BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The questions differentiated well.

Comments on specific questions

Question 3

The majority of candidates did not appreciate that some ribosomes are found in the nucleus. Indeed, some translation and transcription occurs in the nucleus.

Question 5

More than half of all candidates incorrectly thought that photosynthetic prokaryotes contain chloroplasts. There are no membrane bound organelles in prokaryotes.

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Question 10

Stronger candidates knew the correct locations of the bonds shown. Saturated fatty acids will not contain any double bonds between adjacent carbon atoms.

Question 13

Many candidates found this difficult. Heating the experiment up to 80 °C would cause the enzyme to gradually denature. The enzyme would initially work as in the first experiment, X, but as it is denatured no more product would be formed. Therefore A is correct.

Question 17

The majority of candidates did not appreciate that a chromatid is formed from a molecule of DNA.

Question 27

The vast majority of candidates found this difficult. Whilst hydrogen ions are actively transported out of the companion cell, this is to allow them to move back into the companion cell by passive diffusion which also moves sucrose into the companion cell by co-transport.

Question 31

The majority of candidates found this difficult and each option was chosen almost equally.

Question 32

A large majority of candidates were unable to understand the biochemistry of carbon dioxide release from haemoglobin in the red blood cells, resulting in few gaining credit.

Question 36

The majority of candidates found this difficult. Statement 1 is not currently relevant to the control of the spread of malaria. Statement 4 would explain why TB or measles might spread, but not malaria.

Question 37

The majority of candidates answered this correctly.

Question 38

T-lymphocytes can secrete cytokines. Cytotoxins are released by certain pathogens.

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Paper 9700/12
Multiple Choice

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

General comments

The questions differentiated well.

Comments on specific questions

Question 4

The majority of candidates were unable to process the information to obtain the correct answer, **C**. Candidates are expected to know how to calculate the area of a circle.

Question 9

The majority of weaker candidates incorrectly indicated that triglycerides contain a hydrophilic head and always contain unsaturated hydrocarbon tails.

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Question 10

The majority of candidates can identify the features of collagen.

Questions 12 and 13

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

Question 14

The majority of candidates incorrectly thought that the optimum temperature must be 50 °C. These results indicate that the enzyme works faster at 50 °C than at the other two higher temperatures. However there is no evidence about what happens at lower temperatures.

Question 15

The majority of candidates found this information difficult to process and each option was chosen almost equally.

Question 18

The majority of stronger candidates were able to process the information to work out what happens in this situation. However, weaker candidates found this difficult and each option was chosen almost equally.

Question 21

The majority of weaker candidates incorrectly indicated that bacteria or red blood cells can divide by mitosis. Both types of cells have no nucleus; indeed, red blood cells contain no chromosomes.

Questions 25, 26 and 30

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

Question 28

The majority of stronger candidates were able to process the information in the diagram and answered correctly.

Question 34

Almost half of all candidates thought that airway Q was a bronchus. However, the bronchus contains both ciliated cells and goblet cells; it is the bronchiole that contains ciliated cells, but very few goblet cells.

Question 38

The majority of weaker candidates incorrectly answered that antibiotics can prevent the spread of the viral disease measles.

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Paper 9700/13
Multiple Choice

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

General comments

The questions differentiated well.

Comments on specific questions

Question 2

The majority of weaker candidates did not know the size of a typical prokaryote, many thinking they were less than 30 nm, meaning they could only be seen using an electron microscope.

Question 6

Only two fifths of all candidates knew that the situation described only represented a systematic error.

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Question 8

The majority of weaker candidates incorrectly thought that the OH groups on carbon 2 in adjacent glucose molecules are on opposite sides of the cellulose molecule in order to form glycosidic bonds. The glycosidic bonds in cellulose are β-1,4.

Question 13

Almost half of all candidates were able to process the information provided in order to determine the K_m values.

Question 16

Just over half of all candidates incorrectly indicated that statement 1 was correct. However the results at 0.80 and 1.00 both involved a different piece of plant tissue and in each case they had lost water to the surrounding solution by osmosis.

Questions 20 and 28

Weaker candidates found these difficult and in each question each option was chosen almost equally.

Questions 22 and 26

These were answered correctly by the majority of stronger candidates.

Question 29

The majority of candidates found this difficult and were unable to answer correctly. The right atrium would have the lowest average pressure, followed by the veins.

Question 35

A third of the weaker candidates incorrectly indicated that the malarial pathogen is a prokaryote.

Question 39

The majority of candidates did not appreciate that all three statements about macrophages are correct.

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Paper 9700/21
AS Level Structured Questions

Key messages

- The direction of movement of water should be explained in terms of water potential and not in terms of concentration. Osmosis is the term that should be used when describing the movement of water across a partially permeable membrane, such as the tonoplast or the cell surface membrane. Hence, the movement of water vapour out through open stomata in **Question 2(a)(ii)** should be described as diffusion and not osmosis.

- Candidates need to be precise in a response that requires reference to the sequence of three nucleotides known as a DNA triplet (DNA codon), an mRNA codon or a tRNA anticodon. It should be made clear that a codon specifies a particular amino acid and that any particular tRNA with its anticodon will also be related to a specific amino acid. **Question 4(b)(i)** referred to a changed amino acid sequence as a result of a substitution mutation, which means that:
  - only one amino acid is different in the sequence
  - there has been a change in only one DNA triplet
  - only one codon of the transcribed mRNA molecule is different
  - a different tRNA will bring the different amino acid to the ribosome for the process of translation.

- In **Question 5(b)**, many candidates understood that the monoclonal antibody bound to a diseased cell could act as a non-self antigen to trigger an immune response. Candidates should understand that:
  - both B-lymphocytes and T-lymphocytes can be activated following recognition and binding to a specific antigen
  - only B-lymphocytes form plasma cells
  - plasma cells, and not T-lymphocytes, synthesise and secrete antibody.

General comments

Many candidates performed well on those questions requiring knowledge and understanding of syllabus learning outcomes, particularly in **Questions 4(a)** and **4(c)**. Generally only the strongest candidates overall performed well on **Question 3(d)**, **Question 5(a)(ii)** and **5(b)**: enzyme kinetics, use of monoclonal antibodies and autoimmune disease respectively. **Question 3(d)(ii)** was frequently left unanswered.

When observing transmission electron micrographs, it is of benefit to candidates to see a range of transmission and scanning electron micrographs of cells and cell structures. Candidates should not only be able to identify cell structures but should also take note of relative sizes of organelles. For example, in **Question 1(a)**, which used a transmission electron micrograph of part of an animal cell, many incorrectly interpreted structure **C** as a ribosome. **Question 2(a)(ii)** was a good example of the importance of being able to distinguish between the two command terms, describe and explain. Candidates were asked to explain how a named factor affected transpiration rate. Only some did this: many just gave a description. Generally, only the candidates who did well overall were able to answer **Question 3(d)** correctly, with only a few understanding how to determine K_m from a graph.

There were many good answers seen for **Question 4(c)**. This was an extended response question which asked candidates to discuss the consequences of multiple resistance for health authorities and showed that many are aware of the problems and issues arising from the phenomenon of multiple antibiotic resistance. Most of **Question 5** was based on material newly introduced to the syllabus for 2016 onwards. In **Question 5(a)(ii)** many thought that treatment with monoclonal antibody was similar to being given a passive vaccine. Most candidates found **Question 6(a)**, based on the gas exchange system, to be more accessible than **Question 6(c)**, which required knowledge of the carriage of oxygen and an understanding of the oxygen dissociation curve of haemoglobin.

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Comments on specific questions

Question 1

This question assessed candidate knowledge with understanding of learning outcomes from syllabus ***Topic 1***, ***4*** and ***6***.

(a) The majority of candidates were able to correctly identify structures **A** and **B**. Structure **A** was the nuclear envelope, which was clearly visible in the transmission electron micrograph. Nucleus was also accepted. The label line did not point to a nuclear pore. The internal structure of the mitochondrion of **B** was shown and helped candidates to identify this organelle, although some had not paid attention to the introduction stating that **Fig. 1.1** was an animal cell and incorrectly gave chloroplast as their answer. Structure **C** was least well identified, with quite a few naming **C** as a ribosome or as an air space.

(b) A wide variety of answers was seen. Of those who gained credit, some used the labelling in **Fig. 1.1** and chose correctly the cell surface membrane, while others knew that ribosomes were also found in prokaryotes. Many candidates incorrectly stated mitochondrion or nucleus as their response.

(c) Some gave all the points expected for the role of centrioles in mitosis. Not all realised that (because of replication during late interphase) there are two pairs of centrioles involved in mitosis, with each pair migrating to opposite poles during prophase. Many indicated that only one centriole was located at each pole, while others stated that migration occurred during metaphase. The most common correct idea was that centrioles were involved in forming the spindle or spindle fibres, although some also went on to explain that centrioles serve as microtubule organising centres. Stronger responses were clear in explaining the importance of centrioles in facilitating the contraction of spindle fibres during anaphase so that sister chromatids were separated and moved towards opposite poles. Some responses showed more confusion and suggested that centrioles were directly responsible for the movement, while others were vague and described chromosomes separating.

(d) Although there were some excellent responses seen, there were many who incorrectly stated that ions are polar, rather than charged, and that ions are too large to cross the membrane, rather than being unable to cross the hydrophobic core of the phospholipid bilayer. Good answers, when referring to the transport proteins involved in the two stated transport mechanisms, were precise in their descriptions. These included knowledge that: channel proteins are only associated with facilitated diffusion; carrier proteins are involved in both active transport and facilitated diffusion; only active transport involves movement of the ions against the concentration gradient (through carrier proteins).

Question 2

This question required good knowledge and understanding of Transport in plants, ***Topic 7***. In **Question 2(b)**, an understanding of hydrogen bonding (from ***Topic 2***) would have helped candidates consider the movement of water through the xylem.

(a) (i) There were only some candidates who gave all the features expected in a definition of transpiration. It was common for the location of transpiration to be missed, the aerial parts of a plant or the leaves. Many understood that it was water loss from the plant but were not accurate in stating that it was water vapour that was lost. Some used incorrect terminology and described evaporation from the leaf or evaporation from or through stomata, or movement of water vapour through stomata by osmosis. A number of weaker responses defined perspiration rather than transpiration.

(ii) All the factors affecting transpiration rate were seen, with temperature and humidity being the most common. Light as a factor was not sufficient to gain credit: light intensity was given by some. It was less easy to gain credit for the explanation and generally only candidates who did well overall gave a response which was an explanation of the required depth. Those who did not gain credit began by providing a description of how the rate would be altered. These could have improved by then explaining how the factor affected the rate. For those stating light intensity as a factor, very few understood that an increase in light intensity led to stomata opening more widely and most stated that more stomata opened.

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(b) The link between hydrogen bonding and the properties of adhesion and cohesion in water movement through xylem was generally well known. The property of cohesion between water molecules was usually well described. The explanation of water movement involving adhesion was less precise, with only some describing the attraction of water molecules to the lining of the xylem walls, or to the cellulose of the xylem walls. Much of lignin is hydrophobic, so only those candidates who described adhesion of water to the hydrophilic parts of lignin were credited. There were a number who used the two terms the wrong way round: a good description was not penalised for this, but the candidate was not able to gain a mark for the correct use of the two terms.

Question 3

The enzyme lysozyme was used as an unfamiliar example to assess syllabus ***Topics 2*** and ***3***. **Question 3(d)** was the most challenging section of this question for most candidates.

(a) (i) Both types of bond, peptide and disulfide, were required to gain the mark. Some did not notice that two types were required and only named one bond type. Common incorrect responses stated one of the two correct bonds and paired this with hydrogen bonds. 'Peptidic' and 'sulfide' bond were not accepted.

(ii) In this question, it was insufficient to state that primary structure was a chain of amino acids. Candidates also needed to show understanding that the primary structure was the sequence of amino acids in the polypeptide chain.

(b) (i) To gain credit, both the idea of using water and breaking a bond was required. Many knew of the involvement of water but were too vague in stating that water was used to break up a molecule. Very weak responses described condensation or explained that hydrolysis meant that water was split.

(ii) Some candidates knew that peptidoglycan (murein) was a component of bacterial cell walls and had no problems answering this question. Others gained credit by recognising 'glycosidic bonds' in the introduction to **Question 3(b)** to suggest carbohydrate. Most of the incorrect responses stated protein as the molecule.

(iii) Many candidates showed an understanding that the induced fit mechanism involved a change in the shape of the active site on entry of the substrate. Fewer were accurate in describing how this change produced a better fit so that the two were exactly complementary. A number wrote about the enzyme changing the shape of the substrate to allow binding but did not mention the active site shape change. Some gained full credit and completed their response by stating that the binding allowed the formation of the enzyme-substrate complex or gave some detail about how activation energy was lowered. A number of weak responses gave an account of the lock and key mechanism. In these cases it was sometimes possible to gain credit with knowledge that an enzyme-substrate complex formed.

(c) While many knew what was meant by the term extracellular, there was also a wide range of incorrect answers seen. The most common of these were: an addition to the cell; not needed by a cell; not necessary to a cell but present within the cell; an addition to the diet as it cannot be made by the cell; an extra function carried out by a cell; the process of exiting a cell.

(d) (i) Most understood what was mean by V_{max}, but quite a few omitted the units mmol or gave the wrong units, either mol or $\mu mol\ min^{-1}$, and so could not be given credit.

(ii) For those candidates who attempted this question, some remembered to work out $\frac{1}{2}V_{max}$ and gave this as the value of the Michaelis-Menten constant. Only a few remembered that the constant is a substrate concentration and used the $\frac{1}{2}V_{max}$ value and **Fig. 3.2** to arrive at 1 mmol.

(e) Most knew that the curve would be to the right of the curve of **Fig. 3.2**. Quite a few drew a plateau far lower than that of the printed curve and so only gained one mark.

Question 4

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This question used cholera as a theme and was based on ***Topics 6*** and ***10*****. Question 4(b)(ii)** was challenging for many and required a number of steps in the thought process.

(a) (i) The full species name for the causative bacterium, with the correct spelling, was credited. The majority of weaker candidates left this part blank. Others gave the causative organisms for malaria or tuberculosis or named *Escherichia coli*. Many had a vague idea of the actual species name but were unable to spell it correctly: 'Vibro' was commonly seen, as was 'cholera'. A number just stated 'Cholerae'.

(ii) The best responses were concise and precise. These described how the infected person could pass out the pathogen and how the pathogen could infect the healthy person. It was more common for a response to omit how the pathogen gained entry to the uninfected person. Stating that water was contaminated with the pathogen was not sufficient to explain transmission: good responses went on to describe ingestion of contaminated food or drink. The weakest responses described transmission of one of the other infectious diseases in ***Topic 10***.

(iii) Most candidates were able to gain credit here, showing a good understanding of how a natural disaster would increase the incidence of cholera. The range of expected answers was seen, with the most common points relating to problems with sewage or water treatment systems.

(b) (i) Stronger candidates understood that a base substitution would produce a different mRNA codon and that this may then lead to only one amino acid changed in the polypeptide during translation, when a different tRNA would bring a different amino acid. Others missed this point and gave explanations that ended in a totally different amino acid sequence or a different protein. There were numerous incorrect accounts of a substitution being a change in the genetic code.

(ii) There were a number of ideas that needed to be put into place in order to answer this question. Candidates needed to consider that: a change in an amino acid sequence could lead to a change in the organisation of protein structure; resistance to the antibiotic could mean that the antibiotic could no longer interact with the enzyme; a change in the structure of the enzyme could not alter its ability to act as a biological catalyst and hence the active site could not be altered.

(c) Most candidates attempted this part, and of these, almost all gained some credit. Some accounts were very well expressed, with the discussion moving from one idea to the next in a logical manner. Weaker responses were less organised and did not separate ideas out into different points. The full range of points were made, with the most common focusing on a possible increase in death rates and the risks of spread of the disease owing to unsuccessful treatment.

Question 5

Generally, those candidates who did well on this question, assessing ***Topic 11***, were those who performed well overall. Many others had difficulty understanding how monoclonal antibodies could be used therapeutically and a large number did not know what was meant by autoimmune disease.

(a) (i) Candidates used their knowledge of antibody structure and function to name the antigen binding site as the correct answer. 'Binding site' was not given credit. The most common incorrect answer was 'receptor', with 'hinge region' also stated by some.

(ii) There were some candidates who realised that the attached monoclonal antibody acted as a non-self antigen. The quality of the responses describing the immune response to this antigen was very varied and only some correctly described the events that occurred and understood the functions of the various immune system cells involved in the response. Some were too vague to be given credit. Some did not answer the question about the monoclonal antibody and described a response to a pathogen instead. Others believed that the monoclonal antibody was directly responsible for the destruction of the diseased cell and gave a variety of suggestions as to how the antibody could kill the cell. These responses were unable to gain credit.

