BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

There was a good spread of scores. The ten questions that candidates found relatively straightforward were **Questions 7, 10, 11, 17, 18, 31, 32, 33, 37 and 38.** The six hardest questions were **Questions 9, 27, 29, 36, 39 and 40.**

Comments on specific questions

Question 3

Almost 70% of candidates thought that chloroplasts and mitochondria contain both 70S ribosomes and circular DNA.

Question 4

The majority of candidates answered this incorrectly. A build-up of lipids in cells means that the excess lipids are not being broken down. Excess lipids are normally broken down by hydrolytic enzymes found in the lysosomes.

Question 5

The relative difficulty of this question was due to some candidates being unaware that Plasmodium is a eukaryote. As such they possess all three structures.

Question 9

Over 80% of weaker candidates answered incorrectly. Candidates who knew that peptide bonds are only present between amino acids in the primary structure of amino acids would have eliminated all except option **D**. Then the formation of a tertiary structure from a secondary structure may require ionic bonds as may the formation of a quaternary structure from a tertiary structure.

Question 14

Many weaker candidates answered this incorrectly, since they were unable to determine that fat soluble vitamin D would diffuse through the phospholipids and then apply this to the diagram.

Question 16

Almost 40% of candidates correctly knew that mitotic division cannot result in a cell being repaired. Damaged cells are normally destroyed but are replaced as a result of mitotic division.

Question 20

Over 65% of candidates did not know that tRNA contains single stranded RNA which folds such that hydrogen bonding occurs between regions of complementary bases.

Question 27

The sounds that normally occur during a cardiac cycle are caused when either the atrioventricular valves or the semilunar valves close. After atrial systole has occurred the heart enters ventricular systole causing closure of the atrioventricular valves.

Question 29

Those candidates who had studied slides of the gaseous exchange system were advantaged in being able to identify Y as muscle and X as the ciliated epithelium.

Question 36

Many candidates found this question difficult. The cholera pathogen lives in the small intestine and vaccines which stimulate antibody production have little effect in the intestines.

Question 39

The least efficient energy transfer occurs when the producer traps sunlight. 65% of all candidates incorrectly thought it was between the tertiary and secondary consumers.

Question 40

The nitrogen cycle is poorly understood by many candidates and many candidates found this question difficult. Statements **A**, **B** and **C** are all correct, so option **D** is the answer as it does not apply to producers and is an incorrect statement.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

There was a good spread of scores. The ten questions that candidates found relatively straightforward were **Questions 10, 11, 17, 22, 26, 30, 33, 35, 37 and 40.** The six hardest questions were **Questions 4, 12, 14, 20, 27 and 29.**

Comments on specific questions

Question 2

Candidates who had used stage micrometers to calibrate an eyepiece graticule were at an advantage in being able to determine the steps required to find the actual width of a xylem vessel.

Question 4

Less than a quarter of all candidates answered correctly. Both typical eukaryotes and typical prokaryotes contain 70S ribosomes and circular DNA. In eukaryotic cells, these structures are present in the mitochondria.

Question 6

Just over half of all candidates answered correctly. Candidates are expected to carry out microscopy throughout the course and use the knowledge gained to understand the relationships between different tissues.

Question 8

Although fructose has a different ring structure to glucose it has the same formula. Therefore when two molecules of glucose combine to form maltose or when a molecule of glucose and a molecule of fructose combine to form sucrose, the molecular formulae of the two disaccharides is identical.

Question 12

Many candidates found this question difficult. A minority were able to reason that the property of water that helps prevent enzymes from being denatured is that water requires a lot of heat to evaporate. Using heat to evaporate water from the mesophyll cell walls, results in the overall temperature of the plant being kept low enough to prevent enzyme denaturation.

Question 14

Over 40% of candidates incorrectly thought that enzyme concentration would become a limiting factor, whilst almost 60% of candidates incorrectly thought that all the active sites are saturated. The lipids would be digested by lipase to form glycerol and fatty acids. The more the lipids are digested the more acidic the liquid food.

Question 16

This was well answered by the majority of more able candidates, but only a third of weaker candidates answered correctly.

Question 20

A minority of candidates correctly identified the definitions for both diploid and haploid cells.

Question 24

Those candidates who have used microscopes to look at different sections of plant tissue would have found this question straight forward.

Question 27

In order for root pressure to form, cells surrounding the xylem actively secrete mineral ions etc. into the xylem. Active secretion requires ATP from mitochondria which in turn require oxygen to function efficiently.

Question 29

Those candidates who answered correctly were able to deduce that, in order to increase or decrease blood flow, the arteriole would need to have the lumen size increased or decreased, which can only occur using muscles.

BIOLOGY

Paper 9700/13
Multiple Choice

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

General comments

There was a good spread of scores. The ten questions that candidates found relatively straightforward were **Questions 3, 4, 10, 13, 21, 30, 33, 34, 36 and 37.** The six hardest questions were **Questions 1, 19, 27, 28, 31 and 32.**

Comments on specific questions

Question 1

The majority of candidates did not realise that a stage micrometer scale is used to calibrate the eyepiece graticule, which is then used to measure the actual length of cells. Additionally the size of the stage micrometer scale would change as the objective lens is changed.

Question 7

Less than 50% of weaker candidates realised that the diagram showed a chain of β-glucose molecules which are only found in cellulose.

Question 12

Only 40% of weaker candidates reasoned that the concentration of enzyme-substrate complexes would rapidly increase, reach a peak and then decrease as the substrate was broken down.

Question 16

Some candidates incorrectly thought that net diffusion of water would increase, whereas it would in fact decrease.

Question 19

Less than half of candidates realised that the only structural feature of DNA that varies is the number of hydrogen bonds between base pairs.

Question 23

The majority of weaker candidates did not realise that water will enter the cell and leave the cell, but there is no net movement between a cell and the environment when the water potential of the cell and environment are the same.

Question 27

Whilst the majority of the most able candidates answered this correctly, almost equal numbers of weaker candidates chose each option. The more able candidates could reason that the curve to the left would be the one to use, since the muscle cells were inactive so would be producing less carbon dioxide.

Question 28

Some candidates found this question difficult. Candidates should be able to use the diagram to work out when the various heart valves are open or closed and relate this to the volume of blood present in the atria or ventricles.

Question 32

Almost half of all candidates were able to reason that a narrowing of bronchi and bronchioles would reduce the volume of air entering or leaving the lungs, resulting in a decreased diffusion gradient. Additionally there would be an increased risk of lung infection.

Question 40

The least efficient energy transfer occurs when the producer traps sunlight. The majority of weaker candidates incorrectly thought it was between the tertiary and secondary consumers.

BIOLOGY

Paper 9700/21
AS Structured Questions

Key Messages

- Candidates need to be able to distinguish between a type of cell and a tissue; they should also understand that some tissues are composed of more than one type of cell. **Question 1** required knowledge that goblet cells and ciliated epithelial cells are two different cells types in the epithelial tissue lining the small intestine.

- Candidates should associate the presence of a non-self antigen with active immunity, the production of memory cells, and a long-term protection to an infectious disease. In **Question 2(b)**, many thought that the immunity described in **Fig. 2.1** that involved an injection would be considered a passive immunity.

- Candidates need to be able to describe results shown in tabular or graphical form, including describing trends and extracting data accurately from tables and from graphs drawn with and without grid lines.

General comments

Many candidates were well prepared for this examination, with those performing well giving detailed responses where necessary and showing a very high level of understanding of the topics covered by the syllabus. This was exemplified in **Question 5**, where a more detailed understanding of the term autotroph was required in part **(a)** and where two or more steps of thought were required to apply knowledge and understanding to a new situation in part **(b)**. **Questions 2**, **3**, **4** and **6** differentiated particularly well.

In **Question 1**, which should have been relatively straightforward, many candidates did not read the introductory sentence carefully. This clearly informed candidates that the electron micrograph in **Fig. 1.1**. was of cells from the small intestine. However a large proportion only noticed the label 'goblet cell' and automatically assumed that it was in the gas exchange system. Part **(c)** of this question, a calculation using magnification to obtain an actual size, was well done by a large proportion of candidates. **Question 2** included assessing candidate ability of extracting and interpreting data in graphical form. This required candidates to be accurate in data extraction and to be fastidious in their description of the changes seen. Many were able to gain full credit for this but others were more vague in their description and/or included inaccuracies in values given. Part **(a)** of this question was well done by a few candidates, with many others only stating part of the answer, that is active/passive and leaving out artificial/natural or vice versa. Many made a good effort in the first half of **Question 3**, showing good knowledge of peptide bond formation and of the genetic code. However a number of candidates left parts of this question blank. Much of the second half of **Question 3** was generally tackled well only by stronger candidates, with parts **(d)** and **(e**) proving to be particularly challenging. **Question 4** was a straightforward question and those candidates with a good grasp of mitosis were able to do very well. There were a number, however, who would have benefited from more practice identifying stages of mitosis from photomicrographs or prepared slides. **Question 5** was challenging for many candidates: this question required application of knowledge and understanding from topics in ecology. Although **Question 6** was familiar subject matter, in part **(a)**, only some candidates gave the level of detail required and noted that an explanation was required.

Candidates appeared to have sufficient time to complete the paper and where some candidates left blank spaces this often appeared to be correlated with the more challenging questions rather than a shortage of time. Handwriting was usually legible and candidates generally were able to answer within the number of lines provided. By showing their working in **Question 1(c)**, a number of candidates were able to gain partial credit if the calculated value of the actual length of the nucleus was incorrect.

Comments on specific questions

Question 1

Candidates were assessed on topics from ***Section A*** and ***H*** in this question. For parts **(a)** and **(b)** it was essential for candidates to read the information provided about **Fig. 1.1**. This question included an electron micrograph that candidates used to identify cell structures and to make a calculation of actual size.

(a) A high proportion of the candidates who had noted the location of the cells shown in **Fig. 1.1** as the small intestine knew that the structures labelled **A** had a role in absorption. Many also made the link with an increased surface area. Fewer correctly stated microvilli as the cell structures concerned, with some stating 'villi' and others 'cilia'. There were many who had missed the information provided about the small intestine and made an incorrect link with the goblet cells to think that the image was from cells of the gas exchange system. Hence many stated cilia as the structures concerned and gave the role as the movement of mucus, or incorrectly as the movement of pathogens.

(b) Candidates who gave the best responses knew that many mitochondria meant the synthesis of large quantities of ATP for the active uptake of substances, such as glucose, from the small intestine. Many gained partial credit for knowing the role of mitochondria. Some wrote about the need for energy for cilia to move, while others thought that the cells produced mucus and would need energy for this.

(c) Many tackled the calculation confidently to use the correct formula and obtain the correct answer. Some did not know how to convert correctly from their measurement in cm or mm to m but were able to gain partial credit for knowing the formula to use and for measuring the length of nucleus **C** accurately. Some candidates left part **(c)** blank.

(d) Part **(d)** switched focus to the gas exchange system and the role of goblet cells. The majority knew that goblet cells produce or secrete mucus and most stated that mucus is sticky and/or named cell types or substances that would be trapped in the mucus. Some went on to gain full credit by describing how mucus production by goblet cells maintains the health of the gas exchange system by preventing infection. Some gave details of ciliated epithelial cells and cilia wafting the mucus but this was not required.

(e) A few stated correctly two differences between the cells lining the alveoli in cell **B** in **Fig. 1.1**. The most common correct difference stated was the presence of more mitochondria in cell **B**. However some candidates wrote that the cells lining the alveoli had no mitochondria, so did not gain credit. Some gave a difference that was not directly a difference between the two cells, such as the close presence of capillaries around the alveoli, which was not required for this question.

Question 2

Candidates used knowledge and understanding from ***Sections H and I*** in **Question 2**. Part **(a)** was well attempted by only a few and many found part **(b)** to be challenging.

(a) The term disease encompasses all forms of ill health and so requires a definition that takes into account all the different categories. Whilst some definitions were excellent, the majorityof candidates ignored all but infectious diseases and most responses only referred to pathogens or disease causing organisms.

(b) In studying the second level of the flow chart candidates needed to realise that the presence of a non-self antigen would trigger the specific immune response and the production of memory cells in addition to the production of antibodies by plasma cells. This signifies an active immunity and is in contrast to obtaining antibodies from an external source, where a passive immunity is gained as no immune response is stimulated. Some candidates only stated 'active' and 'passive' in the correct boxes and went no further. To gain full credit candidates needed to know that vaccines and injections are considered 'artificial' compared to the 'natural' sources of immunity.

(c) This question required candidates to describe changes in the number of cases of smallpox shown on a graph and this was well done by many. The best responses made it clear when the changes shown in the world were being described or where the changes were for India alone, and gave correct values extracted from **Fig. 2.2** for the main changes. These candidates also noted that the

eradication of smallpox for the world occurred after India. Many noticed that there were three main peaks in the number of cases. Some were careless in their description, such as stating numbers of people dying from smallpox rather than the number of cases or were too vague, for example stating 'in the mid-60s' or 'around 1950'. A number also gave a comparison between the results for India and those for the world, which was not required. These were able to gain some credit if dates were given and changes were noted.

(d) This was answered very adeptly by many candidates, who knew considerable detail about the successful eradication of smallpox. At the other extreme there were some very general responses that were not specific to smallpox, such as an improvement in healthcare, or how people were aware of the disease and knew how to avoid becoming infected. Incorrect ideas included writing about antibiotic treatment, which shows a lack of understanding that smallpox is caused by a virus. Some thought that the eradication of the disease occurred because a vaccine had just been successfully developed at the same time.

Question 3

Most candidates were able to make a good attempt at parts **(a)** to **(c)** of this question, assessing ***Sections B*** and ***F*** of the syllabus. Parts **(d)** and **(e)** required candidates to apply knowledge and understanding to subject matter from ***Section G*** and generally these were tackled well by stronger candidates. Part **(f)** was a very straightforward question assessing knowledge of signs and symptoms of COPD, from ***Section H***.

(a) Amost all candidates knew that a condensation reaction occurred when a dipeptide was formed. Some incorrectly gave the name of the bond formed.

(b) Most used the two amino acids already drawn out to extend the drawing by adding a dipeptide. There were numerous excellent responses with all detail correct, a peptide bond clearly shown (and frequently labelled as such) and a water molecule shown. Slightly weaker responses included incorrectly copying out the R-groups of each amino acid or forgetting to show a water molecule. Many used the oxygen molecule as part of the peptide bond. Those that did not extend the diagram tried to modify the existing diagram with labels or shapes drawn around areas. For these, some credit could be given for knowing that water is eliminated.

(c) (i) Most were able to accurately complete **Fig. 3.2** with the missing RNA codons and the missing DNA triplet base sequence. A proportion of candidates who correctly completed the RNA codons left the DNA base sequence blank. No credit was awarded for incorrectly stating the missing DNA base sequence, usually TTA.

(ii) There were a range of answers given for this straightforward question. Some had no problem correctly naming the RNA as messenger. Others did not heed the instruction to state the full name and only gave mRNA as an answer, while others gave one of the other two types, ribosomal or transfer RNA.

(d) This question was well thought through by the strongest candidates, who ensured that both parts of the question were explained. Many gained partial credit with an acceptable explanation as to why the blood pressure in the pulmonary artery was the same as that in the right ventricle during ventricular systole. For full credit, the best responses went on to explain the lower pressure in the ventricle during diastole. The majority of these wrote about the elastic recoil of the pulmonary artery. Far fewer also realised that the ventricle would have little blood during diastole and so a lower pressure than the pulmonary artery would be measured. A minority gave all the relevant ideas, including a statement of the state of the valves during ventricular diastole and systole. Some candidates confused systole and diastole, writing about systole as relaxation rather than contraction of the ventricle walls.

(e) Of those gaining credit, the majority wrote about the lack of oxygen to cardiac muscle and/or the potential for heart failure. A number had the general idea that insufficient oxygen would be delivered but were not precise enough in their description that it would be heart or cardiac muscle that would be involved. A smaller number realised that there would be an increase in the power of contraction and blood pressure in order to try and compensate and a handful of candidates noted that the thickness of the right ventricle wall would increase. Many responses were quite vague, stating that the heart would pump more blood or that the body would not get enough oxygen. Some ignored the effect on the heart and wrote about breathing rate.

