BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

There was a good spread of scores. The questions that candidates found relatively straightforward were **Questions 1, 8, 12, 15, 18, 31, 33, 36, 38 and 39.** The most difficult questions were **Questions 5, 13, 24, 28, 34 and 35.**

Comments on specific questions

Question 2

This question was straightforward for most candidates. However, the majority of less able candidates answered this incorrectly.

Question 5

The relative difficulty of this question was due to the majority of candidates being unaware that chloroplasts, mitochondria and prokaryotes all contain 70S ribosomes. Therefore options **A**, **B** and **D** are incorrect.

Question 6

More than half of all candidates answered correctly, although less able candidates found this question difficult. Candidates who have carried out tests for biological molecules should know that the observations shown indicate that there is no starch. Additionally, since sucrose is a non-reducing sugar, the presence of this substance cannot be detected because it was not tested for.

Question 7

Most of less able candidates found this difficult, although the majority of more able candidates answered this correctly. Candidates who have carried out practical work that includes tests for biological molecules should know that the second procedure is not involved in order to test the polymer of reducing sugars for the presence of reducing sugars.

Question 11

The majority of candidates answered correctly and showed that they understand the basic dogma of DNA and coding for amino acids.

Question 13

Whilst the vast majority of more able candidates answered correctly, the less able candidates were unable to process the information and appeared to guess the answer.

Question 14

The majority of more able candidates were able to process this information and reason that the number and position of transmembrane proteins involved in active transport would be least changed.

Question 16

Whilst most candidates answered this question correctly, some of the less able candidates do not understand that facilitated diffusion does not require ATP.

Question 19

Many candidates found this question difficult. The first sterile hybrid would have 14 chromosomes (7 from wild wheat and 7 from goat grass), when this chromosome number is doubled to form the fertile hybrid 1 it will have 28 chromosomes. The second sterile hybrid would have 21 chromosomes (14 from fertile hybrid 1 and 7 from another grass), when this chromosome number is doubled to form the fertile hybrid 2 it will have 42 chromosomes.

Question 20

In order to answer this question candidates needed to understand that a chromosome consists of a DNA molecule and that at the end of prophase in mitosis, each cell will contain 92 molecules of DNA as semi-conservative replication of DNA will have occurred in interphase. The majority of less able candidates thought cell 1 had 46 molecules of DNA.

Question 24

Less than half of candidates answered this correctly, although the majority of more able candidates found no difficulty with the question. Less able candidates did not understand this question as almost equal numbers selected each option, indicating that they were guessing.

Question 28

The processes involved in loading sucrose into a sieve tube element are poorly understood by most of the less able candidates, whilst the vast majority of more able candidates answered correctly.

Question 34

Those candidates who realised that the question asked for the minimum number of cell membranes crossed by a molecule of oxygen and a molecule of carbon dioxide when passing to or from the alveoli to the capillary knew that 4 was correct for both. Option **C** was incorrectly selected by many candidates, but oxygen only passes through 5 membranes when it enters the red blood cell.

Question 35

Most candidates found this question difficult, mainly because they were unaware of the slow reproduction of the bacterial pathogen. However, a significant minority answered correctly.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

There was a good spread of scores. The questions that candidates found relatively straightforward were **Questions 5, 7, 11, 12, 13, 21, 28, 35, 38 and 40.** The most difficult questions were **Questions 10, 18, 25, 27, 31 and 32.**

Comments on specific questions

Question 2

Those candidates who had used stage micrometers to calibrate an eyepiece graticule would be familiar with this scenario. Most candidates were able to determine that one eyepiece graticule unit equals 2.5 m. Therefore, 4 eyepiece graticule units equal 10 m, which is 1.0×10^{1} m in standard form.

Question 4

Whilst more than half of all candidates answered this question correctly, a minority incorrectly identified structure **Y**. Since this is a starch grain, it does not contain chlorophyll.

Question 8

Candidates who have carried out tests for both reducing sugars and non-reducing sugars should know that since solution 2 gave a blue colour with the Benedict's test, it could contain either 0.0% reducing sugar or non-reducing sugar. Additionally, candidates should know that the colours produced by the Benedict's test go from green (low concentration of reducing sugar) to yellow (medium concentration of reducing sugar) to brick red (most concentrated reducing sugar concentration.

Question 10

More than a third of all candidates answered this question correctly. However, a significant number of candidates incorrectly thought that glycerol linked to fatty acids enable formation of a lipid bilayer. The formation of a lipid bilayer in cell surface membranes occurs because phospholipids are polar molecules because of the phosphate group which makes the 'head' hydrophilic.

Question 14

Most candidates correctly matched the role of the components to the labelled components.

Question 18

Many candidates found this question difficult, with a significant number incorrectly selecting option **D**. This is not correct, since mitosis does not result in cell repair, although it can result in cell replacement.

Question 25

The majority of more able candidates had no difficulty with this question and only selected those adaptations which would contribute to a reduction in the water potential gradient.

Question 27

Most candidates found this question difficult as they did not know that all four substances are found in blood, lymph and tissue fluid. Proteins such as antibodies will be found in all the fluids.

Question 30

Whilst most candidates answered this question correctly, a minority incorrectly selected options **A** or **B**. These candidates had not taken into account that, in order to pass through a cell, the oxygen or carbon dioxide has to go through the cell membrane on each side of the cell.

Question 31

Many candidates incorrectly selected answers which included statement 3. The release of adrenaline does not increase the risk of atherosclerosis.

Question 32

The majority of more able candidates answered this question correctly. However, most of the less able candidates did not select the correct flow diagram. The tar in cigarette smoke contains carcinogens which cause mutations which lead to uncontrolled cell division.

Question 33

A significant minority of candidates did not realise that lung cancer could reduce the surface area available for gas exchange. However, most of the more able candidates answered correctly.

BIOLOGY

Paper 9700/13
Multiple Choice

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

General comments

There was a good spread of scores. The questions that candidates found relatively straightforward were **Questions 3, 6, 12, 17, 21, 24, 33, 34, 35 and 37.** The most difficult questions were **Questions 1, 5, 8, 20, 32 and 39.**

Comments on specific questions

Question 1

The majority of candidates did not realise that an eyepiece graticule can only be used to determine the length of cells if it has been calibrated against a stage micrometer scale. Additionally the size of the eyepiece graticule does not change as the objective lens is changed.

Question 2

Whilst most candidates understood the use of standard form and answered this question correctly, a minority were unable to manipulate the figures to obtain the answer.

Question 5

The relative difficulty of this question was due to the majority of candidates being unaware that chloroplasts, mitochondria and prokaryotes all contain circular DNA. Therefore options **A**, **B** and **C** are incorrect.

Question 8

Whilst most of the more able candidates answered this correctly, a minority of less able candidates did not understand that condensation reactions are used to form amylose and amylopectin, whilst hydrolysis reactions break them down.

Question 9

A small number of candidates found this difficult. Candidates should know that amylose is formed only from α-glucose.

Question 20

A significant number of candidates did not take into account the size of the cell labelled 4. Cell 4 and the cell to the right of it have been produced recently as a result of cytokinesis. Cell 3 is at least 3 times larger as a result of the G phase in interphase allowing the cell to proceed to prophase.

Question 21

All of the more able candidates were able to process this information and answered correctly.

Question 25

Whilst most of the more able candidates had no difficulty with this question, more than half of less able candidates incorrectly thought that stomata are likely to close when atmospheric humidity is high.

Question 27

Analysis of the responses to this question would indicate that whilst almost 90% of the more able candidates knew the answer, the less able candidates just guessed.

Question 29

In order to answer this question, candidates needed to apply their knowledge of plant transport in a novel situation. They should have been able to eliminate statement 4, since active transport does not affect the transpiration stream. Statement 3 should be eliminated as more water will be transported to the leaves (along with the heavy metals) when the plants photosynthesise.

Question 32

Most candidates found this question difficult as they did not know that all four substances are found in blood, lymph and tissue fluid. Many did not realise that fatty acids will be found in all the fluids.

Question 39

The majority of candidates do not understand that the least efficient energy transfer in a food chain is always between the sun and the producer.

BIOLOGY

Paper 9700/21
As Structured questions

Key messages

- Candidates should read questions all the way through before answering part **(a)** of each question and then should rehearse their answers in their minds before writing. When appropriate, they should use key scientific terms and sequential responses.

- When using the term 'transmission' or phrase 'mode of transmission' as applied to an infectious disease, candidates should consider the transfer of the pathogen from the infected person to an uninfected person. Descriptions of transmission should begin with the infectious person and should include the sequence of events that lead to the pathogen gaining entry into the uninfected person. For example, in **Question 1(d)** a full description of transmission for cholera can be compared to a part-description:
'faeces contaminated with *Vibrio cholera* enter drinking water, which is subsequently drunk by an uninfected person' is a complete answer compared with 'an uninfected person drinks contaminated water' which is incomplete and does not include the name of pathogen or say how the water becomes contaminated.

- In **Question 4(c)** many candidates correctly identified the cells described as memory cells. As a general note when answering questions about memory cells, candidates should realise that there are memory B-lymphocytes and memory T-lymphocytes, but not a general memory cell that, during the secondary immune response, forms both more B-lymphocytes (plasma cells) and more T-lymphocytes.

General comments

For many candidates this proved to be a straightforward paper without any complex data to analyse. However, there were several questions which proved challenging to analyse and these were well attempted by some candidates. Others often did not see beyond the contexts of the questions and did not attempt to consider the requirements in terms of syllabus topics. For example, in **Question 4(b)(i)** candidates wrote about the role of B-lymphocytes and/or plasma cells in an immune response rather than apply their knowledge of protein synthesis from ***Section E*** of the syllabus. They also found it difficult to outline the process of protein synthesis. Similarly, in **Question 3** they did not distinguish between the two stages of starch digestion, writing about the action of maltase as if it were amylase. Also, in **Question 5(c)** there were many occasions where candidates wrote splendid accounts of the cardiac cycle without referring to the control mechanisms.

Candidates often write answers that have the correct ideas but that include more detail than required and in so doing have given incorrect answers. Examples of this are discussed in comments on specific questions in **Question 1(b)** and **Question 5(a)**

There was no evidence that candidates had insufficient time to complete all questions. Some candidates wrote over crossed out attempts so, for example, in **Question 1(b)** the letter **C** became a **D**. In these circumstances, candidates should cross out and rewrite their answers rather than write over them. Care needs to be taken over measurements: some candidates lost credit in **Question 1(a)** by measuring in centimetres instead of millimetres and then multiplying by 1000 instead of by 10 000 to convert their answer into micrometres.

In answer to **Question 3(c)** some candidates wrote excellent answers about competitive inhibition and then went on to say that the inhibition could be non-competitive and so were unable to gain full credit as they had contradicted themselves. The same sort of error happened in **Question 1(d)**, where excellent descriptions

of the faecal-oral route of transmission were given, but then candidates stated that *Vibrio cholerae* is also spread by dirty needles, insect vectors, airborne droplet and/or by sexual intercourse.

In **Question 5 (b)**, many candidates were unsure about the roles of the papillary muscles and heart tendons. Candidates often could say no more than that the atrioventricular valve prevents backflow.

Comments on specific questions

Question 1

This question covered a variety of learning outcomes in the context of cholera from ***Section I*** of the syllabus.

(a) Most candidates calculated the expected answer of x30 000 for the magnification of the diagram of *V. cholerae*. The most common error was to convert the measurement of the scale bar in centimetres by multiplying by 1000 instead of by 10 000. Almost all candidates knew to divide their measurement of the scale bar by its actual length and so gained a mark for their working even if they had made an error in applying a conversion factor. Some candidates muddled cm and mm; for example, they measured the scale bar as 9 mm. A few candidates had measurements of the scale bar that were far smaller than 90 mm (± 2 mm). Some candidates mistakenly added a unit to the answer line and as a result were not awarded full credit for this question.

