BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

Many weaker candidates incorrectly thought that endoplasmic reticulum can be seen at a magnification of ×400.

Question 2

The majority of candidates were able to do the mathematical processing and correctly obtain the answer of 500.

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Question 4

Stronger candidates were able to reason that none of the items could pass through pores 2.4 nm in diameter.

Question 7, 8, 16 and 26

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

Question 9

The majority of weaker candidates found this difficult and incorrectly thought three fatty acids combine with glycogen, not glycerol.

Question 12

Some candidates were unclear about the induced fit hypothesis of enzyme action.

Question 17

Many candidates did not realise that replication of centrioles occurs during interphase, not prophase, and additionally that the spindle fibre begins to form during prophase.

Question 25

Many weaker candidates did not know the correct definition of transpiration.

Question 27

The theory of active loading of sucrose into companion cells was poorly understood by the majority of candidates.

Question 30

The majority of candidates found this question difficult. Whilst hydrogen ions are released from haemoglobinic acid, they combine with the hydrogencarbonate ions which diffuse into the red blood cell and this leads to the release of carbon dioxide.

Question 39

The majority of stronger candidates were able to process the information provided and deduce that statements 2 and 4 were correct.

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Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 2

Whilst the majority of stronger candidates answered correctly, the most common misunderstanding amongst weaker candidates was that the two organelles contained 80S ribosomes.

Question 3

Whilst most of the stronger candidates answered correctly, some candidates were unable to recognise the range of sizes that include most eukaryotic cells.

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Question 4

A minority of candidates were able to process the information in order to identify the organelle as a ribosome which is involved in the synthesis of proteins.

Question 7

Many of the weaker candidates appeared only to consider the quaternary structure of haemoglobin, not the quaternary structure of any protein.

Question 11

The majority of candidates found this difficult and were unable to identify **B** as the answer representing the effect of temperature on the two enzymes.

Question 13

Many candidates were unaware that during cytokinesis the cell membrane has to be fluid.

Question 16

Most of the stronger candidates understood the relationship between DNA and chromatids.

Question 17

The majority of candidates did not know that the phase of mitosis that would be first affected is prophase, since this is when the spindle is formed.

Question 18

Many candidates did not recognise that the production of genetically identical cells was important or that growth of single celled organisms is not a result of mitosis.

Question 23

The majority of the stronger candidates understood the role of tension in the xylem.

Question 29 and 30

The majority of candidates found these questions concerning the processes involved in oxygen and carbon dioxide transport difficult to answer.

Question 39

This was answered correctly by the majority of stronger candidates but the weaker candidates selected each option almost equally.

Question 40

The majority of candidates found this difficult and were unaware that cancer cells can be specifically targeted because they have different antigens from normal body cells.

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Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 3

The majority of candidates did not realise that ATP would be required and therefore did not include the mitochondria.

Question 5

The majority of candidates found this difficult. Candidates should know that protein synthesis occurs in both prokaryotes and eukaryotes and that mRNA, rRNA and tRNA are all involved.

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Question 8

The majority of stronger candidates could correctly process the information in this linear Venn diagram.

Question 9

Candidates who remembered that the heads of phospholipids are hydrophilic were able to correctly select option **C**.

Question 10

Many weaker candidates incorrectly considered hydrogen bonds to be strong.

Question 13

This question was discounted.

Question 16 and 20

The weaker candidates found these difficult and all four options were selected almost equally.

Question 17

Very few candidates knew which of the processes was occurring during prophase.

Question 18

The majority of candidates did not understand that the mitotic cell cycle includes interphase, mitosis and cytokinesis. As such all three processes listed are correct.

Question 23

The majority of the stronger candidates correctly identified option **C**.

Question 26

The role of the co-transporter when loading a sieve tube element was poorly understood by the majority of candidates.

Question 34

The majority of candidates found this very difficult. The molecule of oxygen has to pass through the cell membrane on either side of a cell from the alveolus, then through the cell membrane on either side of a cell from the capillary and finally through one cell membrane to enter the red blood cell. This is five cell membranes which are each composed of a phospholipid bilayer. Therefore, the answer is 5 × 2 = 10.

Question 40

The majority of candidates were able to process this information to correctly select option **D**.

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Paper 9700/21
AS Level Structured Questions

Key messages

- Candidates are expected to have an overall view of the stages involved in protein synthesis and a good understanding of the flow of information from DNA to proteins is highly beneficial when approaching questions involving transcription and/or translation, such as **Question 2(a)(ii)**. Candidates must know what is meant by the terms transcription and translation so that they can use the terms correctly and avoid a common mistake on this paper, where they used them the wrong way around.

- Cohesion and adhesion, terms frequently associated with the movement of water within xylem vessels, both result from hydrogen bond formation owing to the polar nature of water molecules. It is important, as seen in **Question 4(b)**, for candidates to be able to distinguish between the two. Cohesion occurs between water molecules and contributes to transpiration pull in the xylem. Candidates should be precise in describing adhesion between water molecules and the walls of xylem vessels: the hydrophilic cellulose lining is important for adhesion whereas lignin is largely hydrophobic and contributes little to adhesion.

- The movement of water and water vapour should be explained in terms of water potential and not in terms of concentration. This was relevant to **Questions 4(a)** and **(d)**. A gradient created by one area that has a higher water potential and another that has a lower water potential should be described as a water potential gradient and not as a diffusion gradient or a concentration gradient. When describing two adjacent areas with different water potentials, it is not correct for candidates to incorporate the term 'gradient'. For example, 'water moves from a higher water potential to a lower water potential' should be used rather than 'water moves from a higher water potential gradient to a lower water potential gradient'.

- **Question 4(c)** asked candidates to describe graphical data. It is good practice for candidates, as part of their responses, to include data that has been extracted correctly. The data quotes should refer to both variables and include units if appropriate. When asked to describe graphical data, candidates should check to see if a pattern or trend can be described first before giving more details. Many candidates tend to describe the data in far too much detail without first describing the overall trend or pattern and then giving detail to illustrate. In this question many candidates did not include both similarities and differences between the transpiration rates.

General comments

The paper was generally answered well with most candidates making attempts at all questions.

Many candidates lost credit throughout the paper because they confused important key terms, such as cohesion/adhesion, osmosis/diffusion and complementary/specific.

A more careful reading of the questions would help candidates to identify where their answer should begin and where it should end. Candidates should also check the wording of the questions carefully to ensure that they are directing their responses to the question being asked. For example, in **Question 2(b)** the candidates were asked to describe a particular stage occurring during intracellular digestion in a macrophage. Details of endocytosis, diffusion of products of digestion through vacuole membranes, and exocytosis were not relevant. In **Question 5(b)(i)** candidates were asked to outline the changes that are necessary to enable a cell to differentiate into a red blood cell to enable it to perform its function. In this case, details of the events of association and dissociation of oxygen to haemoglobin are not relevant. In

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Question 2(c) many candidates described the roles of T-lymphocytes rather than explain the fact that there are very few that respond to the presence of a particular antigen on an antigen presenting cell.

Many also confused the command words 'describe' and 'explain' and answered questions with descriptions when explanations were required and vice versa.

Comments on specific questions

Question 1

This question assessed candidate knowledge and understanding of Topic 10 of the syllabus. It was a good start to the paper for many candidates, who completed the table with information about the three infectious diseases, giving the correct names of the pathogens, the types of organisms that cause these diseases and the modes of transmission. Stronger candidates knew that *Plasmodium* was a protoctist and avoided the error of others, who identified the pathogen as a bacterium or a virus. Some could have gained more credit with a correct spelling of the cholera pathogen: *Vibrio cholera* was frequently seen. Good answers to the transmission of *Mycobacterium tuberculosis* made it clear that it is transmitted in airborne droplets. Some candidates wrote 'via the air' which was not accepted. Some candidates stated that *Plasmodium* is transmitted in blood transfusion and via needles used in intravenous drug taking. While both of these are theoretically possible ways in which the pathogen is transmitted, they account for a very small proportion of cases and the candidates should have considered the main mode of transmission. Some candidates were considering *Mycobacterium bovis* instead of *M. tuberculosis* and gave milk or animal products as the mode of transmission, while others mistakenly gave sexual transmission for *Plasmodium falciparum*.

Question 2

The theme of this question was macrophages, from Topic 11 of the syllabus, with subject material from Topics 1, 2, 3, 4 and 6 included. Answers to this question were generally very good, although **(c)** proved challenging for most who responded with recalled knowledge rather than applying their knowledge to solve a problem.

(a) (i) Most candidates gave either phagocytosis or endocytosis as the method by which bacteria are engulfed by the macrophage shown in **Fig. 2.1**.

(ii) Candidates were equally successful at naming the two stages at **E** and **F** on the diagram as transcription and translation. Some candidates described both processes instead and were not awarded credit. Others named them but the wrong way around.

(iii) Equally well answered was this question on naming cell structures. Some candidates incorrectly labelled **H** as smooth endoplasmic reticulum.

(b) A number of candidates were able to give complete details of the events occurring after phagosome formation. Some candidates could have improved their response if they had confined their answers to events that happen between **C** and **D**. They gave considerable detail about what happens before and after this stage, rather than answering the question. Details of the enzymes released from the lysosomes into the phagosome and the substrates of these enzymes or the bonds hydrolysed were given by very few. A few candidates made references to the action of hydrogen peroxide in cell killing. A large proportion of answers described the diffusion of the products of hydrolysis out of the phagosome, which was not required as it was a stage too far. A number would have benefited from knowing the difference between lysosomes and lysozyme.

(c) **Fig. 2.2** showed antigen presentation. Many candidates interpreted this question as asking about the role of helper T-lymphocytes or about the roles of all types of T-lymphocytes. Often there were quite lengthy answers full of good detail, but without anything that addressed the question. Stronger answers were far more concise, explaining that only a small number of these cells have the correct specificity with T-cell receptors complementary in shape to this particular antigen. Some candidates pointed out that in a primary immune response there would be very few of these cells as no memory cells would be present, which would mean that numbers of T-lymphocytes of the clone with this specificity would be very small indeed.

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Question 3

This question assessed knowledge of the structure and function of the trachea from Topic 9 and asked candidates to compare the structure of collagen with information provided about elastin, another structural protein found in the gaseous exchange system. In **(c)**, candidates used knowledge from Topic 2.

(a) (i) Many candidates identified the epithelium as ciliated. Some answers showed evidence of knowledge beyond the syllabus by giving the epithelium its full name – pseudostratified ciliated epithelium. 'Squamous' was a common incorrect answer.

(ii) A small number of candidates recognised the structures labelled **O** in the photomicrograph as mucous glands. A common answer was 'blood vessels', although it can be seen that **O** is lined by cells with nuclei circular in cross-section: this shows that they are not blood vessels.

(iii) Structure **P** was recognised as cartilage by many candidates.

(b) The smooth muscle tissue labelled in the photomicrograph forms the trachealis muscle that lies between the ends of the C-shaped rings of cartilage in the trachea: candidates are not required to know this level of detail but are expected to understand that smooth muscle contracts and relaxes. Here, they were told that smooth muscle in the gas exchange system relaxes during exercise and were asked to suggest the advantage of this. Good answers were concise and direct, contrasting with weaker, vague responses. Some stated that more air would enter the lungs and should have explored this idea further to explain that more air can reach the gas exchange surface, so that more oxygen can be absorbed to meet the increased demands of exercise. Many candidates simply stated that relaxing this muscle tissue would allow the trachea and bronchi to widen. This gained partial credit.

(c) Candidates were provided with information about the protein elastin. They were then asked to give two ways in which the structure of collagen differs from the structure of elastin. Almost all candidates responded by describing structural differences, with the strongest making their points sufficiently accurate to gain credit. Many candidates responded to the information about glycine to state that it is found 'regularly' within each collagen molecule. Creditworthy answers stated that it is found at every third position in the primary structure rather than just regularly. There were, however, good answers stating that collagen is composed of three polypeptides and that these are tightly bound together in a triple helix.

Question 4

This question assessed knowledge and understanding of Topic 7 and provided candidates with a graph showing the changes in transpiration rates of three types of forest tree to describe and interpret. Descriptions of the information in **Fig. 4.2** prompted detailed answers that often made effective use of figures taken from the graph. Candidates tended not to apply knowledge of the environmental factors that affect transpiration to their interpretations in **(d)**.

(a) Many answers to this question gave adequate explanations of the meaning of the statement given. Candidates explained that stomata have to be open to allow carbon dioxide to diffuse into leaves for photosynthesis. As a result, water vapour diffuses out through the stomata down a water potential gradient. Less successful answers needed to provide more salient points, such as 'stomata are open', 'water vapour' and movement of carbon dioxide and water vapour 'by diffusion'. Some candidates stated that water 'evaporates from stomata' which is incorrect. Stronger answers went into more detail describing how evaporation occurs at the cell walls of the spongy mesophyll and the water vapour molecules diffuse out of the leaf through stomata.

(b) Candidates tended to explain the role of cohesion and adhesion in water movement in the xylem, stating that hydrogen bonds form between water molecules and between water molecules and the lining of xylem vessels. Some candidates went into detail about hydrogen bonding, which was not necessary. Stronger answers explained that hydrogen bonds form between water and cellulose and between water and the polar parts of lignin. Few went on to say that cohesive and adhesive forces maintain columns of water in the xylem and relate this to transpiration pull. Weaker candidates tended to confuse cohesion and adhesion, so rarely gained much credit.

(c) The graphs in **Fig. 4.2** gave candidates plenty of information to sift through. Some candidates simply described the changes in rates of transpiration of each type of tree over the 14-hour period

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and would have improved their answer by making comparisons between them. Stronger answers included some similarities, for example all trees having transpiration rates of 0 kg h^{-1} at 06.00 and all showing an increase to a peak and then a decrease. Figures were then used to state the timing and rate of these peaks. These three statements could have been made in a few lines; often they were made within lengthy and dense accounts of the changes to the transpiration rates of *each* type of tree. Other points that could be made included the observation that emergent trees had much higher rates of transpiration than the other two types and that they had a much steeper increase in transpiration rate during the early part of the day (06.00 to 10.00). Candidates need to ensure that correct units are given when providing data quotes. Fewer candidates made references to the rate of change in transpiration by stating, for example, that the greatest rate of change in transpiration is shown by the emergent trees. A common mistake when quoting data was to write 14.50 rather than 14.30. Many candidates could have improved their response by using comparative words such as higher or faster rather than high or fast.

(d) A few responses were of a high quality and dealt with a range of environmental factors that influence rates of transpiration. Most candidates used the information about light intensity from **Fig. 4.2** and could have improved by considering other factors such as humidity, temperature and air speed. Many wrote about the different heights of the trees, using the information in **Fig. 4.1**, and suggested that the emergent trees would be exposed to greater wind speeds. An improvement to this would be to also explain the effect of these factors in terms of water potential gradients and rates of diffusion of water vapour. Increases in light intensity cause stomatal apertures to increase. In contrast, candidates responded to the increase in light intensity by stating that stomata simply open in high light intensities and close in the dark.

Question 5

This question was based on stem cells and aspects of cell division and covered knowledge of Topics 1, 5 and 8.

(a) (i) The standard of drawings of the cells during anaphase of mitosis was very variable. Many drawings were clear enough to gain full credit. Errors tended to be drawing too many chromatids (usually six, not four), not showing the chromatids pointing towards the poles and drawing spindle fibres that stopped short of centromeres and/or the poles or that connected separating chromatids across the equator.

(ii) There were many excellent answers describing the roles of the spindle fibres during mitosis. The only common error was to refer to the poles as 'ends' or 'sides' and the equator as the 'middle'.

(b) (i) Many candidates described the differentiation of mature red blood cells very well, with references to: the synthesis of haemoglobin; becoming biconcave as a result of losing their nuclei; and the loss of other organelles, such as mitochondria. Some candidates covered just about everything they knew about red blood cells and included synthesis of carbonic anhydrase and the antigens of the different blood groups, which was not required. Stronger responses demonstrated skills in manipulating knowledge to provide a suitable answer to the question and avoided writing out a well-prepared answer of 'how red blood cells are adapted to their function'. They explained that the nucleus and organelles were lost and haemoglobin synthesised.

(ii) Candidates suggested a variety of fates for cell **Y**. Using the information in **Fig. 5.2**, the candidates who suggested that the cell remains as a stem cell and/or divides by mitosis gained credit. Some thought that the cell would differentiate into a blood cell, red or white. Some named specific white blood cells. Once a stem cell such as that at the top of the flow chart in **Fig. 5.2** divides, one of the daughter cells must retain the ability to divide and give rise to another line of cells.

(c) (i) **Table 5.1** showed data on adaptation to altitude. Some candidates calculated the percentage increase in concentration of haemoglobin correctly. Some did not give an answer.

(ii) This question discriminated well. Some candidates gave full explanations that showed a good understanding of the decrease in the partial pressure of oxygen on moving to high altitude, and the accompanying decrease in percentage saturation of haemoglobin. They explained that increasing the number of red blood cells, and hence the haematocrit, increases the concentration of haemoglobin and this compensates for the lower saturation with oxygen to maintain the total volume of oxygen transported by the blood. Some candidates gave a less convincing explanation and needed to have considered the decrease in partial pressure of oxygen. Instead, they stated

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that the *concentration* of oxygen in the air is less at high altitude compared with sea level. They should also have referred to the degrees of saturation of haemoglobin with oxygen. The strongest candidates took care to ensure their points were made in the correct sequence.