(f) Many were able to think of two signs and symptoms of COPD to gain full credit, generally by describing breathlessness, fatigue and a persistent cough. Some incorrectly thought that a person with COPD would breathe more deeply, which is not in line with the morphological changes associated with emphysema, or that the person would have angina or heart pains, which is associated with coronary heart disease. Some only stated that a person with COPD would have a cough, which is not necessarily indicative of COPD: in these cases describing the cough as one which persists would have been enough to gain credit

Question 4

This assessed ***Section E*** of the syllabus and many performed well on all parts of the question.

(a) Most knew that the missing stage of the cell cycle was interphase. For the weakest, this tended to be the only correct response in completing **Table 4.1**. A few gave cytokinesis instead of interphase, but during this stage of the cell cycle the chromosomes would not be replicating. The second column, matching the stages of mitosis to the correct cell in **Fig. 4.1**, was also well done by many. There were fewer accurate descriptions of chromosome behaviour during prophase and metaphase and a common error was to state that chromosomes moved towards the spindle equator during metaphase rather than stating that they were at the equator. This movement towards the equator happens during late prophase. Stating that chromatids were at the equator was not credited: at this stage the sister chromatids are still joined at the centromere and it is the complete chromosome that is aligned. A greater proportion was able to correctly complete the final column, describing the state of the nuclear envelope during anaphase and telophase.

(b) There was generally a good understanding shown of the differences between mitosis and meiosis that would explain why growth of roots involves mitosis. The majority correctly gave an explanation linked to the constancy of chromosome number. A fairly common error in describing meiosis was to state that gametes form cells with a haploid number of chromosomes. Some weak responses repeated the question and just stated that mitosis was for growth. Some explained why growth of roots involves mitosis but did not explain why meiosis was not involved with growth.

(c) Candidates needed to state two processes in which mitosis was involved rather than to give features of mitosis.. Some had no problems in giving two acceptable points. Cell repair rather than tissue repair was seen in a smaller proportion of responses than in previous sessions. There were various incorrect responses, such as stating stages in the cell cycle or stating processes such as respiration, and some incomplete responses, such as reproduction or forming blood cells.

Question 5

Overall, **Question 5** proved to be one of the most challenging of the paper. Candidates were assessed on the application of knowledge and understanding of ***Section K*** of the syllabus. Part **(a)** tended to be completed to a higher standard than part **(b)**.

(a) A few candidates gave a clear and complete explanation of an autotroph, including an explanation that inorganic compounds are used to synthesise organic compounds. For most others, partial credit was gained either for knowledge that light energy is used or for stating that *D. rotundifola* could photosynthesise. For an explanation of heterotroph only a few could state more than one idea, with most explaining that *D. rotundifola* feeds on other organisms. Stronger responses showed an understanding that energy was gained from organic compounds.

(b) This question required a few steps in the thought process and very few could use their knowledge of the nitrogen cycle to explain the effect of decreased nitrification owing to a reduced quantity of ammonium and nitrites. The best responses went on to consider the effect on the producers of a limited uptake of nitrates. Most disregarded the details and stated that organisms in the ecosystem would die or be reduced in numbers.

Question 6

This question assessed learning outcomes in ***Section A*** and ***Section G***.

(a) The best responses correctly explained the mechanism by which water moved from **X** to **Y** and made reference to the structures of the cell involved in the pathway. Although many gave one or more correct ideas, fewer were able to bring ideas together to give a well-expressed account. The

best explanations included a statement that water moves from a higher to a lower water potential and that movement across the membranes involved was by osmosis. In many responses the cell surface membrane or tonoplast was mentioned, but far fewer thought to name both membranes of the cell.

(b) (i) The vacuole or tonoplast was correctly stated by most candidates for structure **L**, but far fewer were able to correctly identify structure **K** as the plasmodesma, with some leaving this blank. Common incorrect answers for structure **K** were cytoplasm or cell wall.

(ii) Approximately half of all responses were correct in naming the pathway shown by **M** as the apoplast or apolastic pathway. Symplast, cytoplasm, and cell wall were common incorrect answers.

BIOLOGY

Paper 9700/22
AS Structured Questions

Key Messages

- Candidates need to be able to distinguish between a type of cell and a tissue; they should also understand that some tissues are composed of more than one type of cell. **Question 1** required knowledge that goblet cells and ciliated epithelial cells are two different cells types in the epithelial tissue lining the gas exchange system.
- When considering active immunity and the secondary immune response, a clear description of memory cells should be given.
- Candidates need to be able to describe results shown in tabular or graphical form, including describing trends and extracting data accurately from tables and from graphs drawn with and without grid lines.

General comments

The quality of response seen from many candidates indicated thorough preparation for this examination. All questions discriminated well, particularly **Questions 2** and **3**. Most showed a good grasp of scientific terminology and generally the level of understanding of the topics assessed was sound, with differences seen in the level of detail provided by candidates. Those that performed particularly well qualified their ideas with correct factual detail and ensured that responses that required an ordered approach, such as in **Question 4(b)(ii)**, read flowingly and sequentially.

Question 1, required candidates to study a light micrograph of a section through a bronchus and to identify correctly the tissue types visible. Many candidates had clearly benefited from studying prepared slides of this kind, in addition to becoming familiar with labelled diagrams. In **Question 2**, stronger candidates were careful to read each part question and realised that although **Fig. 2.1** had information about the nitrogen cycle, the responses of the part questions required knowledge and understanding extracted from different sections of the syllabus. Candidates were required to extract data and interpret information in graphical form in **Question 3** as this included oxygen dissociation curves. The importance of remaining disciplined when responding to a question, and of checking a response once it has been produced, was highlighted in part **(b)**. Here, a number began their response correctly by referring to haemoglobin but then switched to using 'red blood cell' with the consequence that the rest of the response could not be credited. Part of **Question 4** required candidates to recall detailed knowledge and understanding of cholera, in particular the modes of transmission and control methods, rather than give general points that could be applied to the transmission and control of many other infectious diseases. **Question 4** contained data in tabular form, which many candidates used to their advantage in suggesting differences between two countries in the number of cases of cholera over time. Some had difficulty sequencing the statements in **Question 5(a)**. Parts **(b)** and **(c)** attracted responses from many candidates that gave factually correct details skirting on the topic but not actually answering the question. These questions required some thought before responding; frequently facts or descriptions rather than explanations were given. **Question 6**, which included a challenging extended response about tumour formation, required candidates to apply knowledge and understanding. This proved to be quite taxing for some candidates, many of whom would have benefited from re-reading the information provided to help them focus more closely on the requirements of parts **(a)** and **(b).**

Candidates appeared to have sufficient time to complete the paper. It was rare to find a full question left unanswered and tended to be the most challenging, such as **Questions 5(c)**, **6(a)** and **6(b)**. Most candidates used only the lines provided for each response and handwriting was usually legible. As requested on **Questions 3(c)** and **6(c)**, most candidates did show their working. This proved valuable to some, who were able to gain partial credit when the calculated value was incorrect.

Comments on specific questions

Question 1

Candidates were assessed on topics from ***Section H*** in this question, including their ability to identify structures of the gas exchange system. They were also expected in part **(b)** to be able to apply knowledge of the function of mitochondria (***Section A***).

(a) There were many complete responses provided for **(a)**, with the best using the correct scientific terms, describing clearly the two cell types found in the epithelium and explaining their role in maintaining the health of the gas exchange system. The most common errors were to state that cilia trapped pathogens or that the ciliated cells produced mucus. There were a number who used 'germs' as a term, which was not acceptable. Others only explained that mucus trapped particles and dust and did not mention pathogens or allergens. Some knew about goblet cells and the production of mucus but forgot to explain what was trapped by the mucus. Some candidates thought that **Fig. 1.1** showed alveoli and gave descriptions of how the squamous epithelial cells were adapted for gas exchange. Others described the roles of the three types of tissue, **A**, **B** and **C**. There were quite a few weaker responses that described leaf structure.

(b) Those gaining credit related the cells of tissue **B**, smooth muscle, with the function of mitochondria or explained that many mitochondria would enable the cells to produce a large quantity of ATP. Some went on to outline that ATP was required for muscle contraction, but some contradicted their initial correct statement by describing muscles as stretching and recoiling. There were a number of responses stating only the function of mitochondria. Some incorrectly stated that mitochondria produce energy: here it would have been acceptable to state that they supplied energy to the cell. The most common incorrect responses stated that ATP or energy was required for cilia movement or mucus secretion.

(c) A high proportion recognised that tissue **C** in **Fig. 1.1** was cartilage and correctly named both the trachea and bronchus. The question had given an indication to candidates that there was more than one part of the gas exchange system containing the tissue, but a good number only stated the trachea or included bronchioles. Weaker responses listed all the parts of the system or just gave the lungs as the location.

Question 2

Fig. 2.1 showed detail of the nitrogen cycle and also a section representing transpiration. Candidates used knowledge and understanding from ***Sections D, G, F*** *and* ***K***.

(a) This was a straightforward exercise for many candidates, who had studied **Fig. 2.1** and applied their knowledge of the nitrogen cycle to the diagram in order to identify the process converting ammonium ions to nitrates as nitrification. Weaker responses commonly stated nitrogen fixation or denitrification. The information provided at the start of the question had already directed candidates to consider aspects of the water cycle and many did realise that process **X** was transpiration.

(b) Many knew the names of a bacterium involved in nitrification. Others stated nitrifying bacteria or bacteria but this was only identifying the type of organism involved.

(c) This question relied on a correct interpretation of **Fig. 2.1** and required knowledge that transpiration is an inevitable process, mostly because of the need for the stomata to be open during daylight hours to take in carbon dioxide to be used in photosynthesis. Alternative acceptable responses needed to use clarity and the correct terminology, for example stating that water vapour, rather than water, diffused out of the leaf; for explaining that this occurred down the water potential gradient, rather than using the term 'concentration of water'; and for stating that water potential existed between the leaf (higher water potential) and the atmosphere (lower water potential), rather than just saying 'there is a water potential gradient'. The term concentration gradient, when referring to water, should not be used. Credit was also given to those candidates who explained, with an example, how the transpiration pull resulted in benefits, despite there being potential disadvantages to the plant. Others gave details of water being taken in at the roots and moving to the leaves but gave no advantages of this. A number also wrote that transpiration has a cooling effect on the plant; this was not credited as the process of evaporation removes heat whether or not this is a benefit to the plant. One common error was to state that transpiration occurs in order to

open stomata for gas exchange. Weak responses wrote about the need to complete the nitrogen cycle.

(d) This was generally very well answered by most. Some candidates were not specific enough in the way they worded their response. For example, stating that stomata are found on the underside / lower epidermis of leaves is not the same as stating that they are **only** found on the lower epidermis as all leaves will have stomata on the lower epidermis. Similarly, a waxy cuticle is a feature of mesophytic leaves, but the leaves of xerophytes have a thick (waxy) cuticle. Similarly, stating that stomata are closed is not the same as explaining that stomata may close during the day - the first response does not show an understanding of the need for gaseous exchange to occur. Candidates should refer to stomata rather than 'pores'. 'Coiled' leaves is not the same as rolled or curled leaves so did not gain credit. Many correctly wrote about needle-shaped leaves. Some referred to thorns, which are defence structures, and to cactus spines; these are an evolutionary adaptation in response to an arid climate rather than a morphological difference in leaf structure of xerophytes. Instead of trichomes, or hairs, on leaves, some wrote about prickly leaves; this too did not earn credit.

(e) Many candidates gave very good accounts of active transport and/or facilitated diffusion. At times there was confusion as to the membrane protein involved. The best responses explained that the charged, hydrophilic nature of nitrate ions would not permit transport across the hydrophobic core of the phospholipid bilayer. Weaker responses stated that the root hair cell offered a greater surface area but did not follow this up with details of transport across the membrane. Others just stated that nitrate ions could enter the cell so that water would also enter.

(f) Although the response provided by a good number of candidates indicated that they were attempting to answer correctly the question posed, a large proportion gave irrelevant detail of water movement across the root of the plant. Stronger candidates showed a good understanding of transpiration pull and the forces driving the mass flow of water up the xylem. These also were precise in describing detail, for example by stating the importance of the adhesion of water molecules to the cellulose lining of the xylem, thus showing an understanding that lignin, which impregnates the wall, is far less hydrophilic than cellulose. Some did not seem to know that the walls had a cellulose lining and only mentioned lignin. Well-expressed responses described how the evaporation from the mesophyll cell wall would create a tension in the column of water in the xylem, and how the strong cohesive nature of water molecules would enable the movement up of this column, the transpiration pull. This tension has been described as negative tension or negative hydrostatic pressure. Although some did mention a negative pressure, or tension, they did not link this to the cohesive nature of water. Some candidates described a positive rather than a negative hydrostatic pressure gradient. Good answers also noted that ions would be dissolved in the water. A few noted that the non-living route up the xylem could be described as apoplastic, while others stated that the movement was passive. Many gave a description of the root pressure theory and wrote about differences in hydrostatic pressure, which may only partly explain water movement in plants with very short stems, or were confused with their knowledge of pressure gradients in the movement of phloem sap. Common incorrect responses included the idea that nitrates would move up the xylem by active transport or that water would move up by osmosis.

(g) Most knew the answer to this and gained credit. Some knew that the nucleotides contained nitrogen but did not give the further detail required. Only a few incorrectly stated thymine as an example of a base occurring in RNA. Weaker responses did not discriminate between bases and amino acids, stating that nitrogen occurred in the bases of the amino acids.

Question 3

This question was based on a theme of transport in mammals, ***Section G***, and within this there was an opportunity to assess candidate understanding of haemoglobin from ***Section B*** and to apply knowledge and understanding of subject matter from ***Sections C*** and ***H***.

(a) The best responses were clear in explaining the concepts of, 'closed' and 'double circulation'. For closed circulation those that did not gain credit gave versions on the theme that blood did not escape from the circulatory system. For double circulation, some knew that blood passes through the heart twice but simply stated just that and did not continue further, while others made an error by stating that blood passes through the heart twice in one cardiac cycle or in a single heartbeat. Other responses not gaining credit described circulation twice through the lungs or blood within the heart being deoxygenated on one side and oxygenated on the other.

(b) Candidates needed to use their knowledge of haemoglobin structure and protein levels of organisation to think about the role of haemoglobin and the transport of oxygen. The best responses gave detail, for example stating that: it was haem that binds oxygen, rather than just stating haemoglobin; that each haem could bind to one oxygen molecule rather than stating haem binds oxygen; explaining that quaternary structure involves four polypeptide chains rather than just stating more than one polypeptide chain. Weaker responses listed the four types of R-group interaction and linked one or more of these with the carriage of oxygen. Although the majority correctly understood the importance of the prosthetic group, fewer remembered to explain how the globular structure, with the amino acids with hydrophilic R-groups facing to the outside, allowed the molecule to be soluble in the cytoplasm. Some incorrectly inferred that haemoglobin existed in blood plasma. Others began their response by writing about haemoglobin but then switched to using the term 'red blood cell' when they actually meant haemoglobin. One error seen on a number of occasions was to state that the structure of haemoglobin provided a large surface area for oxygen to bind. There were some that explained how the red blood cell was suited to its function, which gained no credit.

(c) This was quite straightforward for many candidates. Most were able to extract from the graph the correct values of percentage saturation of haemoglobin at the two stated partial pressures and then carry out a simple subtraction. However, quite a few then attempted to convert this to a percentage of 14 out of 96 and only gained partial credit for the correct extraction of data. As each square on the graph grid represented 4 units and the curve clearly passed between two grid lines at 6 kPa, no credit was given to those who gave a value of 84%. Some candidates tried to manipulate the two pressure readings of 6.2 kPa and 13.0 kPa, carrying out subtractions or calculating percentages.

(d) The best answers included each step in the thought process for part **(d)** and were very clear that they understood that this was an example of the body compensating for less oxygen entering the pulmonary capillaries. High quality responses introduced the idea that less oxygen would be available at high altitude and that this would lead to a decreased saturation of haemoglobin. They went on to explain that more red blood cells would mean more haemoglobin for oxygen uptake, so that overall this would make up for the effect of the decreased saturation. The fact that there would be more haemoglobin was a key point that was missed by many. There were some vague or ambiguous explanations and many wrote about transporting more oxygen.

