreciated that many fungi are unicellular, often giving yeast as an example,

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although some, for example mushrooms, can be multicellular. Many stated that fungi consist of hyphae, have a cell wall composed of chitin and reproduce by means of spores. For kingdom Animalia, many candidates commented on the multicellular nature of these organisms and that most would be motile. References to specialised cells differentiated into tissues were less frequent, as was the mention of the presence of cilia or flagella on some cells. The most common shared characteristics included linear DNA associated with histones, membrane bound organelles, which were often listed, and 80s ribosomes. Although many recognised that both kingdoms belong to the domain Eukarya, few mentioned that they are composed of eukaryotic cells. Some candidates stated that both have heterotrophic nutrition although others believed that fungi are autotrophic. No references to glycogen were seen. Weaker candidates confused fungi with bacteria so achieved no credit for either the common features of the two kingdoms or those of fungi alone.

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Question 10

(a) Candidates generally made good attempts at describing the features of the ATP molecule that make it suitable for its role. Nearly all candidates described the molecule as small, although references to its solubility were more vague, and there were many descriptions of ATP being passed from cell to cell rather than between organelles and structures within the cell. References to ATP as an energy source generally described the breakdown of ATP to ADP and inorganic phosphate releasing energy with more developed answers referencing the specific amount of energy released per phosphate, and the reversibility of ATP breakdown. Only good answers approaching full credit referred to ATP being an intermediate between energy yielding and energy requiring reactions, and the high turnover rate of ATP. Weaker responses frequently described the production of ATP during respiration, or reactions/processes in which ATP plays a role, rather than describing the molecular features of ATP itself.

(b) Candidates predominantly achieved credit on generic aspects of experimental investigations, such as using a water-bath to control temperature, assessing over a suitable temperature range, performing repeats and calculating means. However, the specifics of this investigation were frequently lacking in candidate responses. Whilst some candidates understood that methylene blue (or DCPIP) turns colourless during the investigations, and more specifically when reduced, few responses effectively described the assay setup, such as providing glucose as a respiratory substrate, the yeast needing to be in suspension, or how anaerobic conditions would be achieved. In some cases, candidates who suggested temperatures to test often did not give a minimum range of five reasonable temperatures. Weaker responses used the term average rather than mean, and a large number did not show how to calculate rate of respiration. Some candidates also incorrectly referred to the methylene blue changing colour rather than turning colourless. A number of responses confused this investigation with that of aerobic respiration and/or photosynthesis (e.g. use of an absorbent to remove carbon dioxide or measuring volume of gas produced). Some answers also merely described the molecular steps in anaerobic respiration, rather than the experimental investigation.

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Paper 9700/43
A Level Structured Questions

Key messages

Candidates should read all parts of the question carefully and be prepared to identify data trends and patterns and to make comparative judgements about data to derive meaning from scientific results. To access the highest grades, sound knowledge needs to be accompanied by application in suggesting reasons and explanations for observed trends.

General comments

Many candidates performed well throughout the paper. Weaker candidates were challenged most with data analysis, with correct use of biological terminology and with explaining their ideas clearly and unambiguously. The two major misconceptions demonstrated by many candidates occurred in **Questions 2(d)(i)** and **5(b)(i)**. **Questions 6(b)**, **6(c)(i)** and **7(a)** illustrated the need for candidates to refer to axis labels and table headings in full and to use appropriate units when quoting figures.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates named the type of protein shown by **Q** as a receptor. Incorrect answers seen included carrier, enzyme and G-protein.

(ii) Many identified **R** and **S** correctly as a proton pump and a calcium ion channel respectively. Some candidates were imprecise and referred to hydrogen and calcium instead of hydrogen ions and calcium ions.

(iii) Structure **T** could be identified as a phospholipid bilayer or as the cell surface membrane or equivalent (plasma membrane, plasmalemma). Many candidates wrote cell membrane only without specifying the type or location of this particular cell membrane.