Question 6

Stronger candidates found no difficulties answering these questions on membranes from Topic 4 of the syllabus.

(a) Many candidates wrote excellent, concise definitions of the term 'fluid mosaic' as applied to membrane structure. Some candidates needed to state more clearly that it is phospholipids that are responsible for the fluid nature of membranes, and that they move. Stronger responses pointed out that they move within their monolayer. Candidates were better at the mosaic nature of membranes by referring to the 'scattering' of proteins within the membrane. Simply stating that 'mosaic' refers to the pattern of proteins viewed from above was not considered sufficient.

(b) Generally, answers to this question could have been improved. Many candidates gave the right figure (7), but followed it with the symbol for micrometre rather than nanometre. Some did not realise that a numerical answer was expected and wrote a description of the membrane in **Fig. 6.1**.

(c) The diagram provided in **Fig. 6.1** is a very simple block diagram showing the relationship between phospholipids and proteins in membranes, without any detail of either component. Candidates responded well to the instruction to list four features of cell surface membranes of eukaryotic cells that are not visible. The most common answers were cholesterol, glycoproteins, glycolipids, carrier proteins and channel proteins. Some candidates described the differences between phospholipids and the unsaturated fatty acids that they possess.

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Paper 9700/22
AS Level Structured Questions

Key messages

- Having a good overall view of the stages involved in protein synthesis and a good understanding of the flow of information from DNA to proteins is highly beneficial when approaching questions involving transcription and/or translation, such as **Question 6(b)(ii)**. Candidates must know what is meant by the terms transcription and translation so that they can avoid using the term 'transcription' and describing translation and vice versa.

- The movement of water and water vapour should be explained in terms of water potential and not in terms of concentration. This was required in **Question 2(a)(ii)**. A gradient created by one area that has a higher water potential and another that has a lower water potential should be described as a water potential gradient and not as a diffusion gradient or a concentration gradient. When describing two adjacent areas with different water potentials, it is not correct for candidates to incorporate the term 'gradient'. For example, 'water moves from a higher water potential to a lower water potential' should be used rather than 'water moves form a higher water potential gradient to a lower water potential gradient'.

- When asked to describe graphical data, candidates should check to see if a pattern or trend can be described before giving more details. It is common for some credit to be given for data that is correctly extracted, with units if appropriate. Here, it is good practice for candidates to give both axis labels. If more than one curve is shown on a graph, as in **Question 3(b)**, candidates should check carefully the key or label assigned to the curve and then in the response be clear which curve is being described.

General comments

There were many candidates who gave very sound performances, displaying very good knowledge of learning outcomes of the syllabus and showing an ability to apply knowledge with understanding to new contexts. Some questions, such as **Questions 4** and **6**, required candidates to be able to draw from different areas of the syllabus. Well prepared candidates were able to do this with ease. Almost all candidates completed all part-questions.

Candidates often find it more difficult to associate a definition or description with a correct term than providing a definition or explanation of a term. This was shown in **Question 1** where, although many did gain full credit, others found it difficult to recall the correct term to match the statements given.

Stronger candidates were able to handle and assimilate all the information provided in the table and graph of **Question 3** to produce some excellent responses. Others found it more challenging to bring together information to help them respond to questions. For example, information in **(a)(i)** was used to help answer **(a)(ii)** and information in the two different formats of a graph and table were analysed to answer **(b)**. Some candidates needed to pay closer attention to the wording of questions, such as in **(c)** suggestions of how to eradicate measles were given while in **(e)** examples of costs in the smallpox vaccination programme or costs to individuals were given.

Candidates who were skilled at applying knowledge to answer questions set in an unfamiliar context were able to perform well in **Question 6**.

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Comments on specific questions

Question 1

This question assessed candidate knowledge and understanding of learning outcomes from syllabus Topic 3.

A was generally very well known. Some candidates only gave the term 'activation', which was not strictly correct.

B was stated correctly by most. Some gave an amalgam of terminology used in the Enzymes topic of the syllabus: 'induced key', 'induced fit key', 'induced lock and key', 'induced substrate', 'lock and key fit' were seen. These could not be credited. Some weak responses stated 'catalysis'.

C was also well known by many, but there were some who gave named proteins as their response. Of these, 'haemoglobin' was most commonly seen.

D was less well known. A number left this blank, while others gave terms such as 'extrinsic', 'external cellular', 'exocellular', 'exocytosis' and 'catalysts'. Candidates were required to link back to a specific syllabus learning outcome that requires learners to state that enzymes function inside cells (intracellular enzymes) and outside cells (extracellular enzymes).

E was the least well known term. Use of K_m or close or phonetic spellings for 'Michaelis-Menten' were accepted. Many left this blank while others stated 'V_{max}'. Some gave '$^1/_2$Vmax' as their response, presumably remembering this as one stage in deriving K_m, but not realising that this is a rate of reaction rather than a concentration of substrate. Weaker responses confused the description with inhibition, so competitive inhibition and non-competitive inhibition were also seen.

Question 2

In this short question based on marram grass, candidates applied knowledge and understanding of transpiration, water potential gradients and adaptations of the leaves of xerophytic plants from syllabus Topic 7.

(a) (i) Knowledge of the xerophytic leaf features of marram grass was not required to answer this question. Many used a correct term for the adaptations seen. The presence of hairs or hair-like structures was also credited but other terms such as root hairs, needles, spikes and cilia were not as these indicate totally different structures not present. Candidates were told that the leaf had a thick cuticle, no stomata on the outer surface and stomata in pits and were asked for another adaptation visible in **Fig. 2.1**. Greater attention needed to be paid to this wording to gain credit.

(ii) The very best responses used correct terminology and gave precise explanations. These candidates understood: that it is water vapour rather than water that diffuses out through the stomata; that the rolled leaf/trichomes enable this water vapour to collect to create a humid area; and this reduces the water potential gradient between the substomatal air space and the enclosed area to lower the rate of transpiration. Many did gain partial credit with knowledge that a humid area is created in the enclosed area. Here, care needed to be taken to make the location of the humid area clear. For example 'area outside the cells' could refer to the intercellular air spaces. Candidates should describe movement of water and water vapour in terms of water potential and to use the term water potential gradient with care. Responses gaining higher credit used the terminology adeptly and explained that there would be a decreased rate of diffusion of water vapour out. These candidates were also clear that the less steep water potential gradient was created between the substomatal air spaces within the leaf and the enclosed area created by the rolled leaf adaptation, where the trichomes were located. A few also correctly explained that the enclosed area meant that there was no exposure to external air currents. Quite a number incorrectly thought that the rolling of the leaf would have created an enclosed area with a reduced leaf surface area.

(b) This was generally well known. Some gave examples of xerophytes, such as cacti, which was not required. Others knew that the term 'xero' was involved but responses such as 'xerotype', 'xerocyte' and 'xerophyllic' were not credited. 'Xenophyte' was also not credited.

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Question 3

This was a longer question based on the infectious disease measles and assessing syllabus Topics 10 and 11. As noted in General comments, candidates needed to use the skill of gathering information from more than one source to produce a high quality response in **(a)(ii)** and **(b)**.

(a) (i) The calculation required proved to be fairly straightforward for most candidates. The actual number of cases that were stated for Chad and Eritrea were given to the nearest whole case, so this should have been the prompt to candidates to do the same. Common errors were with factors of ten and rounding to 1180 rather than giving 1179 as the answer.

(ii) The most complete responses stated the advantages of showing data as number of cases per 100 000 and then backed up these ideas with numerical data taken from **Table 3.5**. The most common example of supporting evidence was to state the values for the number of cases per 100 000 and to show how the use of actual cases for Chad, Eritrea and Ethiopia gave an incorrect actual ranking for the severity of the disease between the three countries. Many described how the problem of differing population size was overcome by using standardised values; fewer considered how the severity of disease between countries, or the spread of disease within one country, could be gauged. A common error was to state that the standardised values were 'averages'. Weaker responses stated that it was easier or quicker to use estimates rather than count all the people with the disease, which did not show an understanding that the standardised values were derived from the actual number of cases reported. Others stated that the standardised values were easier to handle or to plot on a graph, not noticing that the actual values given were straightforward for handling. A few interpreted 'number of cases' as 'number of deaths'; this was not penalised if the correct ideas were given. As the raw values seemed higher than the standardised values, some suggested that using the raw figures would be 'bad for tourism', or would 'give the country a bad name', which is not the case.

(b) This was a challenging question requiring a number of skills and candidates were expected to take time to plan their response before writing their ideas down. Some candidates did produce excellent responses: well organised, thought processes clearly stated and correct values extracted from the table and graph. A good approach was to study the graph in **Fig. 3.1** and get a good idea of the main trends shown. These trends should then have been considered in conjunction with candidate knowledge and understanding of vaccinations. Not all candidates showed awareness of the fact that for a population to avoid a high number of cases of measles: a high percentage of the population needs to be effectively immunised against the disease; full immunity against measles takes time to develop in an individual; and for the population to remain protected a high percentage cover needs to be maintained. As candidates were told that the data in **Fig. 3.1** was for children under 1 year, some realised that each year there would be a continued need to vaccinate infants in order to increase or maintain percentage cover for the population. The importance of considering percentage vaccination over the years rather than for just one year was missed by some. This was the concept of how a high proportion of vaccinated one-year olds would mean that the following year there would be a high proportion of two-year olds with immunity, and so on, so that eventually a high proportion of young people (most susceptible to measles) should have immunity to help to avoid an epidemic. Finally, the standardised values of cases per 100 000 for each country could be checked to see if the statement was supported or not. When checking **Table 3.1**, two high values should have stood out: 15.31 for 2011 in Central African Republic and 71.60 in 2011 for Chad. Some candidates realised that these represented an epidemic and for Central African Republic, with a decreasing percentage vaccinated there would be little chance of controlling this. Although Chad had a trend of increasing percentage vaccination, some noted that over the years there was still not a sufficient proportion of the population protected. It was not sufficient to say that these were outbreaks. The best responses realised that, for example, values such as 1.48, 0.89 and 0.81 for Eritrea could all be considered low and representative of the success of a vaccination programme. Some interpreted a difference between 1.48 and 0.89 as significant and suggestive of a failure of a vaccination programme. It was not sufficient to state number of cases (per 100 000) without giving the years. Also, many points required candidates to match cases per 100 000 with the trend of percentage vaccinations increasing or decreasing, rather than to give a single year's percentage vaccination and match that to the same year's standardised case value. Most realised that there was little value in making comparisons for any one year between countries as this did not address the issue of vaccination programmes within a country. Some candidates did not pay attention to **(a)(ii)**, where they were told it was advantageous to use cases per 100 000 and gave the actual number of cases, which could not be credited. There were also some who only gave cases per 100 000 for the countries and did not give percentage vaccination values to show

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increasing or decreasing trends or make the statements of this. Others gave values correctly extracted from the graph and table but did not state which country this was.

(c) This was very well answered by candidates and all the points were seen. The most common of these was the fact that the smallpox vaccine was freeze-dried and so thermostable. It was not correct to say that the vaccine was frozen. Although many may have understood that the same vaccine could be used throughout, a proportion of these could not be credited as their response only went as far as stating that the smallpox virus did not mutate and they did not continue to mention the vaccine. Ease of administering the vaccine needed to be qualified further to gain credit: some correctly mentioned the use of the bifurcated needle, others mentioned that it was easy to train individuals to give the vaccine. Weaker responses appeared to have misread the question and explained what needed to be done to improve the measles vaccination programme, without making any reference to the smallpox eradication programme.

(d) To gain credit, answers needed to state both active and artificial immunity.

(e) This was generally very well done, although the quality of expression varied considerably. The best responses were clear that cost was involved: for example 'large quantities of vaccine need to be bought' is a response of a far higher standard than 'they need lots of vaccine'. Weak responses answered from the point of view of an individual rather than a complete vaccination programme, so were not worthy of credit. Others were too vague to be credited.

Question 4

As a general introduction to **Question 4**, which was based on Topics 1, 4, 8 and 9, candidates were presented with an unfamiliar diagram of a simplified circulatory system of a mammal, **Fig. 4.1**. This was required for **(b)** and **(c)** and was useful stimulus material for part **(a)**.

(a) The most complete responses addressed both parts of this question and explained clearly what was meant by 'closed' and what was meant by 'double circulation'. For 'closed', 'blood contained in blood vessels' was sufficient to gain credit as this included the capillaries, arteries and veins. These three types of blood vessel are the minimum that should be known for the blood vessels, so if candidates did choose to name the vessel types then these three were required. For 'double circulation', there were many who expressed knowledge of the pulmonary and systemic circulatory systems in a fluent manner. Many chose instead to describe double circulation in terms of passage of blood twice through the heart for each complete circuit round the body, which was equally acceptable. This would separate the idea of double circulation from the cardiac cycle, which is one heart beat. Some who chose to describe double circulation named the blood vessels of the heart and explained blood entering and leaving, without stating where the blood was going to or coming from.

(b) Most candidates appeared to take care when studying **Fig. 4.1** and correctly named the relevant blood vessels, valve and heart chamber. The most common error was to omit 'right' or 'left' where appropriate.

(c) Knowledge of the composition of blood compared to lymph was required for this question. The most common correct response was that red blood cells were not present in lymph; plasma proteins were also given correctly by a number of candidates. Proteins were not accepted, as this would include molecules such as antibodies that are found in lymph. Common incorrect responses included white blood cells, carbon dioxide and glucose. Only stating a content of a red blood cell, such as haemoglobin or carbonic anhydrase, was not sufficient; where these appeared with red blood cells as an answer, the response was given credit.

(d) The majority of responses were able to gain partial credit for realising that gas exchange involved diffusion of the respiratory gases and for stating the direction of movement of oxygen and of carbon dioxide. A number did not mention carbon dioxide. Many of the candidates who gained full credit gave more detail of the pathway involved, including the squamous epithelium of the alveolar wall and the endothelium of the capillary wall and noted the importance of the red blood cell in the process. 'Epithelium' alone was not sufficient as it was not clear what type of epithelium was being referenced. Some gave features of gas exchange surfaces, such as a large surface area or short diffusion distance, rather than describing the process of gas exchange, which was not required. A few confused 'epithelium' and 'endothelium,' and, for example, wrote about gases crossing the endothelium of the alveolus.

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(e) (i) The label line to cell structure **F** pointed directly to the nucleolus, and this was given by many candidates. There were fewer that knew that structure **G** was the cell surface membrane even though it separated one intestinal epithelial cell from the next. Less precise answers that were accepted for **F** and **G** were 'nucleus' and 'cell membrane'. **G** was left blank by some and there were very many incorrect cell structures stated.

(ii) The best responses were precise and to the point when outlining the features of facilitated diffusion. A number of outstanding responses gave all the points required. There was good knowledge here that carrier proteins were used to transport glucose and that these proteins were specific to the molecule. Specificity and protein conformational change were less frequently seen than the other features of facilitated diffusion. Other responses additionally explained why facilitated diffusion of glucose was necessary, which was not part of the question. Some wrote that both carrier and channel proteins were used, with some describing the movement of ions. The most common error was to state that facilitated diffusion required ATP or energy; some of these responses also explained that glucose went against the concentration gradient, while others stated that glucose moved down the gradient.

Question 5

Candidate knowledge and understanding of syllabus Topic 5 was assessed in **(a)** and **(b)**, where **Fig. 5.1** served as a visual prompt to help candidates. **(c)** required application of knowledge. Here, a link was made between the cell cycle from Topic 5 and cell signalling from Topic 4.

(a) (i) This was a straightforward question that was well answered by many. Most correct answers went down one of two routes: either stating that coiling and/or supercoiling were taking place or stating that condensation occurred. Of the responses that did not gain credit, most gave descriptions of spindle formation and nuclear envelope disassembly, neither of which answered the question about chromosomes becoming visible. A few candidates described coiling as 'recoiling', which was not the correct term to use, and others incorrectly thought that 'uncoiling' or 'decondensing' occurred.

(ii) This was well known and most candidates gave a well-expressed response, with a few describing telomeres and histone proteins. Some only noted the presence of a centromere and could have improved their answer by stating that the sister chromatids were held together by the centromere. Weaker responses did not include the term 'chromatid' and so descriptions of a chromosome composed of two chromosomes, two threads or two chromatins were seen. A few described late prophase which is not required.

(b) Candidates who did well in this question produced a response that was clear, used scientific terminology and was unambiguous. In these responses candidates clearly understood that the chromosome at metaphase consisted of the two sister chromatids connected by the centromere, compared to the anaphase chromosome that was now only one of the chromatids. Also, the position of the chromosomes at metaphase was described as being at the metaphase plate or spindle equator, instead of at the 'centre of the cell' or 'in the middle of the cell'. Similarly, for anaphase, good responses stated 'poles' rather than 'ends'. Other responses could have improved their phraseology, for example, 'chromosomes split' does not give a clear indication that the centromeres divide to separate the sister chromatids. Some were confused or not careful in distinguishing between a chromosome composed of sister chromatids and a bivalent, so descriptions of chromosome pairs, sometimes stated as homologous pairs, lining up at the equator in metaphase were seen. Some could have improved their answer by making it clearer whether they were describing metaphase or late anaphase when stating differences between the two.