(e) There were some clear answers to this question and many gained full credit. Some also explained why the term non-competitive was used. Some candidates used the term 'denature' to explain the changes that occurred in the enzyme molecule and in the active site, implying a total loss of shape. Some candidates gained no credit as they described competitive inhibition, while others described the effects of binding to an allosteric site and then suggested that the inhibitor could also bind to the active site. Where candidates made it clear that non-competitive inhibitors are able to bind to the allosteric site (temporarily) and then stated that other non-competitive inhibitors can bind to the active site permanently, full credit was given. A number thought that a particular non-competitive inhibitor had the 'choice' of binding to the allosteric site temporarily or to the active site permanently.

(f) Responses gaining most credit considered the differences in percentages saturation of haemoglobin over the entire range of partial pressures of oxygen. Hence a number of candidates noticed that the situation reversed at lower partial pressures of oxygen and the haemoglobin of the heavy smoker was more saturated. Some pointed out the disadvantage of this. Some candidates did not use the graph to good effect, for example stating the oxygen partial pressures at a particular saturation of haemoglobin or implying that particular percentage saturation would alter the partial pressure of oxygen. Others incorrectly stated that the presence of carbon monoxide would prevent any oxygen from being transported or that the person would have a heart attack. These candidates should have realised that the cardiovascular system of heavy smokers would still deliver oxygen to the tissues and only those with existing cardiovascular disease would have heart problems.

Question 4

This question assessed ***Sections I*** and ***J*** of the syllabus. Those performing well on part **(a)** demonstrated their knowledge of features of cholera. The quality of response for **(b)(ii)** was very varied, with only some candidates showing a full grasp of the concepts and principles involved in the immune response.

(a) (i) This question differentiated well and included some well-expressed answers demonstrating good understanding that cholera is a disease transmitted in a faecal-oral route. The best responses gave three different reasons and stated the difference between the high economic status country and the low economic status countries. Not all responses were set out in this way. Credit was not given for general ideas such as 'more money for hospitals and treatment', 'better equipped to deal with disease', 'live in better conditions', 'better education'. Overcrowding was frequently cited but did not attract credit unless linked with a cholera specific feature such as poor hygiene or poor sanitation. Poor diet alone was also not credited since people on well-balanced diets that ingest contaminated water will still become ill.

(ii) The best responses firstly used data extracted from **Table 4.1** to make comparisons between the number of cases experienced by Angola and Cameroon over time and to make comparisons between the two countries at any one time. Secondly they suggested cholera-specific reasons to explain each difference. Many noted the dramatic increase in the number of cases of cholera in Cameroon between 2008 and 2010 and realised that there had to be a major reason for this. Some of these candidates had also noticed that the population figures given were very similar in both countries so differences in 2010 between the two were not due solely to changes in the population size. It was crucial for candidates to refer to **Table 4.1**, as instructed, as no credit could be given to candidates who only described a number of effective methods of control and prevention against cholera. Credit was awarded for stating numerical comparisons and many did do this; however a fairly high proportion were less precise and only gave general descriptions. High quality answers avoided vague statements about how governments concentrated, or did not concentrate, on reducing the number of cases or how they worked hard to get rid of the disease. There were also some careless responses that wrote about the wrong countries or assumed they were low economic status countries.

(b) (i) The whole range of answers was seen and there were many detailed accounts focusing on the problems associated with vaccination programmes. Some candidates used their knowledge and understanding of the eradication of smallpox to think about the factors contributing to the success of the smallpox vaccination programme and consider the reverse arguments that they could apply to measles. Hence there were some good suggestions about the antigenic stability of *Morbillivirus* and of the requirement of a high percentage cover. Statements such as 'vaccine storage' and 'boosters are given' did not attract credit unless it was clear that there could be a problem storing vaccines or in administering the boosters. Some were confused about the principles behind immunity and wrote about the virus being resistant to a vaccine. One of the principles behind the specific immune response is that memory cells are produced that are specific to a particular non-self antigen, so a pathogen could change its antigens by mutation and the process of recognition and binding to existing memory cells does not occur. A proportion did not note that the question was about vaccination and wrote about how easily measles is transmitted or stated that vaccination programmes did not exist.

(ii) Well-expressed accounts explained that memory B-lymphocytes would be present in the circulation following a primary immune response and went on to correctly describe the sequential events occurring on second exposure to the antigen, including stating that this was the secondary immune response. These candidates made it clear that they understood that memory B-lymphocytes would undergo clonal selection and clonal expansion to produce (B-lymphocytes that matured into) plasma cells (and more memory cells), and that it was the plasma cell that synthesised and released antibody in higher quantities. Others were able gain some credit, although many of these responses were confused. For example it was not always clear whether they were writing about the primary or secondary response or they described the events occurring in an incorrect sequence. Common errors included stating that memory cells produced antibody on contact with the antigen and describing B-lymphocytes as T-killer lymphocytes or as phagocytes.

Question 5

In this question, candidates were assessed on ***Section G*** of the syllabus. Very good attempts at parts **(b)** and **(c)**, which required explanations, were seen less frequently than descriptive responses that did not fully answer the question.

(a) Many were able to deduce the correct sequence of events. The most common error was to place 'impulses passing up through Purkyne fibres in ventricle walls' before 'impulses reach base of ventricles'. Almost all candidates knew that the first in the sequence of events was the statement

'sinoatrial node sends out impulses' and most knew that this led to the atrial walls contracting. Some did not fully complete the table and left one or more boxes blank.

(b) Only some candidates tackled both the difference in pressure required to cause closure of the valves and the state of the heart associated with this difference. Generally, where partial credit was gained, this was for knowing that the valves close after ventricular systole. Fewer went on to gain full credit by explaining that the valves close when the pressure in the arteries exceeds that in the ventricles. A substantial number described the role of the semi-lunar valves rather than explain the circumstances that cause their closure. Some described events to cause the closure of the atrio-ventricular valves. It is possible that some of these thought that the semi-lunar valves were the atrio-ventricular valves. Others thought that events occurring as a result of atrial contraction would trigger closure.

(c) This question required brief explanations for the differences between the composition of blood and tissue fluid at the arterial end of a capillary bed. Only a minority of candidates stated differences and continued to provide explanations. Where full credit was given, this was usually for stating that only blood contained large plasma proteins and red blood cells as they were too large to pass through the endothelial pores and enter the tissue fluid.

Question 6

This question assessed learning outcomes in ***Sections A***, ***G*** and ***E***. Good answers to part **(a)** covered aspects of tumour formation that could be applied to both plants and animals and considered how tumour cells grow and divide by mitosis in an uncontrolled fashion

(a) In addition to explaining that a tumour results from uncontrolled mitosis, the best responses included a description of cell growth, caused by the proteins coded for by the plasmid genes; and a description of the cells comprising the abnormal mass that is a tumour. Some candidates showed a good understanding that cells of a tumour would be undifferentiated and would have lost the function of the tissue of origin. Almost all knew the link between uncontrolled cell division and a tumour and some went on to note that a mass of cells formed. Some candidates ignored the reminder at the beginning of **Question 6** that tumours can form in plants and wrote extensively about the formation of blood vessels and metastasis or the effects of a tumour on the rest of the organism, which was not required. Quite a few candidates did not seem to know what a tumour was and described a mutation and how this would lead to the formation of an altered polypeptide.

(b) Of those gaining credit most suggested that the bacteria could travel down to the roots in phloem sap. Some tried to give a choice and stated that travel could be either in the phloem or in the xylem, without considering that water is transported from the roots to the leaves. Responses gaining no credit included stating that active transport or diffusion occurred or thinking that the bacteria were in the soil and would be taken into cells by endocytosis, despite being told they entered the stem in wounds.

(c) Many were able to measure accurately the length of the image of bacterial cell **X**, convert to m and then use the formula to arrive at the actual length of the cell. There were some who struggled in their conversion from mm to m.

BIOLOGY

Paper 9700/23
AS Structured Questions

Key messages

- Candidates need to be able to distinguish between a type of cell and a tissue; they should also understand that some tissues are composed of more than one type of cell. **Question 5 (b)** required knowledge that goblet cells and ciliated epithelial cells are two different cell types in the epithelial tissue lining the gas exchange system.
- When considering active immunity and the secondary immune response, a clear description of memory cells should be given. Candidates should associate the presence of a non-self antigen with active immunity, the production of memory cells, and a long-term protection to an infectious disease.
- Candidates need to be able to describe results shown in tabular or graphical form, including describing trends and extracting data accurately from tables and from graphs drawn with and without grid lines.

General comments

In many cases, candidates showed a good understanding of what was required of them throughout the paper. The calculation in **Question 1 (e)** was correctly done and accurately recorded. Many candidates correctly sequenced their answers showing good clarity of thought. This was especially the case in **Question 3 (a)** and in **Question 2 (e)**. A few candidates only were able to give satisfactory definitions of the term *autotroph*. Many needed to give a more complex definition and include reference to the conversion of inorganic compounds to complex organic compounds. Most answers to **Question 2 (d)** on the importance of water as an environment for the pond skater and the northern pike tended to deal with only two properties of water.

Only some candidates responded correctly to the instruction in **Question 4** to discuss enzymes that work according to the induced fit principle. Others did not seem to know about this mechanism and wrote about the lock and key method instead. Also, they did not apply their knowledge of competitive inhibitors to hexokinase which utilises the induced fit method. In **Question 4 (d)(ii)**, candidates had to explain why glucose-6-phosphate does not pass through membranes. Many stated a relevant property of this compound and could have improved their answer by explaining fully why it is unable to pass through the phospholipid bilayer.

Comments on specific questions

Question 1

This question tested knowledge of mitosis from ***Section E*** of the syllabus. There were many good answers to the questions although successful identification of stages of mitosis in part **(b)** proved more challenging for some.

(a) Almost all candidates identified a correct feature indicating that the tissue is from a plant and not an animal. Most stated that cell walls are visible in **Fig. 1.1** and a smaller number made reference to the regular shape of the cells. A few mentioned vacuoles, an answer that was also credited. Chloroplasts were incorrectly given by some candidates. Some candidates gave more than one answer, sometimes with answers that contradicted each other.

(b) Many candidates correctly stated in part **(i)** that cell **B** is in prophase. Quite a few, however, stated cell **A** (interphase) and cell **D** (telophase). Almost all identified **C** as the cell in anaphase in part **(ii)**. Some candidates made lists of two or more cells, which were not credited.

(c) The best responses made clear references to the expected points: condensing of the chromosomes, spindle formation, disappearance of the nucleolus and the disintegration of the nuclear envelope. Many others gave features of metaphase, such as chromosomes aligning on the equator of the cell and attaching to the spindle at the centromere: this may have been due to misidentification. Another common incorrect answer was a reference to the uncoiling of chromosomes and reforming of the nuclear envelope. Some candidates were unaware of the absence of centrioles in plant cells.

(d) (i) Most answers to part **(i)** identified correct roles of mitosis in plant roots. Common answers stated that mitosis produces cells that are genetically identical. The most common error was to state that mitosis is used in the 'repair of cells'. This idea is better expressed as 'repair of tissues by making new cells to replace those that are damaged or lost'. Some good answers went on to explain that root hair cells or root cap cells are lost and need to be replaced.

(ii) Correct answers required the expression of two ideas. The first had to be a change in the nucleotide or base sequence in DNA. Various consequences of this change were accepted for the second idea. Common answers included types of mutation, such as substitution and frameshift, and changes in the amino acid sequence (primary structure) of the polypeptide. A number of candidates put down two or three creditworthy points for the second point, but far fewer obtained the first point. Some candidates incorrectly stated that DNA was made of amino acids and polypeptides made of bases.

(e) Many candidates gave the correct magnification of the image in **Fig. 1.1** which is x750. The main error was incorrect conversion of millimetres to micrometres.

Question 2

This question assessed knowledge and understanding from ***Sections B*** and ***K*** of the syllabus. Part **(a)**, although fairly straightforward, was well attempted by only a small proportion of candidates and only a few full definitions of the term *autotroph* were written. Many referred to these organisms 'producing energy' for the rest of the food chain or the community, which is incorrect.

(a) Most candidates found it difficult to define autotroph satisfactorily, with a high proportion giving a superficial definition and gaining partial credit. Many answers referred to some aspect of energy or photosynthesis and would have been improved by including the information that inorganic compounds are used by autotrophs to make complex organic compounds. Typical responses referred to 'using the' Sun', without any mention of energy, and 'making their own food'.

(b) Almost all candidates gave the role of water fleas in the food chain as a primary consumer and as food for the secondary consumer.

(c) There were candidates who recognised the key points about energy flow through food chains and gave excellent, concise explanations. A number of candidates did not realise that points about energy loss from food chains were relevant here. Some were confused between the size of individual herons and the numbers in the heron population. A single heron requires considerable energy to survive compared to the other organisms in the food chain, but the population of herons and their combined biomass is much less than animals at lower trophic levels, even those that have a much smaller body size.

(d) The majority of candidates had two ideas, or fewer, in their answers to this question. They usually explained that pond skaters make use of the surface of water because of its surface tension. Some went on to explain that the surface tension is the result of hydrogen bonding between water molecules. The second idea was that fish, like the pike, can survive below the ice in very cold conditions. Candidates explained that ice has a lower density than water and that it insulates water beneath it. The other most common correct answer was a reference to the specific heat capacity of water linking it with providing a stable environment.

Answers that gave features more appropriate to plants were not credited. There were some references to light penetrating water for photosynthesis and the importance of water for plants as a

solvent for minerals and for carbon dioxide. None of these roles is relevant to animals. A very small number of candidates stated that light penetrates water so that pike can use vision to hunt or evade predators. Correct answers for the solvent action of water are the provision of dissolved oxygen and the removal of carbon dioxide excreted by the pike. Few referred to water as a medium that supports the fish and provides buoyancy.

A few candidates simply gave a list of the properties of water without reference to the pond skater or the pike. There was a general confusion relating to specific terminologies of phase transfer as candidates did not always make clear what they meant by the terms latent heat of fusion and latent heat of vapourisation.

(e) This question on recycling protein prompted many good answers about decomposition and nitrification. However, many also dealt with other aspects for the nitrogen cycle, such as nitrogen fixation and denitrification, that were not relevant. Nitrification tended to be better known than the role of decomposers. Some candidates correctly stated that decomposers secrete proteases that hydrolyse proteins to amino acids and then deaminate the amino acids that they do not require. These answers were rare. Full credit was often gained for giving the correct sequence of oxidation reactions in nitrification with the two genera of bacteria linked correctly to their reactions. Some candidates were vague here and did not make it clear that ammonium ions are converted to nitrite ions and then nitrite ions are converted to nitrate ions. Answers that described nitrogen fixation were ignored. Incorrect formulae, such as NO_3^+, were also ignored if names, such as ammonium, nitrite and nitrate were given as well, but answers that gave only incorrect formulae were not credited.

A small number of candidates referred to nitrides which meant that otherwise good answers about nitrification did not gain credit. The nitride ion is not soluble and would be incorrect in this context; it was likely to be a careless slip. This is a good example of why candidates should check their answers before the end of the examination.

Question 3

This question was based on a theme of the viral disease measles and in part **(a)** assessed candidate ability to apply knowledge and understanding of the immune response and vaccination (***Section I***). The ability of candidates to extract data from a graph of number of cases of measles was assessed in part **(b)** (***Section H***). The question finished in part **(c)** assessing application on knowledge of ***Section B***.

(a) There were many detailed answers to this question on vaccination. Descriptions of the immune response tended to be the best part of most answers although some candidates completely omitted to include antigens in their response. Some candidates could have improved their response by being clearer about the advantages of booster inoculations and by explaining the advantage of vaccination in terms of a fast secondary response on infection with the specific pathogen. Many candidates referred to secondary responses, without making it clear whether they were writing about a booster or an infection. The best responses showed an understanding that it was a specific antigen on the virus that would be recognised by specific B-lymphocytes and T-lymphocytes. Other antigen types on the virus that are able to stimulate an immune response would activate other specific lymphocytes. Credit was given if candidates described the immune response to the presence of an antigen instead of naming it. Descriptions of antigen presentation tended to be vague, but the roles of B-lymphocytes and T-lymphocytes were generally accurate. Some candidates confused the secondary response with a secondary infection.