(b) This question was very well done. The majority of candidates had excellent recall and understanding of the ion and water movements leading to stomatal closure. Occasional errors included writing stoma/stomata when in fact the guard cell rather than the pore was being referred to, and stating that the water potential in the guard cell decreased instead of increased as a result of changed ion movements, which led to subsequent errors such as more turgid guard cells. Some candidates showed misunderstanding of the term solute potential and its relation to the overall water potential of a cell.

Question 2

(a) Most candidates answered correctly. A minority of candidates missed out this question.

(b) (i) The features of homologous chromosomes that are the same (size, shape, banding pattern and gene loci) were not well known although many answers gained some credit. The commonest error was to state that homologous chromosomes are completely genetically identical, possessing the

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same alleles (rather than the same genes or loci). The vague idea of the homologous chromosomes having the same structure was not creditworthy but descriptions of how they have the same shape (centromere in the same position) were accepted. The term 'homologous chromosomes' was sometimes confused with sister chromatids.

(ii) The correct reasoning of halving the mouse diploid number stated in the question (40) to get 20 was followed by many. Some candidates did not use the question stem information about 2n being 40, and instead used **Fig. 2.1** and halved the number of chromosomes shown to get a wrong answer of 3. A few suggested 23 (the human haploid number).

(c) (i) Unsuccessful answers often focussed on the role of meiosis in producing genetic variation, which was not required. Attempts to explain the halving of chromosome number to make gametes and the restoration of the diploid number when gametes fuse at fertilisation often lacked detail and missed out on key points.

(ii) Candidates found it difficult to explain clearly that two gametes with each containing a recessive allele could fuse to produce an offspring or zygote with two recessive alleles that would therefore express the trait. Many partial or incomplete explanations were seen.

(d) (i) Most candidates gained credit for mentioning a stop codon. Many misunderstood the significance of this and stated that a stop codon halts transcription rather than translation.

(ii) Candidates found this question straightforward and most gained full credit.

Question 3

(a) Most candidates showed understanding of how to calculate a percentage increase but some did not select the appropriate figures from the bullet-pointed list. Another error was to divide by the increased figure of the treated child rather than to the baseline of the child who is not hGH-deficient.

(b) The roles and names of the basic enzymes used in genetic engineering were generally well known.

(c) Candidates found this question challenging although many gained some credit. The commonest fully correct answers related the small size of plasmids to their ease of entering new cells and the possession of marker genes to researchers being able to identify transformed cells. Some candidates who mentioned restriction sites gained credit for their explanation by stating that this allowed new DNA to be inserted into the plasmid.

(d) While many candidates understood the context of therapeutic proteins made by microbes being given to a patient, many answers confused this context with gene therapy (where new DNA is given to the patient so that they make the required proteins themselves). Good answers commonly stated that the proteins produced from recombinant bacteria had lower risks of causing disease and immune side effects, and that they could be produced in larger quantities or according to demand (compared to the same proteins extracted from people who had died).

(e) (i) Most answers were correct.

(ii) Most candidates showed some understanding of the binding of transcription factors to promoter sequences to enable or prevent the binding of RNA polymerase. Questions about eukaryotic control of gene expression should not be answered in the context of the *lac* operon.

(iii) Candidates found it difficult to apply their knowledge of bioinformatics to this example. Good answers mentioned comparing the gene sequences already identified as differing between patterns 1 and 2 with a pre-existing database to discover what these genes were or what their proteins did. It is likely that the microarray chip described in the question provided an identification of each gene but that a database would provide additional information about the role of the gene and its product. Credit was gained for referring to software programmes or algorithms that allow rapid searching or analysis of this type of data.

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Question 4

(a) Candidates frequently mentioned polygenes and the role of the environment, but many had difficulty explaining the idea that there are not discrete classes of phenotype in continuous variation.