(b) Some candidates were able to give a good explanation of auto-immune disease. Others had the correct ideas but were too vague and did not use the terms self, non-self or foreign. Incorrect explanations included: automatic immunity to a disease without needing an immune response; a shutting down of the immune system; a disease that affects the immune system; and an inability of the immune system to recognise foreign antigens.

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Question 6

This question assessed knowledge with understanding of syllabus ***Topics 8*** and ***9***.

(a) To gain full credit, each row of **Table 6.1** had to be completed correctly. Many knew that the trachea contained cartilage, but were less confident about whether cilia or elastic fibres were present. A number may have mistaken bronchioles for bronchi and thought that cartilage was present in these structures. Most candidates realised that the alveoli only contained elastic fibres, so this row was the one that was most frequently correctly completed.

(b) The best responses were precise in their descriptions of the changes that occurred in the bronchi and went on to relate these changes to increased risk of bacterial infection. Few noted the formation of scar tissue or the enlarged size of goblet cells, with most describing the loss of cilia and the increased production of mucus. Good responses showed an understanding that it is mucus and not cilia that trap bacteria.

(c) Of those gaining credit, the majority focused on how an increased partial pressure of carbon dioxide contributed to the release of oxygen from oxyhaemoglobin. This is only important when tissue is very actively respiring. Fewer wrote about the situation in normally respiring tissues to describe how oxygen used up in aerobic respiration would lead to a low partial pressure of oxygen, and how this condition would cause the dissociation of oxygen. Weaker responses described the diffusion of oxygen or gave very general accounts which stated that oxygen would leave the red blood cells to go to the respiring tissue.

(d) Many candidates understood that red blood cells are too large to enter tissue fluid. Additional detail was required to gain credit and some did go on to explain that they were too big to pass through the endothelial pores of the capillaries. There was considerable variation in ideas put forward by others, for example, stating that red blood cells needed to travel in blood and not tissue fluid, or that tissue fluid did not need the oxygen carried by red blood cells. Some indicated that tissue fluid was part of the lymph system.

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Paper 9700/22
AS Level Structured Questions

Key messages

- When answering questions about immunity, such as **Question 5(c)**, candidates should understand that:
  - a vaccine intended to provide active immunity contains specific antigen and not antibody
  - both B-lymphocytes and T-lymphocytes can be activated following recognition and binding to specific antigen
  - only B-lymphocytes form plasma cells
  - plasma cells synthesise and secrete antibody, not T-lymphocytes
  - it is the presence of antigen-specific memory cells that allows a more rapid secondary immune response, and not the presence of antibody secreted from the plasma cells of the primary immune response.

- Candidates need to be precise in a response that requires reference to DNA triplets (DNA codons), mRNA codons or tRNA anticodons. It should be made clear that a particular amino acid is specified by a sequence of three nucleotides. Candidates should be familiar with the features of the genetic code and should be able to use a genetic code, as in **Question 3(d).** For any one mRNA codon, candidates should be able to work out the corresponding tRNA anticodon and the two corresponding DNA triplets (the non-template strand and the strand used as the template for transcription, complementary to the mRNA codon). The tRNA anticodon should be described as complementary to the mRNA codon.

- In **Question 2**, the direction of movement of water should have been explained in terms of water potential and not in terms of concentration. Osmosis is the term that is used when describing the movement of water across a partially permeable membrane, such as the tonoplast or the cell surface membrane. Mass flow in phloem sieve tubes should be explained in terms of hydrostatic pressure difference and not water potential difference.

General comments

Some candidates were extremely well prepared for this examination and very knowledgeable of the syllabus learning outcomes. Others missed information that would have helped avoid errors. For example, in **Question 3**, candidates were told that the glucose isomerase used in the commercial process was extracted from bacteria, yet many answered **Question 3(b)** in terms of using the bacterium. In **Question 6(b)**, candidates needed to make the correct links between the information given and the syllabus learning outcomes and to be sure that they had not missed anything that would help their answers. For example, the relevant information for the answer to **Question 6 (b)(iii)**, lysosomes, were 'membrane-bound cell structures' and 'containing hydrolytic enzymes'. Some did not use this information, describing the granules in the cell types, and made incorrect suggestions based only on **Fig. 6.2**.

In **Question 1** only one cell structure should have been stated for each of descriptions **A** to **E**. Candidates gained no credit if their answer contained a choice of two cell structures. In **Question 2(a)(ii)** there were many answers that showed both knowledge and good understanding of osmosis and diffusion. Some candidates incorrectly continued to answer **Question 2(b)** in terms of the tubing and not in terms of translocation in phloem. In **Question 3(c)** there was evidence that some candidates found data extraction and interpretation a challenge. Two common errors from incorrect extraction from the graph were to state that pH 6 was pH 0 and to get the labelling of the two curves the wrong way around. Some candidates gave very little description and mostly explained the curve, which was not required. Those who did well used comparative language and only described differences: those who gave similarities were not answering the question. Candidates were not expected to have any direct knowledge of the renal artery in **Question 4**, but to apply knowledge of the structure of arteries and to relate the structure to the function of arteries. In **Question 4(c)**, many candidates would have benefitted from checking whether they thought their calculated

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answer was a reasonable figure. **Question 5** showed that some candidates needed a better understanding of what is meant by a non-infectious disease. Many weaker responses incorrectly used the terms infectious, infected, non-infected and pathogens within a response aimed at explaining what is meant by a non-infectious disease.

Comments on specific questions

Question 1

This question assessed knowledge of learning outcomes from syllabus ***Topics 1*** and ***5***. Many candidates gained some credit, with fewer gaining full credit.

Description **A** was well known as the chloroplast. The most common incorrect answer was the mitochondrion, even though the description stated 'absent in animal cells'. Incorrect answers for description **B** generally stated the cell membrane or cell surface membrane as the answer. Centrioles, which are present throughout the cell cycle and are only seen in animal cells, were commonly incorrectly stated for description **C**, the spindle, or spindle fibres. Kinetochores was also given by some, but not credited as these are complexes of proteins with microtubules. Although 'cell wall' was allowed for description **D**, the best responses were precise and correctly linked this with the prokaryotic or bacterial cell wall. In **E** many gave the rough endoplasmic reticulum as the answer, rather than the nucleolus. This may have been because they were thinking about the joining together of the large and small ribosomal subunits at the beginning of translation, but this occurs in the cytoplasm before the whole complex binds to the rough endoplasmic reticulum.

Question 2

In this question, based on syllabus ***Topics 2***, ***4*** and ***7***, a good understanding was required of the principles of transport mechanisms, both across membranes and from one area to another in translocation in plants. Candidates should be encouraged to consider the direction of movement of water in terms of water potential. The membrane should only be described as partially or selectively permeable and candidates should avoid using the term semi-permeable.

(a) (i) Most knew that the tubing would appear more swollen after 20 minutes. A few, who understood that water would enter the tubing, stated incorrectly that the tubing would burst. Some did not add to **Fig. 2.1** but did answer **Question 2(a)(ii)**.

(ii) This was frequently comprehensively answered, with the best responses considering both water and sucrose and noting the partially permeable nature of the Visking tubing. The majority knew that water would enter the tubing, with most of these stating osmosis as the mechanism of entry. There were still quite a few that explained this in terms of the concentration of water molecules, which was not credited. Some gave correct explanations but only stated that the mass would change, rather than state it would increase, while others did not mention mass and stated that the size or volume would increase. Those who mistakenly believed the tubing would not change mass, generally went on to explain incorrectly that movement out of sucrose would balance movement in of water.

(b) Those who gave the best responses explained in a sequential manner, beginning with the entry of sucrose into phloem sieve tubes as the reason for the entry of water and showing a good understanding of the hydrostatic pressure increase at the source and the pressure gradient that is established for mass flow. It was not necessary to explain the mode of entry of sucrose into the companion cell, as many did. Some did not mention the phloem sieve tube and explained everything in terms of the companion cell. Others were too vague and did not state the location for the sap and the entry of water. Some suggested that phloem sap entered the sieve tubes from the companion cells. Not all were clear that some events occurred at the source and some at the sink. Those candidates who described the mass flow of phloem sap in terms of water potential gradients rather than hydrostatic pressure gradients gained only partial credit. The weakest responses explained that movement by mass flow was osmosis or gave an explanation of movement in the xylem tissue.

(c) A high proportion produced excellent diagrams of the dipeptide formed, including showing a molecule of water given off. A number contradicted their diagram by stating that this was a hydrolysis reaction, so could not be given the mark for the production of water. Some weak

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responses stated that a glycosidic bond formed, despite being told in the question that this was the formation of a peptide bond.

Question 3

This question used the production of high fructose corn syrup as an unfamiliar context to assess syllabus ***Topics 2***, ***3*** and ***6***.

(a) This part was challenging for many. The majority of candidates who gained credit showed an understanding that sucrose was a disaccharide and fructose a monosaccharide. Those who gained full credit generally stated that sucrose had a glycosidic bond. Where candidates gave the monomers of sucrose, many were incorrect, with some giving another disaccharide as one of the monomers. Stating that sucrose was a non-reducing sugar was not a structural difference. There were numerous weak and incorrect answers, such as: sucrose is a hexose and fructose is a pentose sugar; sucrose has α-glucose and fructose β-glucose; both are disaccharides but fructose stated as being composed of two glucoses. A number gave features as if they were comparing α-glucose and β-glucose, or starch and cellulose, or amylose and amylopectin.

(b) There were some very well considered responses to this question. The best answers made it clear whether they were referring to the glucose isomerase with an optimum temperature of 37 °C or the enzyme from *T. thermophilus* and approached their response from the point of view of the commercial production of high fructose corn syrup. Not all did this and some gave a response stating and explaining features of an enzyme with a high optimum temperature and/or a low optimum. The weakest responses showed incomplete understanding and there were references to the reaction occurring in hot springs or in hot countries, or references to the bacteria present in commercial production.

(c) Many answered the question correctly and only described differences between the free and immobilised enzymes. Those gaining full credit remembered to state pH and percentage activity when giving correct data quotes and also gave values and descriptive sentences that were direct comparisons. A number gave both similarities and differences, which was not required, while others did not concentrate on describing, but suggested explanations for the differences. Using the terms 'at the start' or 'at the end' for pH 6 and pH 9 were not credited. Some focused on the downward curve of the enzyme free in solution and deduced incorrectly that the range of activity of immobilised enzyme was greater for the range of pH tested. Although explanations were not required, it was clear that many were using the term denaturation in the context of denaturation that occurs in high temperatures and did not understand how changing pH affects enzyme activity. A number of candidates wrote about temperature rather than pH.

(d) (i) Candidates used a genetic code of mRNA codons, which was very accessible to most and was usually correctly answered.

(ii) This part was not well considered by many candidates, who described translation rather than considered the features of the genetic code. **Table 3.2** may have alerted some candidates to the fact that generally more than one codon specifies a particular amino acid and they were able to gain credit from this starting point. Fewer stated that the genetic code is degenerate or explained that there were 64 codons but only 20 amino acids. Others did not make this link and hence a wide range of incorrect responses was seen. Many gave a description of either transcription or translation. Others suggested mutations had occurred. Some thought that bacteria would have a different genetic code, showing a lack of understanding of the universal nature of the code.

Question 4

This question was based mainly on ***Topic 8***, with **Question 4(d)** requiring candidates to apply knowledge and understanding of the properties of water from ***Topic 2***, to consider water as the main component of plasma.

(a) Most candidates gained credit here, with the majority stating correctly that a thick tunica media could be seen. Narrow lumen was credited, although the more precise answer of a narrow lumen in relation to the thickness of the wall was seen in better answers.

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(b) To do well in this question, there needed to be some detail of the basic histology of the tunica media to relate to the function of the artery. Many mentioned both smooth muscle and elastic tissue in the tunica media. It was important to understand that muscle contracts and relaxes and elastic tissue stretches and recoils. Quite a few got this the wrong way around or gave mixed descriptions. Some also noted the presence of cartilage in the tunica media. Many knew that these features helped to prevent rupture of the blood vessel owing to the high pressure of blood flowing through it: fewer gave one or more of the other points expected. Some had not noted that the question was about the tunica media and mentioned the tunica intima or tunica externa. Some candidates incorrectly described rupture as collapse.

(c) Many candidates were able to gain some credit, often for having written an acceptable formula for calculating magnification. Many gave a much-abbreviated formula and unless the measurements taken were shown in the calculation, this could not always be credited. There was considerable flexibility in the measurement to take account of the end bars of **X—Y**. Despite this some did not give a sufficiently accurate measurement, while others measured the thickness of the tunica media or the entire diameter up to the transition with the tunica externa. Although the calculation was checked for accuracy, the final magnification stated should have rounded to at least one decimal place, if not a whole number. Some candidates felt it necessary to multiply their answer by 100 or by 1000: the reason for this was unclear.

(d) There were many good answers to this question, with the relevant and correct properties of water stated, accompanied by further details in relation to plasma. While many understood what was required, a number were too vague or gave mixed terms such as 'high latent heat' or 'high vaporisation capacity'. Terms such as solvent, solute, dissolve and soluble were also sometimes muddled, with water being described as soluble or dissolved. Others were less clear as to what could dissolve in water and some suggested that blood cells could dissolve. Some gave properties of water that did not link to plasma, such as surface tension and animals being able to swim on water, or adhesion of water molecules to the lining of xylem vessels. This highlights the importance of checking that the answer matches the question asked.

Question 5

Both infectious disease and non-infectious disease appeared in **Question 5**. There were some excellent extended responses in **Question 5(a)(ii)**. Syllabus material from ***Topics 10*** and ***11*** was assessed in this question.

(a) (i) A very wide range of acceptable responses was seen for the explanation of non-infectious disease. Some of the best answers were concise and avoided ambiguity. Examples of ambiguous answers for non-infectious included stating that the disease was not transmissible, but continuing with 'by air or contaminated food' for example, opening up the consideration that this could be a disease transmitted by another means. The answer lines were set out to try to remind the candidates that they also needed to explain the 'disease' part of non-infectious disease to gain full credit. Some candidates did not explain this in terms of non-infectious and wrote about pathogens and infection.

(ii) There were many answers that gave very clear and knowledgeable accounts here. These frequently included showing a good understanding of mutation and knowing the types of genes involved. Uncontrolled mitosis was usually stated and many qualified further with an explanation in terms of cell signalling or checkpoints. Some candidates were also aware of the changes that occur in cancer cells, most usually stating a lack of differentiation, inability to show apoptosis and a lack of function (of the tissue of origin). Some interpreted the question to include changes that caused the development of a blood supply for the cancer cells and this was credited. A description of metastasis was not required. A number of weaker wrote about changes in the gas exchange system for a person who smokes.

(b) (i) The type of pathogen represented by **B** in **Fig. 5.1** was usually correct. Many also gained credit for **A**, although protoctist was frequently misspelt. A significant number stated *Plasmodium* despite this being given in the causative organism row of **Fig. 5.1**.

(ii) Many knew that measles and TB were transmitted in the same way and realised that this mode of transmission was already concisely stated in **Fig. 5.1** as aerosol infection. Others gained credit for correctly stating airborne droplets or droplet infection. Just stating 'in the air' or 'airborne' or 'coughing and sneezing' was insufficient.

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(iii) This was usually well known. The most common incorrect answers were chicken pox or giving a choice between smallpox and chicken pox, which was not credited.

(iv) The spelling of *Morbillivirus* should be correct. Some candidates were very close and gained credit. There were many that were incorrect and microvirus, microbillivirus and microvillivirus were often seen. Some wrote only 'virus' which is the type of pathogen and not the causative organism.

(c) Although full credit could be gained with an accurate account of the principles behind vaccination and immunity, the best responses showed a good understanding of the importance of herd immunity and breaking the transmission cycle of an infectious disease. Some gave too much detail about the events occurring during an immune response and then did not answer in terms of vaccination and providing immunity to individuals and the population. Good accounts did not confuse active artificial immunity, upon which the control of infectious diseases is based, with passive artificial immunity. They were clear that memory cells remain after a primary response, rather than antibodies. When stating or describing a secondary immune response, candidates need to be clear that this is in response to the presence of the pathogen with its specific antigens. Many stated 'disease' or 'infection' being present.

Question 6

The mitotic cell cycle was well known by many candidates. The information in the introduction for **Question 6(b)** and **(c)** needed to be considered and for links to be made with the relevant syllabus learning outcomes.

(a) (i) This was frequently all correct. Nuclear division for **J** could only be credited if it was indicated that this was a mitotic, rather than a meiotic division. Some thought that the cell cycle depicted only mitosis, so gave the three phases of interphase. Other weak responses stated phases of mitosis only.