(b) Answers to this question that involved identifying and naming the structures within *V. cholerae* were often successful. The main reason for not gaining full credit was not qualifying the cell membrane (**C**) as the cell surface membrane or the plasma membrane. 'Cellulose cell wall' was an example of an answer with too much information that cost some candidates credit. Structure **G** attracted a variety of answers: 'DNA' and 'chromosome' being the most popular. Candidates should know that plasmids are much smaller than the chromosome shown in Fig. 1.1. There was some confusion over chromatid and chromatin: these were answers given for **G** that did not gain credit. Structure **D** was often identified incorrectly as the ribosome.

(c) This question attracted many correct answers stating several structures characteristic of eukaryotic cells, such as 80S ribosomes, endoplasmic reticulum and nuclei. Credit was lost by imprecise answers and here 'cell wall' unqualified by cellulose did not gain credit. Some candidates saw 'plants' in the question and possibly without thinking wrote 'chlorophyll' rather than the organelle that contains this photosynthetic pigment. Some gave cuticle and stomata or the names of plant tissues, such as mesophyll, xylem and phloem.

(d) Many candidates easily gained full credit here for describing successfully the transmission of the cholera pathogen. They referred to faeces, or sewage, as being the way in which the pathogen leaves the infected person and drinking contaminated water or eating contaminated food as the pathogen's method of entry to the uninfected person. Candidates were provided with considerable guidance by the wording of the question so that reference to infected and uninfected people when describing methods of transmission was usually made. Some candidates stated that water was 'infected' by bacteria. This was not credited. Many were not clear in their answers about what it was that was contaminating water from the infected person or how water/food got into the uninfected person. For example, a significant number of candidates referred to waste or excreted material rather than faeces. Quite a few thought that cholera was caused by a virus; many wrote about airborne transmission instead of the faecal-oral route.

(e) Many candidates knew ways in which the spread of cholera is controlled, but very few were able to say how our knowledge of the pathogen helps in this. The bacteria are at their most vulnerable when passing between hosts. Control methods are most effective when they completely break the transmission cycle as happens in countries with good sewage systems, water treatment plants and piped water supplies. Use of 'lifestraws' to filter water was described by several candidates. Some answers were vague catch-all answers to a pathogen question, making reference to overcrowding, cleanliness, improved living conditions and hand washing.

Question 2

This question assessed knowledge and understanding from ***Section K*** of the syllabus. Candidates were asked to identify some key terms used in ecology and to explain the role of nitrogen-fixing bacteria in ecosystems.

(a) Although many had no problems stating the correct key terms, others muddled the terms. Some had several attempts at their answers. Population and community were frequently switched and ecosystem was often given instead of community.

(b) There was considerable confusion about the role of nitrogen-fixing bacteria. Candidates often confused the process of nitrogen fixation with that of nitrification, or even denitrification, and indeed sometimes conflated the two processes. Many stated incorrectly that nitrogen is fixed as nitrate ions that are used by bacteria and/or host plants. Credit was not awarded for answers like this nor for the statement that these bacteria produce both nitrate ions and ammonium ions. Credit was awarded for the use of fixed nitrogen in making amino acids and then using these in protein synthesis. Fewer candidates saw this question in a wider context and wrote about the role of nitrogen-fixing bacteria in replacing losses in nitrate ions, for example when these ions are leached or when soil is eroded.

Question 3

Knowledge of biochemistry, ***Section B***, is an area of the syllabus that has improved considerably over the years and this question was generally answered well by many candidates.

(a) (i) There were many good answers to this question and, in the great majority of cases it was possible to find how candidates thought that the glucose molecule is added to the growing amylose chain. In almost all cases, water was shown being formed and the glycosidic bond was drawn correctly. More challenging was indicating the –H and HO- groups on the terminal glucose residue of amylose and the glucose molecule respectively. Credit was awarded to candidates who encircled these groups and also accepted –OH and –H respectively. The most common error here was encircling two –OH groups. Some candidates omitted the oxygen bridge although this was very rare; a few made a 1-6 link instead of a 1-4 link. Some candidates stated that a hydrolysis reaction occurred, but still showed water being produced which could not be credited as this was a contradiction.

(ii) Most candidates gave glycosidic as the name of the bond that they had formed in **(a)(i)**. Common errors here were peptide, hydrogen, ester, sulfide and covalent. Misspellings that were not credited included 'glycodisic'.

(b) There were two major problems with completing the table comparing the polysaccharides. Some candidates were careless over naming α- (alpha) and β- (beta) glucose, using the letters a and b instead. The most common answer for the role of cellulose was as a component of cell walls. Some stated that the role of cellulose was in support. This is a role appropriate to cell walls or to cells with cell walls. Credit was awarded if a correct role was given as well. 'Strength' alone was given frequently instead of 'tensile strength'.

The inclusion of energy storage in the table prompted almost all candidates to use the same term for glycogen rather than unacceptable alternatives such as 'food storage'. Some candidates, however, were unclear about the role of glycogen stating that it is 'used for energy', rather than it is a storage material.

(c) (i) The candidates who realised that this was a question about competitive inhibition easily gained the full credit available. Some gave non-competitive inhibition and still managed to gain the points that are common to both forms of inhibition. A very small number gave both competitive and non-competitive inhibition which limited the credit available. The name of this inhibitor led some to believe that it is an enzyme that digests maltase rather than a compound that inhibits the enzyme. Credit was available to award marks for these answers. Many candidates thought that starch was the substrate of maltase. There was also some confusion over maltase and maltose and some candidates appeared not to take care over how they wrote these two words. Many restated their answer to part **(c) (i)** explaining again the role of ascorbase as a competitive inhibitor. Many candidates referred to the digestion of starch - the name of the enzyme should have been a good clue.

(ii) Some candidates did not see the bigger picture here. Slowing down the digestion of maltose meant that less glucose is released to be absorbed into the blood. Many stated that the breakdown of starch would not occur, forgetting that amylase will still be active digesting starch to maltose. Very few candidates realised that the substrate for maltase is maltose. The majority referred to the

breakdown of starch. Very few gave comparative answers by stating that there is less glucose formed or that the formation of glucose is lower when the inhibitor is taken. Very few wrote about glucose entering the blood stream. Most referred to glucose concentrations becoming 'stable'.

Question 4

There were some excellent answers to this question, which included careful reading of **(b)(i)** to stay focused on the correct points. Those that did not gain credit in **(b)(i)** did not realise that it was asking about how antibodies are produced in plasma cells by protein synthesis, and not about the role of B-lymphocytes in an immune response.

(a) (i) Most candidates defined 'non-self' as foreign. There were some alternative ways to express this idea which gained credit if candidates conveyed the idea of 'foreign' by explaining that they were substances not produced or not present within the body. Fewer candidates went on to explain the term *antigen*. There were many very good answers, but many candidates did not see that it was necessary to define this word as part of their answer. Correct answers that were seen more rarely were the nature of a foreign antigen as a macromolecule or as a named example, such as a protein or a glycoprotein. 'A non-self antigen is a foreign protein that stimulates an immune response' was a good, concise answer to this question.

(ii) Those who knew about cell surface receptors often gained full credit on this question on the recognition by B-lymphocytes of non-self antigens. Some stated that there are 'antibodies in the cell surface membrane', which was much more vague. Candidates often went on to state that the binding sites of these receptors are identical to the antibodies that each type of B-lymphocyte can produce. They also referred to the specific shapes of the receptors that are complementary in shape to the antigens. Several candidates explained the specificity of the antibody molecule rather than answering the question. A number of candidates were not sure how to answer this question. There were many comments about antigen presentation by macrophages and about T-lymphocytes that were not relevant to this question.

(b) (i) Candidates who responded correctly to this question often showed good understanding and gained full credit. A proportion of these drew on what seemed to be well-rehearsed answers to give an appropriate overview of the process of protein synthesis within a plasma cell. Some could have improved their response by writing less about transcription and including some more outline detail of translation. In addition, it would have been a benefit for some if they had looked ahead to **(b)(ii)** to avoid continuing their response and writing about export from the cell. Those that did not gain credit usually misinterpreted this question and wrote about the role of B-lymphocytes and plasma cells in an immune response rather than outlining how antibody molecules are produced within the cell.

(ii) To gain full credit, candidates had to explain that antibodies are carried within vesicles that move to the cell surface membrane and then fuse with it. Several candidates did not appreciate that the question asked *how* antibodies are released, not *when* they are released. The only common error was describing exocytosis as active transport. Credit was awarded for stating that the export of antibodies from the cells requires energy to move vesicles to the cell surface membrane. Exocytosis relies on membrane fusion and not on carrier molecules in the membrane. There were some good descriptions of the fusion of vesicles with cell surface membranes, such as vesicles 'everting' to release their contents.

(c) Most answers identified the cells as memory cells and there were many good descriptions of the role of these cells in the secondary immune response. Many candidates wrote concise, well sequenced, answers. These referred to the *same* antigen entering the body to trigger the faster secondary response. Others stated that it was the same 'disease' rather than the same antigen, which was not credit-worthy. A common error was the suggestion that antibodies are released directly from memory cells rather than from plasma cells formed by cell division of memory B-lymphocytes. Many comparative terms, such as faster or longer lasting were used to describe the secondary immune response and these gained credit. More vague answers that stated that memory cells remain in the 'body' or are 'long lasting' gained no credit.

(d) Fig. 4.2 showed a graph of the changes in DNA content over several cell cycles. Identifying the events during the cell cycle when the DNA content halves and doubles proved straightforward for candidates who tended to perform well overall and was frequently problematic for others. **W**, the halving of the DNA content, occurs during cytokinesis, whereas **Z**, the doubling of the content,

occurs when DNA replicates. Common incorrect answers for **W** included mitosis, transcription and telophase; translation was a common incorrect answer for **Z**. Some candidates described what was shown by the graph rather than answer the question and some included data quotes in their response.

(e) Many candidates were able to apply their knowledge of the aetiology of cancer to the particular example of acute lymphoblastic leukaemia. Most started their response by explaining that the children would be exposed to second-hand smoke and would be victims of passive smoking. They continued with a description of the events inside the lungs, although some missed the specific context of this question and wrote about mutations in the bronchial epithelium rather than in the appropriate group of lymphocytes. There were many correct references to proto-oncogenes becoming oncogenes and the mutation of tumour suppressor genes. There were many very excellent responses here, which reflected a good understanding of the sequence of events leading to tumour development.

Question 5

Weaker candidates often relied on knowledge of the pathway taken by blood through the heart or the sequence of actions of the four chambers and did not answer parts **(b)** and **(c)** with the expected information about valve action and control of the heartbeat.

(a) This question on the relative thickness of the two chambers of the heart visible in the photograph in Fig. 5.1 prompted many well written answers. Others could have gained full credit by some reference to the difference in quantity of muscle in the walls of the atrium and ventricle. A common error was to state that there is more *smooth* muscle in the wall of the left ventricle, which meant that credit could not be given. A few candidates misinterpreted the question and compared the thickness of the chambers on the left with those on the right, stating or implying that the wall of the left atrium is thicker than the wall of the right atrium 'because pressure is higher on the left hand side of the heart'. Also, a description of the ventricular wall withstanding the pressure or preventing bursting of the heart missed the point about the left ventricle generating sufficient blood pressure to overcome the resistance of the systemic circuit.

(b) A high proportion of candidates made clear statements to explain how the atrioventricular valve ensures that blood flows in the right direction. All the main ideas were given in these responses; however it was less common to see reference to pressure differences on either side of the valve. Candidates were less confident in their understanding of the role of the valve tendons and papillary muscles and so responses often lacked precision or gave confused accounts. Candidates needed to present the idea that the papillary muscles contract during ventricular systole and that tension in the tendons prevents the atrioventricular valve 'blowing back' into the atrium. Some responses stated this idea well. Candidates used a variety of terms to describe what would happen without this tension in the tendons and, if they had the right idea, gained credit. A number included the incorrect statement that the papillary muscles contract and pull on the tendons while the ventricle is in diastole, so *opening* the valve. Some talked about the blood passing 'through' a valve without a clear statement that the valve was open. The majority referred to the 'prevention of the backflow of blood' and many wrote that papillary muscles pump blood out of the ventricle. There were also many references to tendons contracting.