(c) The quality of response for **(c)** was very varied. Some candidates gave answers that contained far more information than was required at AS Level, which was not necessary. Many responses were well-expressed, with a sequential account of cytokinin as the signalling molecule, binding to the receptor of the target cell and hence triggering the responses within the cell that would bring about cytokinesis. Some were less clear in their answer and could have stated the location of the receptor as being in the cell surface membrane, as well as showing an understanding that cytokinin-receptor binding was specific in nature. A few concentrated on the response within the cell and forgot to provide details of ligand binding to receptor or the location of the receptor. The most common error was to state that the receptor was part of the cytokinin molecule. A number misread cytokinin as cytokine and gave the sequence of events occurring in the immune response that involved cytokine, while others wrote about nerve impulse conduction.

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Question 6

Topics 1, 2 and 6 were assessed in this question. Candidates applied knowledge and understanding to answer questions on an unfamiliar theme, glycogen synthase.

(a) (i) Many candidates were able to gain full credit here with some excellent drawings of the ring form of α-glucose. For others, knowing that glucose is $C_6H_{12}O_6$, may have helped them carry out a quick review and re-think their drawing. One error was to draw out the ring form correctly but to make a mistake on CH_2OH, for example by giving C_2H_5OH, or to forget to add the oxygen into the ring form. A number drew the ring structure and only inserted the hydrogen and hydroxyl group for carbon 1, which meant that credit could not be given. The inversion of the hydroxyl and hydrogen groups on carbons 2 and 3 was also fairly common. Some candidates drew β-glucose, which was not credited.

(ii) Most knew glycosidic bond as the type of bond formed between the two α-glucose molecules and only the weakest responses gave peptide or hydrogen bond.

(iii) Candidates were not expected to know of glycogen synthase or glycogen branching enzyme. The clue was in the term 'branching'. The most common way to gain credit was for candidates to show knowledge that the enzyme catalysed bond formation and to give details that this bond was between carbon 1 and carbon 6. A few candidates went down another correct route, and explained that different active sites were required for the formation of the different bonds involved. Weaker responses simply stated that glycogen branching enzyme was for forming branches. Others wrote about the suitability of amylopectin as a storage molecule, which was not required.

(b) (i) The best responses were concise and gave a similar explanation to that from the relevant syllabus learning outcome. Where this was not known, there were a large range of responses, only some of which were credited. There were three ideas that were being assessed: knowledge that a gene was a physical part of DNA, more detailed knowledge that this was a sequence of nucleotides, and an understanding that the gene contained coded information for the production of a polypeptide. Vague responses, that could have been improved by including these points, included reference to producing characteristics or gave examples such as eye colour, or described how genes produced the overall individual's make-up. The best responses did not confuse the term 'genetic code' with the phrases 'code for' or 'coding for' and so avoided incorrect statements such as 'a gene is a genetic code'. Other common errors were to state that a gene was a triplet of bases or to say that a gene coded for an amino acid.

(ii) Candidates who did well in this question knew the definition of a gene mutation and were also able to think through the chain of events occurring in protein synthesis. For these candidates, the roles of mRNA and tRNA, and the way they interacted to lead to the replacement of one amino acid for another, was fluently expressed. It was made clear that only one codon would be changed. Good responses explained that this was a base (or nucleotide) substitution, rather than stating 'substitution mutation', which was not credited without further detail as many only used the term for the idea of one amino acid being replaced by another. More confused responses were unclear that mRNA was formed as a result of transcription, stating that mRNA copied the information or did not mention tRNA as the molecule that brought the incorrect amino acid to the ribosome. Others misread the question and only focused on how the replacement of the amino acid would lead to a non-functioning protein, giving descriptions of levels of protein structure.

(c) Most gained some credit for **(c)**, with a large number displaying correct knowledge of the cell structures responsible for synthesising ATP and for protein modification. The description for the first cell structure needed to be read carefully, and the strongest responses noticed that this was about the assembly of the ribosomes, so correctly stated nucleolus. Many others saw the term ribosomes and incorrectly gave rough endoplasmic reticulum.

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Paper 9700/23
AS Level Structured Questions

Key messages

- Having a good overall view of the stages involved in protein synthesis and a good understanding of the flow of information from DNA to proteins is highly beneficial when approaching questions involving transcription and/or translation, such as **Question 5(c)(i)**. Candidates must know what is meant by the terms transcription and translation so that they can avoid using the term 'transcription' with a description of translation and vice versa.

- Cohesion and adhesion, terms frequently associated with the movement of water within xylem vessels, both result from hydrogen bond formation owing to the polar nature of water molecules. It is important, as seen in **Question 4(c)**, for candidates to be able to distinguish between the two. Cohesion occurs between water molecules and contributes to transpiration pull in the xylem. Candidates should be precise in describing adhesion between water molecules and walls of xylem vessels: the hydrophilic cellulose lining is important for adhesion whereas lignin is largely hydrophobic and contributes little to adhesion.

- Part of **Question 2(b)** asked candidates to describe graphical data. It is good practice for candidates, as part of their response, to include correctly extracted data and when doing so, to give both axes labels and to remember to give units if appropriate.

General comments

There were a number of candidates who maintained a high standard of response throughout this paper, giving the correct details when necessary and giving answers appropriate to the question being asked. Many of these showed an ability to apply knowledge with understanding, especially when answering **Questions 2**, **3** and **5**. Some part-questions that were assessing skills of application of knowledge were often left blank, such as **Questions 2(a)(ii)**, **3(c)(i) and 3(c)(ii)**.

In **Question 1**, there was a considerable range in the quality of the extended response for **(b)(ii)**. Those who gained full credit in **(b)(ii)** stated a number of different features relating to the appearance of the lining of the bronchus, rather than to state one feature and just elaborate on this.

The parts of **Question 3** that required application of knowledge and understanding were challenging for many candidates. The information given at the beginning of **(b)** was used by some candidates to help them arrive at the correct answer for **(c)(i)** and **(ii)** and it was clear that others would have benefited from referring back to this information when answering **(c)**.

In **Question 5**, good answers to **(b)** used a sequential approach and gave a step-by-step account. In parts **(b)**, **(d)** and **(e)** there was confusion for some candidates and ideas from the immunology topic of the syllabus were introduced incorrectly.

Comments on specific questions

Question 1

This question assessed candidate knowledge with understanding of learning outcomes from syllabus Topic 9. In **(a)(ii)** candidates were expected to identify the nucleus, which is knowledge from Topic 1 and in **(b)(i)** candidates used their knowledge of Topic 5 to identify mitosis as the type of cell division used to replace damaged epithelial cells.

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(a) (i) As instructed, many candidates placed an **X** on the photomicrograph image. Those who gained credit made sure that the **X** was clearly written in the light grey area showing the lumen, rather than placing it halfway between the lumen and the cilia. For those who did not know what was meant by the lumen, the **X** appeared in varying places in or below the ciliated epithelium or left the image blank.

(ii) The structure labelled **A** was the nucleus. As the end of the label line did not point to a nucleolus, this was not accepted as an alternative. It was acceptable for candidates to state that this was the nucleus of a goblet, epithelial or ciliated epithelial cell. However, some candidates named only one of the cell types mentioned, while others stated that **A** was a red blood cell.

(iii) Candidates needed to apply knowledge of the differences between epithelial cells found in an alveolus and the bronchus. Credit was given if it was stated that a feature was absent, for example, stating that there are no goblet cells or ciliated cells in the alveolus, or that these were not squamous epithelial cells. Of those who were correct, the majority gave the presence of cilia as the feature, with most of the rest stating that goblet cells were present.

(b) (i) Mitosis or mitotic division were responses credited. Some only stated cytokinesis, which was not enough as this is the division of the cytoplasm after mitosis has completed. Other responses not credited included meiosis, replication and DNA replication.

(ii) The most complete and precise answers wrote only about the lining of the bronchus, as requested, and used correct descriptive terminology to write about the excessive production of mucus by the enlarged goblet cells, the appearance of the cilia and/or ciliated epithelial cells, and the deposition of tar on or in the lining. Inflammation was correctly linked to the lining of the bronchus instead of to individual cells. There were statements about the bronchus being 'clogged up' with mucus, the cilia being 'killed' and the lining being black. Weaker responses wrote about patches where cells had been killed: these could have been credited if they had been followed up with the idea of scar tissue formation to replace the once-functioning cells. A number of responses included descriptions of how difficult it would be for air to move in or out, which was not required.

Question 2

In this question, based on trypsin, candidates applied knowledge and understanding from syllabus Topics 2 and 3 of enzyme kinetics, the mechanism of enzyme action, and protein structure.

(a (i) It was straightforward to precisely determine the correct value of V_{max} from **Fig. 3.1**, so that $3.4\,\mu M\,min^{-1}$ was the only answer credited. Some did give 3.4 but did not state the units. Others needed to have been more precise and gave $3.5\,\mu M\,min^{-1}$ as their answer; a quick check again of **Fig. 2.1** would have highlighted their error.

(ii) Some candidates were able to use their answer to **(a)(i)** to calculate $^1/_2V_{max}$ and to then use **Fig. 2.1** to derive K_m. Some candidates gave an answer of $1.7\,\mu M\,min^{-1}$, suggesting they had only gone as far as calculating $^1/_2V_{max}$. Others left **(a)(ii)** blank.

(b) Candidates who gave full responses described the shape of the curve and gave biological explanations to support their description. Data was extracted with precision and units were given. Explanations were in terms of mechanism of action of the enzyme trypsin and correct terminology was used, such as: 'active site', 'enzyme-substrate collisions', 'active sites saturated with substrate', 'limiting factor'. The decreasing gradient of the curve was described as such, rather than stating that the rate of reaction was decreasing, which was incorrect. Most of those who gained partial credit were able to give a fair description and needed to improve the quality of the explanation. There were a number who did not give units for the data quoted. A common error was to state that the reaction stopped at 0.45 mM rather than to state that a plateau had been reached. Quite a few stated that the plateau at higher substrate concentrations was due to the substrate running out.

(c) (i) The first sentence of **(c)** informed candidates that trypsin is composed of one polypeptide chain. Consequently, any reference to quaternary structure was incorrect. The strongest responses noted that the tertiary structure arose as a result of the coiling and folding of the polypeptide chain and named the types of bond formed in the tertiary structure, explaining that these were from interactions between the R groups of amino acids. Many others simply stated the types of bond

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that formed. A number described secondary structure only; where coiling and/or folding were noted for secondary structure, credit was given.

Question 3

This was a question using rheumatoid arthritis as an unfamiliar context for assessing syllabus Topic 11. The part questions on monoclonal antibody and its production were least well answered by most candidates.

(a) Almost all candidates concentrated on what was meant by 'non-self'. Many correctly understood that a non-self antigen was treated as foreign. Fewer went on to explain that this meant that an immune response would be initiated and some incorrectly stated that the body would not recognise a non-self antigen. The strongest candidates explained that an antigen was a protein or glycoprotein or polysaccharide. There were some responses that were quite vague and focused on pathogens. Here, a common error was to think that a pathogen and an antigen are the same thing.

(b) (i) The label lines for **P** in **Fig. 3.1** pointed to the antigen binding site. 'Variable region' was also accepted for **P** and was the best known part of the molecule. 'Binding site' alone was not credited, neither was 'receptor'. 'Hinge' alone was not sufficient for **Q**, the hinge region. Some stated that **Q** was a disulfide bond. **R** was either stated to be the heavy chain or was left blank.

(ii) Most correctly gave disulfide bond as their response, with the most common incorrect response being to state hydrogen bond.

(c) (i) This was very well answered by only a few candidates. Here, the response was sequential in nature and used correct scientific terms. Even with those gaining full credit, it was rare for the response to continue further than the production of hybridoma cells, so only a handful noted screening for antibody and large-scale production. Other responses were more confused, with many beginning their answer by stating that the monoclonal antibody, rather than the antigen, was injected into a small mammal, or by stating that the antibody produced by the mammal in response to the antigen was removed and fused with a myeloma cell. Some confused a hybridoma cell with the actual anti-TNF-α monoclonal antibody. Other vague statements described a plasma cell (or B-lymphocyte) being placed into a Petri dish with a tumour cell, but did not mention that the cells needed to be fused. Some focused on outlining the steps involved in an immune response that lead to the production of antibody and were given some credit if this account included the production of specific plasma cells. However, this did not concentrate on the specific learning outcome relating to monoclonal antibody production. Some left **(c)** blank.

(ii) Good answers firstly noted that the anti-TNF-α monoclonal antibody binds to the TNF-α antigen, and then stated that the destruction of the antigen would mean that inflammation would not be triggered. One incorrect idea from some candidates was that the monoclonal antibody somehow prevented the release of the antigen from the macrophage, while others thought that the antibody could destroy the macrophage so that the antigen was not produced at all. In these cases, credit was not given if it was then stated that inflammation cannot occur, as this was not in the correct context of destruction of the antigen.

Question 4

This question was based on Topics 4, 7 and 8.

(a) Most candidates gained credit by adding a label line and label for the obvious phloem sieve tube where the sieve plate could be seen clearly. Most who did not gain credit labelled the larger xylem vessels.

(b) Many gave concise responses and gained full credit here. Others lacked detail, such as stating that nutrients were transported, or that transport occurred from leaves to roots. For the latter, candidates needed to remember that developing leaves could act as sinks, and roots could mobilise stores and act as sources. Common errors were in stating that movement occurred by active transport or diffusion. Some of the weakest responses stated that water and mineral ions were transported, confusing phloem with xylem.

(c) Candidates who did well in **(b)** also noticed that this question asked about how the structure of the walls of xylem vessels was adapted to their functions. This meant that both lignin and cellulose

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needed to be named before linking these to the wall structure and their functions. The hydrophobic nature of lignin and its waterproofing function was well known by these candidates. There was flexibility provided in linking lignin to its role in support so that weaker responses could be credited. However, some stronger responses were detailed and showed understanding of the cohesion-tension theory by stating that the support provided by lignin would help to prevent the inward collapse of the xylem vessel. Others incorrectly stated that lignin prevented the vessel from bursting or stated that it was to 'withstand pressure'. The adhesion of water molecules to the wall of the xylem was only credited if this related to cellulose, which is hydrophilic, or to the hydrophilic areas of lignin. Candidates who did not gain credit either wrote about the function of the xylem wall without giving details of its structure or wrote generally about the structure of the xylem vessel (without naming lignin or cellulose) and linked this to its function. These candidates had missed the point of the question and many wrote about the hollow nature of the xylem vessels and lack of cytoplasm and organelles.

(d) (i) The calculation of surface area to volume ratio of the cube should have been a mathematically straightforward exercise, and a number of candidates had no problems in gaining full credit. For those gaining partial credit it tended to be due to an error when calculating the surface area (often a factor of 10 out) or not knowing how to calculate the ratio. Some just gave the two previously calculated values, while others got the ratio the wrong way round and wrote down 1:60. The ratio proved the most difficult of the three calculations here, followed by the surface area.

(ii) There were some very concise and factually correct responses to **(d)(ii)**. These showed an understanding of the problems associated with a decreased surface area to volume ratio owing to an increase in size. Most of these answers highlighted the longer distances involved and the fact that the rate of diffusion would be too slow to satisfy needs. Other responses focused on the features of a mammalian transport system, which was not required and which highlighted the need for careful reading of the question.

Question 5

Tuberculosis (TB), an infectious disease named in a number of syllabus learning outcomes, was used as a theme in this question. Syllabus material from Topics 1, 6 and 10 was assessed in this question.

(a) This was a straightforward question about transmission of TB. The best answers showed an understanding of how the bacteria causing the disease could be passed from an infected person to an uninfected person. Many realised that, as the introduction to the question only named *Mycobacterium tuberculosis*, it was not necessary to include details of the transmission of *Mycobacterium bovis* from infected cattle. Well-expressed answers made it clear that the bacteria (or pathogen) were contained in the airborne droplets released from the infected person. Others could have improved on a more vague response. For example, phrases such as 'bacteria in the air' did not show an understanding of an aerosol or droplet infection. Similarly, not mentioning how the pathogen was released from the infected person, and then only stating that droplets were breathed in, did not evidence an understanding that the droplets contained the pathogen and that the origin of the droplets was from a person with the disease.

(b) There were many who gave a correct sequential account and some gave all or most of the expected ideas. A few also showed an understanding of gene expression by stating one or more examples of what mechanisms of resistance could be gained with a mutation. Many others realised that a mutation must have occurred and could have improved their response by giving details of how the mutation could be passed on to give an increasing number of bacteria with resistance. Many candidates ignored the idea of streptomycin treatment and needed to have explained that some people do not finish their course of antibiotics, leaving a reservoir of bacteria. A common error was to use the term immunity rather than resistance or to use the term resistance correctly in one sentence and then introduce immunity later. Weak responses wrote only about resistance being passed on to other bacteria and gave no further details or thought that the bacteria were able to 'resist' the immune response of the infected person.

(c) (i) Many gave clear explanations of what is meant by transcription. As noted in the Key messages section, to gain credit in **(c)(i)**, candidates needed to know which set of events in the overall synthesis of a protein are termed transcription and which translation. It was notable that many explained translation. It was not necessary to describe the process of transcription, as some attempted to do. These candidates still gained full credit but would have wasted time as only an explanation of the term was required.