(ii) This was generally well known. The most common incorrect responses were prophase or transcription.

(b) (i) Most correctly stated bone marrow. The most common incorrect responses were spleen, thymus and liver.

(ii) **Fig. 6.2** showed the development of the shape and size of the nucleus of a neutrophil. Many were aware of the shape of the nucleus of the mature neutrophil and generally stated 'lobed' as their response, although this was not always spelled correctly. 'Looped' could not be credited. Those who did not gain credit chose one of the descriptions in the figure to repeat as their answer.

(iii) Candidates were told that the granules described in **Fig. 6.2** contained hydrolytic enzymes and many candidates took this clue to name the structures as lysosomes. Those that did not gain credit named other cell structures, the most common being ribosomes.

(c) (i) The best responses showed an understanding that the neutrophil was a phagocyte and that the bacteria would need to be inside the cell (in a phagocytic vacuole) before the lysosomes containing defensins fused to the vacuole to release their contents. Candidates needed to explain that chemicals that cause pores in the membrane would lead to the membrane losing its partially permeable nature. Some realised the importance of the integrity of the membrane for the survival of the cell and knew leakage of the cell contents would cause death, making it unnecessary for other chemicals produced by the neutrophil to enter the cell. It was not correct to state that the bacterial cell would gain water and burst as the cell wall was still intact. Some suggested a different function for defensins, for example stating that defensins attached to the cell surface membrane of bacteria and acted either as opsonising agents or to activate B-lymphocytes or T-lymphocytes in an immune response. Some very weak responses thought that the pores would be large enough for neutrophils to gain entry into the bacterial cell.

(ii) It was important in this question to know that peptidoglycan is a component of a bacterial cell wall and to distinguish between the two terms lysosome and lysozyme. Many candidates incorrectly described the role of the lysosome and/or its hydrolytic enzymes, writing about phagocytosis or giving general descriptions of the digestion of the bacterial cell components. There were some who suggested peptidoglycan was a component of the cell surface membrane. Some described the mode of action of an enzyme and did not progress to suggest that the cell wall would be weakened and that this would cause osmotic lysis of the cell.

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Paper 9700/23
AS Level Structured Questions

Key messages

- In **Question 3(b)**, the direction of movement of water should be explained in terms of water potential and not in terms of concentration. Osmosis is the term that should be used when describing the movement of water across a partially permeable membrane, such as the tonoplast or the cell surface membrane. Hence, the movement of water via plasmodesmata in the symplast pathway or the movement of water via cell walls in the apoplast pathway should not be described as osmosis as there are no membranes involved.

- Candidates need to be clear in their understanding of DNA triplets (DNA codons), mRNA codons and tRNA anticodons. In **Question 4(b)** a number of candidates confused a codon with an anticodon. Candidates should know that a particular amino acid is specified by a sequence of three nucleotides. The tRNA anticodon should be described as complementary to the mRNA codon. Candidates should know the locations of transcription and translation in eukaryotic cells. In **Question 4(c)**, candidates were told that tRNA is synthesised in the nucleus, which should have guided them to consider the process of transcription.

- For **Question 6(b)**, candidates should understand that both B-lymphocytes and T-lymphocytes can be activated following recognition and binding to the specific antigen that has previously been introduced into the body by the measles vaccine. In addition, candidates should know that only B-lymphocytes form plasma cells and that it is plasma cells that synthesise and secrete antibody, not T-lymphocytes.

- When taking data from graphs or tables, candidates should always give all units where appropriate. For example, in **Question 2(b)(i)** the units for inhibitor and product concentration were given in μM and time in minutes.

General Comments

In **Question 2(b)(i)** candidates were generally very good at identifying the two major trends and using appropriate vocabulary to describe them. Words such as *increase* and *decrease* are the most appropriate in such instances. In both this question and in **Question 6(b)**, candidates made good use of the data provided on the graphs. Units were often used correctly for data that was quoted from **Fig. 2.1**. Many could have improved their answer for **Question 2(b)(i)** by stating that the final concentrations of PABA were recorded at 60 minutes.

Some questions required candidates to adapt rehearsed answers and some were able to do this. For example, **Question 4(c)** asked candidates to outline how tRNA is produced. Many gave details of transcription, with the best responses stating that tRNA was produced: many, however, stated that mRNA is produced. Amongst incorrect responses, some candidates suggested that polypeptides are produced direct from template DNA in their answers. Candidates who wrote about mRNA usually gained some credit. This highlights the importance of reading questions carefully and then re-reading them before completing an answer.

Almost all candidates identified the Bohr effect in **Question 5(c)**. However, fewer showed that they had understood that they were asked to explain the effect of the increase in the partial pressure of carbon dioxide, rather than the effect of the decrease in the partial pressure of oxygen.

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Comments on Specific Questions

Question 1

This question assessed candidate knowledge and understanding of biological molecules and of membrane structure and function from syllabus ***Sections 2***, ***4*** and ***6***.

(a) Many candidates gained full credit by putting ticks into the correct boxes in **Table 1.1**. Common errors included indicating that:

- amylopectin is found in both animal and plant cells
- cellulose is a branched polymer
- RNA is synthesised from amino acids
- polypeptides are not synthesised from amino acids.

(b) A few candidates took the opportunity to label the diagram of the phospholipid molecule. These indicated that the molecule has a hydrophilic head and hydrophobic tail, but only some of these stated here or in their text that the head is a phosphate head or that the tails are fatty acids or hydrocarbon chains. Good answers gave this detail, referred to the bilayer structure and explained that the hydrophobic core prevented the movement of polar substances into or out of cells. Few candidates referred to the types of fatty acids or to the role of unsaturated fatty acids in maintaining the fluidity of membranes. Some candidates showed confusion about the relationship between membrane structures and cells. Some candidates gave correct structural features and then listed several functions of the membrane, but did not link the correct functions to the relevant structures, and so did not answer the question fully and only gained partial credit.

(c) Most candidates gained full credit for naming two other components of membranes and giving a relevant function for each. All the components were seen frequently and their functions were often described successfully. Incorrect components were seen, such as glycocalyx, plasmodesmata and microvilli. Some candidates could have been more careful when describing the functions of channel proteins; only facilitated diffusion should have been stated and not active transport.

Question 2

Much of this question required candidates to apply knowledge and understanding from ***Topics 1***, ***3*** and ***10***. In this question some candidates incorrectly used the term ‘antibodies’ to mean antibacterial or antibiotic.

(a) A number of candidates explained fully how enzymes lower the activation energy needed to allow reactions to proceed. Most responses only stated that enzymes lower activation energy, but not how it is done. Those who gained the highest credit stated correctly that enzymes provide an alternative route or pathway for reactions. They described substrates having shapes complementary to active sites to form enzyme-substrate complexes and went on to explain that the reactants are brought close together so that bonds are weakened and/or groups, such as phosphate groups, can be transferred between them.

(b)(i) Many candidates gave good descriptions of the data shown in **Fig. 2.1**, quoting figures to support the trends that they identified. For the most part, all data quotes were taken accurately either from the plotted points or by taking intercepts to the lines of best fit. Most stated that the production of PABA, or the rate of reaction, decreases as the concentration of the inhibitor increases. Fewer stated that the concentration of PABA increases in all five reactions. Candidates also pointed out that rates of reaction were the same over certain periods of time, for example, the rates for no inhibitor and the lowest concentration of inhibitor were the same for the first 15 minutes. No credit was given for use of figures if units were not used. It was quite common for candidates to omit to state that the final concentrations of PABA were measured at 60 minutes. Many candidates repeated themselves. They stated the effect of increasing concentration of inhibitor then gave several concentrations of PABA to support this observation and then made the same statement again at the end of their answer.

(ii) There were some excellent answers that outlined an experiment to determine whether the inhibitor of the enzyme that catalyses the reaction to produce PABA is competitive or non-competitive. These answers began by stating that concentration of the substrate must be increased. Some also stated five or more concentrations that could be used. They then stated that two sets of these

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reaction mixtures are required: one with the inhibitor and one without the inhibitor. They also stated that the concentration of the inhibitor should be kept constant as well as other variables, such as temperature and pH. Some candidates took at least half the answer space to explain how the results should be interpreted. The simple way to do this was to refer to the maximum rate of reaction (V_{max}) and/or the Michaelis-Menten constant (K_m). Many described the graph that would be obtained. Some candidates gave an oversimplification by stating that the curve for a competitive inhibitor will increase with increasing concentration of substrate, but that the curve for a non-competitive inhibitor will not, which is not true for all concentrations of substrate.

Some candidates produced partial answers, but confused the rate of reaction with concentration of product, and suggested that they should draw a graph to compare final or maximum concentrations of the product rather than V_{max}. Candidates who were not as successful with this question often referred to using only two concentrations of substrate. If they did this and stated that they would be a high and a low concentration, then they could gain credit for the whole answer. Some candidates became confused between substrates and products and referred to the 'production of the substrate' in this reaction.

Many candidates did not outline an experiment and instead answered a different question by describing the mode of action of competitive and non-competitive inhibitors. Some incorrectly suggested that it would be possible to see the type of inhibitor by observing where the inhibitor binds to the enzyme.

(iii) The introduction to this question gave candidates some further information that they had to use in suggesting why the inhibitor of this enzyme could be used as a drug to treat bacterial infections in humans. Some stated simply that the inhibitor will not harm human cells and prevent their growth. Others stated that bacteria cannot grow without PABA, but did not also state that without PABA folic acid cannot be synthesised.

(iv) There were many good reasons put forward to explain why there are few drugs to treat viruses. Candidates stated that viruses have few targets for drug action as they have no cell walls, no cell membranes, no ribosomes and few if any enzymes. As viruses are intracellular parasites, they are often 'hidden' inside host cells and this was the other main type of answer. Candidates often incorrectly stated that there are few drugs available for viral infections because viruses are resistant to them.

(c) There are many ways to reduce the spread of antibiotic resistance in bacteria and candidates showed impressive knowledge of many of these. The most common were making sure that antibiotics are prescribed only when absolutely necessary and ensuring that people complete their course of antibiotics. Others included using antibiotics in combination, keeping some antibiotics 'as a last resort' and not using antibiotics in animal feed.

Question 3

This question was based on the structure of the root and transport of water across the root, assessing transport in plants, ***Topic* 7**. Stronger candidates identified the correct area of the root in **Fig. 3.1** and had few problems naming the tissues and giving clear explanations for water transport between **X** and **Y**.

(a) Most candidates identified xylem (**C**) and phloem (**D**) in **Fig. 3.1** which showed a transverse section of a root of *Ranunculus repens*. Fewer were successful with **A**, which shows the cortex composed of parenchyma tissue and with **B**, which shows the endodermis. Common errors included identifying **A** as mesophyll and **B** as endothelium.

(b) Many candidates answered this question by describing the pathways by which water travels from root hairs to the xylem in the centre of the root. They often described the apoplast and symplast pathways correctly, although some confused them. The question referred candidates to the pathway from the centre of cell **X** to **Y**, the lumen of a xylem vessel. A few candidates adapted the answers that they had learnt to start their description from cell **X**. Most candidates understood that the apoplast pathway is blocked at **B**; however, water can only travel from **X** to the endodermis by the symplast pathway and movement by the apoplast pathway is only possible after water has passed through the endodermal, or passage, cell to the left of the label **B**. Some candidates referred to concentration gradients between **X** and **Y** rather than to water potential gradients and some referred to the mechanism of movement in the xylem. Very few mentioned how the water travelled into **Y** via pits in the cell walls.

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Question 4

Question 4(a) and **(b)** assessed knowledge and understanding from ***Topic 6***. In **Question 4(c)**, candidates needed to apply their understanding of mRNA synthesis to the synthesis of tRNA. Most found this part to be more challenging.

(a) Hydrogen bond was the answer given by most candidates. All the other bonds in the syllabus, such as peptide, glycosidic and phosphodiester, were seen.

(b) Some candidates gave very detailed accounts of the role of tRNA in protein synthesis, often including the roles of mRNA and ribosomes as well. Some answers could have made it clearer that each tRNA molecule carries a *specific* amino acid to ribosomes. Few candidates stated that the tRNA molecule is reused after their amino acid has formed a peptide bond with the elongating polypeptide. Good answers made it clear that once inside a ribosome the anticodon binds to a codon with a complementary base sequence. Others referred to the base sequences 'matching' without explaining further. Some candidates incorrectly stated that 'codon and anticodon must match to *make* the correct amino acid'. As with **Question 1(b)**, many candidates could have benefitted by taking the opportunity to label the diagram provided. Those that did often indicated the site of amino acid attachment and the anticodon, and many gave the codon complementary to CGA. Some labelled the region with the base sequence ACC as the site of attachment of *protein*. Although many candidates mentioned peptide bond formation between the amino acids, it was important to refer to the role of tRNA in bringing two amino acids in close proximity to each other in order to allow a peptide bond to form between them.

(c) Some candidates appeared to be confused between replication and transcription. They did not state that tRNA is produced by assembling nucleotides along **one** strand of DNA and instead described the breakage of hydrogen bonds between the strands of DNA and the assembly of nucleotides on both strands. A few candidates correctly stated that there are genes (or lengths of DNA) that code for tRNA and that it is these that are transcribed. Some mentioned DNA polymerase as being involved in transcription, instead of RNA polymerase. Other errors in answering this question included stating that *mRNA* leaves the nucleus to travel to ribosomes. Some suggested that mRNA is formed and then it changes into tRNA once it is in the cytoplasm; others that ligase breaks the hydrogen bonds between tRNA and the DNA template. A number of candidates suggested that tRNA was made from amino acids and had a 3D structure based on the folding of the polypeptide.

Question 5

This question was based on subject material from ***Topic 8***.

(a) (i) Answers were accepted to this calculation that were expressed to 2, 3 or 4 significant figures. Thus, most candidates who realised that the answer was close to 100% gained credit. Many incorrectly thought the answer was close to 20%, calculating 19.48 as a percentage of 100.

(ii) Many candidates realised that the remaining percentage of oxygen transported in the blood is in solution in the plasma. 'Blood' and 'tissue fluid' were common incorrect answers. Many, however, left this question blank.

(iii) There were two acceptable ways to answer this question. By far the most common was to describe the combination of carbon monoxide with haemoglobin, which was described as producing the stable compound carboxyhaemoglobin. Candidates were less successful at describing what happens in emphysema and only the best responses explained that alveolar walls are broken down by the action of phagocytes, giving less surface area for gas exchange.

(b) Most candidates explained that carbonic anhydrase is the catalyst in the reaction between carbon dioxide and water and gave the correct equations for the formation of carbonic acid and its dissociation into hydrogen ions and hydrogencarbonate ions. Few candidates took their answers further by explaining that the hydrogencarbonate ions diffuse out of the red blood cells into plasma where most carbon dioxide is transported. Instead, they concentrated on the role of the hydrogen ions in promoting the release of oxygen. Candidates did not always phrase answers appropriately. Many candidates, however, gained credit for explaining that carbonic anhydrase is involved in the reverse reaction that occurs as deoxygenated blood flows through capillaries around the alveoli to offload carbon dioxide. Some candidates suggested that this enzyme is found in haemoglobin

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rather than in red blood cells. Others put forward that carbonic anhydrase was formed from the combination of water and carbon dioxide, or that carbonic anhydrase catalysed the breakdown of carbonic acid into hydrogencarbonate ions and hydrogen ions. The formula for carbonic acid was sometimes given as the formula for hydrogencarbonate.

(c) Almost all candidates stated that the effect of carbon dioxide on the oxygen-haemoglobin dissociation curve is known as the Bohr effect or the Bohr shift. Many candidates, however, did not explain the advantage of this effect at partial pressures of oxygen below 8.0 kPa. Many explained the advantage of the lower affinity of haemoglobin for oxygen at low partial pressure of oxygen in the absence of carbon dioxide as shown by the upper curve in **Fig. 5.1**. Some candidates stated that carbon dioxide decreases the affinity of haemoglobin for oxygen and thus more oxygen is released to support the respiration of tissues. Many interpreted this question as asking about adaptation to altitude.

Question 6

The infectious disease measles formed the theme of this question. Subject material from ***Topics 10*** and ***11*** was assessed.

(a) Many candidates identified the pathogen of measles correctly as *Morbillivirus*. Common errors were '*Microbillivirus*' and other misspellings. Also candidates tried various permutations of *Mycobacterium* and *Vibrio.*

(b) The descriptions of the epidemiological data shown in **Fig. 6.1** were generally very good. Most candidates identified the annual fluctuations in the numbers of reported cases of measles, which tend to be higher in the early part of each year. Almost all described the highest numbers as occurring in 2010 and gave accurate data quotes. Few stated that the graph shows five epidemics between 2008 and 2012 although some stated that the numbers are higher in the rest of the world than in Africa except in 2010. It was clear that some candidates were confused by the data, not realising that the chart shows stacked bars.