(b) Most candidates gained credit for their descriptions of the changes in percentage vaccination against measles and the number of cases of this disease from 1980 to 1990. However, candidates rarely noticed that both the percentage vaccinated and the number of cases remained near constant for all or part of the period 1990 to 2002. Candidates stating that there are fluctuations in either the percentages vaccinated or the number of cases gained credit only if it was accompanied with appropriate data from **Fig. 3.1**. Many answers were not supported with accurate or complete data quotes. Some candidates merely listed the data rather than identifying trends.

(c) Many candidates realised that this question asked about a specific substance fitting into a receptor with a complementary shape. However, they often lost credit by stating that these two compounds, CD-46 and MV-8, are enzymes or have active sites. CD-46 is a receptor and it has a shape that is complementary to the shape of all or part of MV-8. Many candidates gave good detail here of binding between the two proteins, but references to their tertiary structures were rare.

Question 4

This first three parts of this question, assessing ***Section C***, proved to be challenging for most candidates. Explanations of what happens in the lock and key mechanism were often good, but applying this knowledge to an enzyme with an active site that is not complementary to its substrate proved challenging. Part **(d)(i)** of, which assessed ***Section D*** of the syllabus, was answered with more confidence than **(d)(ii)**.

(a) Many candidates did not use the information given in the question and wrote about the lock and key mechanism and gained little or no credit. Better answers stated that the enzyme changes shape after glucose binds to the active site. These candidates went on to say that the 'fit' between substrate and active site improves when the enzyme changes shape so that the substrate is bound more strongly. The best answers described how binding occurs by formation of hydrogen bonds. The role of R-groups on amino acid residues in the active site were described in some scripts. Many candidates incorrectly referred to the shape of the substrate changing instead of or as well as the change in shape of the active site.

(b) This question proved to be the most challenging. Some credit was gained by those who stated that competitive inhibitors have a similar shape to the substrate. Candidates rarely pursued this further to say that the inhibitor may have a similar shape to the substrate but will not fit within the active site of the enzyme and therefore not act as an inhibitor. This question also revealed some confusion about how competitive inhibitors function.

(c) Much better answers were seen to this question on denaturation. Weak candidates often did not use that term although most could explain that the active site of the enzyme had been disrupted or destroyed as a result of the heating. Candidates needed to make clear the distinction between complete denaturation of some of the enzyme molecules and the partial denaturation of all of the enzyme molecules. The enzymes might still be functional if the match between substrate and active site is not as perfect as it is at lower temperatures. Good answers also identified that the breakage of hydrogen bonds was the reason for the loss of the shape of the active site. Some candidates listed all types of bonds found within the tertiary structure of proteins being broken by higher temperature; credit was given to those that referred only to hydrogen and/or ionic bonds.

(d) There were very many good comparisons in part **(i)** that gained full credit. Candidates were less successful in explaining in **(ii)** why glucose-6-phosphate cannot move out of cells. Many stated that glucose-6-phosphate is polar, or charged, but did not give a full explanation for the impermeable nature of the cell surface membrane to compounds like this. Candidates often stated that the cell membrane is made of phospholipids, but did not go further to explain the hydrophobic nature of the hydrocarbon chains.

Question 5

This question was based on subject material from ***Section G*** and ***Section H*** of the syllabus.

(a) The great majority of candidates gained full credit for this question. Most stated that damaged alveoli are visible in **Fig. 5.1** and that emphysema is the smoking-related disease that is the result of such damage, although the term emphysema was not always spelled correctly.

(b) Many candidates used their knowledge of the protective function of the epithelial cells that line the airways to explain how smoking increases the risk of infectious diseases. There were good descriptions of the roles of goblet cells, mucus and cilia. Those that did not gain credit in this question frequently gave answers explaining the effects of components of smoke such as cancer and the effects of nicotine on blood pressure.

(c) This question prompted many good answers. Candidates explained that carbon monoxide binds permanently to haemoglobin to form carboxyhaemoglobin. Many also went on to say that this lowers the affinity of haemoglobin for oxygen and decreases the oxygen-carrying capacity of haemoglobin.

Question 6

This question assessed candidate knowledge of transport in plants from ***Section G*** of the syllabus.

(a) Completion of the table was a fairly straightforward task for those who took care over their answers. Candidates often did not gain full credit as they made errors in completing one or two of the rows. There were several common errors:

- omitting ions or salts for xylem in the second row
- stating that substances are transported in phloem from sink to source or implying that this happens
- omitting lignin for the cell wall material in xylem
- identifying the cell wall as partially permeable.

(b) Most candidates gave a correct function of magnesium in plants. Most candidates stated that it is used to make chlorophyll. Other correct functions included its role as a cofactor in various metabolic processes, including energy transfer and DNA synthesis.

BIOLOGY

Paper 9700/31
Advanced Practical Skills 1

Key Messages

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

Candidates should be able to use simple dilution to obtain the required concentrations of a solution by adding a unit volume of a solution of a known concentration, in this case 5% enzyme solution, to water. Candidates should make at least five concentrations using regular intervals for the independent variable, e.g. 5.0%, 4.0%, 3.0%, 2.0% and 1.0%.

Candidates should also be given opportunities to modify a particular procedure for studying a different variable by keeping the previous independent variable constant, e.g. concentration of enzyme solution, then changing the independent variable, e.g. temperature.

General Comments

The majority of Centres returned the Supervisor's report with the results obtained 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.

The majority of Centres provided all the materials required and most 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 gained credit for showing the volumes of enzyme solutions and volumes of water required to make at least four further concentrations of enzyme solution. The most common error was preparing sucrose solutions that did not make up total volumes of 10 cm^3.

(ii) Most candidates correctly described the expected trend by stating that as the concentration of enzyme solution increased the time taken to reach the end-point decreased.

(iii) Many candidates stated correctly that the reason for the expected trend was that at high enzyme concentrations more enzyme substrate complexes were formed.

(iv) Many candidates correctly described how to set up a control using the apparatus provided by replacing the enzyme solution with an equal volume of distilled water.

(v) The majority of candidates organised their results clearly in a ruled table. The better candidates included an appropriately detailed heading for the independent variable (percentage concentration

of enzyme) and the dependent variable (time / s). The most common errors were to omit the heading for the dependent variable or to include 'seconds' in the cells of this column or row. The majority of candidates gained credit for recording the times as whole numbers and recording the lowest concentration of enzyme solution first in the table. The better candidates recorded times showing the highest concentration of enzyme solution had taken less time to reach the end-point than the lower concentrations. The most common error was not including results for the control.

(vi) Many candidates calculated the rate of hydrolysis for 5% enzyme solution by calculating 1 divided by the time taken in seconds to reach the end-point for 5% enzyme solution.

(vii) Many candidates gained credit for identifying the significant source of error in measuring the dependent variable as the difficulty of determining the colour change at the end-point. The most common error was stating a source of error not associated with the dependent variable.

(viii) Many candidates correctly stated that the actual error of the syringe was ± half the smallest division on the syringe with the appropriate units, cm^3.

(b) Many candidates correctly suggested modifications to the investigation to obtain an accurate optimum temperature for the activity of enzyme solution by stating that they would keep the enzyme concentration the same, using at least five temperatures, using a thermostatically-controlled water-bath and by putting the milk in the water-bath before adding the enzyme solution.

Question 2

(a) (i) The better candidates produced drawings using a sharp pencil and did not include any shading. Many candidates were able to draw at least three layers and the correct proportion of the outer vascular bundles. Most candidates used one label line and label to show a vascular bundle.The most common errors were not showing the layers of tissues and the relative proportions of the outer vascular bundles which would be observable using the microscope.

(ii) Those candidates whose drawings were made using a sharp pencil to produce clear, thin lines gained credit. The majority of candidates drew three touching cells, with a space between the cells with the cell walls drawn as double lines. Most candidates used one label line and label to show a cell wall. The most common error was to draw lines that did not meet up precisely or were too thick.

(b) (i) The better candidates showed the measurement of the scale bar to the correct precision and gained credit for showing the conversion of the scale bar to micrometres by multiplying by the appropriate number. Many candidates showed the division of the scale bar by 969 and correctly rounded the answer to a whole number. The most common error was not showing how the conversion from millimetres to micrometres had been achieved.

(ii) The better candidates recorded observations using the most appropriate organization, which included one column for listing the features and two additional columns, one headed **J1** and the other headed **Fig. 2.2**. The majority of candidates were able to gain partial credit for recording appropriate differences.

(c) (i) The majority of candidates drew the graph using the headings given in the table, with sucrose concentration / mol dm^{-3} on the *x*-axis and change in distance between cut ends / mm on the *y*-axis. The better candidates used suitable scales for the axes, using minus signs for the negative values. They also plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting each of the points.

(ii) Many candidates explained the trend on the graph fully. Better candidates also stated that there was no net movement of water where the line of the graph intercepted the *x*-axis. The most common error was to describe the changes in distance between the cut ends for the plant stem rather than explain the changes in distance in terms of water movement.

BIOLOGY

Paper 9700/33
Advanced Practical Skills 1

Key Messages

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

Candidates should be able to use simple dilution to obtain the required concentrations of a solution by adding a unit volume of a solution of a known concentration, in this case 1.0 mol dm^{-3} sucrose solution, to water. Candidates should make at least five concentrations using regular intervals for the independent variable, e.g. 1.0 mol dm^{-3}, 0.8 mol dm^{-3}, 0.6 mol dm^{-3}, 0.4 mol dm^{-3} and 0.2 mol dm^{-3}.

Candidates should also be given the opportunity to estimate unknown concentrations from results for known concentrations. If the value for the unknown concentration is between two known concentrations the answer must state this, e.g. the unknown concentration is between 0.4 mol dm^{-3} and 0.6 mol dm^{-3}.

General Comments

The majority of Centres returned the Supervisor's report with the results obtained 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.

The majority of Centres provided all the materials required and most 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) Most candidates used the arrows shown in the key to indicate that the drop of **P** would move up in the sucrose solution that was more concentrated than **P**, remained at the same level in the sucrose solution that was the same concentration as **P** and moved down in the sucrose solution that was less concentrated than **P**.

(ii) The majority of candidates organised their results clearly in a ruled table. The better candidates included an appropriately detailed heading for the independent variable (sucrose solution) and the dependent variable (direction of movement). The most common error was to omit the heading for the independent variable. The majority of candidates gained credit for recording the downward direction of **P** in **S1** and the upward direction of **P** in **S2**.

(iii) Most candidates completed the statements correctly and estimated correctly the concentration of sucrose in **P**.

(iv) Many candidates gained credit by stating that **S2** would be diluted to prepare further concentrations as **P** was less concentrated than **S2**.

(v) Many candidates gained credit for showing the volumes of sucrose solution and volumes of water required to make at least four further concentrations of sucrose solutions. The most common error was preparing sucrose solutions that did not make up total volumes of 40 cm^3.

(vi) The majority of candidates organised their results clearly in a ruled table with all the headings and recorded the direction of drop **P** for at least three concentrations of sucrose solution in ascending or descending order. The better candidates recorded results for additional measurements. The most common error was not placing the concentrations of sucrose solutions in order.

(vii) Many candidates correctly stated a more accurate estimate of the concentration of sucrose in **P** based on their results. The most common error was to make up a value for the concentration of sucrose that had not been tested instead of stating that the value was between two known concentrations of sucrose.

(viii) Many candidates correctly described a modified procedure using the hydrolysis of the sucrose solutions and **P**, and stating the temperature at which the samples were heated with Benedict's solution. The better candidates recorded the time taken to the first colour change and used the results to identify the sucrose concentration in **P**. Credit was given to those candidates who used the same volume of **P** and sucrose solutions when testing with Benedict's solution.

Question 2

(a) (i) Many candidates correctly circled the two anomalous results.

(ii) Credit was given to those candidates who calculated the missing mean value by omitting the anomalous value, 1.232.

(iii) The majority of candidates drew the chart correctly, using the headings given in the table, with different ages of aphid on the *x*-axis and mean rate of flow of sap / $l h^{-1}$ on the *y*-axis. The better candidates ensured that all five bars were the same width and used a scale of 2 cm to 0.5 for mean rate of flow of sap / $l h^{-1}$. The most common errors were not including a full axis label for each axis, omitting the units for both the *x*-axis and the *y*-axis, not labelling the scale appropriately and drawing lines which were too thick.

(iv) The better candidates described the relationship by stating that as the age increased the mean rate of flow of sap increased.

(v) Many candidates correctly suggested two reasons to explain the relationship described in **(iv)** such as the stylets were longer in older aphids or older aphids used their longer stylets to access sieve tubes that were deeper in the stem. The most common error was stating that older aphids needed more sap without reference to how this could be achieved.

(b) (i) The better candidates produced drawings using a sharp pencil which did not include any shading and used most of the space provided. Many candidates were able to draw the area indicated by the shaded sector in **Fig. 2.2**, with at least five layers of tissue, with the epidermis shown as two lines drawn close together and one label with a label line to the pith. The most common error was not showing more than four layers of tissues which would be observable using the microscope.

(ii) Those candidates whose drawings were made using a sharp pencil to produce clear, thin lines gained credit. The majority of candidates produced drawings of a group of three whole touching cells, with the walls drawn as double lines, an air space between the cells and showing one of the cell structures within one of the cells by using the label **D**. The most common errors were to draw lines that did not meet up precisely and not drawing the cell walls as double lines.

(c) Many candidates showed the measurement of **R** to **T** to the correct precision and converted this from millimetres to micrometres by multiplying by 1000. Most candidates showed the division by 120 and recorded the actual length as a whole number to no more than one decimal place. The most common error was not using appropriate units.

BIOLOGY

Paper 9700/34

Advanced Practical Skills 2

Key Messages

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

Candidates should be able to use a serial dilution to obtain required concentrations of solutions and specified volumes of solutions. In this case candidates were required to decide whether to use a 0.8% or 1.6% albumin solution to start their serial dilution and to prepare 10cm^3 of each solution. Candidates should show a serial dilution of the albumin solution using a constant dilution factor at each step. Candidates should show the preparation of at least four concentrations of albumin solution by this method, e.g. if starting with 0.8% further concentrations could be 0.4%, 0.2%, 0.1% and 0.05% or if starting with 1.6% further concentrations could be 0.8%, 0.4%, 0.2% and 0.1%.

When carrying out practical work candidates should be encouraged to consider how they could modify procedures to increase the accuracy of their measurement of the dependent variable.

General Comments

The majority of Centres returned the Supervisor's report with the results obtained 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.

The majority of Centres provided all the materials required and most 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 organised their results clearly in a ruled table. The better candidates included an appropriate heading for the independent variable (solution) and the dependent variable (number). The most common error was to omit the heading for the independent variable. The majority of candidates gained credit for recording the result for **P1** as a lower number than **P2**. Many candidates recorded the result for **W** as zero.

(ii) The majority of candidates correctly recorded that solution **U** was less concentrated than **P1** and **P2**. The better candidates correctly estimated the concentration of **U** to be less than 0.8%.

(iii) Most candidates correctly stated that they would use 0.8% albumin solution to make further concentrations. The most common error was giving a reason based on prior knowledge of the concentrations provided rather than the colour changes recorded as results.

(iv) Many candidates gained credit for stating the concentrations of four additional concentrations of albumin. The better candidates gained credit for showing the volumes of albumin and volumes of water required. The most common error was preparing albumin solutions that did not make up total volumes of 10 cm^3.

(v) Most candidates gained credit for correctly organising their results and recording both colour and scale number for at least three concentrations of albumin.

(vi) The majority of candidates correctly used their results to estimate the concentration of albumin solution **U**.

(vii) The better candidates gained credit for suggesting the use of a colorimeter to improve the confidence in the accuracy of their estimate. The most common error was stating a modification to the independent variable.