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(ii) Some candidates had noted that rifampicin acted by inhibiting RNA polymerase and realised that this meant that the antibiotic in human cells would need to enter the cell and then enter the nucleus in order to have an effect. Most of these candidates gave an acceptable suggestion that the antibiotic would not be able to cross the nuclear envelope. Very few made the other acceptable suggestion that the human RNA polymerase was slightly different to the bacterial RNA polymerase so that rifampicin would not be able to act as an inhibitor. Most of the answers that did not gain credit used their knowledge of penicillin and stated that human cells did not have cell walls, which was not relevant for **(c)(ii)**.

(d) This was well understood and the whole range of responses was seen. As the question asked for an outline rather than a description, this meant that at least three different steps should have been given to gain full credit rather than just stating one step and elaborating greatly on this. Some stated that broad-spectrum antibiotics should have been avoided, which was credited, but better answers gave a short qualification. If the bacterium is known, then the appropriate antibiotic or antibiotics should be used to target that specific bacterium rather than use a less effective broad spectrum antibiotic. However, if there is a need to quickly cure a bacterial infection and the bacteria is not known, then prescribing broad spectrum antibiotics can be a helpful step to reduce the impact of antibiotic resistance. This is because there is a good chance that all bacteria will be rapidly destroyed and a mutation to give resistance can be avoided. Some started well and gained partial credit but then switched to using the term 'antibodies' for the rest of the answer.

(e) Most knew at least one correct reason as to why antibiotics cannot be used to treat viruses. Most used their knowledge of penicillin and understood that viruses do not have cell walls. Where full credit was gained, the second most common answer was that viruses are within host cells where they may be less accessible to antibiotics. Weaker responses confused antibiotics and antibodies.

Question 6

In this question, the heart was used as the theme to assess knowledge with understanding from Topics 8.

(a) Most knew that **X** was the vena cava, although a number gave pulmonary artery or aorta as their answer.

(b) Almost all candidates compared the left and right ventricles rather than compare the left ventricle with the left atrium, as only a few did. The most common correct idea adopted was the difference in distance the blood needed to be pumped from the different ventricles. Stronger responses linked this to the different pressures required. Weaker responses stated that the thicker left ventricle could withstand higher pressures rather than state that higher pressures were required. Others incorrectly thought that the difference in thickness was to receive higher and lower pressure blood. Very few wrote about resistance to blood flow and only a handful stated that higher pressures would damage the very fine pulmonary capillaries.

(c) Those candidates who gained credit here knew that the sinoatrial node was the pacemaker described and used the full name, rather than using the abbreviation SAN, which was not credited.

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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 simple/proportional dilution to obtain the required concentrations of a solution and be able to specify the volumes required. In this case, candidates were required to dilute a 0.5% reducing sugar solution. Candidates needed to show how they made at least four further concentrations of reducing sugar by this method e.g. 0.4%, 0.3%, 0.2% and 0.1%. They were asked to prepare 10 cm^3 of each solution. Candidates needed to show the correct volume of stock solution (in this case **G**) to make each concentration and the volume of water required to give a total volume of 10 cm^3.
- Candidates should be aware that the wording of questions often indicates how they 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 the relationship between the concentration of sucrose and the enzyme activity' the candidate needs to make sure that they state why something happens, such as referring to the binding of the substrates to the active sites of enzymes and the formation of enzyme-substrate complexes.

General comments

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

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

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

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

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

Comments on specific questions

Question 1

(a) (i) Most candidates were able to draw on **Fig. 1.1** the correct level of water before and after removing the sample; the line labelled 'after' being lower than the line labelled 'before'. Many candidates

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correctly recognised that both levels should be above the level of reducing sugar in the Visking tubing **V**.

(ii) Many candidates gained credit for completing **Table 1.1** by stating at least four further concentrations with the correct volumes of 0.5% reducing sugar **G**, and water. Common errors included carrying out a serial dilution and not a simple dilution, or making the total volume larger than 10 cm^3.

(iii) The majority of candidates organised their results clearly in a ruled table. The stronger candidates included the heading for percentage concentration of reducing sugar and the heading for time with appropriate units (seconds). The most common error was to leave out the units for time. The majority of candidates gained credit for recording the time taken for the first appearance of a colour change. The results showed that as the concentration of reducing sugar decreased, the time taken for the colour change increased. The stronger candidates recorded the time in whole seconds.

(iv) The majority of candidates were able to state which variable should be standardised when testing **U**. A common error was to use the word 'amount' in place of 'volume'.

(v) Many candidates recorded the time taken for the first appearance of a colour change for **U** in whole seconds. A common error was to leave out the units (seconds).

(vi) Many candidates estimated the percentage concentration of reducing sugar in **U** correctly. The most common error was to give a concentration which was not one they had used for the experiment.

(b) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (percentage concentration of sucrose solution) and the *y*-axis (time to decolourise potassium manganate(VII) solution/s). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates used scales of 0.5 to 2 cm for the *x*-axis (with 0.5 at the origin) and 40.0 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 without a sharp pencil, which were consequently too thick, or not ruled to the centre of the point.

(ii) The majority of candidates used their graph to accurately estimate the time taken to decolourise potassium manganate(VII) solution at 1.75% sucrose solution. A common error was to estimate a time which was not to an accuracy of half a square on their scale.

(iii) Many candidates described the relationship between the concentration of sucrose and the enzyme activity. The stronger candidates were able to explain these relationships in terms of more substrate being available to bind to the active sites of enzymes; therefore more enzyme-substrate complexes are formed.

(iv) Many candidates described how the sucrose concentration could be standardised. Most recognised that different pH should be used. The stronger candidates decided to use at least five different pH levels and also recognised the need for pH buffers to maintain the pH.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The majority of candidates gained credit for carefully following the instructions and drawing the shaded area as shown in **Fig. 2.1**. Common errors included drawing xylem vessels and other cells, also labelling additional structures other than xylem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. Many candidates were able to draw four cells of the ring of cells surrounding the vascular tissue in the root 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.

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(b) (i) Many candidates correctly measured the lines on the air spaces in **Fig. 2.2**. The stronger candidates recorded their measurements with the correct units (mm). Most candidates showed the division of the measurements by the magnification (×25). The most common error was to not show the measurements of each air space with the correct units.

(ii) The majority of candidates gained credit for displaying the addition of the measurements and division of this total by the number of measurements. Most candidates gained credit for the correct answer based on their measurements.

(iii) The stronger candidates suggested the stem in **Fig. 2.2** was from an aquatic habitat and the presence of air spaces aided buoyancy.

(c) The stronger candidates organised the table into three columns, with one column for features, one headed **J1** and one headed **Fig. 2.2**. Many candidates listed at least three observable differences between **J1** and **Fig. 2.2**, such as **J1** has larger xylem vessels.

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Paper 9700/32
Advanced Practical Skills 2

Key messages

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

Candidates familiar with carrying out investigations should have experienced setting up a control which removes the effect of the independent variable, including replacing a solution with water or denaturing an enzyme by boiling.

Candidates should be aware that the command word of questions indicates how they 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 enzyme was affected by change in temperature' the candidate needs to state why something happens such as referring to the binding of the substrates to the active sites of enzymes and the formation of enzyme-substrate complexes.

Candidates should be given the opportunity to use an eyepiece graticule to measure cells and become familiar with units such as micrometres used in cell studies.

General comments

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

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

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

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

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

Comments on specific questions

Question 1

(a) (i) The majority of candidates were able to measure the temperature of the room to the required degree of accuracy and include the relevant units.

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(ii) Most candidates decided on using at least three additional temperatures, spaced at even intervals, to test the activity of the yeast cell suspension.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for temperature with units (°C) and the heading for height of the foam with the appropriate units (mm). The majority of candidates gained credit for recording the heights for at least four temperatures. The results showed that, at lower temperatures, the higher the temperature the greater the height of the foam. The stronger candidates recorded the height in whole millimetres.

(iv) The stronger candidates identified two significant sources of error that may have affected the trend in results. One significant error was the difficulty of maintaining the temperature of the water-bath within an acceptable range. Many candidates correctly stated that measuring the height of the foam was difficult as the level of the foam in the test-tube was often uneven.

(v) Many candidates correctly described a suitable control for the investigation. They used boiled yeast cell suspension or replaced the yeast cell suspension with the same volume of water.

(vi) The stronger candidates correctly stated that as the temperature of each of the water-baths increased there was an increase in kinetic energy within the yeast cell suspensions leading to more enzyme-substrate complexes forming. The most common error was describing the changing height of the foam at each temperature without any reference to the enzyme.

(vii) Many candidates were able to state that the independent variable (temperature) was standardised by using a fixed temperature which could be achieved by using a thermostatically controlled water-bath. Many candidates described how they could modify the procedure to investigate the effect of pH by using at least five examples of pH with the use of buffers.

(b) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (percentage concentration of glucose solution) and the *y*-axis (volume of CO_2 released / cm^3). Some candidates, however, labelled the incorrect axis or gave incomplete headings.

Most candidates used scales of 2.0 to 2 cm for the *x*-axis and 2.0 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.

(ii) The majority of candidates used their graph to accurately estimate the volume of CO_2 released at 3.5% concentration of glucose solution.

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 vascular bundles and showing them subdivided into different regions. Credit was given to those candidates who had drawn the vascular bundles in the correct proportion to the width of the lamina. Most candidates correctly identified and labelled the xylem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. Many candidates were able to draw four cells of the innermost ring of cells surrounding the lumen of the canal 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 that the cells formed part of a ring of cells around the canal. Most candidates used a label line to show the cell wall of one cell.

(b) Many candidates correctly counted the number of eyepiece graticule units equal to the length of the vascular bundle labelled in **Fig. 2.2**. The stronger candidates recorded whole numbers of graticule units and showed the multiplication of this number by 29.5. Many candidates showed the

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actual length of the vascular bundle to the required accuracy with the appropriate units (μm). The most common errors were to omit units and not showing all the steps in the calculation.

(c) (i) The stronger candidates 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 **M1** has more vascular bundles.

(ii) The stronger candidates suggested that the observable feature shown by both the leaf on **M1** and the leaf in **Fig. 2.2** which supported the conclusion that these plants grew in dry conditions was a thick cuticle or sunken stomata or fewer stomata. The majority of candidates correctly explained that these features reduced evaporation or decreased transpiration.

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Paper 9700/33
Advanced Practical Skills 1

Key messages

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

Candidates should be able to 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 hydrogen peroxide solution, would be assessed as a medium risk. A high risk would be the use of high concentrations of acids and alkalis.

Candidates should be aware that the command word of questions indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to 'give reasons for'. When the question states 'explain how the enzyme was affected by change in temperature' the candidate needs to state why something happens, such as referring to the binding of the substrates to the active sites of enzymes and the formation of enzyme substrate-complexes.

General comments

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

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

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

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

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

Comments on specific questions

Question 1

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

(b) (i) The majority of candidates were able to measure the temperature of the room to the required degree of accuracy and include the relevant units.

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(ii) Most candidates decided on removing samples for at least three additional temperatures at even intervals.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for temperature with units (°C) and the heading for time with units (seconds). The majority of candidates gained credit for recording the times for at least five temperatures. Many candidates recorded results which showed that the higher the temperature the longer the time for the square to return to the surface. The stronger candidates recorded the time in whole seconds and recorded repeats with means calculated as whole numbers or to an accuracy of no more than one decimal point.

(iv) The stronger candidates identified two significant sources of error that may have affected the trend in results. One significant error was the reuse of hydrogen peroxide solution which may have reduced in concentration as successive squares were placed in the solution. Many candidates correctly stated that the time for the square to reach the surface was extended if the filter paper touched the side of the test-tube. The most common error was stating that stopping the timer at the exact moment that the square came to the surface was significant.

(v) The stronger candidates correctly stated that as the temperature increased the more enzyme-substrate-complexes were formed. However, at higher temperatures the enzyme was denatured.

(vi) Many candidates were able to state that the independent variable (temperature) was standardised by using a fixed temperature which could be achieved by using a thermostatically controlled water-bath. Many candidates described how they could modify the procedure to investigate the effect of the concentration of catalase by using at least five concentrations of catalase prepared by simple or proportional dilution or serial dilution.

(c) Most candidates correctly used the headings given in the table to label the *x*-axis (different plant species) and the *y*-axis (initial rate of activity of catalase / s^{-1}). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates ensured that all five bars were the same width and used a scale of 0.05 to 2 cm for the *y*-axis.

Many candidates plotted the horizontal line at the top of each bar exactly 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.

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 vascular bundles and showing the epidermis as two lines drawn closely together. Credit was given to those candidates who observed an area of cells located at the tip of the leaf and drew a line to show the boundary of these cells.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. Many candidates were able to draw four cells from the epidermis 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 was different from the others, often with an inclusion. 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 diameter 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 failing to show all the steps in the calculation.

(ii) The stronger candidates suggested that the leaf shown in **Fig. 2.2** was from a wet habitat and that the presence of air spaces aided buoyancy. Other features such as palisade cells and stomata present in the upper part of leaf were also credited.

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(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 **K1** has more vascular bundles than **Fig. 2.2**.

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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 able to assess the risk of a procedure. A risk assessment would include judging that the use of certain chemicals may be harmful or irritant. For example, amylase and potassium manganate(VII) solution, would be assessed as a medium level of risk. A high level of risk would be the use of high concentrations of acids and alkalis.
- Candidates should be aware that the wording of questions often indicates how they 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 a temperature rise may affect the mixture of starch and amylase' the candidate needs to make sure that they state how and why something happens, such as referring to the binding of the substrates to the active sites of enzymes and the formation of enzyme-substrate complexes.
- Candidates should be given the opportunity to use an eyepiece graticule to measure cells and become familiar with units used in cell studies such as micrometres.

General comments

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

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

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

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

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

Comments on specific questions

Question 1

(a) (i) The majority of candidates were able to state the times the samples should be removed, and most included units (minutes).

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(ii) Many candidates gained credit for identifying the reagent as iodine solution and were able to describe the test.

(b) The majority of candidates were able to name a hazard and assess the level of risk as medium or high.

(c) (i) The majority of the candidates were able to measure the temperature of the room to the required degree of accuracy and include the relevant units.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for sample time with the appropriate units and the heading for raw results for the glucose test. The most common error was to put the units in the body of the table. The majority of candidates gained credit for recording the correct pattern of results for potassium manganate(VII) (as sample time increases the time to decolourise decreases). The stronger candidates calculated and recorded the processed time in whole seconds.

(iii) The majority of candidates were able to recognise that if the difference in temperature was small then it was not considered to be a significant error.

(iv) The stronger candidates correctly stated that as the temperature increased, the more kinetic energy the enzyme and substrate molecules had, and the more enzyme-substrate complexes were formed as a result. However, at higher temperatures the enzyme was denatured.

(v) Many candidates were able to state that pH could be investigated by selecting different pH levels. The stronger candidates were able to give full details of how the procedure could be modified to fully investigate the effect of pH on the activity of amylase.

(d) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (percentage concentration of starch solution) and the *y*-axis (initial rate of reaction of amylase / arbitrary units). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates used scales of 1 to 2 cm for the *x*-axis and 100 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 without a sharp pencil, which were consequently too thick, or not ruled to the centre of the point.

(ii) Some candidates drew on their graph the V_{max} line at the top of the curve to the *y*-axis from the maximum rate of reaction. A common error was not displaying this on the graph. Many candidates showed ½ V_{max} on their graph and also gained credit for correctly reading the K_m value from the *x*-axis. A common error was to estimate a value which was not to an accuracy of half a square on their *x*-axis scale.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The majority of candidates gained credit for carefully following the instructions and drawing the area described in the question. Many candidates gained credit for drawing two vascular bundles and showed them subdivided into different regions. Most candidates correctly identified and labelled the xylem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. Many candidates were able to draw four adjacent cells in the centre of the stem 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 or drawing cells which did not touch at least two other cells. Most candidates used a label line to show the cell wall of one cell.

(b) (i) Many candidates correctly measured the two lengths required. A common error was to omit the units (mm) and to be unclear about which measurement was the scale bar and which the line across the diameter of cell **X**. Many candidates did not gain credit for showing their working as they left some stages out. Most candidates gained credit for the correct 'actual diameter of cell **X**'.

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(b) (ii) The stronger candidates organised the table into three columns: one column for features, one headed **N1** and one headed **Fig. 2.2**. The stronger candidates listed at least three observable differences between **N1** and **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 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 1.00% glucose 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 glucose solution using a constant dilution factor at each step. The initial step combines 10 cm^3 of the 1.00% glucose 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 glucose solution by this method e.g. 0.50%, 0.25%, 0.125% and 0.063% (0.0625%).

General comments

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

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

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

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

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

Comments on specific questions

Question 1

(a) (i) Many candidates were able to carry out a serial dilution, showing the correct concentration below each beaker (0.50%, 0.25%, 0.125% and 0.0625% (0.063%)) 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 stated that the smallest division on the syringe used in step 3 was either 0.2 cm^3 or 0.1 cm^3. Some candidates correctly stated that the actual error when using this syringe was ± half the smallest division previously given.

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Some candidates correctly stated that the percentage error when using this syringe was half the smallest division divided by 2 and multiplied by 100.

(iii) Many candidates correctly completed **Table 1.1** by inserting the appropriate column heading of percentage concentration of glucose in the left column and the appropriate units for time as seconds to complete the heading for the centre column. Many candidates gained credit for recording the times and colours observed for at least five concentrations of glucose solutions. The stronger candidates recorded the time for the first colour appearing for 1% glucose solution faster than the lowest concentration of glucose solution. The majority of candidates correctly recorded the time taken for the first appearance of any colour change in whole seconds.