(b) (i) Most stated the correct answer of directional selection. Natural selection was insufficiently precise. A few candidates wrote artificial selection or disruptive selection.

(ii) Candidates found this question accessible, with all creditworthy points being given frequently.

(c) Most candidates could make a correct reasoned suggestion.

Question 5

(a) Many answers showed excellent skills of analysis, teasing apart the information in **Table 5.1** to work out all the ways in which pollen transfer between the two plant species is prevented. While many candidates understood the data piecemeal, few recognised that this was an example of adaptation or specialisation of the plant species to their pollinators or vice-versa.

(b) (i) A widespread misconception was apparent in answers to this question. Many candidates thought that the chromosome numbers of two species capable of producing a fertile inter-species hybrid are the same so that the two gametes (one from each parent species) can fuse successfully to make the hybrid zygote. Correct answers showed understanding that the fertility of the hybrid depends on meiosis in the hybrid itself, and whether the two sets of chromosomes derived from parents of different species can pair up in prophase 1 to allow meiosis to proceed and produce viable gametes.

(ii) Candidates found this question more difficult. Stronger responses linked fewer seeds to a smaller F2 population and a reduced chance of a large population in each subsequent generation. Occasionally, candidates suggested that the hybrids were less well adapted to reproduce and perhaps phenotypically, to attract pollinators for example, and therefore were selected against in comparison to the better-adapted parent species.

Question 6

(a) (i) Most answers correctly identified the thylakoid membrane (or lamella or grana) as the location of photosystem II.

(ii) While many candidates described the role of photosystem II in light absorption as requested, others described later events such as electron transfer, photolysis and ATP synthesis.

(b) To describe the effects of cadmium ion concentration on the activity of photosystem II, candidates needed to compare the effects of the four concentrations at a single time point or activity maximum point. From this type of analysis many derived the correct overall trend that as concentration increased, activity decreased. Some also quoted a pair of figures in support and included units. Some instances of faulty reading of figures from the graph were seen and some candidates did not provide units.

(c) (i) Some candidates found it difficult to describe fully all aspects of the data, e.g. to stipulate the month as well as the type of lake (polluted or unpolluted) and the nature of the dependent variable (concentration of functional chlorophyll a) when making a point. Simple repetition of figures from the table was not creditworthy. Candidates gained more credit for making comparative descriptions (e.g. that one figure was higher than another, or the same as another) than for explanations for the patterns shown in the data.

(ii) Some answers stated that copper ions could be incorporated in chlorophyll molecules instead of magnesium ions.

(d) Candidates who concentrated on practical experimental details gained full credit for their descriptions. The ‘describe’ command word meant that explanations of how chromatography works were not needed. Some candidates did not realise that an extract from chloroplasts was the

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starting point and gained no credit for describing how to produce this extract. Weaker answers did not include the need to put the extract onto a (pencil) baseline, to place only the end of the chromatogram under the baseline into the solvent, to use a solvent rather than a solution or water, and to either cover the apparatus to prevent the solvent evaporating, or to stop the process when the solvent front reached a point below the very top of the paper.

Question 7

The role of gibberellin in barley seed germination was tested.

(a) Stronger answers quoted axis labels in full and read numerical coordinates from graph axes accurately. The command word 'describe' meant that candidates could gain credit for accurate descriptions of the two curves separately, and for comparing the two to describe an overall trend (rate of amylase production was higher with gibberellin than without). Some candidates could have gained further credit by including units, stating what the dependent variable was and specifying what point they were comparing, e.g. *y*-axis values from both lines taken at the same time, or *y*-axis values for both lines that represented maximum values.

(b) Most candidates gained credit here. The role of amylase in hydrolysing starch was well known, as was the use of glucose in respiration or to supply ATP. Few candidates mentioned that the amylase must move to the endosperm and there was little awareness that the embryo needs the starch breakdown products for growth.

(c)(i) Many candidates answered correctly, giving the symbol *Le*). Others simply stated any capital letter.