(c) The sequence of events in the control of the heart is a topic that is often answered very confidently. This question was no exception. If candidates had problems it was with the role of the atrioventricular node, which was often given a passive role in passing on 'the impulse' to the ventricles. Some candidates misread the question and described the pulmonary and systemic circulations or described the sequence of events in the cardiac cycle in terms of the flow and pathway of the blood, with no mention of electrical activity. Not all candidates noticed the trigger words in the stem. 'Coordinated and controlled' should have prompted answers about the sinoatrial node, atrioventricular node (AVN) and Purkyne fibres. An error found occasionally was to confuse the two nodes and to call the AVN the 'sinoventricular' node. Few candidates stated at the end of their answers that the two ventricles contract together.

BIOLOGY

Paper 9700/22
AS Structured Questions

Key Messages

- Candidates should read questions all the way through before answering part **(a)** of each question and then should rehearse their answers in their minds before writing. When appropriate, they should use key scientific terms and sequential responses.

- When using the term 'transmission' or phrase 'mode of transmission' as applied to an infectious disease, candidates should consider the transfer of the pathogen from the infected person to an uninfected person. Descriptions of transmission should begin with the infectious person and should include the sequence of events that lead to the pathogen gaining entry into the uninfected person. In **Question 4 (a)**, the phrase aerosol infection or droplet infection is a useful way to complete the tabular summary of the transmission of tuberculosis (TB). If asked for a written description, the following is an example of a complete response: 'droplets containing *Mycobacterium tuberculosis* are released into the air when an infected person coughs or sneezes; these airborne droplets are inhaled by an uninfected person'. This can be compared to: 'airborne droplets are taken in by an uninfected person', which is incomplete and does not include the name of the pathogen, or state that the pathogen is contained within the droplets, or state the origin of the airborne droplets.

- In **Question 4 (c)(ii)** many candidates understood well the role of memory T_h cells, but others gave more confused responses. When answering questions about memory cells, candidates should realise that there are memory B-lymphocytes and memory T-lymphocytes, but not a general memory cell that, during the secondary immune response, forms both more B-lymphocytes (plasma cells) and more T-lymphocytes.

General comments

Many candidates were very well prepared for this paper, with some giving outstanding performances. All questions discriminated well and practically all candidates were able to access all questions, with only a very small number not attempting **Question 5**. Some candidates could have improved considerably on their overall performance by more careful reading of the question, particularly in **Question 1**, **Question 2(b)** and **Question 4(b)**.

Question 1, proved to be a short, straightforward question for those candidates who had noted that the question was about energy flow and not about nutrient cycling. Some appeared to have seen a diagram containing arrows that looked vaguely like a nitrogen cycle diagram and continued to consider the rest of the question in terms of the nitrogen cycle. Generally, knowledge of the apoplast and symplast pathways was very good, as evidenced by a high proportion of high quality responses comparing the two pathways in **Question 2(b)**. However, on many occasions this was spoiled by organising the answer in terms of movement of water in the roots rather than in the leaf: this could have been avoided if the question had been thought through carefully. In **Question 4(b)**, the most disciplined and thoughtful candidates addressed the requirements of the question and avoided writing down points about the control of HIV that were relevant to examination questions from previous sessions.

Most candidates, including those who did extremely well overall, were able to complete responses using the printed lines provided. Those that required extra space could have improved their response by planning their answer first and considering whether any part of it was not relevant to the question. A good example of this is in **Question 3(c)**, where some could have produced better accounts by leaving out descriptions of gas exchange and carriage of oxygen at sea level. Also in **Question 6(c)**, descriptions of the movement of sucrose from mesophyll cells via companion cells to the phloem sieve tubes were not required but were given by a good number of candidates.

Question 6(a) was aimed at specifically assessing candidate knowledge and understanding of the first learning outcome in ***Section G*** of the syllabus. For those well-prepared candidates who were also familiar with the requirements of the syllabus, this question resulted in some extremely well-expressed and concise responses. Others did not appreciate the context of the question and would have been able to do much better if they were familiar with the specific learning outcome.

Many candidates displayed good overall knowledge of the infectious diseases named in the syllabus and did very well in **Question 4(a)**. The weakest area here was knowledge of the causative organism of measles. The subject matter of **Question 4(c)(ii)**, the immune response, is still proving challenging. Overall however, there appears to be improvement in this area, as a good proportion of candidates gained full credit for this part-question.

There appeared to be sufficient time for candidates to complete the paper. The handwriting of most candidates was clearly legible. Some candidates would benefit from improving their handwriting to be absolutely sure that their exam responses can be clearly read.

Comments on specific questions

Question 1

Candidates were expected to apply knowledge of ***Section K*** to Fig. 1.1. Many were able to gain full credit and had few problems. This contrasted with those who saw a cycle and automatically and incorrectly assumed that the question was about the cycling of nitrogen. These candidates should have remained focused on energy flow. Many only responded correctly in parts **(a)** and **(c)**.

(a) Almost all candidates realised that an arrow should be drawn heading to the box labelled 'FOOD WEB'. Fewer knew, or were careful enough, to avoid drawing the arrow from the DECOMPOSER SYSTEM or ORGANIC MATTER IN SOIL boxes. Weaker candidates drew arrows in Fig. 1.1 that did not appear to have any logical reasoning behind their placement. A number did not notice that there was a part **(a)** and left Fig. 1.1 blank.

(b) Only the more able candidates knew which process was represented by **A** on Fig. 1.1. Most gave a stage of the nitrogen cycle, most commonly stating denitrification.

(c) This was generally well known. Of those not gaining credit the most common error was to name bacteria from the nitrogen cycle. Although detritivore was an acceptable type of organism, more vague organism types such as 'worms' were treated as neutral points.

(d) Those candidates who had begun on the correct theme of energy flow generally had no problem in naming two processes represented by arrow **B**. This arrow showed losses to the decomposer system. A few should have taken more care and stated "decomposition" or "decay" as one of their answers, despite the presence of the DECOMPOSER SYSTEM box. Most of the other responses stated two processes linked to the nitrogen cycle, tending to choose two others from that named in part **(b)**: hence nitrification, denitrification, ammonification, nitrogen fixation and deamination were seen.

Question 2

Fig. 2.1 showed cells from a spinach leaf. Using this as a theme, the first part of **Question 2** assessed candidates on aspects of cell structure from ***Section A***. The focus then switched to plant transport from ***Section G*** and the question finished with part-questions on the use of water and magnesium ions from ***Section B***. Many candidates did extremely well on this question, which differentiated well.

(a) A high proportion knew all three structures labelled on the mesophyll cells of Fig. 2.1. The grana and/or thylakoid membranes were the only detail that needed to be observed by candidates in the transmission electron micrograph: this would confirm organelle **B** as the chloroplast. A number of weaker candidates incorrectly wrote chlorophyll. As the question asked for organelles to be named, it was not enough to state thylakoid or granum. The larger organelle labelled **A** could then be confirmed as the nucleus, which was generally spelt correctly. Many did not use as a guide their estimate of comparative sizes of organelles to deduce the nucleus and gave 'mitochondrion' as their answer. Most identified **C** as the (large, permanent) vacuole although there were various

incorrect spellings of this organelle, notably vacule and vacoule. Some of those who had given mitochondrion as **A** named organelle **C** as the nucleus.

(b) Part **(b)** was quite a challenge as candidates needed to know two correct structures only found in animal cells to gain credit. Microvilli and centrioles are covered in ***Section A*** of the syllabus, which many candidates gave as acceptable answers. Cilia and flagella, were also named by some. There is some debate at present as to the use of the term lysosomes in plants; some believe the vacuole to have lysosomal functions. For this question, lysosomes were also accepted as cell structures present in animal cells. Some gave small vacuoles as a structure, which was not precise enough for lysosomes. For this particular question glycogen, which was stated by some candidates, was considered to be one of the chemicals found in the cytoplasm of some animal cell types, and was not listed as a cell structure. Many knew centrioles but then accompanied this with other cell structures such as the Golgi body, mitochondrion and smooth endoplasmic reticulum.

(c) Many organised a clear response by stating the features of the apoplast pathway and then showing how the symplast pathway took a very different route, or vice versa. A high proportion of candidates gave very well expressed accounts to gain full credit, with some of these stating most of the points that were relevant. The main error that many candidates made was to forget that the question asked about pathways of water in the leaf, so reference to the roots was frequently given, e.g. mention of the endodermis, the Casparian strip and suberin. Where possible, standalone references to the root were ignored and credit was given to salient points comparing the two pathways. Common errors included thinking that the apoplast or cell wall pathway included passage through plasmodesmata and that the movement of water occurred by osmosis from cell wall to cell wall, despite some stating that membranes were not involved. Osmosis was also frequently seen as an incorrect point when describing the symplast route and the pathway of water via the plasmodesmata. There were numerous vague references to water crossing membranes in the symplast pathway. Credit was only given when the candidate was clearly referring to water crossing the tonoplast to take a vacuolar route or when entering via the cell surface membrane of the first cell directly adjacent to the xylem.

(d) (i) This was a very straightforward question that should have been well known by all candidates. The problem for many was misreading the question. These candidates read 'used by the plant' rather than 'used by the leaf cell' when considering the role of water. Hence there were many outline descriptions of transport within the plant or of overall support for the plant.

(ii) The majority gave a correct role of magnesium ions in the leaf cell, with most of these referring to chlorophyll. Some responses were too vague to be credited, such as 'used in photosynthesis'. This part-question was the one of **Question 2** that was most frequently left blank.

Question 3

This question, which discriminated very well, had a number of sections mainly aimed at assessing application of knowledge and understanding, as well as assessing skills of analysis and data extraction from a graph with two *y*-axes. More able candidates gave concise responses that gained full credit: others tended to repeat information provided in the question or repeat points in different ways in their responses. Subject matter from ***Sections H***, ***G*** and ***F*** was assessed. Quite a number found parts **(c)**, **(d)(i)** and **(e)** to be particularly challenging, to the extent that **(d)(i)** and **(e)** were left blank by some candidates.

(a) Approximately half of the candidates gave a correct response. Many did not realise that cartilage is also present in the bronchi and only stated trachea, while others included bronchioles. Trachea was not always spelt correctly.

(b) (i) This was usually well done, with many giving a concise description and supporting this with correct data extracted from Fig. 3.1. Units needed to be stated for altitude and pressure at least once and pressure at two different altitudes for either atmospheric pressure or oxygen partial pressure was also required. The most common correct supporting data provided was that for 10 000 m and 0 m for atmospheric pressure. A reading of 20 kPa for oxygen partial pressure at 0 m was not acceptable as the curve clearly extended beyond this. Even though many made this error, it did not prevent full credit being given if the atmospheric pressure readings were correct.

(ii) Many candidates were successful at extracting the correct values from Fig. 3.1 and calculating the change in the atmospheric pressure. Those that did not gain credit generally just gave a reading at 3500 m.

(c) This assessed the ability to apply knowledge of gas exchange in the lungs and the carriage of oxygen by haemoglobin. Candidates were provided with some information about the effects of travelling to high altitude. It was rare to see fluent accounts of the situation in the lungs regarding the uptake of oxygen into the pulmonary capillaries: those that did give good accounts covered all the ideas expected and used appropriate scientific terminology. If candidates did not mention that less oxygen entered the pulmonary capillaries, they were still given credit if they made a statement showing knowledge that oxygen is transported to body tissues by haemoglobin / red blood cells / the blood. A good number missed this easy point and repeated the wording of the question by saying that less oxygen was supplied to the tissues. A few used their knowledge of the effect of altitude on the number of red blood cells and pointed out that initially there would be insufficient red blood cells. It was not unusual for a candidate to use up over half the available space explaining what would occur at sea level and then only give the events at altitude a slight mention. In addition, some thought that they were being asked to explain what the signs and symptoms of hypoxia were. Although many candidates did well on this question, only the most able gained full credit with complete explanations.