(iv) Many candidates correctly described that to standardise the Benedict's test in order to estimate the concentration of glucose in solution **P** the volumes of glucose solution and Benedict's needed to be the same as used to test the dilutions of glucose solution. The stronger candidates also decided to keep the temperature the same and heat the solutions in a boiling water-bath.

(v) Many candidates recorded the time taken for the first colour change, including the appropriate units (seconds) and the colour of Benedict's at 60 seconds for solution **P**.

(vi) Many candidates correctly estimated the concentration of glucose in solution **P** to be either between 0.125% and 0.0625% or 0.125%.

(vii) Many candidates stated that the use of a colorimeter would be an improvement to allow a more accurate estimate of the concentration of glucose in solution **P**. Other correct improvements included carrying out repeats or using more concentrations of glucose solution within the range of the estimate.

(viii) Many candidates stated that drawing a calibration curve would be an improvement to allow a more accurate estimate of the concentration of glucose in solution **P**. The calibration curve could then be used to read off the concentration of glucose in solution **P**.

(b) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (time after eating the meal / minutes) and the *y*-axis (concentration of glucose in blood plasma / mmol dm^{-3}). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Many candidates used scales of 20 minutes to 2 cm for the *x*-axis and 0.5 mmol dm^{-3} to 2 cm for the *y*-axis, with 5 at the origin. 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.

(ii) Many candidates calculated the percentage increase in concentration of glucose in blood plasma between 0 minutes and 20 minutes after eating the meal by showing 6.750 minus 5.125, divided by 5.125 and multiplied by 100. Alternative methods were also credited.

(iii) Many candidates gained credit for using one label line and the label **X** to show the section on the graph between the time at 0 minutes and the time at 20 minutes where the rate of diffusion of glucose into the blood was the most rapid.

(iv) Many candidates correctly suggested that the glucose had been used for respiration as a reason for the concentration of glucose in blood plasma decreasing between 60 minutes and 80 minutes after eating the meal.

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, only drawing the part of the organ as shown in **Fig. 2.1**. Credit was given to those candidates who included at least three layers of tissue. Many candidates gained credit for drawing the layer of tissue just beneath the epidermis.

Many candidates correctly showed the diameter of the stele as approximately one third of the diameter of the root and were credited for drawing a well-proportioned plan diagram. Many

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candidates used one label line and the letter **Z** to identify the endodermis as the position of the tissue which prevents the flow of water through the apoplast pathway.

(ii) Many candidates were able to identify the organ on **L1** as the root and the one observable feature that supported the identification as the central position of the vascular tissue.

(iii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. Many candidates were able to draw four adjacent cells from the cortex with double lines representing the cell walls and included at least one air space between the cells. The most common error was to draw lines that did not meet up precisely or were too thick. Most candidates used one label line and label to identify the cytoplasm in one of the cells.

(b) The majority of candidates correctly measured the line **A**–**B** in whole millimetres or to an accuracy of 0.5 mm. Many candidates showed the conversion of their measurement of line **A**–**B** into micrometres and divided by 3000. The majority of candidates showed the correct magnification from their calculation. The most common error was not showing all the steps in the calculation.

(c) The stronger candidates organised the table with one column for features and one headed similarities between **L1** and **Fig. 2.2**. Many candidates listed at least two observable similarities between **L1** and **Fig. 2.2**.

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Paper 9700/41
A Level Structured Questions

Key messages

- Many candidates performed well on skill AO1 questions that required specific recall of learnt facts. However, the majority found applying their knowledge to the unfamiliar contexts of skill AO2 questions more challenging. For example, in **Question 3**, some candidates stated that scientists might becoming accidentally infected with *Plasmodium*, showing limited understanding of how scientific research is carried out and the safety standards involved

- Candidates showed difficulty in reading and interpreting graphs. Candidates are aware of the need to quote data from more than one point on a graph to show a trend or comparison, but quite often the data they quote is incorrect due to misreading the graph or approximating the figures. Graph questions such as **Question 2** also showed inaccuracies in description, for example candidates stating there was a decrease in rate when they meant that the rate of increase (of the rate of photosynthesis) reduced.

General comments

Stronger candidates gained high credit in this paper, particularly on the **Section B** questions. This resulted from correct interpretation of command words and broad knowledge across the whole syllabus that they were able to integrate with new information from the question.

Generally, candidates were most successful on **Questions 1** and **7,** with many candidates demonstrating an excellent knowledge of the molecular effects of insulin and adrenaline on cell function. Many candidates also had success with aspects of **Questions 5**, **6** and **8.** Questions that involved data handling, such as **Questions 2** and **4** were lower scoring. The new context of bioinformatics in **Question 3** proved to be challenging.

In **Section B**, candidates opting for **Question 9** performed extremely well, with many candidates gaining full credit on both sections. Candidates opting for **Question 10** performed less well.

Comments on specific questions

Question 1

(a) Most candidates used their own knowledge to interpret **Fig. 1.1** and listed three differences between ATP and NAD. Most commonly they stated the correct numbers of phosphates and sugars and that both contain adenine (though a few incorrectly named adenosine as the nitrogenous base). Some named the sugar present in both as ribose. Incorrect answers included ribulose. Many referred to one ribose or pentose sugar being present in ATP compared to the two found in NAD. Only rarely was a reference made to the pyrimidine in NAD. The other main source of error was misinterpreting the hexagon shapes on the diagram for hexose sugars instead of nitrogenous bases.

(b) Many candidates listed energy-requiring processes such as active transport and muscle contraction, rather than chemical reactions requiring ATP such as protein synthesis, DNA replication and glycogenesis. Generic terms like polymerisation, condensation and phosphorylation needed to be qualified with a specific reaction example. A few candidates gave examples from plants, such as making cellulose or starch, rather than mammals as required by the question.

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(c) Few candidates stated that substrate-linked phosphorylation makes ATP during the Krebs' cycle. Non-scoring answers included 'oxidative phosphorylation' or just 'phosphorylation'.

(d) Candidates were confident in outlining the role of NAD as a carrier of hydrogens (atoms, or protons plus electrons) in glycolysis and some correctly referred to its role as a coenzyme.

(e) Most candidates related the higher energy value of lipids compared to carbohydrates to a greater number of hydrogen atoms in the hydrocarbon tails of fatty acids. Incorrect references to more hydrogen bonds or molecules (rather than atoms) lost credit. Many stated that lipids release more energy or give more ATP but did not include per gram, molecule, mole or unit mass (to be able to compare with carbohydrates). Good responses went on to link lipid respiration to more electron transport chain activity or chemiosmosis.

Question 2

(a) Most candidates were able to explain the concept of limiting factors. Crucial points are that the limiting factor is the one out of several that is at its lowest value and that therefore prevents an increase in the rate of the reaction.

(b) Most candidates gave vague answers to this question, about the general necessity to control experimental conditions. Few candidates used knowledge from elsewhere in the syllabus to point out that soil organisms and plant roots would respire and produce an unwanted source of carbon dioxide.

(c) (i) Most candidates described and explained the pattern shown on the graph reasonably well, but some did not follow the instructions to focus only on the plants in set **A**. Errors in describing the graph included referring to points going right along the *x*-axis as 'at first', 'then' and 'later' as though the *x*-axis was a measure of time rather than increasing light intensity. The correct approach was to describe the relationship in two parts, one from 0.5 to around 6 to 7 arbitrary units of light intensity, and the second from this point to 10 arbitrary units of light intensity. An explanation for the relationship shown in each part was given by many candidates. Some candidates did not link their descriptive and explanatory statements to light intensity, making it impossible to distinguish which part of the graph was being referred to.

(ii) The majority of responses correctly noted that the difference in results of sets **A** and **B** was a result of more carbon dioxide being available in **B**. Occasional references to the use of the extra carbon dioxide in fixation or the Calvin cycle were seen. The most common error in this question was where candidates described the difference between the results of set **A** and set **B** instead of explaining the pattern seen.

(d) Many candidates suggested, incorrectly, that the plants in set **D** were exposed to a higher concentration of carbon dioxide throughout the experiment rather than just in the maturation phase. Others did not notice that the units for the *y*-axis stated mean rate of photosynthesis per unit area of leaf, and argued erroneously that plants in set **D** had a greater leaf surface area. The candidates who scored highly showed attention to detail and excellent biological knowledge, to realise that the plants in set **D** had adapted to a high carbon dioxide concentration by developing more stomata, more RuBP and more chloroplasts.

Question 3

(a) (i) Many candidates were able to define bioinformatics using appropriate terminology but others were unclear that bioinformatics allows the use of databases for the analysis of biological information such as gene and protein sequences.

(ii) Candidates did not recognise that the link between gene sequences and molecular targets for drugs gave them an opportunity to show what they knew about the basic relationship between genes, proteins and molecular function. Some candidates stated that bioinformatics allowed identification of specific genes in *Plasmodium* but few took the idea further to the prediction of the primary and 3D structures of the resulting proteins. Stronger answers suggested that drug molecules could act by preventing gene expression or by blocking an enzyme's activity.

(b) (i) Candidates mostly made good suggestions like computer modelling saving time and money. Some pointed out that with computer modelling tests on animals were unnecessary, removing an ethical

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issue. Few considered that modelling allows many variant chemical structures to be tested to find a more effective drug.

(ii) Candidates mostly understood that despite computer modelling, drugs ultimately need to be tested on living organisms to see if the theoretical predictions work in practice and to see if there are any side effects. Very few candidates mentioned that laboratory trials also allow the researchers to determine the best drug dosage.

Question 4

(a) Many candidates found applying their knowledge of content from the syllabus challenging in this question. Technical details of crossing two inbred lines to restore hybrid vigour or specific information about alleles affecting gibberellin synthesis in dwarf maize varieties were rarely seen. Most candidates achieved a proportion of the credit available by saying desirable plants were selected and bred and that this process was repeated for several generations. Some gave good examples of desirable traits likely to be selected for.

(b) Only a few candidates observed the 1:1 ratio of purple and yellow kernels and reasoned that this resulted from a test cross between a plant heterozygous for two alleles of the colour gene and one that was homozygous recessive. Few recognised that the two distinct kernel phenotypes with no intermediates showed discontinuous genetic variation. On the whole, candidates did not give a good genetic explanation and wrote vaguely about meiosis and fertilisation without fully using the information on ratio shown in **Fig. 4.1**.

(c) (i) The description of the graph was well done although some candidates had trouble reading figures off the *x* and *y*-axes correctly. The figures quoted for the area of crops (left hand *y*-axis) or the number of resistant pest species (right hand *y*-axis) quite often did not match up with each other or with the correct year. Most identified the overall trend that the number of resistant pests increased with increased area of genetically modified Bt crops. Not all candidates realised that an increase in resistant pests was an increase in the number of different species that were resistant. In explaining the pattern, most realised that the resistance arose as a result of a mutation but the random or spontaneous nature of this event was either not remarked upon or the opposite was argued, that the presence of Bt induced the mutation to happen. Terms like selection pressure and natural selection were often used and gained credit, but few described the changes as the pest species evolving.

(c) (ii) Candidates did not all understand the meaning of social (pertaining to human society) and environmental (affecting food chains, wild populations and also effects via the environment on human health). Some candidates pointed out disadvantages rather than beneficial advantages. The rapid increase in acreage devoted to growing Bt maize is due to its advantages in decreasing human food losses due to insect damage on the crop cheaply and without having to spray potentially harmful broad-spectrum chemical insecticides.

Question 5

(a) Candidates were asked to describe a method for estimating the population size of a small mammal. Answers that focused on quadrats were clearly inappropriate as unlike plants, water voles move about. Answers that attempted to describe the mark-release-recapture technique varied from vague to competent, although a few answers got all three elements in the correct order. Credit was gained for giving details of the vole trapping, marking and recapture timing protocol. Pitfall traps suitable for insects are not suitable for small mammals. Many candidates had accurately memorised the steps of the calculation for determining the population size and those who used symbols generally gave an adequate explanation of what these symbols meant.

(b) Many candidates scored some or all of the credit for outlining distinguishing features of animal cells. Absence of a cell wall, possession of centrioles and differences in vacuoles were common answers. Occasional references to the possibility of having microvilli or cilia were seen. Few candidates considered food storage as glycogen a distinguishing feature. Not having chloroplasts did not score as this is also true of cells of fungi, some protoctists and plants cells situated underground or far from light in the stem, trunk or fruits. Weaker responses highlighted the eukaryotic features of animal cells held in common with cells of the other eukaryotic kingdoms.

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(c) (i) Candidates wrote confidently about an alien species being a potential predator of native species, or competing with them or spreading disease to them. Candidates realised that these factors could cause reduction in the abundance of other species, perhaps leading to local loss of biodiversity, with consequent effects on food chains and the habitat. It was clear that most candidates were considering alien animal species, but many invasive species with the biggest negative effects on habitats and biodiversity are plants.

(ii) Culling, contraceptive measures and introducing a mink-specific disease were all good suggestions for controlling the numbers of escaped and naturalised mink in Great Britain. Introducing a predator would cause additional unforeseeable effects on the food web.

Question 6

(a) Most candidates set out their dihybrid cross clearly and gained full credit. A significant minority made the black allele dominant instead of recessive. Some candidates chose letter symbols but did not identify them with a key. Other wrong answers included co-dominant and sex-linked alleles, haploid parents, monohybrid crosses and using four different letters instead of two pairs.

(b) Many candidates were unable to describe a test cross, with some stating that they would use a Punnett square, form a table or use the chi-squared test. Some mentioned crossing with a homozygous recessive fly but would not have achieved the goal of identifying the unknown genotype of an organism showing the dominant trait in its phenotype, as answers like 'cross homozygous recessive with a heterozygous fly' were seen.

(c) For those familiar with chi-squared calculations, full credit was straightforward to achieve, although some candidates lost credit for incorrect rounding or totalling.

The most common problem was not knowing how to work out the expected number (332 divided by four). Despite errors in the table, candidates often scored one mark for totalling their incorrect figures from the final column.

(d) Many candidates were confident in interpreting the results of their statistical test and were able to read the table of chi squared values and correctly describe their results in terms of the critical value, probability, chance and the non-significance of the difference between the observed and expected results. Contradictory statements were common though, where candidates argued the opposite conclusion to that shown by their value being smaller than the critical value. Not all candidates realised that the test identifies whether *the difference* between the two sets of results is significant or due to chance, or that the cut-off value for significance is taken as 0.05 (many used 0.50).

Question 7

(a) Many candidates stated a correct and full definition of homeostasis, but some missed the idea of the internal environment staying constant or only fluctuating around a set point.

(b) (i) Most candidates stated that the polypeptides were synthesised in the ribosomes or rough endoplasmic reticulum. Some candidates saw the term β cells and instead of naming a location inside the cell as requested wrote 'islets of Langerhans' or 'pancreas'. Weaker candidates found it hard to integrate their basic knowledge of cell biology with their knowledge of the physiology of blood glucose regulation in all parts of **7(b).**

(ii) The correct answer, exocytosis, was commonly given but a significant number of candidates made alternative suggestions such as secretion (which was repeating the question), osmosis and diffusion.

(iii) The effects of insulin on muscle cells, such as increased uptake of glucose, more glucose respired or glucose converted to glycogen, were well known. The addition of transport proteins to the cell surface membrane was often mentioned, but did not gain credit if GLUT2 proteins were mentioned here rather than GLUT4.

(c) The molecular cascade caused by adrenaline binding to liver cells was well known. The sequence of events resulting in an increase in blood glucose concentration was usually correctly described in

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considerable detail. Missing details were most often the name of the enzyme that converts ATP to cyclic AMP and the term 'second messenger' for cyclic AMP.

Question 8

a) Most candidates were able to gain most of the credit for the correct names of the neurone parts, although some candidates wrote body cell instead of cell body for **C**. **B** could be described as a dendron or a (sensory) axon. To distinguish it from **B**, **D** can be referred to as the terminal axon and is often seen labelled as such in diagrams of a synapse.

(b) Many candidates realised that myelin was an insulator. The role of the nodes of Ranvier and saltatory conduction restricting the action potential only to the gaps was usually described well. Very few candidates could communicate effectively about the nature and position of the local circuits set up.

(c) Many candidates had difficulty distinguishing between the terms depolarisation (membrane potential changing to become less negative or more positive) and an action potential (a specific pattern of depolarisation with a peak at 45 mV). Candidates found difficulty in describing that *only* a stimulus that reached the threshold depolarisation is able to induce an action potential. There were a few correct references to the 'all or nothing' law. It was rare to see a good statement about all action potentials being the same size or voltage regardless of how strong the stimulus is. Irrelevant information about the strength of the stimulus changing the frequency of action potentials was common although this does not answer the question.

Question 9

(a) Candidates were usually well-prepared and able to outline how ATP is synthesised by oxidative phosphorylation. Detail of the role of reduced NAD was provided in most responses, although few candidates mentioned that it was reduced NAD that was passed to the electron transport chain (ETC), most stating that it was free electrons that arrived there. The role of the energy released from the electron transport chain in pumping protons to the intermembrane space, thus creating a proton gradient, was also well known. Similarly, the movement of protons back through ATP synthase, resulting in the combining of ADP and inorganic phosphate, was generally included, although some candidates stated that ATPase hydrolyses ATP rather than making it. Most accounts ended with a good description of the role of oxygen as the final electron acceptor, together with the addition of protons to form water. Errors that lost credit in otherwise good descriptions were confusing hydrogen atoms with hydrogen ions, saying that ATP was first made and then used to pump the protons into the intermembrane space, having electrons crossing the inner mitochondrial membrane, and having the protons diffusing rather than being pumped into the intermembrane space to create the gradient.