(b) (i) The majority of candidates drew the chart using the headings given in the table, with albumin concentration / g per 100 cm^3 on the *x*-axis and frequency / number of people on the *y*-axis. Most candidates drew bars of equal width and distance apart on the *x*-axis and used a suitable scale for the *y*-axis, plotting each bar accurately. The better candidates drew sharp, clear ruled lines for the bars. The most common errors were omitting the units for the *y*-axis, not using more than 6cm of the *x*-axis and drawing lines which were too thick or not ruled.

(ii) The better candidates gained credit for stating a correct reason for the pattern of results shown on the chart drawn.

(iii) Many candidates correctly identified a health problem resulting from a raised blood albumin concentration.

Question 2

(a) (i) The better candidates produced drawings using a sharp pencil to produce clear, thin lines and did not include any shading. Most were able to draw the epidermis as two lines with one closed end and many candidates drew at least two vascular bundles. The majority of candidates used one label line to show the palisade layer in the top half of the leaf. The most common error was to draw a plan diagram that was too narrow across the lamina.

(ii) Those candidates whose drawings were made using a sharp pencil to produce clear, thin lines gained credit. The majority of candidates drew at least four complete cells, showing at least one epidermal cell and drawing the cell walls as double lines with a double lamella between. Most candidates used one label with a label line to show the nucleus within a cell. The most common errors were to draw lines that did not meet up precisely or were too thick.

(b) (i) The better candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed **L1** and the other headed **Fig. 2.2**. The majority of candidates were able to gain partial credit for recording appropriate differences. The most common error was to incorrectly identify the tissues.

(ii) Most candidates showed the measurement of line **X** and the scale bar to the correct precision and using the same units for measuring both lines. Many candidates used a correct procedure to calculate the magnification of the photomicrograph **Fig.2.2** and calculate the actual length of line **X**. The most common error was to convert measurements to meters. The majority of candidates rounded their answer to no more than the correct decimal place for the units used.

(iii) Many candidates gained credit for a description of measuring at least five folds to calculate the mean maximum length. The better candidates recognised the need for a further calculation to convert the mean to actual length.

(iv) Most candidates suggested a correct feature to support the idea that both the specimen on **L1** and the specimen shown in **Fig. 2.2** grow in dry conditions. The better candidates explained how the feature may help the plant to prevent water loss. The most common error was to suggest a feature which was not directly observable in either **L1** or **Fig.2.2**.

BIOLOGY

Paper 9700/35
Advanced Practical Skills 1

Key Messages

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

Candidates should be 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 10% yeast cell suspension to start their serial dilution and to prepare 20cm^3 of each successive dilution. Candidates should show a serial dilution of yeast cell suspension using a constant dilution factor at each step. Candidates should show how to make at least four concentrations of yeast cell suspension by this method, e.g. 5%, 2.5%, 1.25% and 0.625%.

When carrying out practical work candidates should be encouraged to consider how they could improve their investigations to increase the confidence in their results, e.g. by repeating the procedure.

General Comments

The majority of Centres returned the Supervisor's report with the results obtained 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.

The majority of Centres provided all the materials required and most 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. The most common error was preparing yeast cell concentrations that did not make up the total volume of 20 cm^3 and not preparing at least four different concentrations.

(ii) The majority of candidates organised their results clearly in a ruled table. The better candidates included an appropriate heading for the dependent variable (percentage concentration of yeast) and the dependent variable (observation / colour / appearance). The majority of candidates gained credit for recording the colours observed in the correct pattern. The better candidates included repeats in their table.

(iii) Many candidates were able to state the actual error in using the syringe. The most common error was to omit the + / - or the correct units.

(iv) The majority of candidates correctly identified the difficulty in judging the colour change as the significant source of error when measuring the dependent variable.

(v) Some candidates correctly identified that repeating the investigation would increase the confidence in their results. The most common error was to suggest the use of a colorimeter.

(b) (i) Many candidates were able to select two variables which could be standardised in this investigation. The better candidates were able to describe how each of these variables should be standardised. The most common error was to quote variables already stated in the question.

(ii) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (time alginate beads in contact with milk / minutes) and the *y*-axis (percentage of hydrolysis of lactose). Some candidates, however, labelled the incorrect axis or gave incorrect units for time. The *x*-axis must be the dependant variable. Most candidates used suitable scales for the axes. Many candidates plotted the points correctly with a small cross or dot in a circle. Some drew a sharp, ruled line, accurately connecting each pair of points. The most common error was drawing lines which were too thick or not ruled to the centre of the point.

(iii) The majority of candidates answered correctly from their graph.

(iv) Many candidates gained credit for stating that less contact time resulted in fewer enzyme substrate complexes being formed.

(v) Many gained credit for the idea of a decrease in substrate concentration. The most common error involved candidates stating the enzyme's active sites were saturated or that the number of enzyme active sites was a limiting factor.

Question 2

(a) (i) Those candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly gained credit. The better candidates produced drawings which did not include any shading and used most of the space provided. Many candidates were able to draw the three sets of two adjacent cells with double lines representing the cell walls. Most candidates correctly labelled the position of one nucleus. The most common error was to draw lines that did not meet up precisely or were too thick.

(ii) The majority of candidates gained credit for correctly identifying a difference between the cells on slide **I** and slide **M**. The most common error was to describe different stages of plasmolysis or the presence of starch grains in cells on slide **I**.

(b) (i) Those candidates whose drawings did not include any shading and used most of the space provided gained credit. The better candidates carefully followed the instructions and drew only the section indicated by the boundary. Many candidates gained credit for drawing a well-proportioned diagram.

(c) (i) Many candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed **Fig. 2.3** and the other headed **Fig. 2.4**. The majority of candidates were able to gain full credit for recording appropriate differences.

(ii) Most candidates showed the measurements of line **E** and line **L** to the correct precision and using the correct units. The better candidates showed division of the measurement for line **L** by the measurement for line **E** and obtained the correct ratio. The most common error was to add units to the ratio.

BIOLOGY

Paper 9700/36
Advanced Practical Skills 2

Key Messages

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

Candidates should be able to use simple dilution to obtain the required concentrations of a solution by adding a unit volume of a solution of a known concentration, in this case 5% enzyme solution, to water. Candidates should make at least five concentrations using regular intervals for the independent variable, e.g. 5.0%, 4.0%, 3.0%, 2.0% and 1.0%.

When carrying out practical work candidates should be encouraged to gain experience in deciding which variables have been standardised and how to standardise other variables to provide accurate results. If key variables are allowed to change during an investigation the results may change.

General Comments

The majority of Centres returned the Supervisor's report with the results obtained 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.

The majority of Centres provided all the materials required and most 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 gained credit for showing the volumes of enzyme solution and volumes of water required to make at least four further concentrations of enzyme solution. The most common error was preparing enzyme solutions that did not make up total volumes of 20 cm^3.

(ii) The majority of candidates organised their results clearly in a ruled table. The better candidates included an appropriately detailed heading for the independent variable (percentage concentration of enzyme solution) and the dependent variable (time / s). The most common errors were to omit the heading for the independent variable or to include 'seconds' in the cells of this column or row. The majority of candidates gained credit for recording the times as whole numbers and in multiples of 30 seconds. The better candidates recorded times showing that the highest concentration of enzyme solution had taken less time to reach the end-point than lower concentrations.

(iii) Most candidates correctly identified the significant source of error in measuring the dependent variable as the difficulty of judging the colour of the end-point. The most common error was stating errors for other parts of the procedure.

(iv) Many candidates correctly described an improvement to the investigation that would increase confidence in the results, such as stating that they would repeat the experiment more than once or place the enzyme solution in the water-bath to reach the required temperature.

(b) (i) Most candidates stated the two variables that needed to be standardised as temperature and pH and correctly described how these variables would be standardized by the use of a thermostatically controlled water-bath for temperature and by the use of buffers for pH.

(ii) Many candidates correctly calculated the rate of production of glucose to the correct precision.

(iii) The majority of candidates drew the graph using the headings given in the table, with time / minutes on the *x*-axis and mass of glucose / mg on the *y*-axis. The better candidates used appropriate scales for the axes, plotted the points exactly with a small cross or dot in a circle and drew a sharp, ruled line which accurately connected the points. The most common errors were not including a full axis label with units for each axis and drawing lines which were too thick.

(iv) The better candidates correctly explained the reasons for the change in mass in terms of enzyme substrate complexes formed.

Question 2

(a) (i) Most candidates correctly explained that the observable feature on **M1** that identified the specimen as a root was the central stele.

(ii) The better candidates produced drawings using a sharp pencil to produce clear, thin lines and did not include any shading. Many were able to draw the endodermis as two lines and had drawn the central stele in the correct proportion relative to the diameter of the root. Most candidates used one label with a label line to show the xylem correctly. Some candidates had used the eyepiece graticule to help them draw well-proportioned drawings. The most common errors were to draw lines that did not meet up precisely or were too thick.

(ii) Those candidates whose drawings were made using a sharp pencil to produce clear, thin lines gained credit. The majority of candidates drew two groups of three cells, showing at least one xylem cell wall as angular and drawing the cell walls as double lines. Most candidates used one label with a label line to show the lumen within a xylem cell. The most common errors were to draw lines that did not meet up precisely.

(b) The better candidates showed the measurement of lines **Y** and **Z** to the correct precision and using the same units (mm) for measuring both lines. Most candidates presented the simplest ratio of **Y** to **Z** correctly as a larger whole number to a smaller whole number.

(c) The better candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed **M1** and the other headed **Fig. 2.2**. The majority of candidates were able to gain partial credit for recording appropriate differences. The most common error was to incorrectly identify the tissues.

BIOLOGY

Paper 9700/41
A2 Structured Questions

Key Messages

- Candidates should match their answer to the number of marks available for each question. For example, a question that has 3 marks is likely to require at least three different statements in order to achieve full marks.
- It is essential that candidates read the information given in the question carefully to enable them to apply their own biological knowledge, in conjunction with the information provided, in an unfamiliar situation.

General comments

The paper was of appropriate difficulty and was comparable to those of previous sessions. Some questions proved to be difficult for most candidates, particularly **Questions 1(a)**, **5(b)(ii)** and **8(b)**. Most candidates attempted every question and there was little observable evidence that there was not enough time to complete the paper.

A full range of marks were seen with a good and balanced distribution.

Able candidates tackled the questions with sound knowledge and understanding of the areas being tested and demonstrated their ability to interpret new information and data. As a result there were some very good responses that scored highly.

More candidates attempted **Question 10** than **Question 9**. Many candidates achieved full marks for **Question 10(a)** but **Question 10(b)** proved to be more difficult.

Comments on specific questions

Section A

Question 1

(a) Candidates were asked to explain the principles of artificial selection in a novel situation, namely the breeding of guide dogs. Few were able to suggest relevant characteristics of guide dogs. Although some mentioned breeding and selecting offspring, the need to carry on this activity for many generations to improve the allele frequency of the desired characteristics was rarely given.

(b) (i) A common error here was to name sympatric speciation for the jackal and allopatric speciation for the dingo.

(ii) Many stated that members of a species should be able to breed to produce fertile offspring but did not mention the domestic dog. Jackals lack of interbreeding was rarely mentioned as a reason why some members could be described as separate species

Question 2

(a) Most candidates referred to blood vessels or branches but many lost credit because they did not state that new blood vessels or branches into the tumour were stopped from developing. Many mentioned oxygen or nutrients not reaching the tumour but only a few mentioned either metastasis or a valid description of it.

(b) (i) The majority of candidates correctly identified VEGF as the antigen.

(ii) Most referred to the correct cells in a hybridoma but many incorrectly stated that the cells would combine, join or bind instead of fusing.

(c) The majority of candidates knew that the humanised mouse antibody would not cause an immune response or cause side effects. The better candidates understood the reason, i.e. that it would not act as a foreign antigen, or be treated as non-self. Many simply said that it resembles antibodies produced by humans, which is in the question. Few stated that it would allow more than one treatment or remain longer in the body.

(d) The majority of candidates did not show the correct positioning of the chains, although many knew that there should be a 'Y' shape. Most gave the required number of bridges.

Question 3

(a) (i) Most candidates did not achieve full marks on this question. Quite often it was clear that the candidate had a good idea of the role of each enzyme but did not provide enough detail in their answer to be awarded credit.

For reverse transcriptase, the most common misunderstandings were that mRNA turned into cDNA or in some way was converted. Some candidates did not specify the RNA to be mRNA so could not gain credit.

For DNA polymerase, a significant number of candidates confused this with PCR and wrote about it increasing copies of DNA, not making the single stranded DNA double stranded.

Restriction enzyme was the enzyme most candidates knew correctly, either that it cut the DNA / plasmid or that it was responsible for producing the sticky ends on the DNA / plasmid. A minority of candidates did not specifically mention DNA or plasmid, so could not be awarded credit.

Many candidates knew that DNA ligase is involved in joining a gene into a plasmid but did not make reference to it joining the sugar-phosphate backbone or making phosphodiester bonds. A frequent error was to call the sugar-phosphate backbone 'a phosphate backbone'.

(ii) Most candidates displayed a good understanding of insulin being secreted from the pancreas and working on the target tissue in the liver / muscle. However, the majority of candidates wrote about glucose levels or amounts in the blood without the use of the term concentration, so could not be awarded credit. A good proportion of candidates knew of the role of insulin to cause glucose to be converted into glycogen and its correct term of glycogenesis, as well as causing glucose to be respired and taken up into the cell; however most candidates did not state that insulin increased the rate of all these processes, so lost credit. A small number of candidates stated that there was an increase in the permeability of the cell membrane to glucose but needed to specify that it was the cell surface membrane in order to be credited. Some candidates knew of the role of insulin to inhibit the secretion of glucagon.

(iii) Most candidates stated that insulin produced from rDNA technology was identical to human insulin. A significant number of candidates mistakenly thought it was similar to insulin. Most knew that it would not cause an immune response. Candidates needed to both describe and explain one advantage to gain full credit and many did not fulfill this criteria.

(b) (i) Generally, candidates found this question difficult. Many candidates did not describe the differences between the two lines and merely described each line separately. Another common error was to quote comparative figures but not use them to support the point they were describing. For instance, 9.4 and 5.4 would be quoted, as these were the maximum points of activity, but

candidates would not then go on to describe that insulin X had a greater maximum activity compared to human insulin.

(ii) Very few candidates suggested valid points other than the change in tertiary structure. Some referred generally to change in activity or bonds without specifying, and one or two referred to solubility or transport of insulin, but mostly without reference to blood.

Question 4

(a) Most candidates answered this question well. The most common answers were a medical use by humans, ecotourism and an ethical / moral / aesthetic reason. Many candidates wrote incorrectly about habitat destruction and plants providing oxygen for the world.

(b) (i) The most common error was to write about the number of individual plants sampled and not the percentage of polymorphic bands. Many candidates did not compare the individual wild populations to the botanic garden and did not support the statement with comparative figures.

(ii) Candidates found this question difficult. A small number of candidates noticed the small number sampled but could not suggest further explanations such as a small gene pool or some variants not being included in the sample.

(iii) Most candidates stated that high genetic diversity prevents extinction but did not link the fact that conditions are changing and that a species with a high genetic diversity stands an increased chance of having an individual amongst its population that will be able to survive the change. When candidates suggested examples of changes they did not make it clear that it would have to be a new disease in order for it to be a change. A minority of candidates mentioned the decreased chance of two harmful recessive alleles coming together or inbreeding depression. There was also a misuse of the term gene here, when allele would have been the correct term.

(iv) Most candidates missed the point here of similar conditions in both places which may help with possible reintroduction back into the wild. Some candidates were able to link the idea of pollination between the two sites.

(c) (i) Many candidates were able to show that seeds, being small, are easy to store and that storage would require little maintenance. The fact that they can be stored for a long time was mentioned and some stated that plants would be susceptible to disease or being eaten whereas this was unlikely to happen to seeds.

(ii) A majority of candidates knew that this would check if the seeds were still viable or able to germinate. The most common error here was to use the term ‘fertile’ incorrectly or state that they were ‘able to grow’. Many candidates knew that it allowed collection of more seeds. A rare answer included the idea that it enabled you to find the condition for breaking seed dormancy.