(c) This question attracted many answers that described antigen presentation, clonal selection, clonal expansion and antibody production very effectively. Some candidates displayed detailed knowledge of the early stages of the immune response in their answers. Errors included stating that antibodies multiply, T-lymphocytes produce antibodies, not making clear that plasma cells differentiate from B-lymphocytes and stating that during an immune response T-lymphocytes divide into T killer cells and T helper cells. Clones of these classes of T-lymphocytes exist *before* antigens are encountered.

(d) Most candidates showed awareness of general issues concerning the control of infectious diseases. In answering this question about the appearance of measles in countries that have vaccination programmes, many candidates gave two appropriate reasons. The arrival of people infected with the virus, the presence of people who have not been vaccinated for some reason or who did not respond to the vaccine were common reasons given. Some candidates stated that boosters are necessary, but did not make it clear that some children who receive the first vaccination do not receive boosters, often because they have moved home or are in places which do not have health services that ensure a full programme of childhood vaccinations is given to all.

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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 use a serial dilution to obtain required concentrations of solutions and specified volumes of solutions. In this case, candidates were required to dilute a 1.0% reducing sugar solution to start their serial dilution and to prepare 10 cm^3 to use of each successive dilution. Candidates needed to show a four step serial dilution of reducing sugar solution using a constant dilution factor at each step. The initial step combines 10 cm^3 of the 1.0% reducing sugar solution with 10 cm^3 of water to produce a 1:2 dilution. In the second step, 10 cm^3 of the 1:2 dilution is combined with 10 cm^3 of water producing a dilution of 1:4. Candidates needed to show how to make four concentrations of reducing sugar solution by this method e.g. 0.50%, 0.25%, 0.125% and 0.0625%.

Candidates should be able to calculate the linear magnification of photomicrographs using an eyepiece graticule and stage micrometer to measure cells and be familiar with units (millimetre, micrometre) used in cell studies.

General Comments

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.

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

Comments on Specific Questions

Question 1

(a)(i) Many candidates were able to carry out a serial dilution, showing the correct concentration below each beaker (0.50%, 0.25%, 0.125% and 0.0625%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(ii) Many candidates correctly explained that the volume of Benedict's solution required for each reducing sugar test should be equal to or greater than the volume of reducing sugar solution (2 cm^3).

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of reducing sugar and the heading for time with units (seconds). These candidates also recorded the time in whole seconds.

(iv) The stronger candidates calculated the rate of reaction by showing 1 divided by 42 and stated the rate to the appropriate degree of accuracy.

(v) Many candidates correctly stated that the variables that needed to be standardised were the volume of Benedict's solution, the volume of the two samples of milk, **M1** and **M2**, and the

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temperature of the water-bath.

(vi) Many candidates recorded the times for **M1** and **M2** in whole seconds.

(vii) Many candidates estimated the percentage concentration of reducing sugar in each of **M1** and **M2** correctly according to their results. The stronger candidates stated that the estimated concentration was between two known concentrations or was the same as one of the known concentrations.

(viii) The majority of candidates correctly stated that **M2** would be the most suitable for a person who is unable to digest lactose since there was very little reducing sugar contained in **M2**.

(b)(i) Most candidates used the headings given in the table to correctly label the *x*-axis (time after drinking milk containing lactose / minutes) and the *y*-axis (concentration of hydrogen in exhaled air / ppm). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates used a scale of 20 to 2 cm for the *x*-axis and 20 to 2 cm for the *y*-axis. Many candidates plotted the five points accurately and joined the points with a thin line. The most common errors were not including a full axis label for each axis, omitting the units for the *y*-axis, not labelling the scale every 2 cm, and drawing lines which were too thick.

(ii) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. Those candidates who gained most credit did so for carefully following the instructions and drawing the shaded area as shown in Fig.1.3 and for drawing the appropriate amount of detail within the inner section. Many candidates gained credit for drawing the outermost layer as two lines drawn closely together and for including the separation between the outer and inner layer in the drawing.

Question 2

(a)(i) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw a group of three cells, two cells from the upper epidermis and one adjacent cell from the tissue below with double lines representing the cell walls. Candidates who gained most credit included detail of the contents in at least one cell. The most common error was to draw lines that did not meet up precisely or were too thick. Most candidates used a label line to show the cell wall of one cell.

(ii) Many candidates correctly stated that the function of the cell from the tissue below the epidermis was photosynthesis and that the observable feature of the cell that supported their answer was the presence of chloroplasts.

(b) The stronger candidates organised the table into three columns, with one column for features, one headed **J1** and one headed **Fig. 2.1**. Many candidates listed at least three observable differences between **J1** and **Fig. 2.1** such as the palisade cells of **J1** were loosely packed and the palisade cells of **Fig. 2.1** were tightly packed.

(c)(i) Many candidates correctly measured the diameter of the field of view using low power (×100) of the microscope.

(ii) The stronger candidates calculated the fraction of the diameter of the field of view occupied by the leaf in **Fig. 2.2** along line **X**–**Y**.

(iii) The stronger candidates calculated the depth of the midrib by showing the answer to **Question 2(c)(i)** multiplied by the answer to **Question 2(c)(ii)** and then multiplying by 1000 to convert to μm.

(iv) Many candidates correctly stated that the apparatus to be used included an eyepiece graticule and a stage micrometer and described how to calibrate an eyepiece graticule using a stage micrometer. The diameter of the midrib could then be measured using the eyepiece graticule and the measurement converted to the correct units for microscopy (μm).

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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.

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

Candidates should be able to use a serial dilution to obtain required concentrations of solutions and specified volumes of solutions. In this case, candidates were required to dilute a 1.0 mol dm^{-3} sucrose solution to start their serial dilution and to prepare 10 cm^3 to use of each successive dilution. Candidates needed to show a four step serial dilution of sucrose solution using a constant dilution factor at each step. The initial step combines 10 cm^3 of the 1.0 mol dm^{-3} sucrose solution with 10 cm^3 of water to produce a 1:2 dilution. In the second step, 10 cm^3 of the 1:2 dilution is combined with 10 cm^3 of water producing a dilution of 1:4. Candidates needed to show how to make four concentrations of sucrose solution by this method e.g. 0.50 mol dm^{-3}, 0.25 mol dm^{-3}, 0.125 mol dm^{-3} and 0.0625 mol dm^{-3}.

General comments

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.

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

Comments on specific questions

Question 1

(a) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up precisely and used most of the space provided. The most common error was to draw lines that did not meet up precisely. The majority of candidates gained credit for drawing one cell and drew the cell wall as a double line. Most candidates drew a plasmolysed cell and used a label line to show the cell surface membrane of one cell.

(b)(i) Many candidates were able to carry out a serial dilution, showing the correct concentration below each beaker (0.5 mol dm^{-3}, 0.25 mol dm^{-3}, 0.125 mol dm^{-3} and 0.0625 mol dm^{-3}) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger responses included the heading for concentration of sucrose solution with units (mol dm^{-3}) and the heading for time with units (seconds). The majority of candidates gained credit for recording the times for at least four concentrations. Many candidates recorded results which showed that the

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higher the concentration of sucrose solution, the shorter the time for the colour change. The stronger candidates recorded the time in whole seconds.

(iii) The majority of candidates recorded the time in seconds for **U** to change colour and stated the appropriate units.

(iv) Many candidates estimated the concentration of sucrose solution correctly according to their results. The stronger candidates stated that the estimated concentration was between two known concentrations or was the same as one of the known concentrations.

(v) Many candidates correctly described how the procedure could be modified to obtain a more accurate estimate of the concentration of sucrose in **U** by using an increased number of concentrations and between named concentrations. The stronger candidates suggested that these concentrations are prepared by simple (proportional) dilution. Credit was given to those candidates who then repeated the procedure at least twice.

(c)(i) Most candidates correctly used the headings given in the table to label the *x*-axis (concentration of sucrose solution / mmol dm^{-3}) and the *y*-axis (water potential / kPa). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Many candidates plotted the five points accurately and joined the points with a thin line or drew a line of best fit. The most common error was drawing lines which were too thick.

(ii) Most candidates used the graph correctly to estimate the water potential of the concentration of sucrose solution recorded by the student for 0.66 mmol dm^{-3}. The most common error was stating a figure which was not to the appropriate degree of accuracy.

(iii) Many candidates correctly explained the effect of the sucrose solution on the onion cells by stating that the onion cells had a higher water potential than the sucrose solution and water moved out of the cells by osmosis.

Question 2

(a)(i) The majority of candidates described how they would test the samples in order to compare the quantity of starch in each sample by using the same number of drops of each sample and the same number of drops of iodine.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for colour or observation. The majority of candidates gained credit for recording the colour for each of the three samples. The stronger candidates recorded **P2** as the darkest colour.

(iii) Many candidates correctly stated that sample **P2** represented the oldest root.

(b) Credit was awarded to candidates whose drawings used most of the space provided, showed at least three lines and did not include any shading. The stronger candidates gained credit for showing the outline of the root cap and the outline of the stele. Credit was given for the correct proportion of the stele in relation to the cortex. Many candidates gained credit for using one label line and the label **T** to identify a tissue containing cells which may store starch in the root as the cortex.

(c)(i) Many candidates measured the length of the scale bar correctly with the appropriate units. Some candidates then used the length of the scale bar to calculate the actual width, in μm, of the cells labelled **J**, **K**, **L**, **M** and **N**. Credit was given for the correct answers for each of the cells.

(ii) The majority of candidates showed the addition of five measurements recorded in **Question 2(c)(i)** and showed division by five. Credit was given for stating the answer to the appropriate degree of accuracy.

(iii) Many candidates stated one observable difference between the two cells labelled **D** and **E** by correctly stating that cell **D** had no cell contents and cell **E** had cell contents.

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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 be given the opportunity to estimate unknown concentrations from results for known concentrations. If the value for the unknown concentration is greater than the known concentrations then the answer must state this, e.g. the unknown concentration is greater than $1.00\,mol\,dm^{-3}$. If the value for the unknown concentration is between two known concentrations the answer must also state this, e.g. the unknown concentration is between $0.50\,mol\,dm^{-3}$ and $1.00\,mol\,dm^{-3}$. Candidates should avoid stating a concentration that has not been made, e.g. $0.20\,mol\,dm^{-3}$ or a specific concentration between two known concentrations e.g. $0.6\,mol\,dm^{-3}$.

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

General comments

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.

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

Comments on specific questions

Question 1

(a) (i) Most candidates gained credit for correctly using 'least' to complete the sentence. The most common error was to use a word not given in the list of options.

(ii) Most candidates correctly stated an appropriate size of potato pieces.

(iii) The majority of candidates gained credit for how they would obtain accurate results.

(iv) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for solutions and the heading for angle of bend. Most candidates recorded results for all three samples of potato and included repeat measurements. Many candidates recorded their results to whole numbers or to within half a degree.

(v) Most candidates correctly identified **S1**, **S2** and **S3** according to their results.

(vi) Most candidates correctly recorded the angle of bend for the potato from **S4** as a whole number or to within half a degree with the correct units.

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(vii) The stronger candidates estimated the concentration of sodium chloride in **S4** as a range between two known concentrations or the same as one of the known concentrations. The most common error was to give a concentration not stated in their results table.

(viii) Most candidates correctly used the headings given in the text to correctly label the *x*-axis (concentration of sodium chloride/mol dm^{-3}) and the *y*-axis (angle of bend/degrees). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates used a scale which was appropriate for the data produced. Many candidates plotted the points exactly with a small cross or dot in a circle, and some drew a sharp, clear, ruled line, accurately connecting the points. Some candidates incorrectly plotted the estimate from **Question 1(a)(vii)**; candidates were only required to plot the points from their results and the data in the text. The most common error was drawing lines which were too thick or not ruled to the centre of the point. Candidates should be reminded of the need to use a sharp pencil.

(ix) The majority of candidates showed on their graph how to estimate the concentration of sodium chloride solution in **S4** and accurately estimated this concentration from the graph. The most common error was stating a figure which was not to the appropriate degree of accuracy.

(b) Many candidates correctly described how the procedure could be improved to have more confidence in the estimate of **S4**, by using an increased number of known concentrations. The stronger candidates prepared these concentrations by simple (proportional) dilution. Credit was given to those candidates who then repeated the procedure.

(c) Some candidates were able to explain in terms of water potential the effect of putting the potato from **S1** into water on the potato cells. Most candidates described the movement of water into the potato by osmosis. The most common error was not to refer to movement of water into the potato cells or not describing the water as having a higher water potential than the potato cell.

Question 2

(a) (i) Credit was awarded to those whose drawings did not include any shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the shaded area as shown in **Fig. 2.1** and for drawing the appropriate amount of detail within the section. A common error was not to draw the appropriate detail in the vascular tissue. Many candidates gained credit for drawing the outermost layer as two lines drawn closely together.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw a group of four cells from the ring around the vascular bundle which showed some of the differences between these cells. The most common error was to draw lines that did not meet up precisely or were too thick. Most candidates used a label line to show the cell wall of one cell.

(b) (i) Many candidates measured the length of the thickness of the leaf **D**, **E**, **F**, **G** and **H** correctly and recorded them using the correct units. A common error was not to show the units for all measurements. Most candidates showed the division by the magnification (×75). The most common error was not to show all of the stages in the calculation.

(ii) Most candidates showed the addition of the five measurements and the division of this by five to obtain an average, and gained credit for recording their answer to the appropriate significant figure with the correct units.

(c) The stronger candidates organised the table into three columns, with one column for features, one headed **L1** and one headed **Fig. 2.2**. Many candidates listed at least three observable differences between **L1** and **Fig. 2.2** such as epidermis being thinner in **L1** than **Fig. 2.2**.

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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 given the opportunity to estimate unknown concentrations from results for known concentrations. If the value for the unknown concentration is greater than the known concentrations then the answer must state this, e.g. the unknown concentration is greater than 0.75%. If the value for the unknown concentration is between two known concentrations the answer must also state this, e.g. the unknown concentration is between 0.50% and 0.75%. Candidates should avoid stating a concentration that has not been made, e.g. 1.00% or a specific concentration between two known concentrations e.g. 0.6%.

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

General comments

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.

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

Comments on specific questions

Question 1

(a) (i) Most candidates were able to carry out a simple dilution, showing at least three correct percentage dilution concentrations in the table (0.75%, 0.5% and 0.25%). Many candidates stated the correct volumes of **E** and **W** required to make 10 cm^3 of each of these concentrations.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of ethanol and the heading for intensity of colour. Most candidates recorded results for at least five concentrations. The stronger candidates recorded their results using the key provided in **Fig. 1.2**.

(iii) Most candidates stated a result for **U**. The stronger candidates estimated the concentration of **U** as a range between two known concentrations or the same as one of the known concentrations. The most common error was to give a concentration not stated in their results table.

(iv) Some candidates were able to explain how the ethanol affected the release of methylene blue from the plant cells by diffusion. The stronger candidates stated that the membrane had been damaged and had become more permeable as a result of the phospholipids being dissolved in the ethanol. A common error was to describe methylene blue moving out of the cell by osmosis.

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(v) Many candidates correctly described how the independent variable (concentration of ethanol) could be standardised by using a stated concentration or the same concentration of **E**. Many candidates correctly described how the procedure could be modified to investigate the effect of temperature by using at least five different temperatures, using a thermostatically controlled water-bath to achieve these temperatures.

(b) (i) Many candidates correctly recorded the percentage change in mass as 9.0%. The most common error was not recording this to the nearest 0.5%.

(ii) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (concentration of sucrose / mol dm^{-3}) and the *y*-axis (percentage change in mass). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates used a scale of 0.2 to 2 cm for the *x*-axis and 10 to 2 cm for the *y*-axis. Many candidates plotted the points exactly with a small cross or dot in a circle, and some drew a sharp, clear, ruled line, accurately connecting the points. The most common error was drawing lines which were too thick or not ruled to the centre of the point. Candidates should be reminded of the need to use a sharp pencil.

(iii) The majority of candidates showed on their graph how to estimate the percentage change in mass at 0.7 mol dm^{-3} and accurately estimated the percentage change in mass from the graph.

Question 2

(a) (i) Credit was awarded to those whose drawings did not include any shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the shaded area as shown in **Fig. 2.1** and for drawing the appropriate amount of detail within the section. Many candidates gained credit for drawing the layer surrounding the vascular tissue as two lines drawn closely together.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw a group of four cells from the central tissue with double lines representing the cell walls. The most common error was to draw lines that did not meet up precisely or were too thick. Most candidates used a label line to show the cell wall of one cell.