(d) (i) The concept involved in **(d)(i)** was quite difficult to grasp. Candidates appeared to visualise that a decrease in the volume of plasma would somehow create space and so be able to 'fit in' more blood cells. The best responses understood that the concentration of red blood cells, rather than the absolute number, would increase, which would be beneficial in a situation where oxygen uptake was impaired. Some incorrectly thought that less plasma would supply less glucose and nutrients and encourage body cells to lower their rate of respiration and require less oxygen.

(ii) Some had no problem organising a response that went through the correct ideas in a logical and concise manner. These excellent responses made it clear that the increase in heart rate would serve to compensate for both the lack of oxygen taken up in the lungs and the decrease in plasma volume. Others understood that more blood per unit time would reach the lungs and other body tissues, but did not qualify further. This still gained full credit. Where only partial credit was awarded, this was usually for a statement that more blood (per unit time) would be sent to the body tissues, and the idea of being able to take up comparatively more oxygen per unit time in the lungs was neglected.

(e) The responses of the highest quality were specific to the β-globin polypeptide and gave very exact accounts, of a sequential nature, to show how a base substitution mutation could lead to the altered amino acid sequence. These responses did not go on unnecessarily, as many others did, to discuss how this altered sequence would affect protein structure and function. Some began their response with the altered amino acid sequence and only wrote how the sickle cell form of haemoglobin would lead to the inability to bind to oxygen. Although the biology was correct, this was not answering the question. Many candidates who were on the right track could have improved their response with a better understanding of the difference between mRNA codon and the genetic code. There were numerous answers seen stating that the DNA or RNA code or coding changed, which was not creditworthy.

Question 4

This question assessed ***Sections E***, ***I***, and ***J*** of the syllabus. In **(a)** candidates were asked to complete a summary table of infectious diseases. This was partly-completed for them to provide a guide, and although many did well on this, others could have improved by giving more detail in the column heading 'main mode of transmission' (see also **Key Messages**). Part **(b)** was straightforward for some candidates: many however did not read the question carefully and gave general answers related to transmission of HIV.

(a) Almost all knew the missing infectious disease: there were some incorrect spellings, in particular 'maleria'. Far fewer were able to correctly state the name of the causative organism for measles and this was the box that was most frequently left blank. The most common incorrect name given was *Variola*, which is the causative agent for smallpox. *Morbilli* was accepted instead of *Morbillivirus*, but other variations such as *Microvilli* or *Microvillus* were not accepted. The type of causative organism for cholera was very well known although weaker candidates thought that *Vibrio cholerae* was a virus. The type of causative organism for malaria was less well known and weaker responses stated virus, left it blank or repeated *Plasmodium* from the previous column. The main mode of transmission was known by most, but only a proportion of these gained credit with insufficient detail: "female mosquito" or "*Anopheles* mosquito" did not gain credit. Here, candidates should have continued with further qualification. Similarly, a number were insufficiently

precise in stating the main mode of transmission for tuberculosis (TB). The mode of transmission given for measles, printed in the box below, was copied out by many candidates as a correct answer for TB; others who gained credit gave a concise description. Some stated transmission by drinking unpasteurised milk. This was treated as a neutral point as it is not the main mode of transmission of TB. As a general point when describing transmission by this mode, candidates should note that this is unpasteurised milk or meat contaminated by the pathogen.

(b) The idea of WHO publishing a set of recommendations to help countries prevent the spread of HIV was a relatively easy concept for candidates to grasp. The question asked candidates to focus on recommendations concerning the prevention of sexual transmission of HIV. This should have alerted candidates mainly to consider points linked to condoms and femidoms. Some of the best responses gave a variety of valid points about condoms, considering the problems of cost and geographical availability as well as the problems concerned with educating people about their use and overcoming cultural objections. Responses were accepted that covered factors that needed to be considered beforehand and/or responses discussing acceptable and practicable recommendations for consideration by countries. Some were able to write succinctly and cover enough points to do very well. These responses took a common sense approach by discussing factors that were within the realms of possibility and acceptability. The provision of free or cheaper condoms, educating about the use of condoms, carrying out contact tracing and identifying high risk groups were the most popular choices discussed. A large number of candidates did not pay attention to the fact that the question only wanted to know about prevention of sexual transmission and instead gave a textbook account of ways to prevent HIV transmission. Hence there were points made about intravenous drug abusers, blood transfusions and mother to baby transmission, which was not pertinent to the question. Other responses that did not gain credit were far too general or impractical in their approach, for example discussing the economic state of the countries and the provision of health care without mentioning anything to do with sexual transmission or stating that many countries did not have the wealth to tackle the problem yet or suggesting that everyone gets tested for HIV. High quality answers took the path that WHO would have used and avoided ill-considered or socially unacceptable suggestions. One example of a socially unacceptable suggestion that was frequently seen was to suggest that everyone should be told to abstain from sexual intercourse.

(c) (i) Many were confident in the cell cycle and listed the processes in the correct sequence. The majority of those who gave a correct response wrote growth occurring before replication, but those that showed growth after were still credited as it was accepted that aspects of growth still occur after the S-phase of interphase.

(ii) Many were able to gain full credit with knowledge of the role of T-helper cells. These candidates knew that the cells secreted cytokines that were able to enhance the humoral response and phagocytosis, in addition to enhancing the T-killer (cytotoxic) cell response. A few candidates gave a good introduction to their ideas and explained how the memory cells would normally remain in the circulation or lymph system for a secondary immune response on encountering the specific antigen a second time round. Stronger responses made it very clear that the difference between the immune system cell types was known: this contrasted with those that thought that T-helper cells became plasma cells or that T-helper cells produced antibody. Where candidates implied that T-helper cells became plasma cells that secreted antibody, partial credit was awarded. Weaker responses referred to the idea of memory cells remembering the pathogen, or having information about the pathogen or antigen. These needed to understand better the nature of specificity of the immune system cell.

Question 5

In this question, candidates were assessed on ***Sections B, C, D*** and ***J*** of the syllabus. Enzyme action on antibody molecules was introduced as an unfamiliar situation for candidates, who then had to think about antibody structure to function and enzyme structure to function. Knowledge of the structure of the cell surface membrane was required to answer part **(c)**, which asked candidates to consider two slightly different variations of antibody structure and the reasons for this.

(a) Some candidates clearly studied Fig. 5.1 and noted that the label lines leading to the papain cleavage site indicated the hinge region, and were not pointing to the disulfide bridges linking the polypeptide chains. Many of these correctly stated that the region allowed flexibility when binding antigen. Those that did not gain credit wrote about disulfide bridges. A number did not know antibody structure sufficiently well and left **(a)** blank.

(b) (i) Practically all candidates realised that fragments **A** and **B** contained a variable region. Some candidates stopped at this point and did not complete the response, whereas those that gained credit explained that the function was to act as an antigen binding site.

(ii) The function of fragment **A** was less well known and generally only those that performed well overall knew what to write. Some of these gave very comprehensive statements: a response stating that the fragment binds to receptors on a named cell type was qualified with a follow-up statement of how this allowed the cell to respond. A number left **(b)(ii)** blank.

(c) The thought process of some candidates considered the nature of the medium into which antibodies are secreted by plasma cells and the nature of the surface of the plasma cell. This helped them understand the reason for the hydrophilic / hydrophobic difference in the antibody structures and it was then no problem to do well on this question. Otherwise there were a whole variety of suggestions seen that were not credited, such as stating that region **X** needed to be hydrophilic to attach to antigens or pathogens or needed to be hydrophilic to pass through the cell surface membrane of the plasma cell. Suggestions to explain the hydrophobic nature of region **X** varied from stating that it gave protection from attack by pathogen, which was not well thought out, to stating that it did not need to be hydrophilic because it was not in contact with the blood. The latter, if considered further, may have led to creditworthy points about being located in the hydrophobic core of the cell surface membrane or a reverse argument for hydrophilic region **X** and its solubility in plasma. Some candidates did not realise that a plasma cell is a mature B- lymphocyte and that the point of the question was about the different locations of the antibodies, not the differences between the two types of cells.

(d) (i) Many did not need to think hard about **(d)(i)**: knowing the definition of quaternary structure and having been told that papain has tertiary but no quaternary structure, the only answer to this question was ‘one’. The same reasoning was not used by a large number of candidates, who read the question and then used as their prompt ‘tertiary’ and wrote ‘three” or ‘quaternary ‘and wrote “four”.

(ii) Almost all gained partial or full credit for this straightforward question. However, the quality of response varied considerably, with stronger responses being careful to write about hydrophilic and hydrophobic R-groups of amino acids and only stating the R-group interactions occurring in tertiary protein structure rather than including peptide bonds, which are only for primary structure. Candidates needed to use the terms coiling or folding to form tertiary structure: other descriptions such as curling and twisting were ignored.

Question 6

This question assessed learning outcomes in ***Section G***. Parts **(a)** and **(c)** were frequently extremely well set out and covered all the main ideas clearly. Knowledge of translocation of sucrose using the mass flow hypothesis has shown improvement. Parts **(b)(i)** and **(ii)** proved to be very demanding for many candidates as it required application of knowledge and understanding.

(a) As noted in the general comments, some candidates had little trouble in gaining full credit, while others were not familiar with the requirements of the learning outcome. Although plants are considered to have a higher surface area to volume ratio than animals because of their leaves and branching nature, both plants and animals when compared to unicellular organisms have a smaller surface area to volume ratio. Many knew this, although a few got it the wrong way round. Others forgot to state this but did remember to think about longer distances for substances to be transported and how diffusion would be too slow to satisfy requirements. Some were precise in their responses and avoided including oxygen and carbon dioxide when writing about transport systems in plants, as these gases are not transported in xylem and phloem. Many wrote about the usefulness of transport systems rather than explain a ‘need’.

(b) (i) Candidates needed to think first about the complete cardiac cycle before attempting to tackle **(b)(i)**. Most did not find this easy, despite being given the diagrams summarising phases in the cardiac cycle to provide extra guidance. Candidates were told that **P** and **Q** were two types of heart chamber, which could only mean the atria and ventricles. Despite this some labelled ‘left’ and ‘right’ for **P** and **Q**.

(ii) Generally only those candidates who did well overall and who knew the answer to **(b)(i)** were successful in **(b)(ii)**. Once again, a good understanding of the cardiac cycle was necessary. It is a good exercise for candidates to work though the cardiac cycle and visualise the state of the ventricles during atrial systole and diastole and vice versa. Using material such as that in Fig. 6.1 will help many candidates to consolidate their understanding of this section of the syllabus.

(c) Many knew well the mass flow theory for the translocation of sucrose and gave excellent sequential responses to present a logical account. Others wasted time giving details of the events occurring in the companion cell to allow the transfer of sucrose into the phloem sieve tube, which was not required. Only some of these went on to write about the details of mass flow. The best responses used the term 'hydrostatic pressure' and explained that the presence of sucrose in the sieve tubes at the source would lower the water potential, hence lead to an increase in hydrostatic pressure, and then went on to explain mass flow owing to the lower pressure in the sink. More confused answers wrote in terms of sucrose being translocated as a result of differences in water potential. Others did not make it clear that the destination for the sucrose, the location of the lower pressure in the sieve tubes, was in the sink, or named sink.

BIOLOGY

Paper 9700/23
AS Structured Questions

Key Messages

- Candidates should read questions all the way through before answering part **(a)** of each question and then should rehearse their answers in their minds before writing. When appropriate, they should use key scientific terms and sequential responses.

- When using the term 'transmission' or phrase 'mode of transmission' as applied to an infectious disease, candidates should consider the transfer of the pathogen from the infected person to an uninfected person. Descriptions of transmission should begin with the infectious person and should include the sequence of events that lead to the pathogen gaining entry into the uninfected person. In **Question 2(c)**, the phrase aerosol infection or droplet infection is a useful way to complete the tabular summary of the transmission of tuberculosis (TB). If asked for a written description, the following is an example of a complete response: 'droplets containing *Mycobacterium tuberculosis* are released into the air when an infected person coughs or sneezes; these airborne droplets are inhaled by an uninfected person'. This can be compared to: 'airborne droplets are taken in by an uninfected person', which is incomplete and does not include the name of the pathogen, or state that the pathogen is contained within the droplets, or state the origin of the airborne droplets.