Question 5

(a) Most candidates answered this well with many gaining full credit.

(b) (i) Many candidates correctly stated that the ATP was from glycolysis only but did not go on to say that the end product of glycolysis, pyruvate / lactate / ethanol, still contains energy. Good answers usually included the idea that there was no Krebs cycle / link reaction / oxidative phosphorylation / chemiosmosis or the reverse argument for aerobic respiration. Some points that were often missed were that the ETC stops and that there was no oxygen to act as the final electron acceptor.

(ii) This question was not well answered by most candidates. One correct answer frequently given was that there are more hydrogen atoms or C-H bonds in lipids than carbohydrates. Few gave much further detail such as the molecular formula of glucose and a lipid. Some candidates realised that more reduced NAD / FAD is produced.

Question 6

(a) This question proved to be a good discriminator with most gaining at least partial credit.

(b) Most candidates showed that have very good knowledge of the functioning of a cholinergic synapse and many scored maximum credit. Common errors were to state that Ca^{2+} enters the (pre)synaptic membrane instead of the neurone / knob; stating Ca instead of Ca^{2+} and Na instead of Na^{+}; not stating that movement across the cleft was by diffusion; and Na^{+} entering postsynaptic membrane instead of the neurone / knob.

(c) The role of acetylcholinesterase in the hydrolysis of Ach was well known but few went on to state that this stops the continuous production of action potentials (in post-synaptic neurone).

Question 7

(a) Very few candidates gained full credit here. Better candidates explained the meaning of mutation first and then the meaning of recessive. For the former, not many described changes in the structure of DNA, but may have mentioned gene or allele. Many correctly explained the term recessive as being an expression of the allele in the homozygote.

(b) This was a straight forward monohybrid cross. Only a very limited number of candidates were able to provide suitable symbols with a key or referred to alleles. Many used letters with superscripts. Not an insignificant number thought the disorder was sex-linked, using X & Y symbols for the sex chromosomes with superscripts added for the normal / PKU allele. However, even if errors were made with incorrect symbols, many candidates were credited for carrying out the cross correctly. Some lost credit by not assigning the phenotypes to specific genotypes.

(c) While many correctly stated that the primary and tertiary structures of the protein were altered, not many specifically said that there were fewer amino acids. Better candidates referred to changes in the active site. Most deduced that the enzyme / protein changed its function, while fewer said that it became non-functional.

Question 8

(a) (i) The majority of candidates correctly identified **A** as RuBP but only the better candidates were able to identify **B** as fatty acids and **C** as nitrates.

(ii) While many identified the process as phosphorylation, a number incorrectly thought it was oxidative phosphorylation and few stated photophosphorylation or correctly, non-cyclic photophosphorylation.

(iii) Many candidates were able to name either condensation or polymerisation and a few gave the acceptable alternative of anabolic. Almost all were able to give the name of the bond as glycosidic.

(iv) The majority of candidates correctly identified that carbon dioxide diffuses into the leaf via stomata. Few candidates correctly described the process of carbon dioxide into the palisade cells. Some did not identify the cell surface membrane or wall of the palisade cell as the point of entry.

(b) Very few candidates answered this question well. Many incorrectly talked about the role of carbon dioxide instead of concentrating on the acidic nature of hydrogen ions. Very few discussed the removal of protons from the stroma or even mentioned that rubisco is found in the stroma.

Section B

Question 9

(a) Many candidates gained full credit for this question. The presence of a high carbohydrate content and high fibre was well known as was their importance in providing energy and preventing constipation, respectively. Many also knew some details of the vitamin content although weaker candidates often got the actual vitamins confused. Few mentioned that proteins provide amino acids but correctly stated that they were needed for growth. Although low fat content was mentioned essential fatty acids were not. Whilst many did not mention that cereals contain a wide range of minerals an example of a mineral plus its use in the body was frequently given. A minority stated that cereals could be easily stored but many did not discuss the idea of cereals being a staple food.

(b) Many candidates discussed the role of gibberellin in germination in vague terms whilst others incorrectly talked about the effect on stem elongation.

Question 10

(a) Most candidates answered this question well. A good answer generally stated that FSH and LH were released by the anterior pituitary and that the follicle cells secreted oestrogen which had the effect of building up the endometrium lining. A surge in LH leading to ovulation was frequently given plus the developing of the corpus luteum and the ensuing role of the progesterone that it produces.

(b) Good candidates explained the basic principles of homeostasis and give an example. Some were able to give a definition and accurately describe the roles of receptors and effectors and the restoration of the norm. Unfortunately, many simply described in great detail just one example such as temperature regulation without touching on these basic principles.

BIOLOGY

Paper 9700/42
A2 Structured Questions

Key Messages

- Candidates should match their answer to the number of marks available for each question. For example, a question that has 3 marks is likely to require at least three different statements in order to achieve full marks.
- It is essential that candidates read the information given in the question carefully to enable them to apply their own biological knowledge, in conjunction with the information provided, in an unfamiliar situation.

General comments

The paper was of appropriate difficulty and was comparable to those of previous sessions. Some questions proved to be difficult for most candidates, particularly **Questions 1(a)**, **5(b)(ii)** and **8(b)**. Most candidates attempted every question and there was little observable evidence that there was not enough time to complete the paper.

A full range of marks were seen with a good and balanced distribution.

Able candidates tackled the questions with sound knowledge and understanding of the areas being tested and demonstrated their ability to interpret new information and data. As a result there were some very good responses that scored highly.

More candidates attempted **Question 10** than **Question 9**. Many candidates achieved full marks for **Question 10(a)** but **Question 10(b)** proved to be more difficult.

Comments on specific questions

Section A

Question 1

(a) Candidates were asked to explain the principles of artificial selection in a novel situation, namely the breeding of guide dogs. Few were able to suggest relevant characteristics of guide dogs. Although some mentioned breeding and selecting offspring, the need to carry on this activity for many generations to improve the allele frequency of the desired characteristics was rarely given.

(b) (i) A common error here was to name sympatric speciation for the jackal and allopatric speciation for the dingo.

(ii) Many stated that members of a species should be able to breed to produce fertile offspring but did not mention the domestic dog. Jackals lack of interbreeding was rarely mentioned as a reason why some members could be described as separate species

Question 2

(a) Most candidates referred to blood vessels or branches but many lost credit because they did not state that new blood vessels or branches into the tumour were stopped from developing. Many mentioned oxygen or nutrients not reaching the tumour but only a few mentioned either metastasis or a valid description of it.

(b) (i) The majority of candidates correctly identified VEGF as the antigen.

(ii) Most referred to the correct cells in a hybridoma but many incorrectly stated that the cells would combine, join or bind instead of fusing.

(c) The majority of candidates knew that the humanised mouse antibody would not cause an immune response or cause side effects. The better candidates understood the reason, i.e. that it would not act as a foreign antigen, or be treated as non-self. Many simply said that it resembles antibodies produced by humans, which is in the question. Few stated that it would allow more than one treatment or remain longer in the body.

(d) The majority of candidates did not show the correct positioning of the chains, although many knew that there should be a 'Y' shape. Most gave the required number of bridges.

Question 3

(a) (i) Most candidates did not achieve full marks on this question. Quite often it was clear that the candidate had a good idea of the role of each enzyme but did not provide enough detail in their answer to be awarded credit.

For reverse transcriptase, the most common misunderstandings were that mRNA turned into cDNA or in some way was converted. Some candidates did not specify the RNA to be mRNA so could not gain credit.

For DNA polymerase, a significant number of candidates confused this with PCR and wrote about it increasing copies of DNA, not making the single stranded DNA double stranded.

Restriction enzyme was the enzyme most candidates knew correctly, either that it cut the DNA / plasmid or that it was responsible for producing the sticky ends on the DNA / plasmid. A minority of candidates did not specifically mention DNA or plasmid, so could not be awarded credit.

Many candidates knew that DNA ligase is involved in joining a gene into a plasmid but did not make reference to it joining the sugar-phosphate backbone or making phosphodiester bonds. A frequent error was to call the sugar-phosphate backbone 'a phosphate backbone'.

(ii) Most candidates displayed a good understanding of insulin being secreted from the pancreas and working on the target tissue in the liver / muscle. However, the majority of candidates wrote about glucose levels or amounts in the blood without the use of the term concentration, so could not be awarded credit. A good proportion of candidates knew of the role of insulin to cause glucose to be converted into glycogen and its correct term of glycogenesis, as well as causing glucose to be respired and taken up into the cell; however most candidates did not state that insulin increased the rate of all these processes, so lost credit. A small number of candidates stated that there was an increase in the permeability of the cell membrane to glucose but needed to specify that it was the cell surface membrane in order to be credited. Some candidates knew of the role of insulin to inhibit the secretion of glucagon.

(iii) Most candidates stated that insulin produced from rDNA technology was identical to human insulin. A significant number of candidates mistakenly thought it was similar to insulin. Most knew that it would not cause an immune response. Candidates needed to both describe and explain one advantage to gain full credit and many did not fulfill this criteria.

(b) (i) Generally, candidates found this question difficult. Many candidates did not describe the differences between the two lines and merely described each line separately. Another common error was to quote comparative figures but not use them to support the point they were describing. For instance, 9.4 and 5.4 would be quoted, as these were the maximum points of activity, but

candidates would not then go on to describe that insulin X had a greater maximum activity compared to human insulin.

(ii) Very few candidates suggested valid points other than the change in tertiary structure. Some referred generally to change in activity or bonds without specifying, and one or two referred to solubility or transport of insulin, but mostly without reference to blood.

Question 4

(a) Most candidates answered this question well. The most common answers were a medical use by humans, ecotourism and an ethical / moral / aesthetic reason. Many candidates wrote incorrectly about habitat destruction and plants providing oxygen for the world.

(b) (i) The most common error was to write about the number of individual plants sampled and not the percentage of polymorphic bands. Many candidates did not compare the individual wild populations to the botanic garden and did not support the statement with comparative figures.

(ii) Candidates found this question difficult. A small number of candidates noticed the small number sampled but could not suggest further explanations such as a small gene pool or some variants not being included in the sample.

(iii) Most candidates stated that high genetic diversity prevents extinction but did not link the fact that conditions are changing and that a species with a high genetic diversity stands an increased chance of having an individual amongst its population that will be able to survive the change. When candidates suggested examples of changes they did not make it clear that it would have to be a new disease in order for it to be a change. A minority of candidates mentioned the decreased chance of two harmful recessive alleles coming together or inbreeding depression. There was also a misuse of the term gene here, when allele would have been the correct term.

(iv) Most candidates missed the point here of similar conditions in both places which may help with possible reintroduction back into the wild. Some candidates were able to link the idea of pollination between the two sites.

(c) (i) Many candidates were able to show that seeds, being small, are easy to store and that storage would require little maintenance. The fact that they can be stored for a long time was mentioned and some stated that plants would be susceptible to disease or being eaten whereas this was unlikely to happen to seeds.

(ii) A majority of candidates knew that this would check if the seeds were still viable or able to germinate. The most common error here was to use the term ‘fertile’ incorrectly or state that they were ‘able to grow’. Many candidates knew that it allowed collection of more seeds. A rare answer included the idea that it enabled you to find the condition for breaking seed dormancy.

Question 5

(a) Most candidates answered this well with many gaining full credit.

(b) (i) Many candidates correctly stated that the ATP was from glycolysis only but did not go on to say that the end product of glycolysis, pyruvate / lactate / ethanol, still contains energy. Good answers usually included the idea that there was no Krebs cycle / link reaction / oxidative phosphorylation / chemiosmosis or the reverse argument for aerobic respiration. Some points that were often missed were that the ETC stops and that there was no oxygen to act as the final electron acceptor.

(ii) This question was not well answered by most candidates. One correct answer frequently given was that there are more hydrogen atoms or C-H bonds in lipids than carbohydrates. Few gave much further detail such as the molecular formula of glucose and a lipid. Some candidates realised that more reduced NAD / FAD is produced.

Question 6

(a) This question proved to be a good discriminator with most gaining at least partial credit.

(b) Most candidates showed that have very good knowledge of the functioning of a cholinergic synapse and many scored maximum credit. Common errors were to state that Ca^{2+} enters the (pre)synaptic membrane instead of the neurone / knob; stating Ca instead of Ca^{2+} and Na instead of Na^{+}; not stating that movement across the cleft was by diffusion; and Na^{+} entering postsynaptic membrane instead of the neurone / knob.

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(b) This was a straight forward monohybrid cross. Only a very limited number of candidates were able to provide suitable symbols with a key or referred to alleles. Many used letters with superscripts. Not an insignificant number thought the disorder was sex-linked, using X & Y symbols for the sex chromosomes with superscripts added for the normal / PKU allele. However, even if errors were made with incorrect symbols, many candidates were credited for carrying out the cross correctly. Some lost credit by not assigning the phenotypes to specific genotypes.

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Question 8

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Section B

Question 9

(a) Many candidates gained full credit for this question. The presence of a high carbohydrate content and high fibre was well known as was their importance in providing energy and preventing constipation, respectively. Many also knew some details of the vitamin content although weaker candidates often got the actual vitamins confused. Few mentioned that proteins provide amino acids but correctly stated that they were needed for growth. Although low fat content was mentioned essential fatty acids were not. Whilst many did not mention that cereals contain a wide range of minerals an example of a mineral plus its use in the body was frequently given. A minority stated that cereals could be easily stored but many did not discuss the idea of cereals being a staple food.

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Question 10

(a) Most candidates answered this question well. A good answer generally stated that FSH and LH were released by the anterior pituitary and that the follicle cells secreted oestrogen which had the effect of building up the endometrium lining. A surge in LH leading to ovulation was frequently given plus the developing of the corpus luteum and the ensuing role of the progesterone that it produces.

(b) Good candidates explained the basic principles of homeostasis and give an example. Some were able to give a definition and accurately describe the roles of receptors and effectors and the restoration of the norm. Unfortunately, many simply described in great detail just one example such as temperature regulation without touching on these basic principles.

BIOLOGY

Paper 9700/43
A2 Structured Questions

Key Messages

- Candidates should try to apply their biological knowledge to the given situation in the question, rather than just stating general principles.
- Candidates should be careful when using the terms 'initially' and 'later' when describing results on a graph; they are only correct when the axis is representing time.

General Comments

The paper was of appropriate difficulty and accessible to candidates. The paper discriminated well between candidates at all grades. The majority of candidates attempted all parts of the questions, having sufficient time to complete the paper.

The main source of difficulty in general was the interpretation of data. This was particularly noticeable in **Question 5(b) (i)** where a straightforward set of results were given. A significant number of candidates were unable to describe the obvious trends in the figures. Another weak area was the drawing of the graph in **Question 8 (b) (i)**. Choosing suitable scales for the axes and drawing lines of best fit caused problems for a number of candidates. Both are skills, needed by candidates at this level, which should have been practised.

The majority of candidates selected **Question 10** as the free response question in ***section B***, although it was rare for them to achieve full credit in either part of this question.

Comments on Specific Questions

Section A

Question 1

(a) (i) Most candidates were able to use the information provided in the table to explain how a single base substitution could result in the replacement of arginine with glutamine in PAH. Credit was not given for inaccurate wording, such as 'C substitutes T'. Most responses correctly described the change from the original triplet to another, although a few responses did not state what the changed triplet code would be.

(ii) Candidates generally knew that the consequence of the single base substitution would be an alteration of the active site or tertiary structure of PAH.

(b) Good responses recognised that the mechanism which has resulted in the different number of PKU cases in European and Sub-Saharan populations was natural selection. In attempting to explain the mechanism many candidates referred to the increased amount of fungus in Europe, but this did not always gain credit, as a comparative reference was needed to explain the difference. Where candidates realised that the carriers of the recessive PKU allele were at an advantage, by being more resistant to ochratoxin A, they were able to gain credit for the higher survival rate of the carriers. In addition they usually then described the carriers passing on the advantageous allele, increasing the allele's frequency. Confused accounts lost credit where it was unclear to which country reference was being made or where no reference was made to the carriers of the recessive allele. Few recognised the fungus or ochratoxin A as the selection pressure operating in this scenario.