(b) (i) Many candidates measured the length of the air spaces **V**, **W**, **X**, **Y** and **Z** correctly and recorded them using the correct units. A common error was not showing the units for all measurements. Most candidates showed the division by the magnification (×36). Many candidates showed how they then converted this into μm either by multiplying by 1000 (if measurements in mm) or by 10 000 (if measurements in cm). The most common error was not showing all of the stages in the calculation.

(ii) Most candidates showed the addition of the five measurements and the division of this by five to obtain an average, and gained credit for recording their answer to the appropriate significant figure with the correct units.

(c) The stronger candidates organised the table into three columns, with one column for features, one headed **K1** and one headed **Fig. 2.2**. Many candidates listed at least three observable differences between **K1** and **Fig. 2.2** such as root hairs being present in **K1** but absent in **Fig. 2.2**.

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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 assess the risk of a procedure. A risk assessment would include judging that the use of chemicals which might be harmful or an irritant, for example an acid of 1% concentration would be assessed as a medium risk. A high risk would be use of high concentrations of acids and alkalis.

Candidates should be aware that the wording of questions often indicate how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. When the question states to 'explain how the results of the investigation support the idea that glucose enters cells by facilitated diffusion', the answer needs to include a reason why something happens, such as referring to carrier proteins being limited in availability at high concentrations of external glucose.

General Comments

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.

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

Comments on Specific Questions

Question 1

(a) Many candidates were able to name the hazard, acid, as a harmful irritant and assess the level of risk as medium or high.

(b) (i) Many candidates were able to carry out a serial dilution, showing the correct concentration below each beaker (0.50%, 0.25%, 0.125% and 0.0625%) and transferring 20 cm^3 of the previous concentration to the next beaker and adding 20 cm^3 of distilled water to each beaker.

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

(iii) The majority of candidates recorded the time in seconds for **U** to change colour and stated the appropriate units.

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(iv) Many candidates estimated the concentration of antibiotic solution correctly according to their results. The stronger candidates stated that the estimated concentration was between two known concentrations or was the same as one of the known concentrations.

(v) The stronger candidates identified one significant source of error that may have affected the trend in results. One significant source of error was the difficulty of identifying the end-point.

(vi) Many candidates were able to state that the independent variable (concentration of the antibiotic solution) was standardised by using one concentration for the investigation. Many candidates described how they could modify the procedure to investigate the effect of temperature by using at least five temperatures which could be achieved by using a thermostatically controlled water-bath.

(c) (i) The majority of candidates used the headings given in the table to correctly label the *x*-axis (external concentration of glucose / mmol dm^{-3}) and the *y*-axis (rate of glucose uptake by cells / mmol cm^{-3} h^{-1}). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates used a scale of 5 to 2 cm for the *x*-axis and 100 to 2 cm for the *y*-axis. Many candidates plotted the six points accurately and joined the points with a thin line.
The most common errors were not including a full axis label for each axis, omitting the units for the *y*-axis, not labelling the scale every 2 cm, and drawing lines which were too thick.

(ii) Most candidates used the graph correctly to estimate the rate of glucose uptake by cells for an external concentration of glucose of 7 mmol dm^{-3}. The most common error was stating a figure which was not to the appropriate degree of accuracy.

(iii) Many candidates correctly referred to the limited availability of carrier proteins at high external concentrations of glucose, as shown by the rate of glucose uptake by cells not increasing significantly between 10 mmol dm^{-3} and 20 mmol dm^{-3}.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the shaded area as shown in **Fig. 2.1**. Many candidates gained credit for drawing two lines and part of the vascular bundle and showed the epidermis as two lines drawn closely together. Most candidates used a label line to show the phloem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent cells from the xylem tissue in the vascular bundle with double lines representing the cell walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing a cell which had at least five sides. Most candidates used a label line to show the cell wall of one cell.

(b) (i) Many candidates correctly measured the depth of the midrib and the length of the vascular bundle showing the units for both measurements. The stronger candidates showed the final ratio as the larger number to the smaller number to the simplest ratio. The most common errors were to omit units and not showing all the steps in the calculation.

(ii) The stronger candidates suggested that the observable features of the plant shown in **Fig. 2.2** which supported the conclusion that the plant may grow in an aquatic habitat included air spaces or a thick cuticle.

(c) Candidates who gained most credit organised the table into three columns, with one column for features, one headed **M1** and one headed **Fig. 2.2**. Many candidates listed at least three observable differences between **M1** and **Fig. 2.2** such as the vascular bundle of **M1** was round and the vascular bundle of **Fig. 2.2** was oval.

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Paper 9700/41
A Level Structured Questions

Key Messages

Candidates would be advised to read the questions more carefully to ensure they are addressing the meaning of the question before starting their answer.

It should be noted that if the mark weighting for a question is, for example, three marks, then a candidate would be expected to write at least three different ideas to achieve full marks.

General Comments

There were some very good Centres with candidates gaining high levels of credit. More able candidates attempted all questions while weaker ones omitted some sections or even entire questions.

Question 2 and **Question 3** proved to be challenging for many candidates. **Question 9(a)** was not well answered as many did not read what was required of the question and gave a lot of irrelevant information.

Comments on Specific Questions

Section A

Question 1

(a) Most candidates could name aquaporins and stated that they moved within vesicles. Many referred to the increased permeability of the collecting duct but fewer mentioned that water then leaves the lumen by osmosis. A minority of candidates mentioned enzymes, phosphorylase or cell signalling.

(b) (i) Many candidates stated that the gene or allele was located on the X chromosome, and sometimes the Y chromosome. A common error was to say that sex linkage was the development of the gender of the organism.

(ii) This question was poorly answered. The first point was rarely correctly addressed as very few candidates included the word allele in their answer and even fewer named the DI allele. Many did not use conventional symbols or follow the usual conventions for genetic diagrams. The most common errors were that X and Y chromosomes were not included and parental genotypes were incorrectly entered. Most candidates were then able to correctly deduce the gametes and offspring genotypes. However, they often then did not correctly match the offspring genotypes with the phenotypes or did not state the gender of the offspring.

Question 2

(a) A common error here was that many candidates answered in terms of the structure of C4 plants rather than their biochemistry. Nevertheless, full credit was often achieved by those who mentioned that the first product was a four-carbon compound and then named it as oxaloacetate or malate.

(b) (i) Most candidates could state that the rates in C4 plants were higher but few went on to work out the mean, with most quoting figures straight from **Table 2.1**. The greater variation within C4 plants was almost never mentioned.

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(ii) This question enabled candidates to display their knowledge of the Calvin cycle by stating that rubisco catalyses the reaction between carbon dioxide and RuBP and that this is carbon fixation. Fewer candidates stated that the six-carbon intermediate compound is unstable while many did not mention that two molecules of glycerate phosphate would be produced.

(iii) Many were able to show that PEP carboxylase was more active in C4 plants and rubisco in C3 plants. Some candidates lost credit by not being specific about the particular carboxylase they were describing. Very few gave reasons for the differences in activity between the two types of plants.

(c) Many candidates did not recognise that C4 plants are adapted for life in high temperatures and light intensities. Some mentioned that a lot of ATP is produced but incorrectly linked the production to respiration. Very few mentioned photophosphorylation or the light-dependent reaction.

Question 3

(a) (i) Most candidates knew that the sample was heated to separate the two strands of the DNA, or to denature it, with many giving both these alternatives. Many showed that this would be achieved by the breaking of hydrogen bonds. Few mentioned that bases would be exposed or that template strands would be created. Some candidates confused DNA replication with either protein synthesis, referring to transcription and mRNA, or electrophoresis, referring to cutting the DNA into small pieces.

(ii) Few candidates correctly described the role of the primer which is to attach to the DNA close to the section of interest by complementary base pairing. Many incorrect responses suggested that the primer was there as a starting point for the polymerase.

(iii) This question was generally well answered. The most common reason given for the use of *Taq* polymerase was that it is thermostable. Most candidates correctly mentioned the synthesis of complementary DNA strands, though some lost the mark for missing out 'complementary' or 'DNA'. A few thought polymerase only joined the strands together.

(b) (i) Many candidates correctly stated that there were many mitochondria but only one nucleus. Gaining full credit was less common as few mentioned that the cell was diploid. Some stated there were two copies of DNA rather than two copies of each chromosome.

(ii) Very few candidates showed understanding of the mechanism of mtDNA inheritance. Many seemed unable to use the family tree correctly to identify the individuals.

Question 4

(a) This question, which involved analysing data with regard to the effectiveness of two insecticides deltamethrin and malathion, enabled the majority of candidates to achieve full credit. Most appreciated that overall deltamethrin was more effective than malathion, but that there were variations between the two for different sites and for different years, particularly that malathion proved to be more effective than deltamethrin in 2007 in Jamnagar. The increase in effectiveness of malathion and/or decrease in effectiveness in Jamnagar over the two years was also observed by many candidates.

(b) Many candidates stated that mosquitoes evolved resistance due to a mutation although some mistakenly attributed this to a consequence of the use of the insecticide. Good responses identified the selection pressure as the insecticide deltamethrin, and that the mosquitoes which had acquired an allele for resistance to it due to the mutation, had a selective advantage thus being able to reproduce and pass this allele on to their offspring, thereby increasing the allele frequency.

(c) Many candidates were aware that the percentage of mosquitoes killed by malathion increased. Few related the figures as being due to the removal of the selection pressure or that resistance to malathion no longer provided a selective advantage.

(d) A majority correctly identified the variation as discontinuous.

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(e) Very few candidates correctly used the Hardy-Weinberg equation to calculate *p* correctly. Some calculated 0.76, but thought this was *q* rather than q^2 so the remaining mathematics was not correct. Some did get $q = 0.87$, but did not know how to calculate *p*. There were many candidates who did not attempt the question.

Question 5

(a) (i) The answer to this question involved an initial definition of an ecosystem, linking this to an explanation of why the three listed environments could not be referred to as an ecosystem. The concept of an ecosystem in terms of a defined area which is self-contained or a functional unit was not appreciated by most candidates. Consequently, subsequent explanations linked to their original definitions were vague and largely incorrect.

(ii) The question clearly directed candidates to consider the three different levels of biodiversity and when candidates specifically referred to ecosystem diversity, species diversity, species abundance and genetic diversity, they gained full credit on this question. Many candidates did not reference these levels of biodiversity at all so gained little, if any, credit. A few candidates recognised that more habitat would become available but didn't make it clear that it was the variety of habitats that would increase. Some candidates incorrectly put forward an argument that biodiversity would decrease.

(b) This question was generally well answered with most candidates mentioning the need for research or education, the need to ban hunting, the need for zoos or reserves and captive breeding. A few candidates recognised the part played by CITES or WWF, some specifically mentioning trade agreements.

Question 6

(a) (i) Many candidates correctly linked a surge in LH with a high concentration of oestrogen, while others mentioned the link with subsequent ovulation.

(ii) Most candidates knew that the fall in progesterone concentration towards the end of the cycle meant that the woman could not be pregnant. There was good use of the term 'concentration' as opposed to 'levels' when referring to hormone quantity.

(b) (i) Most candidates performed well in this question. Many knew that oestrogen and progesterone worked by negative feedback on the anterior pituitary gland to inhibit the secretion of FSH and LH. A few candidates lost credit as they referred to just the 'pituitary'. In addition, too many candidates incorrectly wrote the inhibition was on FSH or LH directly and not their secretion, which resulted in loss of credit. Likewise, many incorrectly referred to the inhibition being on the production of FSH and LH and not on their secretion or release. Only a minority of candidates mentioned the Graafian follicle not developing, with a few candidates just referring to the follicle and so not gaining the credit. Most candidates correctly stated that ovulation would not occur, that the cervical mucus would thicken and that the endometrium would remain thin.

(ii) Most correctly identified the reason here, to allow menstruation to occur and as evidence that pregnancy had not occurred.

(iii) This question was generally well answered with most candidates recognising the issues associated with remembering to take a pill every day. A few did know that it would keep the concentration of hormones steady and that this would reduce side effects. Some candidates incorrectly wrote that there would be no side effects.

Question 7

(a) (i) Most candidates correctly distinguished between regions of the myofibril containing only actin and those containing both actin and myosin, but some confused the middle of the H-zone with the I-band, and less able candidates sometimes located actin and myosin on the neurone instead of the myofibril.

(ii) Most candidates knew how the arrival of an action potential at a neuromuscular junction results in the sarcolemma being depolarised, but marks were lost for lack of detail. Many did not say exactly where events occur. For example, that the calcium ion channels are opening in the presynaptic

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membrane and entering the presynaptic knob or neurone, rather than simply the neuromuscular junction in general. Almost all candidates thought the sodium ions enter the sarcolemma, when in fact they enter the sarcoplasm. Only the stronger candidates mentioned that acetylcholine is released from the vesicles by exocytosis, and that it reaches the sarcolemma by diffusion.

(b) Here, candidates were asked to arrange in the correct order a list of events that occur during muscle contraction. While many of them grouped the events **SVQU** (from the depolarisation of the sarcolemma to the calcium ions binding to troponin) and **YWRX** (details of the power stroke) together correctly, they were less clear about which order they should be in within each group.

Question 8

(a) Most candidates knew that gibberellins were involved in germination, even though spelling was sometimes not quite accurate.

(b) (i) Many knew that the potassium hydroxide is used to absorb the carbon dioxide produced by the seeds, thus causing the reduction in volume of the air in the tube, allowing measurement of respiration by following the movement of the coloured liquid. Some showed a lack of understanding of chemistry, suggesting the solution might both absorb carbon dioxide and provide oxygen to the seeds, or provide water or hydrogen ions to them.

(ii) Most candidates understood the role of oxygen in aerobic respiration. The commonest error was to state that oxygen accepts hydrogen rather than hydrogen ions/protons.

(c) (i) Only a few understood why the respirometers were left in the water bath for 10 minutes before starting the experiment, i.e. for equilibration.

(ii) While almost all candidates realised the respirometers with glass beads were controls, few seemed to understand how they worked. Good responses stated that this was to eliminate variations in results that were not due to the seeds, or to eliminate the effects of variables other than the independent variable.

(iii) Many candidates lost marks here for not giving the answer to the correct number of decimal places, or for rounding figures incorrectly.

(iv) Many could show that there would be an increase in kinetic energy and that there would consequently be more enzyme-substrate complexes formed.

(v) A majority noted that enzymes would be denatured but fewer mentioned that there would be a change in the active site or the 3D shape of the enzyme.

Section B

Question 9

(a) Most candidates who selected this optional question made good references in their answers initially to the definition of homeostasis and the idea that a normal value is maintained. However, many answers were restricted to the initial three marking points as candidates frequently did not address the question asked regarding the importance of homeostasis. Although many candidates gave good descriptive examples of how homeostasis is maintained, such as detection of temperature or water potential through thermoreceptors or osmoreceptors and physiological methods for returning the values to the set point, this did not demonstrate why this process needs to occur. However, any candidate who described blood glucose levels as a parameter for detection could gain the credit for an internal environment that is sensed. As such, only stronger candidates could discriminate their answers by addressing the question and giving examples of what would happen if homeostasis was not performed. Of these, the majority focused on body temperature and the effect on enzyme activity at low temperatures and denaturation at high temperatures. Only excellent answers were awarded full credit by giving at least two examples of different parameters and the effect of their dysregulation, hence this question provided good discrimination between candidates at different levels.

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(b) Candidates were required to outline cell signalling in the control of blood glucose concentrations specifically by adrenaline, and in general this question was answered more effectively than **Question 9(a)**. There were some excellent answers from candidates who had successfully learnt the role that adrenaline plays and its resulting effects on cells. Those candidates gaining full credit provided an answer that addressed the initial cell surface events to stimulate signalling, the downstream intracellular signalling events and the resulting effect. It is noted that of the points that were less frequently observed, many candidates did not reference the change in receptor conformation or name the enzyme adenylyl cyclase that produces cyclic AMP. Several candidates also mistakenly described activation, rather than production, of cAMP, suggesting it is already present in the cell. Unfortunately, there were several candidates who only addressed the control of blood glucose concentration and focused their answer on the roles of the hormones insulin and glucagon, which was not required by the question.