(b) The sequence of events in respiration of yeast in anaerobic conditions was also recalled well. The word 'glycolysis' was needed to refer to the early stages. Candidates need to make clear whether they are writing ethan**a**l or ethan**o**l in each stage of the process. Few references were seen to pyruvate decarboxylase, the enzyme that catalyses the removal of carbon dioxide from pyruvate, although the role of alcohol dehydrogenase was usually mentioned. Most candidates finished by explaining that the process resulted in the regeneration of NAD, so that glycolysis can continue.

Question 10

(a) Many weaker candidates referred to events involving the centrioles and nuclear membranes as well as naming the stages, none of which was required in the answer. The correct use of the term bivalent was not often seen and too few candidates referred to pairs of homologous chromosomes lining up on the equator in meiosis I. Some candidates confused chromosomes and chromatids, referring to 'sister chromosomes' or crossing-over between sister chromatids. It was common for candidates to refer to crossing-over but often when the chromosomes were lined up on the equator (metaphase I) rather than at the start of the process (prophase I).

(b) Few candidates were clear on the differences between regulatory and structural genes, or able to name examples of each type of gene or their protein products. They did not explain that regulatory genes work by switching other genes on and off. The best answers mentioned the lac operon, using terms like operator and promoter and referring to the binding of RNA polymerase to DNA to

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initiate transcription. The terms inducible and repressible sometimes appeared but very few candidates mentioned the role of DELLA protein repressors.

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Paper 9700/42
A Level Structured Questions

Key messages

- It is important, when describing a graph, to be clear that the data on the *y*-axis depends on the data on the *x*-axis and not the other way round.
- When the mark weighting of a question is, for example, 3 marks then the candidate should realise that at least three different statements need to be made.

General comments

This year's paper followed a similar pattern to last year, in terms of the standard of questions and difficulty involved. There was a broad range of questions covering the syllabus and this gave candidates ample opportunity to demonstrate their ability. Consequently, there were some excellent answers and a noticeable number of high marks obtained.

Generally, candidates appeared to find this paper more accessible than last year, particularly questions **1, 5, 6, 7, 8,** and **9** where weaker candidates were able to gain some credit. Questions **3** and **4** showed the greatest discrimination between candidates.

Comments on specific questions

Section A

Question 1

(a) (i) The majority of candidates gained both marks for identifying two structural similarities between ATP and coenzyme A. However, some stated that both would contain phosphate groups, without giving the number, or failed to name the nitrogenous base.

(ii) The role of coenzyme A in respiration was often inaccurately described; many commented that pyruvate, rather than acetate, would combine with coenzyme A, and that acetyl coenzyme A would enter Krebs cycle and combine with oxaloacetate. Nevertheless, most recognised that coenzyme A would be used in the link reaction.

(b) (i) Almost every candidate correctly stated that the reactions shown in **Figure 1.2** would occur in either liver or muscle cells.

(ii) The mechanism by which glucose would enter these cells was less well answered. Although many understood that facilitated diffusion would take place, some simply named diffusion, or suggested active transport or endocytosis.

(iii) Most candidates were able to name both types of reaction taking place at **F** and **G**. As there were a variety of correct responses for each reaction, candidates gained credit in a number of different ways. The most frequent responses were condensation and hydrolysis respectively, although some stated polymerisation or glycogenesis for **F** and glycogenolysis or phosphorylation for **G**. The other alternatives, such as anabolic and catabolic, were rarely seen.

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(iv) Again, most candidates were able to suggest an example of another metabolic pathway for phosphorylated glucose, with respiration being the most common response, followed by glycolysis. However, some candidates mentioned lipid or fatty acid synthesis.

Question 2

(a) Candidates were required to describe and explain the effects of temperature on the rate of photosynthesis. Many went no further than the descriptive part thereby failing to explain the effects. Most candidates appreciated that an increase in temperature increased the rate of photosynthesis at one or both light intensities, but failed to emphasise that at low light intensities the effect was negligible. A noticeable number appreciated that light intensity was a limiting factor at low light intensity, but fewer gave temperature as a limiting factor at high light intensity. Stronger candidates did provide explanations in terms of increased kinetic energy, leading to greater enzyme activity, increased number of collisions and formation of enzyme-substrate complexes.

(b) (i) Many candidates were able to express in words what was being shown on the graph about absorption or rate of photosynthesis with respect to wavelength, as defined by absorption spectrum and action spectrum respectively. This proved challenging to some who found it difficult to explain what was being communicated.

(ii) The majority of candidates did not perceive that there is a greater rate of photosynthesis at wavelengths that are absorbed the most, so little credit was awarded here. Many, however, were aware that light absorbed was used in photosynthesis.

(c) The majority of candidates were aware that energy was passed from the accessory pigment to the primary pigment and that the accessory pigment formed part of a photosystem.

Question 3

(a) While the vast majority of candidates understood that restriction endonuclease enzymes cut DNA, many neglected to add that they would cut at a specific site or base sequence. Some mentioned that the DNA would be cut at palindromic sequences, leaving either sticky or blunt ends. Relatively few commented that these enzymes were isolated from bacteria where they would be used to destroy bacteriophage DNA.

There were very few references to the X chromosome containing the required restriction site for the restriction endonuclease although some candidates appreciated that the X and Y chromosomes would differ in length or size.

(b) Many candidates appreciated that the gene for GFP was introduced into an autosome along with the I-PpoI gene to act as a marker which could then be used to identify the genetically modified male mosquitoes. However, some suggested that the gene would fluoresce under UV light, rather than the protein, or stated that the autosome, rather than the mosquitoes or their transformed cells, would glow.

(c) The reason why GM males produced no offspring at all was poorly explained by a significant number of candidates. Although many understood that the X chromosome would originate from the female, relatively few mentioned that this chromosome would be destroyed in the zygote, often suggesting that the destruction would take place in the female gamete or the offspring, without any mention of a zygote. However, many appreciated that the zygote formed would not be viable and therefore would not develop.

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(d) (i) There were few correct explanations for the differences in the number of female mosquitoes in cages A and B. Some candidates understood that all the offspring in cage A were due to the females mating with non-genetically modified males, while others stated that no offspring would be produced from GM males. However, there were no comments as to GM males having no effect on the number of females.

In cage B, while some candidates mentioned that only male offspring would be produced from GM males, few stated that there would be no female offspring. No reference to GM males being unable to produce spermatozoa containing an X chromosome was seen. Nevertheless, many candidates gained some credit for describing the fluctuation in the number of female mosquitoes in cage A and the decrease in cage B, although there were fewer statements that there were more females in cage A than cage B.

(ii) There were many suggestions as to the difficulties that might arise if the technique of releasing GM males with the modified I-Ppol gene were used to try to control populations of *A. gambiae* in the wild, but few achieved credit. Many candidates commented on the effect a reduction of the mosquito population would have on the food chain. Some believed that the I-Ppol gene would be transmitted to populations of other species or that mosquitoes would develop resistance to the gene. Others suggested that wild female mosquitoes would not mate with GM males.

However, stronger candidates appreciated that the release of a small number of GM males would not have a significant effect on the wild population or that the GM males might not survive in the wild. Very few mentioned that their might be an influx of non-GM mosquitoes from other areas although some referred to local opposition to the release of GM males.

Question 4

(a) The majority of candidates were credited for crossing plants with desirable characteristics and for naming one such example. However, some candidates mentioned the selection of alleles which is not possible when selecting by phenotypic traits, or discussing genetic modification instead. Extended answers included a description of reselection of offspring with desirable characteristics and the continuation of crossing the plants over many generations. This combination of marking points was the most common option to gain full credit. Fewer candidates developed their answer to discuss the frequency of desirable alleles increasing or that humans apply the selection criteria; where they did, candidates had often already achieved full marks as described above. A common error for some candidates was to fail to make it clear that it was the offspring with those advantageous characteristics that would only be bred subsequently. A few candidates failed to outline the process and simply stated some improvements that had been made to food crops through selective breeding and so limiting any marks achieved. A minority of candidates identified polyploidy in their responses.

(b) This question was generally answered in insufficient detail as many candidates gave weak responses that continuous variation refers to phenotypes not being in discrete groups. Some candidates were able to discuss the ranges in phenotypes observed, such as through the mention of intermediate values or any value between extremes, although the normal distribution of such phenotypes was rarely described. Of the few drawn examples of normal distribution, many were not labelled in full. Where candidates understood continuous variation, they most frequently described it as an interaction with the environment often quoting a named environmental factor such as temperature or nutrients. A large minority were able to name polygenes and additive effects but sometimes it was incorrectly described as a single gene effect with a minimal number of alleles.

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(c) Most candidates earned credit for describing the relationship on the graph provided, giving the general trend observed, although a few candidates incorrectly suggested that the resistant weeds drove the increase in the area of resistant crops planted. A number of candidates didn't achieve the relationship mark as they did not state that it was the area of planting. Figures quotes were often poorly reproduced; in particular, the number of weed species was read off the incorrect axis despite the labelling provided. Percentages and numbers were often misread from the graph even when correct axes were quoted and some candidates missed out the correct units for data quotes. Few candidates were able to explain why this observation occurred, with vague references to resistant weeds surviving but not stating this was due to a selective advantage. Occasionally good explanations did include references to spontaneous mutations in the weed species, although some candidates incorrectly stated that the mutation was caused by the use of the herbicide.

The most common misconception here was for horizontal resistance gene transmission from crop to weed via cross pollination.

(d) The majority of candidates recognised that an increased yield was a social advantage of growing glyphosate-resistant wheat crops. However, frequent reference to profits indicated confusion with social advantage.

Very few candidates gained credit for an environmental advantage. A large number of candidates referenced biodiversity changes or consequential effects on food chains. A common answer was to suggest that an environmental advantage would be reduced used of herbicide, which is incorrect as herbicide is still required. Very few candidates realised that less fertiliser would be required due to the lack of uptake of mineral ions by competing weed species.

Question 5

(a) Candidates gained marks for stating the use of the mark-release-recapture method and/or for adequate detail of marking the racoons although many candidates failed to gain these marks due an incorrect definition of the method or lack of detail in marking. Further detail on how the racoon might be trapped or on information regarding the time allowed before the second trapping was largely not given. Candidates frequently gave insufficient or inaccurate information on how to calculate the population size from the data collected.

(b) (i) The majority of Candidates were aware of the three domain system of classification and correctly identified the domain as that of the Eukarya. There was some confusion either with the five kingdom system of classification or with the Animalia kingdom within the Eukarya as Animalia was commonly stated in error.

(ii) Candidates who had correctly identified the domain usually gained full credit for this part; the most common answers were the presence of a nucleus, double membrane-bound organelles and 80S ribosomes. References to linear DNA and histones were also relatively common.

(c) The majority of Candidates gained full credit for this part, being fully aware of how racoons competed with other organisms for food and habitat and combined with predation could decrease population sizes and lead to the extinction of some species. The spreading of diseases to other species was rarely given. The concept of racoons spreading disease to humans either indirectly through contamination of food or buildings or by biting was well appreciated.

Question 6

(a) Although candidates were told that the gene for feather colour was on an autosome, had two alleles and three phenotypes, few described the inheritance as co-dominance, and the majority just stated autosomal. The inheritance of barred vs. non-barred feathers on sex chromosomes was more frequently described as sex-linked, although incomplete answers lacking detail just stated sex inheritance, which was not sufficient. Some repeated the alleles provided in the question as answers, rather than the mode of inheritance.

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(b) Strong candidates who understood genetic inheritance were able to achieve full credit, with a number producing genetic plots to demonstrate their thought processes effectively. Candidates often lost credit by failing to show two alleles per phenotype (even if homozygous), not showing the two traits as separate genes or on separate chromosomes (autosome vs. sex chromosome), writing the gametes as single alleles instead of combining one allele for feather colour with one allele for feather pattern, putting the alleles for feather colour on the sex chromosomes in addition to the alleles for pattern rather than as a separate autosome, or putting an allele on the W chromosome.

(c) Despite the co-dominance of the alleles for feather colour meaning that a cross was not required to determine the genotype for feather colour, it was less frequently described that blue feather must mean the chicken is heterozygous for this feature. Most candidates understood the cross to determine the phenotype for feather pattern would need to be with a non-barred female and described this as a test cross. Those that developed answers to describe how the phenotype of the offspring would reveal the genotype of the father were generally correctly described.

A few candidates received no credit as they talked about isolating DNA and carrying out tests to determine genotype rather than carrying out a simple cross.

Question 7

(a) Most candidates were familiar with the term 'deamination' and its meaning, the idea that amino acids are deaminated and ammonia formed, although fewer understood that the ammonia was derived from the amino group. The stronger candidates also understood that the ammonia is then combined with carbon dioxide and converted to urea. Some referred to the urea or ornithine cycle.

(b) There was a good understanding of the general principles of ultrafiltration, the cause and effect of high blood pressure, and the conserving or excreting of different substances. However, details of filtration were generally lacking in detail and often inaccurate. Many had the idea that there is high pressure in the glomerulus, but were unclear as to what kind of pressure it was, and there were also confused remarks about water potential and solute potential. Credit was lost by lack of precision, for example, mentioning that substances or particles (rather than molecules) of a certain size were filtered out. There was confusion over the sequence of the different layers, the position of holes or filters on which layers, and confusion between capillary endothelium and capsule epithelium. There was frequent reference to basal membrane instead of basement membrane, and to blood entering the Bowman's capsule. Some candidates thought ultrafiltration took place in the proximal convoluted tubule, distal convoluted tubule, loop of Henle or collecting duct, and a few described reabsorption instead.

(c) The first three parts of the nephron were correctly identified by the majority of candidates. The most common error was failure to correctly identify the last marking point as the proximal convoluted tubule.

Question 8

(a) Candidates generally scored highly here but some inaccurately labelled Y on the pre-synaptic rather than the post-synaptic membrane.

(b) Many candidates gained full credit on this question. The most common error arose from candidates stating that the insecticide bonded to the receptor on the post synaptic membrane, rather than referring to its effect on the functioning of acetylcholinesterase.

(c) The majority of candidates gained full credit by mentioning one-way transmission and memory or integration of nerve pathways.

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Section B

Question 9

(a) This question was quite well completed although marks were lost by a lack of precision by some candidates. Most were able to state that glucose needed to be phosphorylated by ATP but fewer were able to give the reason for this. The production of fructose bisphosphate was mentioned and its breakdown into two molecules of triose phosphate, although some gave their answer as triphosphate. The majority of candidates were able to state that reduced NAD and a small amount of ATP were produced.

(b) Candidates displayed much knowledge in describing the Krebs cycle. As in question **1(a)(ii)** many incorrectly restated that acetyl CoA combined with oxaloacetate rather than the 2 carbon acetyl group. However, many were able to describe the complete cycle accurately.

Question 10

(a) The process of chiasmata and crossing over was well described with many candidates gaining full credit for this section. Fewer were able to display accuracy in describing independent assortment and whilst there was some mention of random fusion of gametes, chromosome mutation and random mating were rarely seen.

(b) The functioning of the *lac* operon was clearly very well understood with many clear detailed descriptions seen, scoring maximum credit.

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Paper 9700/43
A Level Structured Questions

Key messages

- Many candidates performed well on skill AO1 questions that required specific recall of learnt facts. However, the majority found applying their knowledge to the unfamiliar contexts of skill AO2 questions more challenging. For example, in **Question 3**, some candidates stated that scientists might becoming accidentally infected with *Plasmodium*, showing limited understanding of how scientific research is carried out and the safety standards involved

- Candidates showed difficulty in reading and interpreting graphs. Candidates are aware of the need to quote data from more than one point on a graph to show a trend or comparison, but quite often the data they quote is incorrect due to misreading the graph or approximating the figures. Graph questions such as **Question 2** also showed inaccuracies in description, for example candidates stating there was a decrease in rate when they meant that the rate of increase (of the rate of photosynthesis) reduced.

General comments

Stronger candidates gained high credit in this paper, particularly on the **Section B** questions. This resulted from correct interpretation of command words and broad knowledge across the whole syllabus that they were able to integrate with new information from the question.

Generally, candidates were most successful on **Questions 1** and **7,** with many candidates demonstrating an excellent knowledge of the molecular effects of insulin and adrenaline on cell function. Many candidates also had success with aspects of **Questions 5**, **6** and **8.** Questions that involved data handling, such as **Questions 2** and **4** were lower scoring. The new context of bioinformatics in **Question 3** proved to be challenging.

In **Section B**, candidates opting for **Question 9** performed extremely well, with many candidates gaining full credit on both sections. Candidates opting for **Question 10** performed less well.

Comments on specific questions

Question 1

(a) Most candidates used their own knowledge to interpret **Fig. 1.1** and listed three differences between ATP and NAD. Most commonly they stated the correct numbers of phosphates and sugars and that both contain adenine (though a few incorrectly named adenosine as the nitrogenous base). Some named the sugar present in both as ribose. Incorrect answers included ribulose. Many referred to one ribose or pentose sugar being present in ATP compared to the two found in NAD. Only rarely was a reference made to the pyrimidine in NAD. The other main source of error was misinterpreting the hexagon shapes on the diagram for hexose sugars instead of nitrogenous bases.