- In **Question 2 (a)(i)** and **(d)**, a number of candidates referred to the role of memory cells as part of their response, with only some of these producing clear statements. As a general note when answering questions involving knowledge of memory cells, candidates should realise that there are memory B-lymphocytes and memory T-lymphocytes, but not a general memory cell that, during the secondary immune response, forms both more B-lymphocytes (plasma cells) and more T-lymphocytes.

General comments

Many candidates coped extremely well with this paper, showing an excellent grasp of the wide range of subject matter assessed. These candidates gauged well the level of detail required to answer successfully the parts of each question and produced well-organised and well-expressed accounts in the more extended responses. Others could have improved their overall performance by producing more detailed responses to fully answer the question: this was particularly apparent in **Question 3(a)** and **(b)**, and **Question 5(a)**. Some candidates clearly had large gaps in their knowledge and were not able to write enough on many part-questions to gain much credit. All questions discriminated well, with **Question 1**, followed by **Questions 2** and **6**, proving to be the most accessible and **Question 5** the most challenging.

Question 1 was a short, straightforward question, especially for those candidates who had a good grasp of the structure of biological molecules from ***Section B*** of the syllabus. This question contained many scientific terms and some candidates could have benefited by being more confident as to the meaning of these terms. For example in **Question 1(b)**, it was clear that many did not know the meaning of the term 'polymer', as named monomers were frequently seen. In **Question 2** knowledge of the definition of infectious disease was generally good. The response given by many candidates for the definition of vaccination was too vague and lacking in scientific knowledge. The importance of a sound understanding of scientific terms was also highlighted in **Question 4(c)**, where a large proportion of candidates gave a complete description of water movement from the roots to the leaf and out to the atmosphere when asked to describe the process of transpiration, and in **Question 5(c)**, where a number incorrectly described translation rather than transcription.

In **Question 3**, many candidates gave correct details in part **(a)** by explaining how glutamycin could act as a competitive inhibitor for the enzyme GluTR. Some then went on to give an 'either' 'or' choice by continuing

to write details about non-competitive inhibition. This was not appropriate for this particular question and it meant that full credit could not be given for the first part of the response.

Most candidates, including those who did extremely well overall, were able to complete responses using the printed lines provided. Some of the best responses in the extended answers were so concise and succinct that less than half the number of lines was required for full credit to be awarded. Those that required extra space, particularly when answering **Questions 3(a)** and **4(c)** could have improved their response by planning their answer first and considering whether any part of it was not relevant to the question.

Question 6(b) was aimed at assessing candidate knowledge and understanding of structure to function for arteries and capillaries from ***Section G*** of the syllabus. Many did very well on this: others gave structural features accompanied by only more general functions of the blood vessels.

There appeared to be sufficient time for candidates to complete the paper and the blanks that were left in the script indicated gaps in knowledge rather than lack of time. **Question 3(c)** parts **(i)**, **(ii)** and **(iii)**, about the relationship between *Rhizobium* and legumes, was most frequently left blank.

The responses for most candidates were clearly legible, although there were also quite a few scripts where it was difficult to read answers because of extremely poor handwriting.

Comments on specific questions

Question 1

Many were very familiar with the biological molecules shown in Fig. 1.1 and ***Section B*** of the syllabus and so steadily and easily worked through the very short answers required for each part-question. Some of these candidates gained full credit for the complete question. Those lacking in knowledge appeared to use a lot of guesswork and some very illogical incorrect answers were seen.

(a) Most candidates were able to identify **B** as a nucleotide in part **(i)**. Parts **(ii)** and **(iii)** required another step in the thought process as candidates were required to mentally match the bond type to a molecule and then identify the molecule in Fig. 1.1. More knew that peptide bond formation was matched to molecule **D**; fewer knew that ester bonds were present in molecule **A**.

(b) (i) This was the most challenging part of **Question 1**. Generally the candidates who knew the correct answer were those that performed well overall. Glycogen was a correct response that was seen infrequently, with most who gained credit giving starch, amylose or amylopectin. Glucose was the most common incorrect answer and possibly some may have misread the question and thought that they were being asked to name molecule **C**. Cellulose was also named by a number of candidates, but as the monomer for this polysaccharide is β-glucose then it was an incorrect answer. There were quite a few that gave 'polysaccharide' as their answer.

(ii) Many gave clear, scientific answers for **(b)(ii)**, generally in terms of pointing out the double bond in the part labelled **2** compared to no double bond in the part labelled **1**, or by using the terms unsaturated and saturated. Some made sure of gaining credit by including both points. There were quite a few that only gave a descriptive comment of the different shapes seen, describing in various ways the continuous pattern of part **1**, or the parallel lines in part **2**.

(iii) Most knew that the question was about protein structure and many of these gave two correct R-group interactions. There were a number that only gained partial credit by including peptide bond as one of their choices, and some made it obvious that knowledge was lacking by only naming one bond and leaving the second line blank. A few gave tertiary structure and quaternary structure, presumably as two levels of protein organisation that display three-dimensional structure. Others gave main bond types such as peptide bond and ester bond.

Question 2

Using tuberculosis (TB) as a main theme, the subject matter from ***Sections I*** and ***J*** was assessed in **Question 2**. There was a great difference noted in the quality of response when defining vaccination and infectious disease, with far fewer giving satisfactory definitions of vaccination. Part **(c)** on the transmission of TB was attempted well by stronger candidates who ensured that detail was provided; others were much more vague or lacking the necessary detail to do well.

(a) (i) In their definition of vaccination, many candidates were able to explain or infer that vaccination did not cause the disease in the person; far fewer were able to state that the vaccine contained the (foreign) antigen and/or that the vaccine caused an immune response to be generated. A number gained credit by showing knowledge that specific memory cells were produced and some did give the full term used to describe the type of immunity provided. As noted in the general comments, some did not seem to understand that there is more than one type of memory cell. There were many answers that would have been improved by greater accuracy. Some were too vague to gain credit, for example "an injection to prevent an infection" while others did not refer to antigens and pathogens, for example "injection of dead infection". Many referred incorrectly to a vaccine as a medicine to prevent disease.

(ii) There were many that gave correct detail in defining infectious disease to gain full credit. Most concentrated on the meaning of infectious, with the best responses using the term pathogen and explaining clearly about transmission of the disease. Examples of the types of organisms that are considered pathogens or the modes of transmission were not required and in many cases were surplus to the response, but in others formed the entire response. In these instances, credit could not be given if more than one correct type of pathogen was given and if there were a number of different modes exemplified to show an understanding of passage between organisms. Only a few completed their response with an explanation of 'disease'.

(b) A very high proportion of candidates had a good attempt at part **(b)** and gave at least one valid suggestion from the list of expected points. Candidates could gain full credit with only one suggestion accompanied by extracted comparative data from Table 2.1 to support their point. Values comparing India and Swaziland were frequently given to support the explanation of how number of cases per 1000 000 population took into account the population size of the country.

(c) Many organised a well-expressed and full description of the transmission of TB. The best responses noted that the pathogen, *Mycobacterium tuberculosis* occurred in airborne droplets released from the infected person and gave examples of the way the droplets passed into the atmosphere. These responses continued with details of entry into the uninfected person and used the terms 'inhaled' or 'breathed in'. Some excellent responses also noted that transmission could occur by eating meat or drinking unpasteurised milk contaminated with the pathogen; others attempted also to state this but forgot to state that the meat or milk was contaminated. Quite a few gave the impression that all unpasteurised milk was unsafe to drink. Some did realise that the mode of transmission was airborne but did not mention the aerosol nature and a good number only stated that the organisms were present in the air ready to enter the uninfected person when breathing in the air. Some thought the droplets could land on food and enter via the digestive system. The weakest responses gave a list of different modes of transmission, clearly displaying their lack of specific knowledge about the disease.

(d) Almost all candidates gained some credit with knowledge that people with HIV/AIDS have a weakened immune system. Far fewer gave further explanations in terms of T-lymphocytes and of these only some gave correct details. A number thought that T-lymphocytes produce antibodies. Some gave relevant information about a lack of memory cells, the best of these made it clear that they knew that there are different types of memory cell.

Question 3

The extended response required for part **(a)** meant that candidates had to be diligent in giving a number of correct points and had to be confident about the nature of the inhibition and write only about competitive inhibition. Part **(b)** was generally well understood and those candidates that gained full credit for this question gave a number of correct features about active transport. Part **(c)** was most challenging for many candidates, with the best responses covering both sides of the mutualism shown between *Rhizobium* in their answers to parts **(ii)** and **(iii)**. There were various learning outcomes from ***Sections C***, ***D*** and ***K*** assessed in **Question 3**.

(a) The detail of glutamyl-tRNA and glutamycin shown in Fig. 3.1 made it very apparent to many candidates that the two structures were similar enough for competitive inhibition of enzyme GluTR to occur. As stated in **General comments** some candidates gave excellent descriptions of the features of competitive inhibition and would have done very well if they had not continued to describe all the details of non-competitive inhibition. In instances such as these candidates could still be credited for statements about: the similarity between the substrate and the inhibitor; the fact

that substrate cannot enter the active site; and for knowledge that there would be a slower rate of reaction. The latter two points were not always seen: frequently when both competitive and non-competitive inhibition were described, detail only about where the inhibitor would bind to the enzyme was given.

(b) Active transport was well known and many candidates were aware that a detailed response was required in order to gain full credit. These candidates ensured that they mentioned the involvement of a carrier or transport membrane protein in addition to stating points about movement against the concentration gradient and the requirement of ATP for the transport. The majority of those who gained partial credit did not remember to include points about the membrane protein. Some also gave detail about the conformational change involved in the transport protein. A high proportion of those that were aware of a membrane protein incorrectly stated that it was a channel protein, a type of protein used in facilitated diffusion but not active transport.

(c) (i) Most knew that nitrogen fixation was carried out by *Rhizobium*, although some wrote 'fixation' and did not gain credit. The weakest responses named other stages of the nitrogen cycle, or respiration, and even named stages of mitosis were seen.

(ii) If candidates had read ahead to part **(iii)** they would have realised that information about nitrogen fixation was more relevant to that part-question and part **(ii)** required more detail about mutualism and the advantage to *Rhizobium* of being in the relationship. The best responses used the term mutualism or mutualistic relationship and gave correct detail about the benefits to *Rhizobium* of living in the root nodules of the legume, briefly making a correct statement of the benefit to the plant. Most gave details that they repeated in part **(iii)** and did not mention at all how *Rhizobium* would be advantaged.

(iii) Although candidates often included two correct details here, there were some very confused responses seen. Strong responses were clear that the product of nitrogen fixation was ammonium, not nitrates, and that the plant could obtain the products directly rather than rely on events occurring in the soil to form nitrate to be absorbed. Many knew that amino acids and proteins could be synthesised for the growth of the plant.

Question 4

This question assessed plant transport from ***Section G*** of the syllabus. Part **(a)** required candidates to identify xerophytic features taken from Fig. 4.1 and could have been better attempted by a large proportion of candidates. Features of leaves of xerophytes are usually well known, so the additional process of identifying particular features from an image must have been more challenging for these candidates.

(a) In **(a)** some correctly described the location of the stomata as being in pits or crypts (or other acceptable wording) rather than just stating 'sunken' stomata, which is descriptive of stomata that are just below the plane of the epidermis, in a slight depression. Many identified the thicker cuticle and the trichomes or hairs. Some did spot the trichomes but called them cilia. Others named 'waxy cuticle' but as this is present in all leaves it could not be credited without the idea of 'thick'. There were many weak responses stating general features of leaves, and even weaker responses that named cell structures.

(b) The diameter of the vascular bundle was correctly calculated by many candidates. Fewer had noted the instruction in the question to give the answer to the nearest 100 m to gain full credit, while others were not sure how to convert their measurement, made in cm or mm, to m. There were quite a few that did not know the formula to use for the calculation and only made the measurement or left all of part **(b)** blank.