Question 10

(a) Candidates were specifically asked about the role of auxin in cell elongation. Several candidates described events on an organism level, describing stem and root extension, apical buds and avoiding lateral extension, rather than events on a cellular level. However, most responses did move on to answer the question, but could have avoided superfluous text in their answer. Most answers provided a good explanation of the initial cellular events regarding the activation of proton pumps in the plant cell surface membrane and the pumping of hydrogen ions specifically into the cell wall to acidify this cellular location, although many answers missed out on a simple point by omitting the requirement for ATP/energy usage in active transport. Relatively few answers described the use of expansin proteins, and a number contradicted their answers by describing these proteins as the pH-dependent enzymes. The effect on the cell walls was usually poorly communicated by suggesting that bonds loosen rather than break between the cellulose microfibrils, instead of stating that the overall structure of the cell wall becomes more elastic because of the accumulation of individual bonds being broken between multiple microfibrils. As such, only the strongest responses that could discriminate themselves as more complete answers to the question posed were awarded full credit. Many candidates gave good descriptions of the water potential of the cell decreasing due to the relative increase in potassium ions, resulting in entry of water into the cell, causing the cell to expand.

(b) This question also required candidates to provide an answer that explained how abscisic acid stimulates the initial signalling events at the cell surface level to stimulate the cell, the subsequent intracellular events and the resulting response to the extracellular signal. All three elements needed to be addressed to demonstrate a complete answer and gain a high degree of credit. Most candidates recognised that ABA is a stress hormone or effectively the conditions in which it is produced, and most recognised that, with respect to stomata, its effect is on the guard cells and the inhibition of proton pumps. Many mid-range responses then omitted the intracellular signalling regarding the high hydrogen ion concentration in the cells causing the influx of calcium ions acting as a second messenger. The role of potassium ions in causing an increase in the water potential of the guard cells was well understood. Whilst many candidates recognised that this caused water to leave the cell, the process was often confused, with the description given often referring to diffusion of an ion or protein, rather than the specific method of osmosis of water. Candidates generally recognised that this caused the stomata to close by the guard cells becoming flaccid, although beyond the movement of water this was rarely further described through the change in the guard cell volume.

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Paper 9700/42
A Level Structured Questions

Key Messages

Candidates would be advised to read the questions more carefully to ensure they are addressing the meaning of the question before starting their answer.

It should be noted that if the mark weighting for a question is, for example, three marks, then a candidate would be expected to write at least three different ideas to achieve full marks.

General Comments

There were some very good Centres with candidates gaining high levels of credit. More able candidates attempted all questions while weaker ones omitted some sections or even entire questions.

Question 2 and **Question 3** proved to be challenging for many candidates. **Question 9(a)** was not well answered as many did not read what was required of the question and gave a lot of irrelevant information.

Comments on Specific Questions

Section A

Question 1

(a) Most candidates could name aquaporins and stated that they moved within vesicles. Many referred to the increased permeability of the collecting duct but fewer mentioned that water then leaves the lumen by osmosis. A minority of candidates mentioned enzymes, phosphorylase or cell signalling.

(b) (i) Many candidates stated that the gene or allele was located on the X chromosome, and sometimes the Y chromosome. A common error was to say that sex linkage was the development of the gender of the organism.

(ii) This question was poorly answered. The first point was rarely correctly addressed as very few candidates included the word allele in their answer and even fewer named the DI allele. Many did not use conventional symbols or follow the usual conventions for genetic diagrams. The most common errors were that X and Y chromosomes were not included and parental genotypes were incorrectly entered. Most candidates were then able to correctly deduce the gametes and offspring genotypes. However, they often then did not correctly match the offspring genotypes with the phenotypes or did not state the gender of the offspring.

Question 2

(a) A common error here was that many candidates answered in terms of the structure of C4 plants rather than their biochemistry. Nevertheless, full credit was often achieved by those who mentioned that the first product was a four-carbon compound and then named it as oxaloacetate or malate.

(b) (i) Most candidates could state that the rates in C4 plants were higher but few went on to work out the mean, with most quoting figures straight from **Table 2.1**. The greater variation within C4 plants was almost never mentioned.

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(ii) This question enabled candidates to display their knowledge of the Calvin cycle by stating that rubisco catalyses the reaction between carbon dioxide and RuBP and that this is carbon fixation. Fewer candidates stated that the six-carbon intermediate compound is unstable while many did not mention that two molecules of glycerate phosphate would be produced.

(iii) Many were able to show that PEP carboxylase was more active in C4 plants and rubisco in C3 plants. Some candidates lost credit by not being specific about the particular carboxylase they were describing. Very few gave reasons for the differences in activity between the two types of plants.

(c) Many candidates did not recognise that C4 plants are adapted for life in high temperatures and light intensities. Some mentioned that a lot of ATP is produced but incorrectly linked the production to respiration. Very few mentioned photophosphorylation or the light-dependent reaction.

Question 3

(a) (i) Most candidates knew that the sample was heated to separate the two strands of the DNA, or to denature it, with many giving both these alternatives. Many showed that this would be achieved by the breaking of hydrogen bonds. Few mentioned that bases would be exposed or that template strands would be created. Some candidates confused DNA replication with either protein synthesis, referring to transcription and mRNA, or electrophoresis, referring to cutting the DNA into small pieces.

(ii) Few candidates correctly described the role of the primer which is to attach to the DNA close to the section of interest by complementary base pairing. Many incorrect responses suggested that the primer was there as a starting point for the polymerase.

(iii) This question was generally well answered. The most common reason given for the use of *Taq* polymerase was that it is thermostable. Most candidates correctly mentioned the synthesis of complementary DNA strands, though some lost the mark for missing out 'complementary' or 'DNA'. A few thought polymerase only joined the strands together.

(b) (i) Many candidates correctly stated that there were many mitochondria but only one nucleus. Gaining full credit was less common as few mentioned that the cell was diploid. Some stated there were two copies of DNA rather than two copies of each chromosome.

(ii) Very few candidates showed understanding of the mechanism of mtDNA inheritance. Many seemed unable to use the family tree correctly to identify the individuals.

Question 4

(a) This question, which involved analysing data with regard to the effectiveness of two insecticides deltamethrin and malathion, enabled the majority of candidates to achieve full credit. Most appreciated that overall deltamethrin was more effective than malathion, but that there were variations between the two for different sites and for different years, particularly that malathion proved to be more effective than deltamethrin in 2007 in Jamnagar. The increase in effectiveness of malathion and/or decrease in effectiveness in Jamnagar over the two years was also observed by many candidates.

(b) Many candidates stated that mosquitoes evolved resistance due to a mutation although some mistakenly attributed this to a consequence of the use of the insecticide. Good responses identified the selection pressure as the insecticide deltamethrin, and that the mosquitoes which had acquired an allele for resistance to it due to the mutation, had a selective advantage thus being able to reproduce and pass this allele on to their offspring, thereby increasing the allele frequency.

(c) Many candidates were aware that the percentage of mosquitoes killed by malathion increased. Few related the figures as being due to the removal of the selection pressure or that resistance to malathion no longer provided a selective advantage.

(d) A majority correctly identified the variation as discontinuous.

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(e) Very few candidates correctly used the Hardy-Weinberg equation to calculate *p* correctly. Some calculated 0.76, but thought this was *q* rather than q^2 so the remaining mathematics was not correct. Some did get $q = 0.87$, but did not know how to calculate *p*. There were many candidates who did not attempt the question.

Question 5

(a) (i) The answer to this question involved an initial definition of an ecosystem, linking this to an explanation of why the three listed environments could not be referred to as an ecosystem. The concept of an ecosystem in terms of a defined area which is self-contained or a functional unit was not appreciated by most candidates. Consequently, subsequent explanations linked to their original definitions were vague and largely incorrect.

(ii) The question clearly directed candidates to consider the three different levels of biodiversity and when candidates specifically referred to ecosystem diversity, species diversity, species abundance and genetic diversity, they gained full credit on this question. Many candidates did not reference these levels of biodiversity at all so gained little, if any, credit. A few candidates recognised that more habitat would become available but didn't make it clear that it was the variety of habitats that would increase. Some candidates incorrectly put forward an argument that biodiversity would decrease.

(b) This question was generally well answered with most candidates mentioning the need for research or education, the need to ban hunting, the need for zoos or reserves and captive breeding. A few candidates recognised the part played by CITES or WWF, some specifically mentioning trade agreements.

Question 6

(a) (i) Many candidates correctly linked a surge in LH with a high concentration of oestrogen, while others mentioned the link with subsequent ovulation.

(ii) Most candidates knew that the fall in progesterone concentration towards the end of the cycle meant that the woman could not be pregnant. There was good use of the term 'concentration' as opposed to 'levels' when referring to hormone quantity.

(b) (i) Most candidates performed well in this question. Many knew that oestrogen and progesterone worked by negative feedback on the anterior pituitary gland to inhibit the secretion of FSH and LH. A few candidates lost credit as they referred to just the 'pituitary'. In addition, too many candidates incorrectly wrote the inhibition was on FSH or LH directly and not their secretion, which resulted in loss of credit. Likewise, many incorrectly referred to the inhibition being on the production of FSH and LH and not on their secretion or release. Only a minority of candidates mentioned the Graafian follicle not developing, with a few candidates just referring to the follicle and so not gaining the credit. Most candidates correctly stated that ovulation would not occur, that the cervical mucus would thicken and that the endometrium would remain thin.

(ii) Most correctly identified the reason here, to allow menstruation to occur and as evidence that pregnancy had not occurred.

(iii) This question was generally well answered with most candidates recognising the issues associated with remembering to take a pill every day. A few did know that it would keep the concentration of hormones steady and that this would reduce side effects. Some candidates incorrectly wrote that there would be no side effects.

Question 7

(a) (i) Most candidates correctly distinguished between regions of the myofibril containing only actin and those containing both actin and myosin, but some confused the middle of the H-zone with the I-band, and less able candidates sometimes located actin and myosin on the neurone instead of the myofibril.

(ii) Most candidates knew how the arrival of an action potential at a neuromuscular junction results in the sarcolemma being depolarised, but marks were lost for lack of detail. Many did not say exactly where events occur. For example, that the calcium ion channels are opening in the presynaptic

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membrane and entering the presynaptic knob or neurone, rather than simply the neuromuscular junction in general. Almost all candidates thought the sodium ions enter the sarcolemma, when in fact they enter the sarcoplasm. Only the stronger candidates mentioned that acetylcholine is released from the vesicles by exocytosis, and that it reaches the sarcolemma by diffusion.

(b) Here, candidates were asked to arrange in the correct order a list of events that occur during muscle contraction. While many of them grouped the events **SVQU** (from the depolarisation of the sarcolemma to the calcium ions binding to troponin) and **YWRX** (details of the power stroke) together correctly, they were less clear about which order they should be in within each group.

Question 8

(a) Most candidates knew that gibberellins were involved in germination, even though spelling was sometimes not quite accurate.

(b) (i) Many knew that the potassium hydroxide is used to absorb the carbon dioxide produced by the seeds, thus causing the reduction in volume of the air in the tube, allowing measurement of respiration by following the movement of the coloured liquid. Some showed a lack of understanding of chemistry, suggesting the solution might both absorb carbon dioxide and provide oxygen to the seeds, or provide water or hydrogen ions to them.

(ii) Most candidates understood the role of oxygen in aerobic respiration. The commonest error was to state that oxygen accepts hydrogen rather than hydrogen ions/protons.

(c) (i) Only a few understood why the respirometers were left in the water bath for 10 minutes before starting the experiment, i.e. for equilibration.

(ii) While almost all candidates realised the respirometers with glass beads were controls, few seemed to understand how they worked. Good responses stated that this was to eliminate variations in results that were not due to the seeds, or to eliminate the effects of variables other than the independent variable.

(iii) Many candidates lost marks here for not giving the answer to the correct number of decimal places, or for rounding figures incorrectly.

(iv) Many could show that there would be an increase in kinetic energy and that there would consequently be more enzyme-substrate complexes formed.

(v) A majority noted that enzymes would be denatured but fewer mentioned that there would be a change in the active site or the 3D shape of the enzyme.

Section B

Question 9

(a) Most candidates who selected this optional question made good references in their answers initially to the definition of homeostasis and the idea that a normal value is maintained. However, many answers were restricted to the initial three marking points as candidates frequently did not address the question asked regarding the importance of homeostasis. Although many candidates gave good descriptive examples of how homeostasis is maintained, such as detection of temperature or water potential through thermoreceptors or osmoreceptors and physiological methods for returning the values to the set point, this did not demonstrate why this process needs to occur. However, any candidate who described blood glucose levels as a parameter for detection could gain the credit for an internal environment that is sensed. As such, only stronger candidates could discriminate their answers by addressing the question and giving examples of what would happen if homeostasis was not performed. Of these, the majority focused on body temperature and the effect on enzyme activity at low temperatures and denaturation at high temperatures. Only excellent answers were awarded full credit by giving at least two examples of different parameters and the effect of their dysregulation, hence this question provided good discrimination between candidates at different levels.

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(b) Candidates were required to outline cell signalling in the control of blood glucose concentrations specifically by adrenaline, and in general this question was answered more effectively than **Question 9(a)**. There were some excellent answers from candidates who had successfully learnt the role that adrenaline plays and its resulting effects on cells. Those candidates gaining full credit provided an answer that addressed the initial cell surface events to stimulate signalling, the downstream intracellular signalling events and the resulting effect. It is noted that of the points that were less frequently observed, many candidates did not reference the change in receptor conformation or name the enzyme adenylyl cyclase that produces cyclic AMP. Several candidates also mistakenly described activation, rather than production, of cAMP, suggesting it is already present in the cell. Unfortunately, there were several candidates who only addressed the control of blood glucose concentration and focused their answer on the roles of the hormones insulin and glucagon, which was not required by the question.

Question 10

(a) Candidates were specifically asked about the role of auxin in cell elongation. Several candidates described events on an organism level, describing stem and root extension, apical buds and avoiding lateral extension, rather than events on a cellular level. However, most responses did move on to answer the question, but could have avoided superfluous text in their answer. Most answers provided a good explanation of the initial cellular events regarding the activation of proton pumps in the plant cell surface membrane and the pumping of hydrogen ions specifically into the cell wall to acidify this cellular location, although many answers missed out on a simple point by omitting the requirement for ATP/energy usage in active transport. Relatively few answers described the use of expansin proteins, and a number contradicted their answers by describing these proteins as the pH-dependent enzymes. The effect on the cell walls was usually poorly communicated by suggesting that bonds loosen rather than break between the cellulose microfibrils, instead of stating that the overall structure of the cell wall becomes more elastic because of the accumulation of individual bonds being broken between multiple microfibrils. As such, only the strongest responses that could discriminate themselves as more complete answers to the question posed were awarded full credit. Many candidates gave good descriptions of the water potential of the cell decreasing due to the relative increase in potassium ions, resulting in entry of water into the cell, causing the cell to expand.

(b) This question also required candidates to provide an answer that explained how abscisic acid stimulates the initial signalling events at the cell surface level to stimulate the cell, the subsequent intracellular events and the resulting response to the extracellular signal. All three elements needed to be addressed to demonstrate a complete answer and gain a high degree of credit. Most candidates recognised that ABA is a stress hormone or effectively the conditions in which it is produced, and most recognised that, with respect to stomata, its effect is on the guard cells and the inhibition of proton pumps. Many mid-range responses then omitted the intracellular signalling regarding the high hydrogen ion concentration in the cells causing the influx of calcium ions acting as a second messenger. The role of potassium ions in causing an increase in the water potential of the guard cells was well understood. Whilst many candidates recognised that this caused water to leave the cell, the process was often confused, with the description given often referring to diffusion of an ion or protein, rather than the specific method of osmosis of water. Candidates generally recognised that this caused the stomata to close by the guard cells becoming flaccid, although beyond the movement of water this was rarely further described through the change in the guard cell volume.

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Paper 9700/43
A Level Structured Questions

Key messages

Candidates need to be able to apply their knowledge to problem-solving in new situations. Data analysis and other AO2 skill questions need thought and cannot be attempted successfully by simply writing down remembered facts as a 'model' answer. This may involve higher order skills such as understanding, analysing and evaluating. These skills can be developed with practice and appropriate feedback to students to allow them to develop confidence in sequencing their own thoughts and presenting their own ideas.

Candidates need to pay particular attention to the meaning of command words when interpreting questions.

General comments

Candidates showed good knowledge of many areas of the syllabus such as reproductive hormones, muscle contraction, respiration and kidney function. Many also showed competent skills in solving a genetics problem and in numerical calculations. Applying their knowledge of photosynthesis to new situations challenged candidates, as did a series of questions analysing aspects of the genetic engineering of Golden Rice, resistance of malarial parasites to drugs and some insect diversity data from the African savannah. The candidates who performed best dealt with these novel situations by trying to apply the principles they knew within the context of the new information provided. Detailed knowledge of modern ideas about the mechanism of closure of the Venus fly trap and the effect of gibberellin on stem elongation was rarely displayed.