(b) Many candidates listed energy-requiring processes such as active transport and muscle contraction, rather than chemical reactions requiring ATP such as protein synthesis, DNA replication and glycogenesis. Generic terms like polymerisation, condensation and phosphorylation needed to be qualified with a specific reaction example. A few candidates gave examples from plants, such as making cellulose or starch, rather than mammals as required by the question.

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(c) Few candidates stated that substrate-linked phosphorylation makes ATP during the Krebs' cycle. Non-scoring answers included 'oxidative phosphorylation' or just 'phosphorylation'.

(d) Candidates were confident in outlining the role of NAD as a carrier of hydrogens (atoms, or protons plus electrons) in glycolysis and some correctly referred to its role as a coenzyme.

(e) Most candidates related the higher energy value of lipids compared to carbohydrates to a greater number of hydrogen atoms in the hydrocarbon tails of fatty acids. Incorrect references to more hydrogen bonds or molecules (rather than atoms) lost credit. Many stated that lipids release more energy or give more ATP but did not include per gram, molecule, mole or unit mass (to be able to compare with carbohydrates). Good responses went on to link lipid respiration to more electron transport chain activity or chemiosmosis.

Question 2

(a) Most candidates were able to explain the concept of limiting factors. Crucial points are that the limiting factor is the one out of several that is at its lowest value and that therefore prevents an increase in the rate of the reaction.

(b) Most candidates gave vague answers to this question, about the general necessity to control experimental conditions. Few candidates used knowledge from elsewhere in the syllabus to point out that soil organisms and plant roots would respire and produce an unwanted source of carbon dioxide.

(c) (i) Most candidates described and explained the pattern shown on the graph reasonably well, but some did not follow the instructions to focus only on the plants in set **A**. Errors in describing the graph included referring to points going right along the *x*-axis as 'at first', 'then' and 'later' as though the *x*-axis was a measure of time rather than increasing light intensity. The correct approach was to describe the relationship in two parts, one from 0.5 to around 6 to 7 arbitrary units of light intensity, and the second from this point to 10 arbitrary units of light intensity. An explanation for the relationship shown in each part was given by many candidates. Some candidates did not link their descriptive and explanatory statements to light intensity, making it impossible to distinguish which part of the graph was being referred to.

(ii) The majority of responses correctly noted that the difference in results of sets **A** and **B** was a result of more carbon dioxide being available in **B**. Occasional references to the use of the extra carbon dioxide in fixation or the Calvin cycle were seen. The most common error in this question was where candidates described the difference between the results of set **A** and set **B** instead of explaining the pattern seen.

(d) Many candidates suggested, incorrectly, that the plants in set **D** were exposed to a higher concentration of carbon dioxide throughout the experiment rather than just in the maturation phase. Others did not notice that the units for the *y*-axis stated mean rate of photosynthesis per unit area of leaf, and argued erroneously that plants in set **D** had a greater leaf surface area. The candidates who scored highly showed attention to detail and excellent biological knowledge, to realise that the plants in set **D** had adapted to a high carbon dioxide concentration by developing more stomata, more RuBP and more chloroplasts.

Question 3

(a) (i) Many candidates were able to define bioinformatics using appropriate terminology but others were unclear that bioinformatics allows the use of databases for the analysis of biological information such as gene and protein sequences.

(ii) Candidates did not recognise that the link between gene sequences and molecular targets for drugs gave them an opportunity to show what they knew about the basic relationship between genes, proteins and molecular function. Some candidates stated that bioinformatics allowed identification of specific genes in *Plasmodium* but few took the idea further to the prediction of the primary and 3D structures of the resulting proteins. Stronger answers suggested that drug molecules could act by preventing gene expression or by blocking an enzyme's activity.

(b) (i) Candidates mostly made good suggestions like computer modelling saving time and money. Some pointed out that with computer modelling tests on animals were unnecessary, removing an ethical

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issue. Few considered that modelling allows many variant chemical structures to be tested to find a more effective drug.

(ii) Candidates mostly understood that despite computer modelling, drugs ultimately need to be tested on living organisms to see if the theoretical predictions work in practice and to see if there are any side effects. Very few candidates mentioned that laboratory trials also allow the researchers to determine the best drug dosage.

Question 4

(a) Many candidates found applying their knowledge of content from the syllabus challenging in this question. Technical details of crossing two inbred lines to restore hybrid vigour or specific information about alleles affecting gibberellin synthesis in dwarf maize varieties were rarely seen. Most candidates achieved a proportion of the credit available by saying desirable plants were selected and bred and that this process was repeated for several generations. Some gave good examples of desirable traits likely to be selected for.

(b) Only a few candidates observed the 1:1 ratio of purple and yellow kernels and reasoned that this resulted from a test cross between a plant heterozygous for two alleles of the colour gene and one that was homozygous recessive. Few recognised that the two distinct kernel phenotypes with no intermediates showed discontinuous genetic variation. On the whole, candidates did not give a good genetic explanation and wrote vaguely about meiosis and fertilisation without fully using the information on ratio shown in **Fig. 4.1**.

(c) (i) The description of the graph was well done although some candidates had trouble reading figures off the *x* and *y*-axes correctly. The figures quoted for the area of crops (left hand *y*-axis) or the number of resistant pest species (right hand *y*-axis) quite often did not match up with each other or with the correct year. Most identified the overall trend that the number of resistant pests increased with increased area of genetically modified Bt crops. Not all candidates realised that an increase in resistant pests was an increase in the number of different species that were resistant. In explaining the pattern, most realised that the resistance arose as a result of a mutation but the random or spontaneous nature of this event was either not remarked upon or the opposite was argued, that the presence of Bt induced the mutation to happen. Terms like selection pressure and natural selection were often used and gained credit, but few described the changes as the pest species evolving.

(c) (ii) Candidates did not all understand the meaning of social (pertaining to human society) and environmental (affecting food chains, wild populations and also effects via the environment on human health). Some candidates pointed out disadvantages rather than beneficial advantages. The rapid increase in acreage devoted to growing Bt maize is due to its advantages in decreasing human food losses due to insect damage on the crop cheaply and without having to spray potentially harmful broad-spectrum chemical insecticides.

Question 5

(a) Candidates were asked to describe a method for estimating the population size of a small mammal. Answers that focused on quadrats were clearly inappropriate as unlike plants, water voles move about. Answers that attempted to describe the mark-release-recapture technique varied from vague to competent, although a few answers got all three elements in the correct order. Credit was gained for giving details of the vole trapping, marking and recapture timing protocol. Pitfall traps suitable for insects are not suitable for small mammals. Many candidates had accurately memorised the steps of the calculation for determining the population size and those who used symbols generally gave an adequate explanation of what these symbols meant.

(b) Many candidates scored some or all of the credit for outlining distinguishing features of animal cells. Absence of a cell wall, possession of centrioles and differences in vacuoles were common answers. Occasional references to the possibility of having microvilli or cilia were seen. Few candidates considered food storage as glycogen a distinguishing feature. Not having chloroplasts did not score as this is also true of cells of fungi, some protoctists and plants cells situated underground or far from light in the stem, trunk or fruits. Weaker responses highlighted the eukaryotic features of animal cells held in common with cells of the other eukaryotic kingdoms.

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(c) (i) Candidates wrote confidently about an alien species being a potential predator of native species, or competing with them or spreading disease to them. Candidates realised that these factors could cause reduction in the abundance of other species, perhaps leading to local loss of biodiversity, with consequent effects on food chains and the habitat. It was clear that most candidates were considering alien animal species, but many invasive species with the biggest negative effects on habitats and biodiversity are plants.

(ii) Culling, contraceptive measures and introducing a mink-specific disease were all good suggestions for controlling the numbers of escaped and naturalised mink in Great Britain. Introducing a predator would cause additional unforeseeable effects on the food web.

Question 6

(a) Most candidates set out their dihybrid cross clearly and gained full credit. A significant minority made the black allele dominant instead of recessive. Some candidates chose letter symbols but did not identify them with a key. Other wrong answers included co-dominant and sex-linked alleles, haploid parents, monohybrid crosses and using four different letters instead of two pairs.

(b) Many candidates were unable to describe a test cross, with some stating that they would use a Punnett square, form a table or use the chi-squared test. Some mentioned crossing with a homozygous recessive fly but would not have achieved the goal of identifying the unknown genotype of an organism showing the dominant trait in its phenotype, as answers like 'cross homozygous recessive with a heterozygous fly' were seen.

(c) For those familiar with chi-squared calculations, full credit was straightforward to achieve, although some candidates lost credit for incorrect rounding or totalling.

The most common problem was not knowing how to work out the expected number (332 divided by four). Despite errors in the table, candidates often scored one mark for totalling their incorrect figures from the final column.

(d) Many candidates were confident in interpreting the results of their statistical test and were able to read the table of chi squared values and correctly describe their results in terms of the critical value, probability, chance and the non-significance of the difference between the observed and expected results. Contradictory statements were common though, where candidates argued the opposite conclusion to that shown by their value being smaller than the critical value. Not all candidates realised that the test identifies whether *the difference* between the two sets of results is significant or due to chance, or that the cut-off value for significance is taken as 0.05 (many used 0.50).

Question 7

(a) Many candidates stated a correct and full definition of homeostasis, but some missed the idea of the internal environment staying constant or only fluctuating around a set point.

(b) (i) Most candidates stated that the polypeptides were synthesised in the ribosomes or rough endoplasmic reticulum. Some candidates saw the term β cells and instead of naming a location inside the cell as requested wrote 'islets of Langerhans' or 'pancreas'. Weaker candidates found it hard to integrate their basic knowledge of cell biology with their knowledge of the physiology of blood glucose regulation in all parts of **7(b).**

(ii) The correct answer, exocytosis, was commonly given but a significant number of candidates made alternative suggestions such as secretion (which was repeating the question), osmosis and diffusion.

(iii) The effects of insulin on muscle cells, such as increased uptake of glucose, more glucose respired or glucose converted to glycogen, were well known. The addition of transport proteins to the cell surface membrane was often mentioned, but did not gain credit if GLUT2 proteins were mentioned here rather than GLUT4.

(c) The molecular cascade caused by adrenaline binding to liver cells was well known. The sequence of events resulting in an increase in blood glucose concentration was usually correctly described in

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considerable detail. Missing details were most often the name of the enzyme that converts ATP to cyclic AMP and the term 'second messenger' for cyclic AMP.

Question 8

a) Most candidates were able to gain most of the credit for the correct names of the neurone parts, although some candidates wrote body cell instead of cell body for **C**. **B** could be described as a dendron or a (sensory) axon. To distinguish it from **B**, **D** can be referred to as the terminal axon and is often seen labelled as such in diagrams of a synapse.

(b) Many candidates realised that myelin was an insulator. The role of the nodes of Ranvier and saltatory conduction restricting the action potential only to the gaps was usually described well. Very few candidates could communicate effectively about the nature and position of the local circuits set up.

(c) Many candidates had difficulty distinguishing between the terms depolarisation (membrane potential changing to become less negative or more positive) and an action potential (a specific pattern of depolarisation with a peak at 45 mV). Candidates found difficulty in describing that *only* a stimulus that reached the threshold depolarisation is able to induce an action potential. There were a few correct references to the 'all or nothing' law. It was rare to see a good statement about all action potentials being the same size or voltage regardless of how strong the stimulus is. Irrelevant information about the strength of the stimulus changing the frequency of action potentials was common although this does not answer the question.

Question 9

(a) Candidates were usually well-prepared and able to outline how ATP is synthesised by oxidative phosphorylation. Detail of the role of reduced NAD was provided in most responses, although few candidates mentioned that it was reduced NAD that was passed to the electron transport chain (ETC), most stating that it was free electrons that arrived there. The role of the energy released from the electron transport chain in pumping protons to the intermembrane space, thus creating a proton gradient, was also well known. Similarly, the movement of protons back through ATP synthase, resulting in the combining of ADP and inorganic phosphate, was generally included, although some candidates stated that ATPase hydrolyses ATP rather than making it. Most accounts ended with a good description of the role of oxygen as the final electron acceptor, together with the addition of protons to form water. Errors that lost credit in otherwise good descriptions were confusing hydrogen atoms with hydrogen ions, saying that ATP was first made and then used to pump the protons into the intermembrane space, having electrons crossing the inner mitochondrial membrane, and having the protons diffusing rather than being pumped into the intermembrane space to create the gradient.

(b) The sequence of events in respiration of yeast in anaerobic conditions was also recalled well. The word 'glycolysis' was needed to refer to the early stages. Candidates need to make clear whether they are writing ethan**a**l or ethan**o**l in each stage of the process. Few references were seen to pyruvate decarboxylase, the enzyme that catalyses the removal of carbon dioxide from pyruvate, although the role of alcohol dehydrogenase was usually mentioned. Most candidates finished by explaining that the process resulted in the regeneration of NAD, so that glycolysis can continue.

Question 10

(a) Many weaker candidates referred to events involving the centrioles and nuclear membranes as well as naming the stages, none of which was required in the answer. The correct use of the term bivalent was not often seen and too few candidates referred to pairs of homologous chromosomes lining up on the equator in meiosis I. Some candidates confused chromosomes and chromatids, referring to 'sister chromosomes' or crossing-over between sister chromatids. It was common for candidates to refer to crossing-over but often when the chromosomes were lined up on the equator (metaphase I) rather than at the start of the process (prophase I).

(b) Few candidates were clear on the differences between regulatory and structural genes, or able to name examples of each type of gene or their protein products. They did not explain that regulatory genes work by switching other genes on and off. The best answers mentioned the lac operon, using terms like operator and promoter and referring to the binding of RNA polymerase to DNA to

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initiate transcription. The terms inducible and repressible sometimes appeared but very few candidates mentioned the role of DELLA protein repressors.

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Paper 9700/51
Planning, Analysis and Evaluation

Key messages

- Where planning is being tested the question requires that the method should be detailed enough for another person to follow. Candidates should present their plan as a logical series of steps which would allow a successful investigation to be carried out to gather the information required.
- When analysing and evaluating data of various types in order to draw conclusions, just restating the raw data is not generally enough. It is important to analyse it in the context of the investigation from which the data is drawn, and then show that it has been processed in some way to draw conclusions.

General comments

The responses to the paper covered the whole range of available marks and there was no evidence that candidates were under any time pressure.

Comments on specific questions

Question 1

This question introduced candidates to a fieldwork investigation and an analysis of the statistical significance of the data using Spearman's rank.

(a) (i) The majority of candidates answered this well. Some confused the dependent and independent variables. The commonest error was to omit any reference to plants in the dependent variable and to refer only to the distribution or abundance of species. The independent variable is just the distance from the pond, not the distance a particular plant is from the pond, which is what is being investigated.

(ii) There was a considerable range in the responses seen. Some weaker responses had the general idea but did not set their description out in a logical and clear way. Whilst thinking about the dependent, independent and control variables may be helpful in the initial planning of the answer, it is not necessary to requote them all in the actual write up. In some cases, a considerable list of variables to be controlled was given, including many that it would not be possible to standardise in field investigations. These included temperature, light intensity, carbon dioxide level and soil pH.

Most candidates realised that the land plants had to be counted at regular intervals away from the pond, making use of a quadrat. However, some candidates described randomly placing or throwing the quadrats, thereby missing the point of systematic sampling. The stronger responses started by introducing the use of a transect, either line or belt, giving details such as the length of the transect and the equipment by which this would be measured. Some lengths were far too short for meaningful data to be collected, such as a couple of metres, or impracticably long, such as several kilometres. Details such as using the same quadrat were credited. Very few candidates suggested randomising where to start the transect around the pond, which would be important and does not negate the systematic nature of the sampling. Many candidates realised that to improve reliability repeats were needed, but then just stated 'repeat three times and take a mean'. This was not sufficient. It needed to be clear that it was the whole transect that was being repeated, starting at different sites around the pond.

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Relatively few anticipated the need to overcome difficulties in the method, such as how to identify the plant species or taking care not to miss small plants. As the question required a plan to investigate changes in distribution and abundance of plants at different distances from the edge of the pond, some indication of counting or getting a percentage cover was expected rather than stating 'record' unqualified. Quite a few mentioned measuring the height of plants which did not answer the question. A number of responses suggested that the sampling should be carried out at one time of year. Although that would allow a comparison at that season, it would not account for different plant species found at different times, which would apply to short-lived annuals or seasonal perennials. Generally, fieldwork is not really low risk, the risks just vary from many of those in the laboratory. They relate to the particular terrain and indeed part of the world. In addition to the possible allergic risks and the possible threats from domestic or wild animals in the field, there is always an inherent risk in working in areas close to water. Many candidates realised this and made sensible suggestions as to the precautions to be taken. Some inappropriately suggested things like 'to avoid dangers of drowning do not do the investigation near the pond' when, in fact, the investigation started at the edge of the pond.

A number of responses unnecessarily described the processing of the data with details of Simpson's Diversity Index or Spearman's Rank and the plotting of kite diagrams or graphs.

(b) (i) Almost all candidates completed the table correctly.

(ii) The rank correlation was carried out correctly by most candidates. The commonest error was not to subtract from 1. This gives an answer with a value of greater than +1, outside of the possible range of values, between +1 and –1. In a Spearman's Rank Correlation calculation, this should have prompted candidates to check their calculation.