(c) The best responses did not require all the space provided as they gave very concise accounts that were packed full of the correct detail. Excellent responses seen were variations of the following: "Transpiration is the loss of water vapour from the leaves. Water evaporates from the surface of spongy mesophyll cells into the airspaces. The water vapour then diffuses out through open stomata into the atmosphere down the water potential gradient". Some candidates were confident enough to only start their account from the evaporation of water from the mesophyll cell wall but many others felt the need to write about water leaving the xylem, then note the apoplast and symplast pathways and/or give further detail about the transpiration stream. Where possible, these additional irrelevant details were ignored and points pertinent to the question were credited. Not all remembered to state that the water vapour left the leaf through *open* stomata or noted that it was

water *vapour* that exited. Many stated that water evaporated from the surface of the leaf or from the guard cells or stomata. A fairly common error was to state that water moved out of the leaf by osmosis.

Question 5

In this question, candidates were required to think about carriage of oxygen and haemoglobin from ***Section G,*** and then consider learning outcomes from ***Section F*** of the syllabus. Almost all parts in this question required extended prose and only the most focused and well prepared candidates gave sufficient detail in all parts to do well. Most found **(c)(iii)** to be very challenging and gave suggestions that were not feasible.

(a) Many came up with one good point, usually showing an understanding that respiring tissue will produce areas of low oxygen partial pressure. Others knew also that the partial pressure of carbon dioxide would be high, and some of these continued to explain how this would generate hydrogen ions within the red blood cell to combine with haemoglobin. Good responses knew the term haemoglobinic acid. Only some stated the Bohr effect as a term and few noted that the haemoglobin's affinity for oxygen would be lower in this situation. There were numerous responses that had a good general idea but could not give the precise detail required. For example, stating that actively respiring cells produce carbon dioxide but not qualifying this with the idea of a higher partial pressure of carbon dioxide. Another example was to state that haemoglobin had an affinity for carbon dioxide but not mention the affinity for oxygen. For those that knew that carbon dioxide combined with haemoglobin, only a small number knew that carbaminohaemoglobin was formed: many stated carboxyhaemoglobin. Many did not realise that they were required to think about carbon dioxide and only focused on describing the dissociation of oxygen from oxyhaemoglobin to pass into the tissues from the red blood cell.

(b) Many had a very good understanding that the increase in red blood cells was to compensate for the lack of oxygen that entered the circulation to be distributed to tissues, and generally responses were clear to explain this. A number gave further qualification to gain full credit. The fact that there would be a lower percentage saturation of haemoglobin was noted by some. A common error was to state that more oxygen could be carried at high altitude rather than to explain that overall the same amount of oxygen would reach the cells as at lower altitudes.

(c) (i) The best responses were very precise in the information provided about transcription. For example, stating that a copy of the DNA is made by synthesising mRNA from a DNA template strand is very clear. This is in contrast with responses stating that "mRNA copies the DNA", which imply that mRNA is already present and that both strands of the DNA are copied. Some did give creditworthy detail about the process, noting the requirement for RNA polymerase and the presence of RNA nucleotides. Imprecise references to DNA and RNA carrying 'the code' were commonly seen; not all candidates seemed to know the difference between the genetic code and the idea of DNA as a molecule containing coded information for the production of a polypeptide.

(ii) As with **(c)(i)**, there were some excellent responses that used correct scientific terminology to give a detailed sequential account, contrasting with many vague or confused responses. Stronger responses showed an understanding that a mutation is a change in the sequence of nucleotides (or bases) in the DNA that is then present in the mRNA formed. There were good descriptions of the consequential effect occurring during translation. Some candidates gave examples of types of mutation. Most responses that gained partial credit did so for their descriptions of how a change in primary structure of the polypeptide formed would affect the tertiary structure and hence function of the protein.

(iii) Those candidates that had gained credit for **(c)(ii)** had thought carefully about the process of transcription and made suggestions as to how a protein could prevent some stage of this process in **(c)(iii)**. Hence there were, for example, acceptable statements about inhibiting the enzyme involved in unwinding the DNA double helix and statements about preventing the attachment or progression of mRNA polymerase. Most did not go down this pathway and wrote about transcription factors as mutagens or suggested that they prevented the mRNA from exiting the nucleus. Others wrote about hindering transcription.

Question 6

Part **(a)** of this question made links between ***Section H*** and ***Section G*** by looking at the effects of smoking on arteries. Part **(b)** assessed knowledge of artery and capillary structure and function.

(a) (i) To gain full credit, candidates needed to use correct scientific terminology, such as 'the lumen is narrower' rather than 'the artery is smaller' and, for example, references to the build-up of atheroma rather than just stating that 'the artery is partially blocked'. Frequent incorrect descriptions were to state that tar had built up on the artery wall, or to state that the artery walls were thinner. Some thought the atheroma was a large blood clot.

(ii) All the correct points were seen in responses. Answers needed to address the question directly and explain how the arteries were affected. It was not sufficient for candidates to state that nicotine caused an increase in blood pressure; the response here should have continued by stating that this could lead to damage to the tunica intima, which could ultimately lead to atheroma formation. Some candidates were still focused on tar and erroneously stated that nicotine would make it easier for tar to collect.

(b) (i) Many knew a correct structural feature of the artery wall but fewer took this feature to link it directly to a function. Credit was awarded for a full, correct description of a general function of arteries. Most candidates described a thicker muscular wall as a structural feature, but a common error was to think that this allowed stretching under high blood pressure. Stronger responses correctly noted the elastic tissue present in the arterial wall as having this function.

(ii) Candidates knew that capillaries had thin walls or walls that were one cell thick. Some were less careful in the way that they worded their response and stated that the capillaries had thin cell walls. For a function, candidates needed to explain more than stating 'easier' diffusion. Many good responses wrote about the short diffusion distance. Others wrote about the small cross-sectional area of the capillary allowing all body cells to be reached. Weaker responses were less clear and wrote about capillaries delivering blood to the tissues, a function that could be assigned to arteries and arterioles.

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 encouraged to learn the methods for the tests for biological molecules, such as for the Benedict's test. The volume of Benedict's solution must be the same or more than the volume of the sample being tested and the temperature of the water-bath must be maintained at 80 °C or up to 100 °C. As this test was used to compare concentrations of glucose in **S1** and **S2** to known concentrations of **G**, the candidates were required to standardise temperature and then maintain the same temperature for all the tests.

Candidates should be given the opportunity to draw both graphs and charts. In this case, a bar chart was required. The bars should be plotted accurately and drawn carefully along the horizontal lines with a fine ruled line. All the lines, both vertical and horizontal should be clear, sharp and unbroken.

Candidates should be given the opportunity to estimate unknown concentrations from results for known concentrations. If the value for the unknown concentration is greater than the known concentration then the estimate must state this, e.g. the unknown concentration is greater than 2%. If the value for the unknown concentration is between two known concentrations the answer must state this, e.g. the unknown concentration is between 1% and 2%. Candidates should avoid stating a concentration that has not been made, e.g. 2.5% or a concentration between two known concentrations i.e. 1.5%.

Candidates should be encouraged to evaluate and identify sources of error in an investigation such as the difference between a systematic and a random error. For example, if a thermometer reads 1 °C above the actual reading this would affect the true value of the result but not the general trend. A random error would include variations in the temperature of a room during the investigation.

General Comments

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

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) Many candidates completed the table correctly to show the volume of Benedict's solution required for each test. The volume of Benedict's solution must be the same or more than the volume of the sample being tested.

(ii) The majority of candidates organised their results clearly by presenting a fully ruled table with all the cells drawn, and a ruled outer boundary. The better candidates included an appropriately detailed heading for the independent variable (temperature / °C) 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.

(iii) Many candidates correctly stated that their results supported the hypothesis and were able to give a valid reason to support this. The most common error was stating that their results did not support the hypothesis when in fact they did.

(iv) Many candidates correctly chose a suitable temperature for carrying out the Benedict's test, and some were able to give a valid reason why that temperature had been chosen.

The most common errors included, not including units (°C), choosing a temperature which had not been tested or stating that the temperature chosen was the optimum temperature when this was not evident from the candidate's own results.

(v) Many candidates correctly described how to carry out a serial dilution of **G**, reducing the concentration by half between each concentration by transferring 15 cm^3 of the previous concentration to the next beaker and adding 15 cm^3 of water to each beaker. The majority of candidates used the correct concentrations to label the beakers (1% and 0.5%). The most common error was the omission of units (cm^3 and %).

(vi) The better candidates stated the volume of Benedict's solution used in **1(a)(i)** and correctly identified that the volumes of glucose, **S1** and **S2** should equal the volume of **G** used in **1(a)(i)**.

(vii) The majority of candidates gained credit for recording results for the four concentrations of glucose, **S1** and **S2**, and recording the correct pattern of results with the shortest time for the highest concentration of glucose. The most common error was to record final colours rather that the time taken to the first appearance of a colour change.

(viii) Many candidates correctly showed the position of **S1** and **S2** on the given scale. Some candidates correctly labelled each percentage of glucose on the scale given.

(ix) Many candidates correctly realised that in order to modify the procedure to improve the confidence in their results, a range of different glucose concentrations was needed. Most candidates recognised that repeating the experiment would improve confidence in their results.

The most common error was to state that using a colorimeter would improve the confidence in their results. However this would not have enabled the candidates to record the time taken for the first appearance of colour.

(x) Many candidates correctly stated that by using the same syringe for measuring the volumes, the trend was not affected because the error was consistent. Some candidates correctly stated that if more than one syringe was used, the actual volume used would differ and the error would not be consistent.

Question 2

(a) (i) The better candidates used a sharp pencil to produce drawings which did not include any shading and used most of the space provided. Many were able to draw the layers of different tissues within the midrib of the leaf. Some candidates had used the eyepiece graticules to help them draw well-proportioned drawings. Most candidates used a label line to show the position of the xylem. The most common error was not showing the layers of tissues which would be observable using the microscope.

(ii) Those candidates who had experience of drawing cells as part of their course were likely to have gained the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided. The majority of candidates gained credit for carefully following the instructions by selecting two chains of xylem vessel elements, drawing three complete adjacent xylem vessels from each of these selected chains. Most candidates used a label line to show one lumen correctly.

The most common errors were lines drawn that did not meet up precisely, or were too thick or not drawing the vessels as a group. Candidates should be encouraged to draw what they observe on the particular slide provided.

(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 230 and correctly rounded the answer to one decimal place.

The most common error was not showing how the conversion from millimetres to micrometres had been achieved.

(b) (ii) Many candidates correctly stated the closed stomata as the observable feature visible in the photomicrograph provided and were able to explain how this feature reduces water loss. The most common error was the identification of features that were not observable in the photomicrograph provided.

(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 Fig. 2.2 and the other headed Fig. 2.3. The majority of candidates were able to gain partial credit for recording appropriate differences.

(d) Many candidates drew the chart, using the headings given in the table, with concentration of CO_2 / $mol\,mol^{-1}$ on the *x*-axis and mean number of stomata / mm^2 on the *y*-axis. The better candidates used even bar widths and 20 to 2 cm for the *y*-axis, with zero at the origin. They also plotted each bar accurately, in the order of Table 2.1, with clear, ruled horizontal lines and with labels for concentrations of CO_2 (i.e. 380, 560 and 800) and upper and lower epidermis directly below the relevant bar.

The most common errors were not including a full axis label for each axis, omitting the units for the *x*-axis and *y*-axis and drawing lines which did not meet precisely, were too thick or not ruled.

BIOLOGY

Paper 9700/32
Advanced Practical Skills 2

Key Messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills that can be applied to the requirements of the examination. They should also be given opportunities to reflect on this work in order to modify a particular procedure to study a different variable by keeping the previous independent variable constant, for example concentration of calcium chloride solution and then changing the independent variable, for example time of heating the solution. To do this the other variables need to be standardized such as keeping the volume and concentration of the enzyme and substrate the same.