Comments on specific questions

Question 1

(a) Most candidates showed some understanding of the meaning of the terms *locus* and *homozygous* but many did not express their ideas clearly enough to achieve full credit. There was confusion about defining a *locus* as a position on a chromosome as opposed to a piece of DNA or a chromatid, and between choosing between the appropriate term gene and the less appropriate term in this situation, allele. For *homozygous* the idea that two alleles are the same is needed, with similar being too ambiguous and reference to dominant or recessive alleles being an unnecessary addition.

(b) Many candidates achieved all or nearly all of the marks for this question. Errors in working included deriving gametes containing two alleles of the same gene (e.g. **Bb** and **ee**) rather than gametes containing a single allele from each gene (e.g. **Be** and **be**) and giving incomplete genotypes using dashes despite the fact that the information given in the question allowed the parental genotypes to be known in full. Few candidates rounded off their work by giving the ratio of phenotypes simplified to 3:3:1:1.

Question 2

(a) (i) Many candidates did not provide an answer comparing the biochemistry of C4 and C3 plants as asked, but instead wrote about histological and anatomical differences between the two. Some candidates mentioned PEP but did not explain its role in fixing carbon dioxide. Credit was most often gained for detailing the number of carbons in the first product of photosynthesis in C4 plants and mentioning the compounds oxaloacetate or malate.

(ii) Most candidates correctly linked the quaternary structure of rubisco to its possessing more than one polypeptide. Some candidates said that it has more than two polypeptides rather than that it

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has two or more polypeptides, which is a subtle but important distinction. Some candidates suggested that quaternary meant that the polypeptides had to be different to each other, e.g. large and small. A misapprehension was the idea that quaternary meant that a protein had to consist of four polypeptides.

(iii) Candidates generally showed good knowledge of the aspects of the structure of a protein enzyme that makes it soluble, but some confused hydrophilic and hydrophobic amino acids with the heads and tails of fatty acids. The ability of rubsico to form hydrogen bonds with water and the globular nature of the protein were also frequently mentioned.

(b) Few candidates fully explained the consequences of the equation given for the reaction of RuBP with oxygen, to work out the resulting impact on the normal metabolism of the plant. The lack of fixation of carbon dioxide and the waste of ATP energy in making RuBP that would not be regenerated rarely featured in answers. More general comments on the decrease in photosynthesis, RuBP available and in the products TP or glucose gained most credit. Many answers stopped short of making the last point by just quoting the equation and saying less GP was made, showing that the idea of consequences as the final effects of a sequence of events had not been appreciated.

(c) There were some well-considered answers as to why rubisco does not need to be in an active form in darkness. Answers referred to both the light dependent and light independent reactions stopping, the latter due to the inability to gain ATP and reduced NADP from the former. Errors in answers included ambiguous spellings of photophosphorylation (sometimes confusing it with photorespiration) and referring to reduced NAD instead of reduced NADP.

Question 3

(a) (i) Most candidates correctly identified restriction endonucleases as the enzymes needed both for obtaining the genes of interest and for cutting the plasmids.

(ii) Ligase was generally correctly identified as the enzyme used to introduce the genes coding for β-carotene into the plasmids. Incorrect answers included reverse transcriptase and DNA polymerase.

(iii) Generally, candidates were aware that promoters are added to allow transcription of the inserted genes. High-achieving candidates mentioned RNA polymerase binding to the promoter. Transcription factors and the idea that promoters control the level of expression of a gene were rarely mentioned. Confusing DNA polymerase with RNA polymerase was a common mistake, and some candidates confused transcription with DNA replication.

(iv) Properties of plasmids known by candidates to make them suitable for their role in producing Golden Rice included that they were small, circular and possessed restriction sites. Some candidates mentioned the existence of marker genes such as antibiotic resistance genes within plasmids. Few displayed knowledge of plasmids having their own origin of replication.

(b) This question was poorly answered. Candidates who had read the stem material carefully and understood something of the processes of genetic engineering and selective breeding still needed to address each of the two parts of the question separately and distinguish between normal rice and Golden Rice in order to gain credit. So, for example, they referred to Golden Rice throughout, without appreciating that the local varieties are just varieties of rice and are not golden unless bred with the engineered line. The term Golden Rice can only be applied to lines that possess the inserted alleles for β-carotene. A problem common amongst weaker candidates was to refer to inserting β-carotene (e.g. into the aleurone layer) rather than inserting the *gene* for β-carotene, or to say that originally rice lacked β-carotene instead of the *gene* for β-carotene.

(c) (i) A relatively small percentage of candidates understood that deuterium was used as a label or marker to show that β-carotene produced in the Golden Rice was being absorbed into the human body and used to synthesize vitamin A. Candidates often incorrectly stated that the deuterium was to help plant growth.

(ii) Only a few candidates understood that time was needed for vitamin A to be made in the human body from β-carotene absorbed in the gut from Golden Rice. Many candidates wrongly thought

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that the vitamin A gene had been engineered into the rice and so referred to time being required for vitamin A itself to be absorbed.

Question 4

(a) Candidates had scope to compare the data for the effectiveness of the two drugs within a country or to compare the effectiveness of one drug across a time-span of ten years. Most answers gained reasonable credit. Poor responses simply quoted each successive line of data in the table without drawing any judgements or inferences. The obvious patterns that many candidates drew attention to were the better performance of Fansidar® compared to chloroquine in three out of four of the situations, the reversal of this trend in Kenya in 2006, the decline in performance of Fansidar® over time and the improvement in chloroquine in Kenya over time.

A number of candidates made a mistake in comparing the numerical data as shown in this example: they stated that Fansidar® was 80% more effective than chloroquine (in Kenya in 1996), Candidates need to understand that raw percentage figures like 5% and 85% cannot be compared by saying that the larger figure is 80% more than the smaller figure. For example, if chloroquine is 5% effective, then an 88% increase in effectiveness would give a value of 9.4% for Fansidar®.

(b) Candidates struggled with this question. Many discussed only Uganda and merely stated that because chloroquine was ineffective it was discontinued and therefore no parasites were killed by it. Candidates who gained credit pinpointed the increase in effectiveness of chloroquine in Kenya between 1996 and 2006. A few of these explained that when chloroquine was no longer acting as a selection pressure, the non-resistant forms now had an advantage. Candidates generally found it difficult to visualise that the removal of a previous selection pressure acts effectively as a new selection pressure favouring the variants that were previously selected against.

(c) This question was well answered. Typically, candidates referred to mutation giving resistance, survival of or selection for the mutants and the passing on and increase in frequency of the allele for resistance. Most candidates did not mention that the mutation is random and a few wrongly thought the mutation only came about due to the selection pressure of the anti-malarial drug. Credit was lost where reference was made to the gene rather than the allele for resistance, where it was stated that allele frequency changed but not in what direction (i.e. an increase or decrease), and where it was not clear which allele was being discussed.

(d) A range of answers was provided, including disruptive, directional and genetic variation. Enough information was provided in the question for candidates to be able to narrow down this example of genetic variation as discontinuous, affecting one gene only.

(e) Candidates stated a variety of conditions necessary for the application of the Hardy-Weinberg principle and pointed out that in the scenario of *Plasmodium* parasites gaining resistance to a drug, problem issues were that mutation, selection and migration are or may be occurring, and that the parasites are haploid and may reproduce asexually. Most candidates, however, only gave a single distinct idea. Despite many instances of candidates writing out the equations for calculating allele frequencies p and q in diploid populations, very few candidates understood the theory sufficiently to realise that in haploid organisms, p and q can simply be counted directly as resistant or susceptible phenotypes.

Question 5

(a) A large number of candidates correctly described an ecosystem as an area where there were interactions between biotic and abiotic components. Some candidates confused the meaning of abiotic factor, however and made references to dead organisms as abiotic. Some did not appreciate that the word ‘environment’ includes the biotic, living components as well as the physico-chemical parameters of climate, edaphic factors and so on. Generally, candidates agreed with the suggestion that a tree could be considered to be a small ecosystem, but relatively few were able to explain this in terms of it being a community of organisms, being a habitat for many species or supporting many interactions. It was rare to see any discussion of the possibility that it was not correct to consider an isolated tree as a distinct ecosystem, but a few correct references were seen to the tree being part of the larger savannah ecosystem interacting with organisms that made transient visits to the tree.

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(b) (i) This was a simple calculation which involved finding the mean of two numbers. 105 was the expected answer, but the unrounded figure 104.5 was also accepted along with an answer rounded down to 104. This question was frequently unanswered.

(ii) This question showed weaknesses in candidates' knowledge of taxonomy, with many selecting names of orders or families from **Table 5.2** instead of recognising the binomial Latin names in **Table 5.1** as containing genus and species names. Those candidates who did give the names of the three *Acacia* species were not always able to separate the names correctly into separate genus and species components. Most candidates who knew the first part of the name was the genus reproduced it correctly with a capital letter at the start. Some mistakenly used a capital letter for *mellifera*, *nilotica* or *tortilis*.

(iii) While many candidates were aware that the larger the sample the more accurate it would be, there was often no reference to how this idea applied to the data in **Table 5.1**. A few responses did note that in this study the sample sizes were small, or that they were not the same, making comparisons invalid.

(c) This question gave those candidates with a real understanding of ecology an opportunity to express this in the context of conservation. Few candidates, however, were able to suggest ideas and speculations on how collecting data on insect diversity could be relevant to the conservation of other larger animals. Good responses described possible inter-relationships between the species or how the activities of insects might affect the food sources of the elephants. A few candidates referred to the research as raising awareness of, or money for, the game reserve. The need to conserve the whole ecosystem in order to conserve individual species should be emphasised in responses to such questions.

Question 6

(a) (i) Most candidates correctly identified **C** as the stage in the cycle where ovulation occurs. A few confused the peaks in oestrogen or progesterone with ovulation, and therefore answered **B** or **D**.

(ii) Most candidates correctly identified a decrease in progesterone with the woman not becoming pregnant. A number of candidates referred to oestrogen decreasing instead but to gain credit for this they had to specify the decrease in the **D/E** region of the graph, since the oestrogen concentration decreases at an earlier point on the graph also.

(iii) Almost all candidates correctly identified the corpus luteum as the ovarian structure secreting progesterone.

(iv) This part of the question was slightly less well answered, with a significant number of candidates either discussing the wall of the uterus instead of the lining, or implying that progesterone was only involved in the thickening of the lining, rather than its maintenance. Candidates must be careful to use the correct term: *endometrium* refers to the inner lining of the uterus while the term *uterus wall* indicates the muscular outer myometrium. Some candidates correctly referred to progesterone causing negative feedback or inhibition of FSH, GnRH or LH.

(b) Many candidates gained full credit for this question. Most referred to the inhibition of FSH, LH or GnRH, but candidates should be aware that it is the secretion of these hormones from endocrine cells that is inhibited and not the production of them within the cells. References to the pituitary gland as the site of production of the hormones needed to specify the anterior lobe. Good responses also included the inhibition of follicle development, prevention of ovulation and the thickening in consistency of the cervical mucus. This is not to be confused with a greater quantity of mucus.

Question 7

(a) Many candidates were unable to name the structures present in a section of striated muscle tissue. Only a few candidates recognised both structure **P** as the Z line and region **Q** as the A band.

(b) The role of calcium ions in the shortening of a sarcomere was generally well known, with good descriptions of the effect of the ions on troponin and tropomyosin. Candidates did not always make it clear that the binding site for myosin is on the actin filament, but most referred to the myosin head

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binding and tilting, resulting in the actin being pulled along. Details of the events in the presynaptic neurone were not required by the question and so gained no credit.

(c) The majority of responses correctly referred to the mitochondria being necessary for the production of ATP. The need for the ATP was usually linked to movement of vesicles or exocytosis or its use in sodium-potassium pumps. A few candidates recognised that synthesis of acetylcholine or acetylcholinesterase also needs ATP. The role of ATP in the movement by active transport of calcium ions into the sarcoplasmic reticulum or out of the presynaptic neurone was also occasionally mentioned, but frequently credit could not be awarded due to candidates stating the incorrect direction of movement which instead occurs by diffusion.

Question 8

(a) (i) Relatively few candidates were able to name solution X in the respirometer as sodium hydroxide or potassium hydroxide. Some suggestions, such as lime water, would not be able to absorb the carbon dioxide quickly enough in an investigation of this kind. Some substances named absorbed carbon dioxide but were not solutions, e.g. soda lime, which is a solid. Other compounds named included hydrogen peroxide, which would not absorb carbon dioxide at all but would evolve oxygen, further invalidating the measurement achieved by the respirometer.

(ii) Many candidates found it difficult to think of a factor that should be taken into account when using woodlice in a respirometer, rather than germinating seeds. The most common correct response was the problem of the woodlice moving around. A few candidates also gained credit by referring to the ethical responsibility of the experimenter not to raise the temperature too high so as not to harm or kill the woodlice.

(iii) The vast majority of candidates recognised the stage in aerobic respiration where oxygen is used as oxidative phosphorylation or the electron transport chain.

(b) (i) Candidates were required to divide the volume of oxygen used by the time taken of 15 minutes, giving answers of $0.012\,cm^3\,min^{-1}$ and $0.028\,cm^3\,min^{-1}$ at 15 °C and 25 °C respectively. Some candidates did not attempt the calculation while many manipulated the figures in a different way.

(ii) A significant number of candidates were unable to explain the difference in the rates of oxygen uptake at different temperatures. References to increased metabolic activity or respiration rate, resulting in more oxygen being used up, provided insufficient explanation. Those candidates who made the link between higher temperature and increased kinetic energy resulting in faster molecular movement mostly continued to gain additional credit for increased collision rate and increased enzyme-substrate complex formation.

(c) The majority of candidates could make at least three comparisons concerning the ways in which pyruvate is converted to ethanol in yeast cells or to lactate in mammalian tissue. Most could accurately recall differences in decarboxylation and reversibility and the vast majority could name the molecules involved at each step. Most candidates could name at least one of the enzymes involved, usually correctly naming both. The best responses also referred to similarities in the pathways, through reference to the use of reduced NAD in both or the regeneration of NAD in both. Candidates must make a clear distinction in their writing between the ‘a’ and the ‘o’ in ethanal and ethanol, as this is vital to gain marks for the steps involved in yeast.

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Question 9

(a) Generally, candidates had a good knowledge of how glucose is reabsorbed into the blood from a kidney nephron. Most stated that glucose was absorbed exclusively in the proximal convoluted tubule and provided good descriptions of the mechanism for its movement from the filtrate to the blood. There was a good understanding of the role of sodium ions and the co-transport of glucose, in most cases describing the pumping of sodium ions out of the tubule cells into the tissue fluid, resulting in a lower sodium ion concentration in the cells. The subsequent movement of sodium ions back into the cells was also well known, although it was not always clear that the sodium ions were coming from the filtrate or lumen of the tubule. References to the 'tubule' are ambiguous, since the 'tubule' consists of both the cells that make up the tubule wall and the central cavity, the lumen, which contains the filtrate. Co-transport was well described, with candidates referring to the sodium ions moving by facilitated diffusion bringing glucose with them.

Only a few candidates gained credit for cell adaptations that facilitate reabsorption, such as microvilli increasing the surface area for absorption, or the role of tight junctions or GLUT proteins. Similarly, very few stated that in normal circumstances *all* the glucose is reabsorbed in the proximal convoluted tubule.

Irrelevant material regarding ultrafiltration and events in the loop of Henlé and collecting duct, were not required by the question and so did not gain any credit. Candidates must be able to correctly refer to the lumen or tubule cells and also to distinguish between the basal cell surface membrane of the tubule cells (which faces the capillaries) and the basement membrane, which is a collagen and glycoprotein structure supporting a layer of epithelial cells.

(b) The role of ADH when the water potential of the blood decreases was generally very well described. Most answers stated that the change in water potential was sensed by osmoreceptors in the hypothalamus, although some incorrectly referred to the hypothalamus as being situated in the pituitary gland. The role of the posterior pituitary in releasing ADH was usually given, but the role of neurosecretory cells in ADH production was not. Few responses described the hormone being carried in the blood but most described the action of ADH in binding to receptors. Detail of this was usually provided, bringing about an increase in the permeability of the collecting duct to water by the addition of aquaporins to the membrane. Most candidates went on to describe the movement of water by osmosis out of the filtrate into the blood. The formation of a concentrated, small volume of urine and the resultant increase in water potential of the blood were both often mentioned.

Question 10

(a) Few candidates were able to describe the response of the Venus fly trap to touch in any detail. The stronger responses noted that at least two sensory hairs needed to be touched before a full action potential could be triggered. These candidates usually referred to the hinge cells and most gave some details of hydrogen ions being pumped out of the cells, cross-links between cellulose fibrils breaking in the cell wall and calcium pectate glue dissolving. Most described a change in the shape of the lobes of the trap from convex to concave though only a few mentioned the speed of the trap closing. Some responses gave further detail of the mechanism behind this change, mentioning calcium ions entering cells, the subsequent entry of water by osmosis and the expansion of the hinge cells.