(iii) Most candidates realised that a negative coefficient indicated a negative correlation and many went further to say a value as large as –0.92 showed a strongly negative correlation. Quite a few thought that a negative value indicated no correlation.

(c) (i) Most candidates were aware that they needed to use the column for 10 pairs of data, although there was occasionally confusion with degrees of freedom and so the responses ended up being in terms of the 9 column. Practice using such tables of data is invaluable. Most used the critical value terminology correctly or quoted the two critical values and explained that the calculated value was greater.

(ii) Many responses suggested difficulty in understanding what Spearman's rank test actually shows. Many candidates did not demonstrate understanding that correlation is not the same as causation. Thus, the candidates' conclusion in the question is not proved to be valid just by showing the correlation. There are a range of other biotic or abiotic factors that might be involved. Some answers were too general by not qualifying 'factor' by an example or at least as biotic or abiotic. Other answers were too positive and stated that the distribution was caused by some other stated factor.

Question 2

This question contained some important material to read through. The data tables needed careful study to ensure that the treatments and purpose of each group of rats was understood. The individual parts of the question needed to be answered in the context of the investigation into topiramate on the secretion of brain chemicals like dopamine.

(a) (i) There were many correct responses here. The most usual errors were to be too general and use 'amount' in place of precise terms like concentration or to mention concentration of nicotine which was already standardised.

(ii) This proved demanding for many candidates. They found expressing the purpose of a control difficult in the context of the investigation described. There were many who described what was done (no topiramate in **1** and **5** or no nicotine in **4**) without explaining why, or who just said they were to compare with and without topiramate or nicotine, without explaining what that showed or tested. Controls **1** and **5** were to see if or to show that, topiramate caused the blocking of dopamine secretion, whilst control **4** showed any effect topiramate has on dopamine secretion on its own or without nicotine.

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(b) The bar charts were usually read correctly and the data manipulated to show a correct ratio and in some way made it clear which figure referred to group **5** and which to group **1**. There are a variety of appropriate ways of expressing the answer; the traditional ratio expression, e.g. 35 : 8; 4.375 : 1, quotients, e.g. 4.375 or fractions, 35/8; 4.375/1 etc. The commonest answer seen was 35 : 8, i.e. each reduced to the smallest whole number. There were a number of answers where there was an attempt to calculate a percentage change by subtracting 64 from 280 and dividing by 64.

(c) Many weaker responses were just descriptions of the data rather than conclusions related to the effect of topiramate on the secretion of dopamine. Many candidates did not take into account the controls when drawing conclusions. Thus groups **2**, **3** and **6** all show a reduction of secretion when compared with their relevant controls. Groups **2** and **3**, where the topiramate concentration varied, showed that higher concentrations had a greater effect on lowering dopamine secretion. When comparing rats pre-treated with nicotine (group **6**) with those not pre-treated (group **3**) the effect is greater as a percentage change in untreated rats (75%) than in treated rats (57%). Just the idea that a given concentration of topiramate has a greater effect in reducing dopamine secretion on untreated rats was worthy of credit, and extra credit was given for supporting this with appropriate processed figures.

(d) As in **(c)**, many candidates did not take the answer far enough and quoted only the material in the question, rather than combining it with the material in the previous information to evaluate the success of topiramate in treating the addiction. Good responses were able to make the link between topiramate blocking the pleasure and reward response, and smokers therefore gaining less pleasure from smoking, making it easier to give up. Only the strongest responses developed the idea that as topiramate affects a number of brain chemicals there would be an overall cumulative or additive effect in reducing the reward. Most responses just repeated the two bullet points in the question, without getting the idea of the link to further enhancing the reduction in the desire to smoke.

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Paper 9700/52
Planning, Analysis and Evaluation

Key messages.

- Candidates should be able to describe an experimental method in a logical sequence that includes sufficient practical detail, including appropriate apparatus, for another person to carry out the experiment without any additional information.
- Candidates should be familiar with scientific process so that they can identify precisely the different types of variable and explain the role of controls.
- Candidates need to be practised in interpreting complex data so they can recognise trends and process data in order to draw conclusions or to explain the reasons for trends.

General comments

Candidates appeared to have sufficient time to complete the examination paper. Most candidates were able to confine their answers to the space provided and few candidates omitted any part of a question. There were many candidates who gave clearly presented answers, although there were candidates who did not gain maximum credit due to imprecise use of language. For example, in **Question 2(a)** and **2(b)** where many candidates referred to 'amount of cigarettes' or 'amount of volunteers', rather that stating actual values from **Table 2.1**, or using more precise terms such as 'number'.

Comments on specific questions

Question 1

This question was about using sampling techniques to compare grazed and un-grazed grassland. Candidates were expected to use their knowledge of techniques used for field studies and the information needed to calculate a Simpson's Index of Diversity, to describe a method by which random quadrats could be used to collect data from different types of grassland. Calculation of mode, median, standard error and confidence intervals were also tested. In addition, the technique used for estimating populations of animals was also tested.

While many candidates showed a good understanding of techniques used in field studies, there were those who described only a theoretical knowledge and as a result did not give practical details on how to randomise quadrats and collect data, describe how to obtain reliable results or use appropriate methods.

(a) There were relatively few good answers to this question. Many candidates appeared to be uncertain about the specific data needed to calculate Simpson's Index of Diversity. The most common imprecise answer was to 'count the number of species', which is insufficient as the population of each species is required. Another common statement was to state that 'n is the number of individuals in a species', which is correct, but for the calculation of Simpson's Index of Diversity, the number of all the species is needed. Some answers also confused the data represented by *n* and *N*.

(b) There were some good answers to this part of the question, gaining maximum credit. The strongest answers gave a clear description of how to mark out a standard area of study in each type of grassland and how to generate random co-ordinates for placing a stated number of quadrats of the same area in both grasslands. These answers also described how to count the numbers in each species and recognised that sampling should be done in more than one area of

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each of the grasslands. Weaker answers often described methods of estimating frequency or species richness, which are not appropriate for collecting data for Simpson's Index of Diversity. These candidates also referred to 'repeating three times and taking a mean', which was not credited. It needed to be clear that the procedure was replicated in different areas within the same grasslands, or that sampling was carried out in different seasons.

In some cases candidates seemed uncertain about the meaning of the term 'quadrat', as they described using tapes to create blocks or boxes of various sizes. These needed to be the standard $1\,m^2$ area. Credit was not given for 'random throwing' of quadrats. A great many candidates did not gain credit for using a quadrat due to incorrect spelling resulting in the word 'quadrant', which has a specific mathematical meaning. Weaker answers often did not get further than stating that random quadrats should be used or described using a transect line with systematic sampling. In some cases candidates described counting the number of herbivores, birds or insects, which was not relevant to the question. Other candidates described setting up grazed and ungrazed areas for study. There was a great range of acceptable hazards and safety precautions, the most common were related to toxic species of plants or insects, although there were candidates who stated that field studies were hazard free. In some cases candidates stated that pH of soil, rainfall and light should all be standardised, which would not be possible in field investigations. A great many candidates wrote extensively about how to process the results and explained how the results of the calculation of Simpson's Index of Diversity would be used, none of which was necessary.

Candidates needed to be able to produce an answer which is a workable procedure along the lines of a practical schedule so that there is a logical sequence that specifies what apparatus to use, shows how the relevant variables have been standardised and how the independent variable is to be measured. It should be sufficient so that another person could carry it out. Limited credit is available for answers that only list the different variables.

(c) Most candidates gave a correct answer. The most common error was 'grazing' for the independent variable, without any qualification.

(d) (i) Almost all candidates correctly calculated the mode and median for the data in **Table 1.1**.

(ii) The majority of candidates correctly calculated the standard errors. The most common error was to give their answer in a different number of significant figures from that in the question.

(iii) Most candidates were able to calculate the expected confidence interval. Most mistakes were the result of inaccurate rounding up of figures.

(iv) To answer this question, candidates needed to understand what confidence intervals show. Very few candidates gained maximum credit and the majority did not gain any credit. Some candidates who had an understanding of confidence intervals, did not gain credit as they referred to the height of the plants, rather than the mean height, which was the parameter being assessed. There was considerable confusion between probability and certainty, standard error, standard deviation and range, reliability and accuracy. Very careful use of language was required here.

(e) Many candidates were able to give two correct answers, commonly a reference to using non-toxic markers and using marks that did not affect the survival of the species. Some answers were too vague to gain credit and needed to include both a time between capture and recapture, and the reason for the time; to allow mixing of the marked individuals with the rest of the population. Other answers did not gain credit as they were not critical to the validity of the results, for example, trapping the same number each time. Weaker answers included checking the insects were the same species, collecting two samples and taking a mean or marking the second sample.

(f) There were a great many good answers to this question. Weaker answers were often too vague as they referred to food supply or plants, rather than seeds. Some candidates did not realise that grazing will constantly remove the growing parts of plants, so that many would not flower and produce seeds.

Question 2

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This question was about an investigation into the effect of smoking on peak expiratory flow rate (PEFR). Candidates were expected to use the information about how peak flow is measured to identify variables and select relevant data to interpret the experimental results in the question.

(a) The majority of candidates gave at least two acceptable answers. The most common answers were age and the number in each of the test groups. Stronger answers pointed out that there were two variables so in order to quantify the effect of smoking, the age should be kept constant. Weaker answers often lost out as they referred to standardising the mean age, or to the number of the volunteers but without mentioning 'per group'. Some candidates did not appear to have read the question carefully enough and so gave variables that had been standardised such as the sex of the volunteers. Other suggestions that were not credited included 'all volunteers should have started smoking at the same age' and 'volunteers should smoke the same numbers of cigarettes at the same time'.

(b) Candidates found it difficult to express themselves clearly when answering this question. Stronger answers were able to select the relevant data from **Table 2.1** and link it to the two stated conclusions. The strongest answers showed that the candidates understood that there were two variables and that only mean values showed any trend. These candidates also recognised that a major issue with the data was the lack of clear age groups because of the large standard deviations and the overlap of PEFR between some of the groups smoking different numbers of cigarettes. Weaker answers tended to quote data without saying how it supported or did not support the conclusions.

(c) (i) The majority of candidates did not give creditworthy answers as they gave a null hypothesis more suited to the *t*-test such as 'no significant difference between the number of packets smoked and the mean PFER'. Since the data is looking for a correlation between the number of packets smoked and the decrease in PEFR, then the null hypothesis also needs to be stated in these terms. Some candidates just copied the wording of the conclusion in the question.

(ii) The majority of candidates gave two correct answers. Almost all candidates realised that the group size was too small. Many candidates also realised that the number of packets of cigarettes for group **5** was larger than for the other groups, but sometimes lost out by miscalculating the intervals as 49 and 79, rather than 50 and 80.

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Paper 9700/53
Planning, Analysis and Evaluation

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Question 1

This question introduced candidates to a fieldwork investigation and an analysis of the statistical significance of the data using Spearman's rank.

(a) (i) The majority of candidates answered this well. Some confused the dependent and independent variables. The commonest error was to omit any reference to plants in the dependent variable and to refer only to the distribution or abundance of species. The independent variable is just the distance from the pond, not the distance a particular plant is from the pond, which is what is being investigated.

(ii) There was a considerable range in the responses seen. Some weaker responses had the general idea but did not set their description out in a logical and clear way. Whilst thinking about the dependent, independent and control variables may be helpful in the initial planning of the answer, it is not necessary to requote them all in the actual write up. In some cases, a considerable list of variables to be controlled was given, including many that it would not be possible to standardise in field investigations. These included temperature, light intensity, carbon dioxide level and soil pH.

Most candidates realised that the land plants had to be counted at regular intervals away from the pond, making use of a quadrat. However, some candidates described randomly placing or throwing the quadrats, thereby missing the point of systematic sampling. The stronger responses started by introducing the use of a transect, either line or belt, giving details such as the length of the transect and the equipment by which this would be measured. Some lengths were far too short for meaningful data to be collected, such as a couple of metres, or impracticably long, such as several kilometres. Details such as using the same quadrat were credited. Very few candidates suggested randomising where to start the transect around the pond, which would be important and does not negate the systematic nature of the sampling. Many candidates realised that to improve reliability repeats were needed, but then just stated 'repeat three times and take a mean'. This was not sufficient. It needed to be clear that it was the whole transect that was being repeated, starting at different sites around the pond.

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Relatively few anticipated the need to overcome difficulties in the method, such as how to identify the plant species or taking care not to miss small plants. As the question required a plan to investigate changes in distribution and abundance of plants at different distances from the edge of the pond, some indication of counting or getting a percentage cover was expected rather than stating 'record' unqualified. Quite a few mentioned measuring the height of plants which did not answer the question. A number of responses suggested that the sampling should be carried out at one time of year. Although that would allow a comparison at that season, it would not account for different plant species found at different times, which would apply to short-lived annuals or seasonal perennials. Generally, fieldwork is not really low risk, the risks just vary from many of those in the laboratory. They relate to the particular terrain and indeed part of the world. In addition to the possible allergic risks and the possible threats from domestic or wild animals in the field, there is always an inherent risk in working in areas close to water. Many candidates realised this and made sensible suggestions as to the precautions to be taken. Some inappropriately suggested things like 'to avoid dangers of drowning do not do the investigation near the pond' when, in fact, the investigation started at the edge of the pond.

A number of responses unnecessarily described the processing of the data with details of Simpson's Diversity Index or Spearman's Rank and the plotting of kite diagrams or graphs.

(b) (i) Almost all candidates completed the table correctly.

(ii) The rank correlation was carried out correctly by most candidates. The commonest error was not to subtract from 1. This gives an answer with a value of greater than +1, outside of the possible range of values, between +1 and –1. In a Spearman's Rank Correlation calculation, this should have prompted candidates to check their calculation.

(iii) Most candidates realised that a negative coefficient indicated a negative correlation and many went further to say a value as large as –0.92 showed a strongly negative correlation. Quite a few thought that a negative value indicated no correlation.

(c) (i) Most candidates were aware that they needed to use the column for 10 pairs of data, although there was occasionally confusion with degrees of freedom and so the responses ended up being in terms of the 9 column. Practice using such tables of data is invaluable. Most used the critical value terminology correctly or quoted the two critical values and explained that the calculated value was greater.

(ii) Many responses suggested difficulty in understanding what Spearman's rank test actually shows. Many candidates did not demonstrate understanding that correlation is not the same as causation. Thus, the candidates' conclusion in the question is not proved to be valid just by showing the correlation. There are a range of other biotic or abiotic factors that might be involved. Some answers were too general by not qualifying 'factor' by an example or at least as biotic or abiotic. Other answers were too positive and stated that the distribution was caused by some other stated factor.

Question 2

This question contained some important material to read through. The data tables needed careful study to ensure that the treatments and purpose of each group of rats was understood. The individual parts of the question needed to be answered in the context of the investigation into topiramate on the secretion of brain chemicals like dopamine.

(a) (i) There were many correct responses here. The most usual errors were to be too general and use 'amount' in place of precise terms like concentration or to mention concentration of nicotine which was already standardised.

(ii) This proved demanding for many candidates. They found expressing the purpose of a control difficult in the context of the investigation described. There were many who described what was done (no topiramate in **1** and **5** or no nicotine in **4**) without explaining why, or who just said they were to compare with and without topiramate or nicotine, without explaining what that showed or tested. Controls **1** and **5** were to see if or to show that, topiramate caused the blocking of dopamine secretion, whilst control **4** showed any effect topiramate has on dopamine secretion on its own or without nicotine.

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(b) The bar charts were usually read correctly and the data manipulated to show a correct ratio and in some way made it clear which figure referred to group **5** and which to group **1**. There are a variety of appropriate ways of expressing the answer; the traditional ratio expression, e.g. 35 : 8; 4.375 : 1, quotients, e.g. 4.375 or fractions, 35/8; 4.375/1 etc. The commonest answer seen was 35 : 8, i.e. each reduced to the smallest whole number. There were a number of answers where there was an attempt to calculate a percentage change by subtracting 64 from 280 and dividing by 64.

(c) Many weaker responses were just descriptions of the data rather than conclusions related to the effect of topiramate on the secretion of dopamine. Many candidates did not take into account the controls when drawing conclusions. Thus groups **2**, **3** and **6** all show a reduction of secretion when compared with their relevant controls. Groups **2** and **3**, where the topiramate concentration varied, showed that higher concentrations had a greater effect on lowering dopamine secretion. When comparing rats pre-treated with nicotine (group **6**) with those not pre-treated (group **3**) the effect is greater as a percentage change in untreated rats (75%) than in treated rats (57%). Just the idea that a given concentration of topiramate has a greater effect in reducing dopamine secretion on untreated rats was worthy of credit, and extra credit was given for supporting this with appropriate processed figures.

(d) As in **(c)**, many candidates did not take the answer far enough and quoted only the material in the question, rather than combining it with the material in the previous information to evaluate the success of topiramate in treating the addiction. Good responses were able to make the link between topiramate blocking the pleasure and reward response, and smokers therefore gaining less pleasure from smoking, making it easier to give up. Only the strongest responses developed the idea that as topiramate affects a number of brain chemicals there would be an overall cumulative or additive effect in reducing the reward. Most responses just repeated the two bullet points in the question, without getting the idea of the link to further enhancing the reduction in the desire to smoke.

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