(ii) The role of the *Le* allele in coding for an enzyme that converts an inactive gibberellin precursor into an active form of gibberellin was not well known. Generally, candidates suggested that the allele coded for gibberellin, implying wrongly that gibberellin is a protein.

(iii) Many candidates attempted to describe the role of DELLA in gene expression. In fact, the question stem had summarised the DELLA-mediated effect of gibberellin to set the context and the question asked for the effects of the growth genes that were now being expressed. The minority of candidates who achieved full credit mentioned cell division and cell elongation.

Question 8

Candidates performed well on this short question on respiration, identifying key processes, structures and reactants.

Section B

Question 9

(a) Few candidates had a clear and correct knowledge of the features of viruses. Answers that confused viruses with prokaryotes and protoctists were common. Good answers generally covered points such as the protein coat, presence of DNA or RNA (but not both), lack of respiration or some other feature of metabolism, reproduction in a host cell and being non-living. A few answers linked viruses to obligate parasitism and disease and gave figures to show viruses are small in size.

(b) The commonest global non-governmental organisations mentioned were the IUCN, WWF and CITES. Well-known activities of these groups were fund-raising, education, listing or monitoring of endangered species and lobbying of governments to regulate trade in endangered species or to ban or restrict hunting of endangered species. Strong answers referred to particular endangered species and steps taken to protect them, including habitat-level conservation. The roles of individual zoos and botanic gardens or seed banks did not fit the global scope of the question. The most common incorrect organisations that were given included the World Health Organization and animal welfare charities that concentrate on improving conditions for domestic or farm animals.

Question 10

(a) Some candidates used general terms instead of those specific to the neuromuscular junction context (e.g. post-synaptic membrane and cytoplasm instead of sarcolemma/motor end plate and

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sarcoplasm), or confused terms relating to muscle cells (sarcolemma and sarcoplasmic reticulum for instance). Candidates needed to specify that entities such as calcium ions and sodium ions are ions, to use the correct symbols for ions (e.g. Ca^{2+}), and to state that ions move into or out of a compartment like the cytoplasm, sarcoplasm or sarcoplasmic reticulum cisternae and not into the membrane. The scope of the question meant that events in the pre-synaptic motor neurone and in the muscle cell as far as calcium ions binding to troponin should have been described. Some candidates only wrote about the post-synaptic events in the muscle, and some of these wrote about the sliding filament mechanism, which was not required.

(b) Knowledge of the mutant alleles that cause Huntington's disease and their effects on the phenotype was limited in many cases. The best-known facts were that Huntington's is a neurological disease that begins in middle age and impairs cognition and control of muscular movement. Candidates who knew something about the extra repeats of the triplet CAG often did not convey their meaning adequately, e.g. mistakes were made about a repeating CAG 'gene'. There was also confusion between referring to the extra repeats as a 'stutter' and a supposed phenotypic effect of vocal stuttering. The weakest answers reviewed mutation in general and then attempted to show how Huntington's disease is inherited (some stated it is recessive and sex-linked when in fact it is dominant and autosomal). Some candidates knew that more repeats correlate with an earlier onset of disease.

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Paper 9700/51
Planning, Analysis and Evaluation

Key messages

- When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow.
- When planning such investigations, it is not necessary to copy out all the information given in the question paper. The information provided should serve as the basis for developing the method asked for in the question.

General comments

The responses covered the full range of credit and there was no evidence that candidates were short of time on this paper.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to correctly state a hypothesis, linking an increase in temperature to an increase in carbon dioxide. Less successful attempts made reference to a change in carbon dioxide, rather than an increase. A few candidates gave a null hypothesis rather than a hypothesis.

(ii) Many candidates correctly identified the independent variable as temperature. Candidates need to be clear that the dependent variable is something that is measured, in this case the colour or pH of the solution, rather than the concentration of carbon dioxide. Credit was given for time taken for the solution to change to yellow/orange. A few candidates gave the same answer for both the independent and dependent variable and therefore could not gain credit for either.