(b) Many candidates only described the role of gibberellin in seeds, which was irrelevant to the question since that asked about stem elongation. Reference to the control of gibberellin synthesis by the *Le/le* gene, with the dominant allele resulting in enzyme activity, converting inactive gibberellin to an active form, was often omitted. If candidates demonstrated understanding of this genetic control, they often went on to gain high levels of credit. Some candidates knew that DELLA proteins are destroyed in the presence of gibberellin, but very few could provide further detail of how this resulted in the transcription of growth genes. The idea of the transcription factor or PIF, when set free from the DELLA protein, being able to bind to the DNA triggering transcription, was the link that was usually missing. Many candidates repeated 'stem elongation' as part of their explanation, but did not specify that gibberellin leads to cell elongation and cell division. Good responses explained cell elongation in terms of loosened cell walls and the entry of water into the cells.

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Key messages

- Candidates need to read the questions carefully to make sure that their answers relate to what is being asked. This is particularly important when evaluating given information such as a method for an investigation or the results of an investigation.
- Candidates need to be familiar with the different types of data specified in the syllabus and understand how to choose a statistical test suited to the data. When evaluating the results of statistical tests candidates should understand how to interpret probability values and recognise that the smaller the probability value, the greater the chance that the external factor being tested is causing the observed data.
- One of the main components of this paper is planning, so there will always be a section testing this skill. Questions always specify that any method described should be detailed enough for another person to follow. In effect, this means describing suitable apparatus, volumes and concentrations of solutions if appropriate so that someone who has never done the experiment could follow the instructions and obtain valid results.

General comments

The questions produced a good range of marks and candidates appeared to have sufficient time to complete them. **Questions 1(b)(i)** and **1(d)** caused problems to some candidates as they did not show they understood how to formulate a hypothesis. The main feature of a hypothesis is that it should be testable so it should always include a quantifiable measurement. A great many candidates found **Question 2(b)** challenging, in particular using the chi-squared test and in using probability tables to find the significance of a test result.

Answers requiring knowledge of practical procedures were often given in terms of theoretical knowledge rather than practical experience. This was evident in **Questions 1(a)(ii)**, **1(b)(ii)** and **1(c)(i)**. In **Question 1(a)(ii)**, it was clear that many candidates knew a formula for making a range of solutions with different concentrations, but did not translate this into practical instructions. **In Question 1(b)(ii)** candidates often did not mention suitable equipment that could be used to carry out the method described. The syllabus specifies that candidates should know how to use an eyepiece graticule and stage micrometer to measure cells, but in **Question 1(c)(i)** there were many who showed considerable confusion about how to do this. Candidates should be aware that this paper can test skills from topics that are in the AS part of the syllabus in addition to A Level topics.

Comments on specific questions

Question 1

(a) (i) Most candidates could correctly identify the independent and dependent variables. Weaker answers for the independent variable included 'amount of potassium chloride' or 'the potassium chloride solution'. For the dependent variable, weaker responses were the number of stomata or the diameter of the stomata.

(ii) This question was rarely well answered. Many candidates wrote extensively about the formula $c_1v_1 = c_2v_2$ and how it should be used, but did not give any actual volumes that would match the expected range of concentrations. Stronger responses identified the actual concentrations and

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gave the volumes of potassium chloride and water that would be used. These answers also included some practical detail of making a solution. Weaker answers tended to give the volumes needed to make a concentration of 200 mmol dm^{-3} potassium chloride solution, but did not follow up with other concentrations. Alternatively, the correct proportions of potassium chloride and water were given, but without a link to a specific concentration. Common errors were to use serial dilution, giving incorrect concentrations, or to make correct dilutions from 100 cm^3 of one dilution, but to then remove some of it make the next dilution.

(b) (i) Many candidates were able to suggest a suitable hypothesis, although it was not always clear whether they were referring to the number of open stomata or how wide the stomata had opened. For example, 'the more concentration of potassium chloride solution the more the stomata open' is ambiguous. Credit was only given if the hypothesis referred to the *number* of open stomata since this was stated in the information provided. Some candidates did not show understanding of what is meant by hypothesis or that they understood the nature of the experiment. These candidates often wrote several sentences about the role of stomata in photosynthesis or transpiration.

(ii) Candidates should write a method that could be used as a protocol by another person. Those who produced an answer modelled on previous mark schemes often did not gain credit, as variables were listed without any practical detail of what to do in an experiment. For example, candidates stated that the controlled variables were temperature and light, but did not describe how these variables were going to be standardised.

Candidates were often able to give a basic plan but rarely gained maximum credit as their answers lacked practical detail. Many candidates described how to make up different concentrations of potassium chloride, which was not required. Stronger responses identified suitable apparatus in which to float leaf strips, commonly Petri dishes or beakers. Weaker answers described using test-tubes and sometimes microscope slides, neither of which is suitable for floating leaf tissue. The weakest answers simply said 'put the leaves in the solutions'. Many candidates, in spite of the information in **Fig. 1.1**, did not seem to appreciate that leaf strips are not the same as epidermal strips and as a result did not describe a suitable apparatus for cutting leaf strips. The best answers recognised the other external factors that might influence the opening of stomata. These answers included relevant practical details such as keeping the solutions containing the leaf strips in the dark and at a constant temperature, so only the effect of potassium chloride was being assessed. Most candidates were aware that counting stomata was involved in obtaining the results. Good answers referred to making epidermal strips, mounting these on a microscope slide and using a microscope to count the number of open stomata in a defined area, commonly the field of view. Mounting leaf strips was also acceptable. It was rare for candidates to make more than one count per leaf strip, although good practice is to make several counts per leaf strip so that variation in stomatal distribution is taken into account. Consequently many candidates did not recognise that the three strips were replicates, so there was no need to repeat the whole investigation. Weaker answers lacked practical detail, for example, 'the strips are put on a microscope and the open stomata observed'. A number of candidates stated that a magnifying glass or a hand lens could be used to count open stomata. Neither of these is suitable as the magnification is insufficient to observe stomata clearly enough to determine whether they are open or not. Almost all candidates realised that this was a low risk experiment. Credit was allowed for a suitable hazard and precaution. Candidates should not assume that all chemicals are allergens or irritants and credit is given only if the stated hazard is valid.

(c)(i) Some candidates gained maximum credit for this question. Others showed confusion about whether a slide micrometer or an eyepiece graticule should be used to measure the aperture of a stoma. Weaker answers often started with 'the eyepiece graticule and stage micrometer are used to measure the aperture'. Many candidates incorrectly referred to measuring the length of the stomatal aperture. There was also a good deal of uncertainty about how to calibrate an eyepiece graticule in order to calculate actual measurements. A common inappropriate answer to this question was to use the image size and magnification to find the actual size.

(ii) Almost all candidates selected two correct values.

(iii) The majority of candidates gave a correct answer. The most common error was to divide 4.6 by 180, instead of dividing 2.1 by 60.

(iv) This question required candidates to evaluate the method used to obtain the results. Candidates who understood this often suggested increasing the number of stomata counted and increasing the

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number of sample leaves. Candidates who chose to modify the sampling times sometimes showed confusion between range and interval. Many candidates gave answers that changed the independent variable of the experiment, commonly to vary the light intensity. Some weaker answers stated that the rate of opening should be measured instead of the aperture, suggesting a misconception of what is meant by 'rate'.

(d) Some candidates gave correct answers. Others wrote a hypothesis about light intensity rather than light duration. Some candidates were unable to formulate a hypothesis.

Question 2

(a) Although many candidates were able to identify the two variables that had been standardised, a large proportion answered in terms of what *should have* been standardised. The most common correct answer was the number of fields and the same crop. The most common errors were to state that the butterfly population and the amount of herbicide was standardised.

(b) (i) The most common correct answer was that it has discrete data. Discontinuous was not accepted as this can be confused with a type of genetic variation. Answers that were in terms of finding a difference between observed and expected data were accepted.

(ii) Many candidates could not give a suitable null hypothesis. A null hypothesis assumes that there is no significant difference between the results from investigations carried out in different conditions. In this case, an acceptable null hypothesis would include three main components: no significant difference between; butterfly populations or numbers of butterflies; and fields with headlands and fields without headlands.

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(iii) Familiarity with the chi-squared test would be of benefit to candidates in answering this question. Many candidates did not show that they understood how to work out the expected number (*E*) of butterflies from the observed number (*O*) of butterflies. Some candidates who did correctly work out *E* and processed the figures correctly, did not appear to know that the two figures needed to be added to obtain the chi-squared value. Candidates who had incorrect values for *E* were allowed error carried forward if these were processed correctly to obtain a chi-squared value.

(iv) The majority of candidates gave a correct answer. Common incorrect responses, as a result of candidates choosing an incorrect number of degrees of freedom, were 5.99 and 7.82. Weaker answers had probability values such as $p < 0.01$ or $p < 0.05$.

(v) Candidates who had correctly calculated the value of chi-squared usually answered correctly. Error carried forward was allowed for incorrect values of chi-squared interpreted correctly from the probability table.

(c) For this question candidates were expected to use the data in **Table 2.3** about the butterfly populations and draw conclusions about the effect of herbicides on all of the species. Most candidates found it difficult to interpret the statistical data, and tended to answer in terms of 'more significant' or 'less significant' rather than the probability of herbicide being the cause of the decrease in butterfly numbers. Stronger answers recognised that the numbers of all species were reduced by the use of herbicide although species **S** was the only one where this was not significant. Only the strongest responses commented about the degree of severity of the effect of the herbicide on the different species based on the probability values; in particular species **R** with 99.9% certainty that the herbicide was causing the decrease in numbers. Weaker answers tended to ignore the results of the chi-squared test and refer to raw data. Using the raw data for species **V** also lead to an incorrect conclusion that the number of species had decreased; the probability value suggests otherwise. Many of these candidates also tended to describe the data rather than make comparisons. For example, although some candidates noted that the result for species **S** was not significant, they did not identify clearly enough that this was the *only* one of the species studied. Some candidates misinterpreted the question and answered in terms of not using herbicides, commonly stating that without herbicides the number of butterflies increased.

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Paper 9700/52
Planning, Analysis and Evaluation

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Paper 9700/53
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Key messages

- Candidates should read questions carefully in order to focus precisely on what was being asked. Some candidates seemed to rely on using a learnt response from a previous mark scheme rather than analyse carefully what the current question asked.
- The glossary of command words in the syllabus is designed to guide the candidates on the approach and depth expected in an answer.
- To develop skills in planning an experimental procedure and to identify potential areas of improvement, students could practise writing a set of laboratory instructions and then getting another student to try to follow them.

General comments

The paper achieved a wide range of scores and there was no evidence that the candidates were short of time. Most candidates were able to write concise answers in the spaces provided.

Comments on specific questions

Question 1

(a) Responses here needed to be in the context of the information given in the stem of **Question 1**.

(i) This was generally well answered with the concentration of calcium chloride being identified as the independent variable and the number of closed stomata as the dependent variable. The commonest error was to omit the idea of concentration and just state the number or range of $CaCl_2$ solutions. Occasionally the rate of closure rather than the number of closed stomata was given as the dependent variable.

(ii) Many candidates correctly stated that serial dilution was used.

(b) (i) A hypothesis must be able to be tested and so candidates should include a quantifiable measurement in their answer, in this case the number or percentage of closed stomata. Many answered this well, but weaker responses omitted any mention of number or commented on the rate of closure. Another common error was to suggest a hypothesis for only one concentration rather than across the range.

(ii) Good answers were set out as a logical set of laboratory instructions. Poorer responses often included irrelevant material, such as including details of the dilution, which was not required, or reiterating the independent and dependent variables. There seemed to be some confusion between epidermal strips and leaf strips. In this investigation, it should have been epidermal strips that were placed in the range of calcium chloride solutions. Candidates needed to mention a suitable container in which to immerse the strips and also mention the use of a microscope to observe the stomata. Some candidates calculated rather than counted the number of closed stomata. The idea that the counting needs to be in some way standardised was not often seen. This could be either by counting the number of closed stomata in the first, e.g. 50, stomata observed, or counting in a fixed area such as a field of view. Some responses seemed to suggest that every stoma on the whole peel was observed/counted, but this is not practicable. Although

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responses commonly included some reference to replication, most were too generalised and indicated simply 'repeat three times and take a mean'. What was required was a clear idea that at least three separate areas per strip would be counted and the mean calculated from these counts.

Although it is a fairly low risk investigation, candidates were aware that calcium chloride is an irritant. As this investigation was to see the effect of calcium chloride on overcoming the effect of light thereby closing stomata, it was essential that the investigation should be carried out in the light. This was not clearly stated in many responses. The important environmental condition to keep constant was temperature as this could affect the closure. Many responses mentioned this with a suitable way of achieving it, although there were some general references to room temperature or air conditioning. Another valid condition to control was the covering of the containers to prevent evaporation, since this would have changed the calcium chloride concentration over the time period of the investigation.

(c) (i) Those who focussed on the method of measuring had no difficulty in finding appropriate ways of standardising. Incorrect responses mentioned selection of the sample, standardisation of conditions or repeats.

(ii) Although there were many correct answers, common errors were 7.5, 0.6 and dividing 0.75 by 400.

(d) (i) Many candidates described the general shape of the graph or stated the size of the aperture at a particular concentration of ABA, neither of which is required. The range of data needed to be considered to provide evidence for the hypothesis that stomata on the upper and lower leaf surface respond differently. The most significant piece of evidence is that, over the ABA range considered, those on the upper epidermis initially increase in width before reducing, whilst those on the lower epidermis reduce in width throughout. Some credit was given for those who discussed the width of the aperture being greater throughout almost all the ABA concentrations. Many candidates incorrectly referred to measuring the length or height of the stomatal aperture.

(ii) There was considerable confusion as to what confidence limits are. Many confused the idea with significance and made erroneous statements such as 'the means are significant' or 'the means are 95% due to chance' or 'the means are 95% due to another factor'.

(iii) The majority of candidates appreciated that this required the comparison of two means from normally distributed data and thus a *t*-test was used. Some did not mention two means. Chi-squared tests were the most common erroneous response.

(e) Many candidates gave good answers showing that they appreciated which aspects of the experimental design ensured that the results were trustworthy. Candidates who lost credit reiterated one or both of the investigations stating what should be done, rather than stating what had been done.

Question 2

(a) (i) Since the question asked for an outline of the test, the answer did not require the full detail expected in a plan, just the key essentials. Many responses repeated the method carried out in the original investigation. These could not gain credit. As the hypothesis focussed on the effects of a substance from older couch grass roots inhibiting younger barley root growth, the key point was to outline a method by which young barley could be grown both with substances from older couch grass roots and without the substances. Couch grass could be grown for a period of time and then either an extract made from the older roots and applied to pots of young barley, or the couch grass removed and the young barley then planted in the soil where the older couch had been growing. A control of young barley grown on its own in fresh soil is needed, and the conditions under which each is grown must be standardised. To test the hypothesis it would be necessary to measure the root growth after a period of time and compare the two sets of data. Many candidates indicated that they would just grow barley and couch grass together for varying lengths of time and measure the yield. This does not answer the question as to whether the older couch grass produces an inhibitory substance.

(ii) The commonest alternative idea for a hypothesis to explain the drop in yield was competition for stated resources. It was not always clear that candidates were referring to older couch grass i.e. couch grass planted before barley. It is only older couch grass that caused the drop in yield noted.

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Other ideas such as older couch grass harbouring disease or changing soil pH were occasionally seen and credited.

(iii) Many candidates were able to give a null hypothesis in terms of no significant difference in the yield of barley between the experimental conditions (with couch grass) and the control (without couch grass). Sometimes the element 'between' was missing. Quite a few responses erroneously referred to 'no significant correlation'.

(b) (i) There were plenty of correct calculations. Some candidates did not fill in the totals boxes. The commonest error was to express 0.300 as 0.3. The number of decimal places in a calculation should always match the number used in the rest of the table.

(ii) Candidates should be aware that the answers should be positive statements in the context of the question and not just a reiteration in words of the data. Thus, describing what happens without pesticides is not answering the question. To say that fields with pesticides have fewer organisms needs to be qualified by the statement that this shows pesticides reduce the number of organisms. Likewise, the lower value of *D* in fields treated with pesticides shows that biodiversity is reduced. Credit was also given for comments on the fact that the actual reduction in biodiversity was not very large – even though the reduction in numbers was considerable. The elimination of bees showed that pesticides have a huge effect on this group. The other group which stands out is the ground beetles; the reduction in numbers here is only 56% compared to 87% or above in all the other types of organisms. Some rudimentary processing of the data shows that the response in beetles was different to that in the other groups.

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