Question 2

(a) A minority of candidates gained full credit here with many only referring to keeping animals in captivity, when the emphasis in the question was on the advantages of a captive breeding programme. The idea of the animals being protected from danger was well known but providing adequate food or the monitoring of the health of mothers and offspring (to ensure breeding is successful) was less often mentioned. A significant number of candidates did not mention methods used to promote breeding, such as IVF, storage of gametes or artificial incubation of eggs. A small number of responses referred to the transfer of breeding partners between zoos or the breeding programmes enabling genetic diversity to be maintained due to the maintenance of good records by the zoos involved.

(b) Candidates were aware that animals being bred in captivity may not breed successfully because of stress, or that a chosen mate might be rejected. Possible changes in behaviour or reproductive cycles were suggested, but few explained that the problems arose because the animals were not in their natural habitat.

(c) Most responses referred to the difficulty of obtaining food, resulting from a lack of learned behaviour. Some candidates were also aware that the returned animals would be more susceptible to disease or would have difficulty integrating with members of their own species.

(d) Most realised that the condor eating the killed animals would be poisoned by the lead in the carcass.

Question 3

(a) (i) The majority of candidates correctly identified reverse transcriptase and DNA polymerase as the enzymes used. Occasionally the names for **X** and **Y** were reversed, while a significant number of candidates incorrectly named **Y** as DNA ligase.

(ii) Few candidates fully understood why mRNA was used as the starting point in this procedure. Candidates rarely suggested that it was because there was a large amount of the mRNA readily available. Many incorrectly believed that the gene was harder to obtain from DNA because it is found in the nucleus rather than the cytoplasm. A minority of candidates explained that the difficulty lay in locating and retrieving the correct gene from the DNA, due to the DNA coding for multiple genes. A significant number did realise that mRNA only coded for the required gene, with a few taking this further, referring to the idea that the introns had already been removed.

(b) This question proved difficult for most candidates. A few correctly mentioned the need for RER or Golgi apparatus. A small minority of candidates explained that these organelles were needed to modify the insulin or recognised that the eukaryotic cells had the advantage of having promoters already present.

(c) Candidates were usually able to state the advantages of using genetically engineered insulin, referring to it being identical to human insulin, having a rapid response or avoiding ethical issues. A few responses gained credit for the ideas of being cheap to produce in large volumes, reducing the risk of disease or being used when tolerance to animal insulin has developed.

Question 4

(a) Most candidates could outline two uses of energy in living organisms, with muscle contraction and active transport being the most frequent responses. One fairly common misunderstanding was to state that organisms need energy for respiration.

(b) (i) The structure of ATP was well known but some candidates referred to the base adenine as adenosine, not realising that adenosine was represented by both parts **A** and **B** together on this diagram.

(ii) Some candidates had learnt this well and could identify several features of ATP that are related to its role as energy currency. The most common answers were its solubility in water and small size, although solubility was not always qualified as 'in water'. These features were frequently related to ease of transport of ATP but many incorrect references were seen to ATP being transported

around the body rather than within a cell. Not all candidates realised that when describing the energy released from hydrolysis of ATP the unit kJ mol^{-1} should be used.

(c) (i) Few candidates answered in terms of an explanation of how aerobic respiration may be affected by a decrease in oxygen availability. Consequently responses often described the effect of a total lack of oxygen on the processes involved. The idea that the oxygen was needed as an electron acceptor was usually mentioned but could only be credited when described as the final acceptor.

(ii) The advantage to *T. Thermophilus,* HB8, of having the enzyme nitrate reductase, as a final electron acceptor, was not fully appreciated by the majority of candidates. Although realising that this would allow aerobic respiration to continue, the reasoning was very rarely followed through to the idea of allowing more ATP to be produced.

(d) (i) Many accurate comparisons of the growth of the two strains of bacteria in aerobic and anaerobic conditions in separate cultures were given. Candidates usually noted that HB8 always does better than mutant HB8 and that both strains grow better in aerobic conditions. Most responses included supporting data with correct units.

(ii) Candidates in most responses noted that in mixed cultures, both strains of bacteria grew better in aerobic conditions. A few candidates also recognised the very significant difference in the growth of the HB8 mutant when in aerobic compared to anaerobic conditions. Supporting figures were usually given.

(iii) Explaining the results in flask 6 proved challenging for many candidates who assumed that the mutation had made the enzyme, nitrate reductase, completely non-functional. The figures on the graph show some growth of the mutant HB8 in anaerobic conditions indicating that the enzyme nitrate reductase activity is reduced but still allows nitrate to act as the final electron acceptor in the electron transport chain. A suggestion that HB8 might be a better competitor than the mutant could also have gained credit.

Question 5

(a) (i) The main operating conditions of continuous culture were well described by most candidates. Reference was usually made to nutrients being added throughout the process, although many incorrect references were seen to waste being continuously collected instead of a product. Temperature, pH or oxygen, together with the maintenance of a constant volume, were other conditions also commonly mentioned as needing to be controlled.

(ii) Many candidates were able to state the advantages of using continuous culture, such as knowing that the organisms could be maintained in exponential growth phase, small vessels could be used or that production costs were cheaper. References to a faster enzyme production rate could not always be credited where no reference was made to time, only to the amount produced.

(b) (i) Candidates who described the trends and gave supporting figures were able to gain full credit. Weaker responses listed numerous figures but did not link these to trends. Many candidates described the increasing percentage breakdown after 7 days as the dye concentration increased without noting the decrease above 150 mg dm^{-3} dye concentration or incorrectly referred to there being no trend at all.

(ii) Good responses described the time taken for the white-rot fungal cells to secrete the enzymes or that the enzymes would be in a lower concentration. Some candidates took this further by suggesting that the free enzymes would be able to form complexes with the substrate faster, although this did need to be linked to the increased speed of complex formation.

(c) The advantages of using immobilised enzymes were well known; being able to be re-used, being thermostable and being able to withstand changes of pH. Many references to immobilised enzymes not contaminating the product were made but it was not always clear that the product was the water itself.

Question 6

(a) The role of Fe^{2+} in the transport of oxygen or haemoglobin structure was well known, as was the type of cell involved in co-transport in the kidney. Many candidates correctly described the involvement of Ca^{2+} in synaptic transmission. A number of vague references to impulse transmission were seen that could not be credited, as it was not clear that the context was the synapse.

(b) Some candidates knew that chemoreceptors will only send impulses to the brain if a receptor or generator potential is reached. Many incorrectly referred to an action potential.

(c) Responses often revealed a poor knowledge of nephron structure, when outlining how molecules pass from the blood to become part of the glomerular filtrate. The majority of candidates correctly referred to the difference in the diameters of the afferent and efferent arterioles but did not always link this to high blood pressure in the glomerulus. The endothelium of the capillaries, the basement membrane and the layer of podocyte cells were often mentioned but it was not always clear how the molecules were able to move through them. It was expected that the presence of holes in the endothelium and gaps between podocytes would be described as allowing movement, with the basement membrane being a selective barrier. Good responses included this together with extra detail of the maximum size of molecules able to pass through the basement membrane. Many candidates gave a very confused account, often incorrectly thinking that the molecules eventually ended up in the glomerulus, instead of in the renal capsule.

Question 7

(a) Most candidates were able to define a gene as a length or section of DNA but did not always explain that it coded for a protein. Some were not specific enough in their answers, referring to the production of a characteristic instead of a protein.

The allele was usually described as an alternative form of a gene but candidates were not always clear that an allele involved a single gene, 'a different form of gene' not being precise enough. Few candidates referred to the fact that the alternative forms of a gene occupy the same locus or position (on homologous chromosomes).

(b) Many candidates successfully identified the phenotypes and genotypes in this pedigree diagram of the inheritance of the ABO blood group system. The most common incorrect responses included the reversal of the phenotypes and genotypes or not using two alleles in each genotype.

Question 8

(a) The majority of candidates labelled all three structures correctly on the diagram. In only a few responses was there confusion between the cell wall, **Y**, and membrane structure, **Z**.

(b) (i) The graphs drawn to show the relationship between light intensity and the rate of photosynthesis usually had the axes labelled and points correctly plotted. A number of candidates chose inappropriate scales for the axes, which caused inaccuracies when plotting the points and in a few cases the plot at a light intensity of 150 a.u. was omitted altogether. Usually the line of best fit was drawn through the points but frequently was of a poor quality.

(ii) Explaining the shape of the graph with reference to limiting factors produced very mixed responses, a large number of candidates not mentioning limiting factors at all, despite this being in the question. The best responses made it clear that light was limiting the rate when at a low intensity, while another factor, such as carbon dioxide concentration, was limiting the rate when light intensity was high. Many references were seen to 'initially' and 'later' which were inappropriate here as the *x*-axis does not refer to time in this context.

(c) (i) The accessory pigments were usually named correctly as chlorophyll b and carotenoids.

(ii) Most candidates stated that the role of the accessory pigments was to absorb light, with many also noting that the energy was then passed to the primary pigment in the reaction centre. Few recognised that the accessory pigments were able to absorb wavelengths of light that were not readily absorbed by the primary pigment.

(iii) Candidates usually knew that most of the light of wavelength 550 nm is reflected.

(iv) The graph showing the relationship between the wavelength of light and the rate of photosynthesis was stated to be an action spectrum by the majority of candidates.

Question 9

(a) Most candidates were able to describe that vitamin A is found in the aleurone layer and that this presented a problem as this layer is removed in the production of white rice. Candidates often knew the name Golden Rice™ but usually knew very little about the technical process of transferring genes coding for vitamin A production into the rice plant. Very few responses mentioned that the genes extracted from a bacterium and daffodils were inserted into a plasmid, with promoters added. The use of *Agrobacterium tumefaciens* in transferring the plasmid to rice embryos also needed to be described. Only a very few candidates realised that the rice embryos containing the gene coding for vitamin A production would then need to be grown into adult plants. It was also rarely stated that these plants would then produce seeds containing vitamin A in the endosperm, so enhancing the vitamin A content of rice.

(b) The disadvantages of using genetically modified plants were frequently quite poorly described. Most candidates referred to the high expense of buying GM seeds or the high price of GM crops for sale. Other known disadvantages were the possibility of adverse effects on humans, the potential production of more resistant weeds or harmful effects on other species in the food chain. A few candidates realised that GM crops might cross-pollinate with wild or organic species, or that they might not grow well in all conditions. Less well known were the disadvantages of losing traditional varieties of crop or the potential loss of genetic diversity in general.

Question 10

(a) Candidates were mostly well prepared for this question. The stages in the technique of in-vitro fertilisation were generally well known. The main problem was the use, in the wrong context, of terms which have specific meanings in the reproductive process. Terms such as follicle, oocyte, ovum and embryo, are not interchangeable, so candidates need to understand when it is appropriate to use them. Most responses described the use of hormones to stimulate the maturation of follicles or oocytes, but it was not always clear that the essential feature of this process was to ensure that many matured at the same time. Candidates were familiar with the process of harvesting the oocytes, although additional references to the stimulation of ovulation sometimes negated this mark. Mixing the oocytes with sperm and waiting a reasonable time for the embryo to develop was usually described adequately, together with the implantation of several embryos into the uterus. Many responses described hormones being used to ensure maintenance of the endometrium and a number of candidates were familiar with the use of ICSI.

(b) There was a lot of variation in candidate knowledge of the ethical implications of IVF, but most candidates discussed surplus embryos being discarded, along with the idea that a technological intervention in reproduction is not natural. Other well known issues included the unknown effects of freezing embryos or issues regarding the use of stem cells. Most responses referred to the possibilities of single people or women past the menopause having children or to issues arising from the use of surrogate mothers. Few references were seen to the potential problems of multiple births, although references to possible birth defects were sometimes given.

BIOLOGY

Paper 9700/51

Planning, Analysis and Evaluation

Key messages

- When describing an experimental method, candidates should organise it into a logical sequence and include sufficient practical detail for another person to carry out the experiment without any additional information.
- Candidates should use scientific terminology when referring to quantities, such as volume, concentration and mass. Answers that use 'amount' are not credited.
- When evaluating conclusions based on experimental data, candidates should be aware that a statement or inference for which there is no experimental evidence cannot be supported.

General comments

Candidates appeared to have sufficient time to complete the examination paper. Most candidates were able to answer within the number of lines provided. There were instances where the quality of writing made it difficult to read the intended answer, particularly when answers were crossed out and rewritten above or when numbers were changed without crossing out the original.

Answers varied in quality and it was evident in **Question 1(a)(ii)** and **Question 1(b)** that many candidates found it difficult to describe a workable practical method. The best candidates were able to show an understanding of experimental procedure and apply this to questions, enabling them to identify variables, describe how to obtain reliable results and use appropriate apparatus. Less good responses often reflected uncertainty about units for volume and concentration and how to sequence the method for an investigation. Some of the mathematical processes tested seemed unfamiliar to candidates, in particular how to use control values to calculate rate and the meaning of 'significant at $P < 0.05$'.

Comments on specific questions

Question 1

This question was about the effect of immobilisation on the activity of an enzyme. Candidates were expected to devise a method by which the activity of the same enzymes in an immobilised state and in a free (non-immobilised) state could be compared by measuring time to decolourise a redox indicator. The use of statistics was also tested.

(a) (i) Most candidates correctly identified the dependent variable but only high scoring candidates gave a precise answer for the independent variable. Poorer answers were too vague, for example 'the enzyme' or 'type of enzyme' or 'immobilisation'.

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(b) There were some good answers to this question, gaining maximum credit. However, many candidates had not read the question carefully and so made a range of concentrations of either the enzyme or the ethanol. The best answers usually included relevant practical details such as using the same appropriate apparatus and procedure for both the immobilised and free enzyme. Candidates, who had clearly carried out experiments using columns containing beads of immobilised enzyme through which substrate was poured and product collected, also described this as way of testing a free enzyme. This is unworkable for a free enzyme so did not gain credit. Most candidates gained credit for a method of measuring the dependent variable and also for using a water-bath to maintain a constant temperature for both experiments; some also referred to using a buffer to maintain a constant pH. Poorer answers often stated 'use a water-bath' and 'use buffer', which were not credited as no reason was given for their use. Only the best answers showed an understanding that the temperatures of the enzyme and substrate should be equilibrated at the test temperature before mixing and that the indicator should be added before the enzyme and substrate are mixed.

Many candidates ignored the information in the question which stated that specific concentrations of enzyme, ethanol and NAD were used and so referred to using the 'same concentrations', but without any reference to volume. To make a valid comparison between the same enzyme in two different states, the volume is as critical as the concentration. In some answers it appeared that the candidates were using concentration units ($mg\,dm^{-3}$ or $mol\,dm^{-3}$) as volume units. Poorer answers often referred to 'same amounts' throughout their answer and frequently omitted to mention using NAD.

Most candidates referred to improving reliability by taking a mean of three repeats, although only better answers made it clear that this was obtained from the results of three separate experiments for the free enzyme and for the immobilised enzyme. Candidates should be encouraged to refer to replicates, rather than repeats or readings.

Many candidates recognised that this was a low risk investigation so that no special precautions, other than standard laboratory safety, were necessary. Credit was allowed for those candidates who knew that ethanol is flammable and should not be used near open flames. Poorer answers stated that ethanol is toxic, which is true in high concentrations inside cells, but not when used in the low concentrations for *in vitro* experiments.

Some candidates gave an answer clearly modelled on previous mark schemes for this type of question, which is inapproriate in this case. Commonly they gave a list of variables that restated the independent and dependent variables, followed by the variables to standardise but without describing any methods. For example in this investigation, many candidates listed 'the enzyme' as the independent variable and then described how to immobilise 'the enzyme'. Similarly, the dependent variable was listed a 'time for methylene blue to change colour', without any reference to how this was to be measured. Candidates are expected to describe a method that could be used as a procedure by another person, so that practical details are in a correct sequence that specifies what apparatus to use, how to standardise variables that may affect the results and how to measure the independent variable.

(c) (i) Very few candidates were able to explain how to use the results of a control experiment in a calculation. Better answers described the expected method of finding rate by dividing 1 by the time taken for the methylene blue to decolourise. Poorer answers made assumptions about further calculations not provided by the question. These candidates, for example, divided the amount (concentration) of product collected by time or the amount (concentration) of the substrate used. There were many candidates who were not familiar with rate calculations, for example some calculated a mean of the free and immobilised enzyme, others calculated a percentage difference between the free and immobilised enzyme.