(iii) There were many clear and detailed plans which gained credit. Less creditworthy responses tended to just copy out the basic procedure, which was not required. Candidates should use the basic information to develop a clear and logical scientific investigation to address the specific question regarding the effect of temperature on carbon dioxide production during respiration.

Many candidates chose to test at least five different temperatures and provided a method for doing this. Some candidates added details such as volumes of hydrogencarbonate indicator solution and *Chlorella* suspension rather than just stating they would standardise these. Many candidates correctly mentioned mixing the *Chlorella* and indicator together. In order to gain credit for this they needed to then identify when the end-point would be reached, either by recording the colour or pH after a set time or by recording the time taken for the solution to turn a stated colour or pH. Therefore, just stating they would record the time for a colour change did not gain credit.

Many excellent responses contained details about how to ensure the indicator solution was at the same starting pH by using the oxygen pump. Other candidates needed to include more detail, as it was unclear which pump was being added to which solution.

Many responses mentioned replicating the test a suitable number of times, but this was sometimes linked to calculating an average. It is important to use the term mean in scientific work. In this particular experiment, if the candidate had chosen to record either the time taken to reach a specific colour or had recorded a pH, credit was awarded for reference to calculating a mean.

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However, if the candidate had chosen to record the colour of the solution after a set time, calculating a mean was not appropriate, as you cannot calculate the mean of a colour.

Safety issues should be specific to the investigation or an assessment made of the risk. This investigation was low risk. Credit was given to responses which correctly identified that some people could be allergic to *Chlorella* and should therefore wear gloves or that hydrogencarbonate could be an irritant and gloves should be worn.

(b) (i) The correct answer was 1 divided by the time taken for a stated colour or pH to be reached. Since the question asked how to calculate rate, candidates needed to make reference to the time taken for the dependent variable, in this case the colour or pH of the solution, to appear.

(ii) Many candidates were able to correctly place temperature on the *x*-axis. Fewer were able to correctly label the *y*-axis. Candidates should use the information provided in the question when labelling axes. The label on the *y*-axis should have been rate of respiration which was stated in the question. Some candidates missed out units and therefore could not gain full credit. The majority of candidates were able to sketch a graph to show the expected result of the effect of temperature on the rate of respiration.

(c) (i) The majority of candidates gave the correct answer.

(ii) Some candidates showed a good understanding of the null hypothesis. These candidates realised that as the statistical test being used in the question was a Pearson's linear correlation, they therefore needed to refer to a correlation in their null hypothesis. A common error was to include the term 'difference', which was not relevant to this statistical test. A few answers included a description of the results rather than a null hypothesis. A common error was to state there is a 'correlation' or a 'relationship' – in other words to state the alternative hypothesis. Many other answers did not specify both variables.

(iii) Most candidates were able to state that a Pearson's linear correlation coefficient value of 0.85 indicated a positive correlation. Fewer were able to state that this suggested the correlation was strong. Credit was given to candidates who made reference to the fact that 0.85 was close to 1.0.

(iv) Careful study of **Table 1.1** was required for candidates to do well in this question. Candidates needed to consider the whole range of data and information provided in the question when asked to explain why the conclusion may not be valid. Successful responses referred to no replicates. Many candidates discussed that more intermediate cell densities should have been tested; to improve answers, candidates needed to make reference to the fact that it was the range of cell densities tested which needed expanding. Credit was also given for reference to the fact that there were fewer than the number of paired observations recommended for a Pearson's linear correlation test.

Question 2

(a) Candidates were asked to suggest a tissue in which the fungal pathogen could be found and to suggest a reason for their answer. Since the pathogen caused the leaf cells to lose turgor, the tissue selected should have been involved in water transport in some way. The most common correct answer was xylem as it transports water. Less successful attempts made reference to organelles, cells or organs, which were not credited due to the question specifically asking for a tissue.