Candidates should be encouraged to understand the command terms used in questions. For example, the term 'explain' should be understood to mean that scientific reasons are required to explain why, for example, the graph has a particular trend.

Candidates should be encouraged to evaluate and identify sources of error in an investigation such as the difference between a systematic and a random error. For example, if a thermometer reads 1 °C above the actual reading this would affect the true value of the result but not the general trend. A random error would include variations in the temperature of a room during the investigation.

General Comments

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

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) Many candidates completed Fig.1.2 correctly to show three further concentrations of calcium chloride solution. The better candidates correctly selected the next three concentrations (10.0%, 5.0% and 2.5%), showed the transfer of 10 cm^3 of the previous concentrations to each of the last two beakers and added 10 cm^3 of distilled water to each of the three dilutions.

(ii) The majority of candidates organised their results clearly by presenting a fully ruled table with all the cells drawn, and a ruled outer boundary. The better candidates included an appropriately detailed heading for the independent variable (percentage concentration of calcium chloride solution) 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 recorded the highest concentration of calcium chloride first in the table. The better candidates recorded times showing the highest concentration of calcium chloride solution took less time to coagulate the milk than the lower concentrations.

(iii) Most candidates gained credit for identifying the significant source of error in measuring the dependent variable as the difficulty determining the moment of coagulation which was the end-point. The most common error was stating an error not associated with the dependent variable.

(iv) Many candidates correctly stated that by using the same syringe for measuring the volumes, the trend was not affected because the error was consistent. Some candidates correctly stated that if more than one syringe was used the accuracy of the volume put into the test-tube is affected and it will not be the true value.

(v) Many candidates correctly described replacing the calcium chloride solution with the same volume of water. The most common error was to describe boiling the enzyme as a control for this investigation.

(b) (i) Many candidates correctly stated the two variables that needed to be standardised. The variables that were credited included the concentration of calcium chloride solution, the volume and type of milk, the temperature of the water-bath, the volume and concentration of the enzyme.

(ii) The majority of candidates drew the graph, using the headings given in the table, with time of heating solution **E** / seconds on the *x*-axis and time to reach the end-point / seconds on the *y*-axis. The better candidates used scales of 50 to 2 cm for the *x*-axis and 50 to 2 cm for the *y*-axis, 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.

(iii) The better candidates explained the trend shown in the graph by stating that the structure of the active site had been altered by the time of heating, so reducing the number of enzyme-substrate complexes that were formed. Most candidates correctly stated that as the time of heating increased more of the enzyme had been denatured.

Question 2

(a) The better candidates used a sharp pencil to produce drawings which did not include any shading and used most of the space provided. Many candidates were able to draw the layers making up the margins of the root with an obvious tip at one end. Most candidates used a label line to show the position of the area in which there were cells showing stages of mitosis, just behind the root tip.

The most common error was not showing the layers of tissues which would be observable using the microscope.

(b) Those candidates who had experience of drawing cells as part of their course were likely to gain the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided. The majority of candidates gained credit for carefully following the instructions by drawing the five cells labelled **P**, **Q**, **R**, **S** and **T** on Fig. 2.1, showing the enclosures in these cells and by drawing at least three of the chromosomes in cell **Q** as one group rather than as individual chromosomes.

Many candidates correctly used two labels with label lines to correctly show two different stages of mitosis and correctly annotated one of these stages to describe an observable feature that supported their identification. The most common errors were to draw lines that did not join up and to draw the chromosomes as pairs. Candidates should be encouraged to draw what they observe.

(c) 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 31 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.

(d) The better candidates recorded observations using the most appropriate organization, which included one column for listing the features and two additional columns, one headed Fig. 2.1 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 include named structures involved with mitosis that were not observable, such as spindle fibres and microtubules.

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 familiar with how to use the microscope provided in the examination and how to make slides in order to study cells. They should be familiar with taking a sample of cells, mounting them onto a slide, lowering a coverslip onto the cells and observing them under the microscope. When carrying out practical work candidates should be encouraged to obtain quantitative results, for example by counting the number of stained yeast cells in different samples that had been heated to different temperatures.

Candidates should be encouraged to evaluate and identify sources of error in an investigation such as the difference between a systematic and a random error. For example, if a thermometer read 1 °C above the actual reading this would affect the true value of the result but not the general trend. A random error would include variations in the temperature of a room during the investigation.

General Comments

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

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) Most candidates correctly recorded the volume of **H** needed to reach the end-point to the correct degree of accuracy with the appropriate units (cm^3).

(ii) The majority of candidates correctly decided that 2 minutes was the length of time to leave the delivery tube in each test-tube containing **C**. The most common error was selecting a time interval which gave too few readings.

(iii) Many candidates gained credit for suggesting that the most significant source of error that may occur when the delivery tube was moved from one test-tube to the next was the loss of carbon dioxide. Other sources of error that were credited included the different times the delivery tube was in each test-tube and that the end of the delivery tube was at a different level in **C** for each test-tube.

Some candidates then correctly described how to reduce these errors by blocking the end of the delivery tube, stopping the clock when removing the delivery tube from each test-tube and then starting the clock again when the delivery tube had been transferred to the next test-tube or by marking the delivery tube so that the end of the delivery tube was at the same level in **C** each time.

(iv) The majority of candidates organised their results clearly by presenting a fully ruled table with all the cells drawn, and a ruled outer boundary. The better candidates included an appropriately detailed heading for the independent variable (time / minutes) and the dependent variable (volume of hydrochloric acid / cm^3). The majority of candidates gained credit for recording at least four volumes, to an accuracy of no more than one decimal place. The better candidates recorded all the volumes as less than the volume recorded in **(a)(i)**.

The most common errors were to omit the heading for the independent variable or to include 'minutes' in the cells of this column or row.

(v) Most candidates gained credit for identifying the significant source of error in measuring the dependent variable as the difficulty of determining the colour change of **C** from blue to yellow, which was the end-point. The most common error was stating an error not associated with the dependent variable.

(vi) Many candidates correctly stated that by using the same syringe for measuring the volumes, the trend was not affected because the error was consistent. Some candidates correctly stated that if more than one syringe was used the accuracy of the volume put into the test-tube is affected and the volume will not be the true value.

(b) (i) The majority of candidates drew the chart, using the heading given in the table, with mean leaf area / cm^2 $plant^{-1}$ $x10^3$ on the *y*-axis. The better candidates ensured that all six bars were the same width (commonly 1 cm) and used a scale of 2 cm to 1.0 for the mean leaf area / cm^2 $plant^{-1}$ $x10^3$. Many candidates plotted the horizontal line at the top of each bar exactly with a thin line. The better candidates correctly arranged the bars in pairs for each component with a gap between each pair.

The most common errors were: incorrectly labelling the *y*-axis; not including a value for the scale on each 2 cm of the *y*-axis; incorrectly arranging the bars; shading the bars so that the horizontal or vertical lines became unclear; and using lines which were too thick or not ruled.

(ii) Many candidates correctly described the trend by stating that, as the concentration of carbon dioxide / mol mol^{-1} increased, the mean leaf area / cm^2 $plant^{-1}$ $x10^3$ for both **R** and **T** increased. The better candidates gained credit for stating figures from the chart to support this statement.

(iii) Many candidates correctly suggested that the greater the leaf area the more transport occurred in the plant and there would be an increase in transpiration or translocation.

(c) The better candidates used a sharp pencil to produce drawings with clear, thin lines, did not include any shading and used most of the space provided. Many candidates were able to draw both the upper and lower epidermal layers of the leaf and included the vascular bundle. Some candidates had used an eyepiece graticule to help them draw the correct depth of the midrib to the correct proportion in relation to the size of the vascular bundle. Most candidates used a label line to show the vascular bundle correctly.

The most common errors were not drawing the midrib in the correct proportion in relation to the size of the vascular bundle and not showing all the different tissues and their correct distribution, as would be observable using the microscope.

Question 2

(a) (i) The majority of candidates gained credit for carefully following the instructions by drawing three whole yeast cells in each of the boxes labelled **S1**, **S2** and **S3** and annotating each of the drawings describing the effect of methylene blue on the yeast cells. The most common error was not annotating the yeast cells.

(ii) The better candidates identified the temperature that was used to heat each of the suspensions as 100 °C for **S1**, 45 °C for **S2** and 80 °C for **S3**.

(iii) Most candidates correctly explained that the yeast cells that had been heated at 100 °C could be identified as those that had been stained blue. The most common error was suggesting that observing yeast cells that were dead indicated that they had been heated at 100 °C.

(iv) The candidates who considered the question carefully were able to suggest how the investigation could be modified to estimate the temperature used to heat the yeast cells. Many candidates correctly suggested that at least two temperatures would be needed, between 45 °C and 80 °C, and the better candidates suggested temperatures that were 10 °C apart, such as 60 °C and 70 °C. Some candidates described how the number of dead cells in a sample of yeast cells would then be counted for each of the selected temperatures. Few candidates were able to suggest that the results could then be plotted on a graph to find the unknown temperature.

(b) (i) Those candidates who had experience of drawing cells as part of their course were likely to have gained the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly, did not include any shading and used most of the space provided.

The majority of candidates gained credit for carefully following the instructions by drawing the five whole yeast cells shown on Fig. 2.2, showing the nuclei within the cells and by drawing the buds on two of the yeast cells. Most candidates used a label line to show either the nucleus or the cytoplasm to indicate the feature of these cells which identified them as being similar to animal cells.

The most common errors were to draw lines that did not join up or drawing parts of cells and to label features of cells that are not observable, such as the membrane.

(ii) The better candidates showed the measurement of **X1**, **X2**, **X3**, **X4** and **X5** to the correct precision, showed the addition of these measurements and division by the number of measurements. Candidates gained credit for showing the conversion of these measurements to m by multiplying by the appropriate number and by showing division by 1200.

The most common error was not showing clearly how the conversion from millimetres to micrometres had been achieved.

BIOLOGY

Paper 9700/34
Advanced Practical Skills 2

Key Messages

Candidates should be given the opportunity to experience a variety of practical work through out the course, in order to develop the skills that can be applied to the requirements of the examination. They should also be given opportunities to reflect on this work in order to modify a particular procedure. For example, in this paper, candidates were required to suggest a modification to the investigation to determine an unknown concentration of ascorbic acid in the water after 15 minutes. To do this the candidates were required to suggest a method of obtaining a number of different known concentrations of ascorbic acid. Candidates should be encouraged to a plot graph of results of known concentrations of ascorbic acid in order to determine the concentration of the unknown ascorbic acid solution.

Candidates should be familiar with how to use the microscope provided in the examination. When asked to draw structures or cells, candidates should follow instructions carefully to draw the required number of the correct structures or whole cells, using a suitable pencil to obtain clear, sharp lines. Only the structure specified should be labelled.

Candidates should be given the opportunity to draw graphs from a variety of different data so that the orientation of the axes is correct and the selected scales use most of the grid. Candidates should chose scales that ensure the graph is easy to use to obtain data, such as 0.5, 1, 2, 5, 10 or 20 units to a 20 mm square.

General Comments

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

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) The majority of candidates correctly stated that there would be an increase in the concentration of ascorbic acid in the water. The most common error was to describe the concentration of ascorbic

acid inside the Visking tubing. Some candidates explained the trend rather than described the trend.

(ii) The majority of candidates recorded a suitable volume of iodine (**I**) required to reach the end point. The most common error was to omit the units (cm^3).

(iii) The majority of candidates correctly showed both water levels above the Visking tubing and followed the instructions to label them 'before' and 'after'.

(iv) The better candidates were able to both state the variable and were able to describe how they would ensure this variable was standardised. The most common error was just to state the variable to be standardised, but not provide the method by which this standardisation was carried out.

(v) The majority of candidates organised their results clearly by presenting a fully ruled table with all the cells drawn, and a ruled outer boundary. Many candidates included an appropriately detailed heading for the independent variable (time / minutes) and the dependent variable (volume of iodine / cm^3). The majority of candidates gained credit for recording results for the four times (0, 5, 10 and 15 minutes) and recording the correct pattern of results, with 5 minutes having a lower value than 10 and 15 minutes.