(ii) Most candidates gained some credit for this question, commonly for defining standard deviation. Better answers also commented on the reliability of the data in relation to the standard deviation. Some candidates confused standard deviation with standard error and so referred to the reliability of the mean rather than the reliability of the results. A common answer, which was not credited, was that standard deviation shows the reliability of the experiment. A common misconception was that a small standard deviation means the results are significant.

(d) There were very few good answers which clearly explained the meaning of both 'significant' and '$P < 0.05$'. Many answers were confused and described probability in ways which suggested that

candidates did not understand these terms. Others included statistical terminology that was irrelevant.

Candidates with some understanding of statistical tests usually gained credit for describing 'significance'. Good answers made it clear that it meant that the differences in the results were not due to chance or were due to an external factor. The understanding of 'P < 0.05' was less well explained. The best responses made it clear that it means that there is a 5% or less chance that the differences were due to chance. Credit was also allowed for stating that it means that there is a 95% or more chance that the difference in the results is due to an outside factor. It was important that the value was processed into an appropriate %, not just left as the raw figure. Poorer answers made fundamental errors in explaining the terms, for example, that 'P < 0.05' meant that 5% of the results were due to chance, which suggests that out of each 100 results, some results are significant and some are not.

Question 2

This question was about the results of a field investigation into feeding relationships. As this was an investigation likely to be unfamiliar to most candidates there was a lot of information given about the experimental set up that candidates needed to use to identify the variables and how these had been taken into account during the investigation. Candidates were expected to evaluate the conclusions in relation to the experimental results and then suggest how the whole investigation might be improved to achieve the stated aim.

(a) (i) Most candidates were able to identify an appropriate variable, commonly the time for which the radioactive phosphate was supplied.

(ii) Many candidates were able to identify a variable that should have been standardised, commonly the concentration of radioactively labelled phosphate in the solution, or the volume of the solution containing the radioactively labelled phosphate ions. Some answers did not gain credit because of inappropriate wording, for example, the volume of the phosphate ions.

(b) (i) Many candidates understood the principle of this calculation, but did not gain credit as they divided the 'amount' or number of phosphate ions by the mass of the sample. Geiger counters measure radioactivity, as specified by the question. Poorer answers divided by time or unit biomass

(ii) Only the best answers showed an understanding that the tissue samples of different mass could only be compared if the radioactivity per unit mass was known. Answers often re-stated the sentence from the stem of the question about masses being varied but did not link this to making comparisons, so did not gain credit. Others stated that without calculating per unit biomass the results would not be valid, missing the key element about making the results comparable. Some gave answers such as 'to see feeding relationships' or 'to show the movement of phosphate through the food chain'.

(c) (i) Very few candidates gained maximum credit for this question. In some cases this appeared to be the result of misinterpreting **Fig. 2.2**, for example, stating that species **X** was another plant or relating the feeding of secondary consumers only to species **X**. When evaluating conclusions in relation to data and experimental procedure candidates should consider what the data actually shows, not what might be reasonably inferred from biological knowledge. Most candidates gained credit for their answer for conclusion 3; better answers also gained credit for their answer to conclusion 1 and sometimes conclusion 2. Answers for conclusion 4 were rarely correct. Some answers described the curves on the graph.

To evaluate conclusion 1, candidates needed to use the curves for other primary consumers and that of secondary and tertiary consumers and realise that there is a time delay before radioactivity appears in the secondary and tertiary consumers, thus supporting the conclusion. Most candidates compared only species **X** to the secondary and tertiary consumers, stating that as radioactivity in **X** decreased the secondary and tertiary consumers increased because they had eaten species **X**. Other answers omitted to mention any primary consumers.

To evaluate conclusion 2, candidates needed to use the curve for species **X** and note that the radioactivity does increase while the well are attached, but there is no experimental evidence about how the phosphate is being used. Some candidates suggested it could not be true because the radioactivity decreased rapidly after the well were removed and so could not have been

incorporated into any molecules. These answers were not credited as there is no experimental evidence to support this.

To evaluate conclusion 3, candidates needed to use the curve for other primary consumers and notice that radioactivity increases during the first week when the wells were attached. As these plants are the only source of radioactivity, the conclusion is supported. A common error in these answers was that the other primary consumers must be eating species **X**.

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(ii) Candidates found this question difficult and few gave a correct answer. The majority included an inference from knowledge which was not supported by the data. Radioactivity of Species **X** increases rapidly when the wells are present, other primary consumers are less rapid, so the conclusion that **X** absorbs / takes in phosphate more rapidly than other primary consumers can be supported.

(d) Most candidates did not appear to consider that the presentation of the data for the investigation was not especially helpful in working out feeding relationships, which was the aim of the study. A few good answers pointed out that the data for each of the individual species studies should be shown separately. Better answers also noted that only one species of plant had been labelled and that there were other members of the community that had not been considered, such as quaternary consumers and the decomposer system. Poorer answers were often too vague to be credited, for example ‘use more plants’, which could mean either more of the same type of plant, or different species of plant. A very common answer was ‘do more repeats and take a mean’ which is not appropriate for this type of field experiment where samples are being taken from a number of organisms over a period of time.

BIOLOGY

Paper 9700/52

Planning, Analysis and Evaluation

Key messages

- When describing an experimental method, candidates should organise it into a logical sequence and include sufficient practical detail for another person to carry out the experiment without any additional information.
- Candidates should use scientific terminology when referring to quantities, such as volume, concentration and mass. Answers that use 'amount' are not credited.
- When evaluating conclusions based on experimental data, candidates should be aware that a statement or inference for which there is no experimental evidence cannot be supported.

General comments

Candidates appeared to have sufficient time to complete the examination paper. Most candidates were able to answer within the number of lines provided. There were instances where the quality of writing made it difficult to read the intended answer, particularly when answers were crossed out and rewritten above or when numbers were changed without crossing out the original.

Answers varied in quality and it was evident in **Question 1(a)(ii)** and **Question 1(b)** that many candidates found it difficult to describe a workable practical method. The best candidates were able to show an understanding of experimental procedure and apply this to questions, enabling them to identify variables, describe how to obtain reliable results and use appropriate apparatus. Less good responses often reflected uncertainty about units for volume and concentration and how to sequence the method for an investigation. Some of the mathematical processes tested seemed unfamiliar to candidates, in particular how to use control values to calculate rate and the meaning of 'significant at $P < 0.05$'.

Comments on specific questions

Question 1

This question was about the effect of immobilisation on the activity of an enzyme. Candidates were expected to devise a method by which the activity of the same enzymes in an immobilised state and in a free (non-immobilised) state could be compared by measuring time to decolourise a redox indicator. The use of statistics was also tested.

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BIOLOGY

Paper 9700/53
Planning, Analysis and Evaluation

Key Messages

- It is important to read the question carefully before starting to construct the answer.
- When describing an experimental method, candidates should organise it into a logical sequence and include sufficient practical detail for another person to carry out the experiment without any additional information.

General Comments

A good spread of marks was seen and candidates did not seem to have had a problem with completing the paper in the allocated time. There were some good answers on those questions requiring an understanding of statistics, although some candidates found it difficult to express such ideas clearly.

Comments on Specific Questions

Question 1

This question focused on immobilised enzymes and many candidates seemed familiar with the concept, and also with the practicalities. This suggested that many had practical experience in this area.

(a) (i) Many candidates gained credit here by correctly stating that the null hypothesis would be that there would be no significant difference in the enzyme activity regardless of the type of immobilisation. This was sometimes acceptably expressed in terms of production of glucose. Many candidates did not qualify 'difference' with the term 'significant'. Some candidates stated that there was no significant difference in the types of immobilisation with no reference to the reaction or product. There were some who confused the null hypothesis with the alternative hypothesis.

(ii) This was generally well answered. Some lost credit by referring to the immobilisation of the enzyme without the qualification of type or method of immobilisation. There were also some responses which incorrectly cited the concentration of lactose.

(iii) This question required that the candidates indicated that the dependent variable was glucose concentration as well as describing a suitable method of measuring it. The syllabus refers to the use of a biosensor. Descriptions such as glucose monitor or a suitable alternative like clinistix or dip stick were all acceptable. A large number of responses gave the Benedict's Test as their answer, which measures any reducing sugar, not just glucose. Credit was gained if they linked it to comparison to a colour standard or measuring colour using a colorimeter or weighing the precipitate. Answers which did not gain credit were those stating that the darker colour shows a higher concentration, as that is not measuring the actual concentration. There were a number of candidates who suggested timing the reaction until it went red. This would not give the concentration of glucose.

(b) For this question candidates need to give practical details of how such an investigation would be carried out. A good way to approach this is to try to set the answer out as a set of laboratory instructions. Where appropriate, the reason behind the procedure described should be given, for instance why a particular precaution is needed. There were a number of very good and clear descriptions of the method, suggesting many candidates were familiar with this technique. Some candidates gave detailed accounts of how enzymes are immobilised, even though they are told in the introduction to the question that they had been immobilised already. Some candidates described a simple outline of the principles of the technique. Whilst this showed understanding of

the basis of the investigation, it lacked the practical details required to gain full credit. In most cases it was clear that they would carry out an equivalent procedure on each of the three types of immobilised lactase, though there were a few who only used one type of immobilisation. There were also those who described using a range of different concentrations of lactose with each type of immobilisation, often with details of serial dilution. Credit was still available in this case if they had standardised the approach, but much time was wasted on dilution techniques.

Although it was anticipated that candidates would use the information given when suggesting a procedure and thus use some type of column, credit was given for equivalent ideas if the investigation was carried out in separate flasks or other container. Credit for procedural details was given for using a suitable apparatus for the column and collecting the product of the reaction. Burettes or syringe barrels were most suitable for the column, but other pieces of apparatus were allowed. A beaker was the most usual way of collecting the product, although quite a few responses did not include this practical detail. Reference to a method of controlling the flow rate through the column was expected. Answers such as 'pour carefully or slowly' was not specific enough for credit. Most candidates gained credit for a correct reference to standardising the time for reaction between the enzymes and substrate and for a method of measuring the glucose concentration.

Most candidates were aware that the enzyme concentration in the three different mobilisation methods needed to be the same. A number of responses contradicted themselves by suggesting weighing out the same mass of immobilised enzyme. This would not give equivalent concentrations as the immobilising agents have very different masses. Immobilising the same mass of enzyme was accepted. Similarly, candidates were aware that the volume of lactose solution should be standardised, although many referred to 20 mg cm^{-3} as a volume, when it is the concentration they were provided with. Those who used milk did not gain credit here.

The need to maintain a constant temperature and pH with methods for controlling them were well known. Air conditioning is not a suitable method for experimental control of temperature. Although candidates often referred to standardising the time that the enzyme was in contact with the substrate, expressed in a variety of ways, they did not always mention a suitable timer.

Most candidates referred to improving reliability by repeating at least twice and either calculating a mean or to allow anomalies to be dealt with. Better answers identified a suitable hazard and precaution. Some responses were too general - stating that the solutions are harmful is not sufficient. Candidate should identify a specific risk and then give an appropriate precaution. Overall this investigation would not be particularly hazardous if normal laboratory rules were followed and so mention of a low risk was credited

(c) (i)(ii) The vast majority of candidates calculated correctly. Most also knew that time was needed to calculate a rate. A few suggested time for the Benedict's test and thus got the context wrong. Relatively few gave the volume of lactose solution as the other required piece of information.

(d) (i) There were some good answers which clearly explained what both 'significant' and '$P < 0.05$' meant, but also many cases where there was muddled expression which which suggested that candidates did not understand these terms. Understanding of the term significant was the point where credit was most often given. Good responses made it clear that it meant that the differences in the results were not due to chance or were due to an external factor.

The understanding of $P < 0.05$ was less well explained, but the best responses made it clear that it meant that there was a 5% or less chance that the differences were due to chance. It was important that the value was processed into an appropriate %, rather than left as the raw figure. There were a variety of ways of expressing these ideas that gained credit. However there were a number of answers which made key errors in explaining the terms. Some responses suggested that '$P < 0.05$' meant that 5% of the results were due to chance which is not the correct explanation as it suggests that out of each 100 results, some results are significant and some are not. Many candidates included statistical terminology that was irrelevant which resulted in confused answers.

(ii) This question was generally well answered. Most candidates quoted the mean total glucose collected was the highest or gave the value. A few only referred to the mean concentration being higher, which does not take account of the volume collected. Use of **Table 1.2** was also often well done but weaker responses only said that **A** and **B** or **A** and **C** were significant, leaving out the idea that it is the difference between **A** and **B** or **A** and **C** that is significant.

Question 2

This question proved to be challenging for many candidates. Candidates needed to read the material very carefully in order to apply their ideas to novel situations.

(a) (i) Most candidates gained some credit for this question with many responses covering the ideas that it would make comparison between different sized leaves possible. Poorer answers gave the idea of different sized leaves, but followed this up with rather general references to 'fairer' or 'more accurate'.

(ii) This question was often misinterpreted as asking for the mean cpm of one leaf, or one plant, not all the covered or all the uncovered leaves. Thus credit was lost as candidates either divided by area or by five (the number of leaves on one plant). The divisor should have been 30.

(b) (i) Candidates found this question difficult. There were two observations that the candidates were asked to comment on and answers which separated out the two tended to make clearer statements. Linking the higher count in uncovered leaves to higher photosynthesis and to higher transpiration gained credit as did the greater production of phosphate containing organic molecules like ATP (which would tend to stay in the leaf longer). There was some confusion in thinking that making molecules like ATP would reduce the radioactivity. Suggesting valid reasons for the peak at day three proved more challenging for candidates. The change from labelled to unlabelled phosphate had occurred at day 0, thus for the first day or so labelled phosphate would still be passing up the plant into the leaves. After day three some will be passing out of the leaves in various synthesised organic molecules and be replaced in the leaf by unlabelled phosphate. A number of responses thought that radioactivity was lost by evaporation

(ii) This question was specifically about the reliability of the results. Many gained some credit for the general idea of repeating the experiment, but did not develop this into precisely what that meant in terms of 'more readings per leaf'. Details like taking more leaves or more plants were often missed. Relatively few responses suggested that calculating the standard error or standard deviation would be suitable in that it would allow an assessment of the reliability of the results. Some candidates misinterpreted the question and talked about control variables like light and temperature being standardised, or suggested trying different species or ages of plants.

(c) This question produced many confused accounts that gained little credit. The information in the question makes it clear that radioactivity causes dark spots to appear on an X-ray film. Despite this, many candidates suggested that the leaf should be subjected to X-rays, and some even considered that the parts containing ^{32}P would show up white. Careful thought after reading the material might have reduced these errors. The question was asking them to describe how to find out which tissue is transporting the ^{32}P to the leaves. Thus cutting a section of the stem (or leaf), placing the X-ray film on it and waiting for it to develop black spots will indicate the tissue area concerned. This would then need to be identified by comparison with an anatomical section, micrograph or diagram to identify the actual tissue. Some credit was gained for responses which placed the film on or above the leaf rather than on sections of the stem or leaf, or even where tissues were dissected out and then had the film placed on them, though the latter approach would not be very practicable. Other answers that did not gain credit were the idea that the water could be extracted separately from each tissue to see which water blackened the film and the idea that the whole leaf could be extracted and then the extract separated by electrophoresis on agar gel.

(d) There were many confused answers here. The candidates needed to relate back to the original data and then predict the effect of carrying out the experiment in moving air. The key point was that any differences would need to be related to the difference in this experiment, which was the introduction of moving air. Thus, covering the leaves would mean that the moving air would have little or no effect on transpiration.

In uncovered leaves the measurements would change and there were various possible suggestions as to what might occur, but few candidates were able to successfully link them to the effect of moving air. A few responses gained credit for suggesting that if the air movement was considerable it would cause stomatal closure thus lowering the level of ^{32}P or making it like covered leaves, as less is drawn up. There were also some creditable responses suggesting that moving air could draw more air through the leaf, increasing gas exchange and thus photosynthesis.