(b) The majority of candidates successfully identified the reason why the results for the F2 generation were considered to be anomalous was that a ratio of 3:1 was expected. More successful candidates were able to suggest that the reason was due to interactions between genes. It was common to see references to mutations or miscounting which were not creditworthy.

(c) (i) There were some good responses here which showed a thorough understanding of the use of microarrays. The very best answers included details such as known sequences of single-stranded DNA being attached to the wells on the plates, mRNA from both the resistant and non-resistant plants being converted into cDNA and these cDNA molecules being labelled with different coloured fluorescent dyes which allows the presence of genes to be identified. Less successful attempts confused mRNA, DNA and cDNA and many did not highlight the need to use a different coloured dye for genetic material taken from the resistant and non-resistant plants.

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(ii) The vast majority of candidates were able to select the correct numbers from the table, although fewer expressed these numbers to their simplest form and therefore were unable to gain credit. Many candidates gave their answer to whole numbers as directed in the question.

(iii) Many candidates were able to calculate the percentage change correctly, with many rounding their answer correctly, i.e. to no more than one decimal place more than the raw data they were manipulating.

(iv) Candidates who ensured that they applied their answers to the specific data provided and used the column headings in tables to help guide their response were most likely to gain full credit. Successful responses compared the number of genes expressed in the resistant variety at 24 hours after infection with the fungal pathogen with number of genes expressed at 48 hours. Candidates who also compared the number of genes expressed by the resistant variety with the non-resistant variety at one particular time also went on to gain full credit.

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Key messages

To do well in this paper it is essential that candidates read carefully through the questions before starting to write their answers. The introductions to the questions contain information that needs to be understood to answer the questions successfully.

General comments

Responses covered the whole range of possible credit and there was no evidence that candidates were short of time to complete the paper. The ability to plan an experimental procedure is an area where careful understanding of the introductory material is particularly important.

Descriptive statistics, such as those in **Question 1(c)** involving standard deviation, standard error and 95% confidence intervals, was an area that candidates found more difficult.

Comments on specific questions

Question 1

(a) (i) This was generally well answered. A few candidates thought the independent variable was the type of yeast rather than its mass or the concentration of its suspension, underlining the importance of careful reading of all the preliminary information in the question. A number of candidates suggested the rate of respiration for the dependent variable rather than the absorbance or the colour of the suspension. This did not gain credit as respiration was not directly measured. A few suggested time for the colour change which was an incorrect response here.

(ii) Many good answers were seen but some responses gave variables that should have been standardised rather than those that clearly had been. The most common answers gaining full credit included temperature, time of incubation and volume of distilled water. Suggesting the same type of indicator and colorimeter also gained credit.

(iii) Few candidates were able to give a suitable control for the investigation. The living yeast should be replaced with something that would not respire but in other ways would mimic a yeast suspension. The best suggestion would be to use boiled yeast and there were some responses suggesting this. Others suggested an inert material like glass or plastic powder which also gained credit. In this situation just replacing yeast with distilled water would not be appropriate.

(iv) Many candidates gained full credit here. The most common error was to label the *x*-axis as yeast concentration, which was not what the question asked. A few responses showed the axes inverted.

(b) There were many well-structured and logically set out descriptions of a suitable method. It was important that the method described would realistically work and give appropriate results in line with the aim of the experiment asked for, which was to compare the respiration rate of the three listing all the possible variables and restating information straight from the question paper. Candidates should begin their response with the actual laboratory, procedure which should be set out as a series of correctly sequenced steps.

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Most responses stated that the mass of each type of yeast should be the same and added to a known volume of water (or volume of a stock suspension of yeast used should be the same). It was important to mention that a suitable vessel such as a flask or beaker would be used for the investigation. The volume and concentration of the nutrient solution also needed to be standardised. Some responses listed a range of concentrations for each type of yeast, which was not required. Having at least three replicates was usually mentioned but candidates must be sure to use the correct terminology. Most candidates appreciated that the risk was low or medium and if they described it as medium, identified yeast as a possible allergen or TTC as a possible irritant coupled with a suitable precaution.

(c) (i) Standard error was often confused with standard deviation. Successful answers explained that standard error shows how close the sample mean is to the true/population mean, distinguishing between the sample mean and the true mean.

(ii) Some candidates made very clear statements showing that they understood the idea that 95% of the repeated data would fall within these limits, or that the true mean lies within these confidence limits. Weaker responses discussed reliability or significance in a general way which did not answer the question. Responses that focused on linking the non-overlap of the confidence limits at 1,3 and 4 hours and explained that this shows that the means at those times can be considered reliable, gained credit if they also identified the times when no overlap occurred.

(iii) There were two aspects of the data which could be used to support the conclusion. Both the table and the graph showed the highest absorbance at the conditions given in the question. This was stated by most candidates. Few responses used the standard error or confidence limit values in support, for example in the graph at 4 hours the standard error bars at pH 6 do not overlap with the other pH values.

Question 2

(a) (i) The majority of candidates were able to calculate the percentage change for plant nurseries correctly. A few did not give their answer to the nearest whole number so did not gain full credit. Some candidates calculated the change for the total number of cases, which was not required.

(ii) Many good answers clearly identified woodland and roadsides as habitats where ash dieback had increased overall, whilst it had decreased overall in the other three environments. A few candidates gave only one example of each which did not answer the question. Suggesting explanations was less successful and a few candidates made no attempt. Good answers were able to link the chosen habitat to a positive idea as to why that habitat might show an increase or decrease in cases. For example, in woodland the density of trees might favour the spread of disease or the size of woodlands in general might make access for carrying out control methods more difficult. Examples of care that were accepted included ideas on screening plants for disease and destroying those found or trying potentially suitable treatments such as possible fungicides.

(b) (i) There were many good answers that concisely and accurately stated that the hybridisation relied on complementary base pairing. Some lost credit by omitting the word ‘bases’. Some candidates gave details of the overall process involved in microarray technology, which was not required.

(ii) In general, candidates made the link between the level of gene expression and the intensity or brightness of the fluorescence or colour. Weaker responses often did not make this link and mentioned fluorescence or colour without the idea of level.

(c) (i) There were many good responses giving the idea that as the trees were growing next to diseased trees and yet remained healthy, they must have some tolerance to dieback. Sampling these trees would allow the samples to be tested to find out what the genetic basis of this tolerance might be. Weaker responses suggested that it was to see if the healthy trees would catch the disease and that the healthy trees had been planted next to infected ones rather than that they were naturally growing there.

(ii) Many candidates gained maximum credit by describing two appropriate ideas. The most common suggestions were the varying ages sampled and the multiple locations chosen. The latter needed more than just ‘different location sampled’ to gain credit. Less commonly seen but equally creditworthy were the wide spread of sampling across Europe, the different sizes of the populations

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sampled and the fact that diseased and healthy trees were sampled. Some candidates described how a random or systematic method of choosing the trees to be sampled could be carried out, which was not required.

(iii) Many good answers were given suggesting that a numeric scale allowed easier analysis. This was often correctly explained in terms of calculations being carried out, computational handling of data or graphic representation. All of these would allow clear comparisons to be made. Incorrect responses suggested recording would be easier as the numeric scale would prevent subjective judgement of the degree of damage. The numeric scale would be applied to the data after the degree of damage had been assessed subjectively.

(d) (i) The correct answer of guanine or G was often stated. Many candidates confused the triplet codon with the base and so did not gain credit.

(ii) Many candidates were able to describe how the change in the base would change the structure of the protein produced and then linked this to a change in the function of the protein. Weaker responses described the change in the protein without relating this to a change in function.

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