The most common errors were to omit the correct heading for the dependent variable, to include cm^3 in the cells of this column or row or to not record the results to one decimal place.

(vi) Many candidates correctly described how their results supported their expected trend. The most common error was not referring to their expected trend from **(a)(i)**. This was especially evident where results did not match the expected trend.

(vii) Many candidates were able to suggest a procedure for obtaining a number of different concentrations of ascorbic acid. The better candidates also suggested the use of a graph using the results of the known concentrations to find the unknown concentration of ascorbic acid.

The most common errors were to omit a method for obtaining the different concentrations of ascorbic acid, instead just stating the different concentrations to be used.

(viii) Many candidates correctly stated that by using the same syringe for measuring the volumes, the trend was not affected because the error was consistent. Some candidates correctly stated that if more than one syringe was used, the actual volume used would differ and the error would not be consistent.

(b) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (volume of iodine solution / cm^3) and the *y*-axis (percentage of starch which reacted). Some candidates, however, labelled the incorrect axis. The *x*-axis must be the dependant variable.

Many candidates used scales of 2 cm to 0.5 cm^3 for the volume of iodine concentration and 2 cm to 20 for the percentage of starch reacted. Better candidates plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear, ruled line, accurately connecting each pair of points. The most common errors were using an unsuitable scale on the *x*-axis, plotting points which were too large or too small (point not visible when a line is drawn through it) and drawing lines which were too thick or not ruled to the centre of the point.

(ii) Many candidates who had correctly plotted their graph were able to estimate the volume of iodine solution needed for 100% starch to be reacted. As a general rule, lines on graphs should not be extrapolated; however in this case extrapolation was required to be shown.

(iii) The better candidates were able to explain how the presence of ascorbic acid may affect the use of the iodine solution as a test for the presence of starch in different plant tissues. Common errors included not referring to the colour change or describing ascorbic acid as an enzyme inhibitor preventing the iodine from reacting with the starch.

(iv) The majority of candidates appreciated the need to use excess iodine in order to show the presence of all of the starch in a plant tissue.

Question 2

(a) (i) Those candidates who had experience of producing large drawings as part of their course were likely to gain the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used most of the space provided. The better candidates used a sharp pencil to produce drawings which did not include any shading and used most of the space provided. Many were able to draw the three whole enclosed structures. Some candidates had used the eyepiece graticules to help them draw well-proportioned drawings.

Most candidates used a label line to show the position of the nucleus. Some candidates, however, assumed the whole structures were cells and drew a nucleus in the centre of the enclosed area. Candidates should be encouraged to draw what they observe.

(ii) Many candidates were able to identify the wall of the alveoli as the site of gas exchange. A small number of candidates did not complete this question.

(b) (i) The better candidates were able to identify the closed stomata as the observable feature which has reduced transpiration and were able to explain how this feature reduced transpiration.

(ii) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The better candidates gained credit for carefully following the instructions and only drawing the whole cells within the boundary. Many candidates had used the scale provided to help them draw well-proportioned diagrams. Most candidates used a label line to show the one guard cell correctly. Candidates should be encouraged to draw only what they observe on the photomicrograph.

(iii) 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 54 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.

BIOLOGY

Paper 9700/35
Advanced Practical Skills 1

Key Messages

Candidates should be encouraged to learn the methods for the tests for biological molecules, such as for the Benedict's test. The volume of Benedict's solution must be the same or more than the volume of the sample being tested and the temperature of the water-bath must be maintained at 80 °C or up to 100 °C. As this test was being used to compare concentrations of glucose in **S3**, **G1** and **G2** the same temperature needed to be maintained for all the tests.

Candidates should be encouraged to understand the command terms used in the questions. For example, the term 'explain' should be understood to mean that scientific reasons are required to explain why, for example, the graph has a particular trend.

Candidates should be given the opportunity to estimate unknown concentrations from results for known concentrations. If the value for the unknown concentration is greater than the known concentration then the estimate must state this, e.g. the unknown concentration is greater than 1.0%. If the value for the unknown concentration is between two known concentrations the answer must state this, e.g. the unknown concentration is between 0.1% and 1.0%. Candidates should avoid stating a concentration that has not been made, e.g. 0. 5%.

Candidates should be encouraged to evaluate and identify sources of error in an investigation such as the difference between a systematic and a random error. For example, if a thermometer reads 1 °C above the actual reading this would affect the true value of the result but not the general trend. A random error would include variations in the temperature of a room during the investigation.

General Comments

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

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

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

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

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

Comments on Specific Questions

Question 1

(a) (i) Many candidates completed the table correctly to predict the colour that was observed when the three samples **S1**, **S2** and **S3** were tested for starch.

Many candidates correctly predicted that for the extract taken in the middle of winter, the colour of the iodine solution would be blue or black (starch present), for the extract taken at the beginning of spring, the colour would be a lighter blue or lighter black (a small amount of starch present), for the extract taken in the middle of spring the colour would be orange or yellow or brown (no starch present).

(ii) The majority of candidates correctly stated that the reagent to be used to compare the concentrations of starch was iodine solution. Some candidates correctly described that the same number of drops or the same volume of iodine solution as well the same number of drops or the same volume of starch would be used in order to standardise the test for each sample.

(iii) The majority of candidates organised their results clearly by presenting a fully ruled table with all the headings. Most gained credit for recording the colour changes for the three samples. The better candidates recorded correct colours for **S1** (lighter blue or lighter black), **S2** (most blue or black) and **S3** (orange or yellow or brown).

The most common error was recording 'no change' for **S3** which was not accepted as a colour.

(iv) Most candidates gained credit for completing the table correctly, matching the samples with the time of year that each extract was taken from the root (**S2** the middle of winter, **S1** beginning of spring, and **S3** the middle of spring).

(v) The majority of candidates organised their results clearly by presenting a fully ruled table with all the cells drawn, and a ruled outer boundary. The better candidates included an appropriately detailed heading for the independent variable (samples) 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. The better candidates recorded the time for **G1** as the longest time and the time for **S3** taking the shortest time.

(vi) Some candidates used their results to correctly estimate the concentration of glucose in **S3** as being greater than 1%.

The most common error was to make up a value for the concentration of glucose that had not been tested instead of stating that the value was between two known concentrations of glucose.

(vii) Many candidates correctly described a modified investigation to obtain a more accurate estimate of the glucose concentration in **S3** by testing more concentrations of glucose above 1% with Benedict's solution. The better candidates stated two concentrations of glucose such as 2% and 3%. Many candidates correctly suggested modifications such as using a thermostatically controlled water-bath, carrying out each test separately and repeating the experiment at least twice.

(viii) Many candidates correctly stated that by using the same syringe for measuring the volumes, the trend was not affected because the error was consistent. Some candidates correctly stated that if more than one syringe was used the accuracy of the volume put into the test-tube is affected and it will not be the true value.

(b) (i) The majority of candidates drew the graph, using the headings given in the table, with time in storage / days on the *x*-axis and mean percentage change in water content on the *y*-axis. The better candidates used scales of 5 to 2 cm for the *x*-axis and 5 to 2 cm for the *y*-axis, plotted the points exactly with a small cross or dot in a circle and drew a sharp, clear ruled line accurately connecting each pair of points.

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 every 2 cm, and drawing lines which were too thick or not ruled

(b) (ii) The better candidates stated that the sample of ten roots stored for 20 days would have the highest percentage gain in mass after soaking in the dilute sucrose solution. Some candidates explained that the cells of these roots stored for 20 days had the lowest water potential and more water would diffuse or move by the process of osmosis into these cells.

The most common error was not providing an explanation in terms of water potential.

Question 2

(a) The better candidates used a sharp pencil to produce drawings which did not include any shading and used most of the space provided. Many candidates were able to draw one of the blood vessels with thicker walls than the other vessel and at least one of the blood vessels with at least two layers of tissue. The most common error was not showing any layers of tissues which would be observable using the microscope.

Some candidates used ruled label lines to describe (annotate) the layer lining the inside of the artery as being folded and the not folded in the vein. The most common error was not looking at the layer lining the inside of each vessel using a higher magnification.

(b) Those candidates who had experience of drawing cells as part of their course were likely to gain the most credit. Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, sharp lines which joined up neatly and used most of the space provided.

The majority of candidates carefully followed the instructions by drawing the five whole white blood cells on Fig.2.1, showing the nucleus in each of these cells as a different shape and occupying most of the cytoplasm. Most candidates used ruled label lines to one cell to correctly identify the nucleus, the cytoplasm and the cell membrane as cell structures that can also be found in plant cells.

The most common errors were to draw lines that did not join up or drawing the nuclei as having the same shape. Candidates should be encouraged to draw what they observe.

(c) (i) Most candidates stated that the difference between the blood shown in Fig. 2.1 and that in Fig. 2.2 was the greater number of white blood cells present in Fig. 2.1. Many candidates correctly explained that the reason for this difference was the uncontrolled production of white blood cells.

The most common error was incorrectly linking the increase in the number of white blood cells to their role in defending against infection and that the increase in numbers of white blood cells was the response of the body to the cancer.

(ii) Many candidates showed the measurement of **P**, **Q**, **R**, **S** and **T** to the correct precision, showed the addition of these measurements and division by the number of measurements. The better candidates gained credit for showing the conversion of these measurements to micrometres by multiplying by the appropriate number and by showing division by 500.

The most common error was not showing how the conversion from millimetres to micrometres had been achieved.

(d) The better candidates recorded observations using the most appropriate organisation, which included one column for listing the features and two additional columns, one headed Fig. 2.2 and the other headed Fig. 2.3. The majority of candidates were able to gain partial credit for recording appropriate differences.

BIOLOGY

Paper 9700/41
A2 Structured Questions

Key messages

1. Candidates should be reminded to interpret question command words correctly. A glossary of terms is to be found in an appendix towards the back of the syllabus. 'Describe' and 'explain' are most frequently confused.

2. Candidates should practise combining their own biological knowledge with the contextual information provided in an exam question. There are many occasions when a memorised text book answer does not fully answer the question.

3. Candidates need more practice in interpreting and making sense of tables of data. They should use past paper questions and mark schemes to learn how to gain credit for quoting data and for describing trends in words as well as figures.

4. Candidates should be alerted to notice questions that ask for a comparison between two entities or processes, or a comparison between a situation at one time (such as the beginning of a process or experiment) and another. In these cases answers should be comparative, often using words like more/less, lower/higher, increased/decreased, etc. Examples such as these can be seen in **Questions 1(a)(ii)**, **1(b)**, **4(c)(i)**, **5(b)(ii)** and some marking points on **9(b)**.

General comments

There were many excellent scripts this year, with well-prepared candidates scoring highly. The candidates who did best were able to combine their factual knowledge with an ability to interpret the demands of the question and to understand and use new information from the question context. Careful reading of the whole question was needed for this.

Generally candidates were most successful on **Questions 1** (photosynthesis recall), **7** (genetics cross) and **8** (respiration recall). Questions that involved data handling (**Questions 3** and **4**) were lower-scoring. Both essays were done well by prepared candidates but in **Question 9** there was a tendency for candidates to be more knowledgeable about endangered species than about protoctists.

Comments on specific questions

Section A

Question 1

(a) (i) The precise location in the chloroplast of RuBP and GP was clearly given as the stroma by many candidates, although incorrect responses frequently referred to the thylakoids.

(ii) Most candidates correctly linked the change in concentration of RuBP to the reduced concentration of carbon dioxide over the time period. Further explanation needed was the idea of less carbon fixation or less RuBP converted to GP. A few responses noted that RuBP was also being reformed from TP. Candidates needed to refer to concentration changing rather than to 'amounts' or 'levels' to gain full credit.

(iii) The calculation frequently produced the correct answer of 0.01 arbitrary units per second. Incorrect responses were usually due to not noticing the instruction to give the answer to two decimal places.

(b) Few candidates explained that a decrease in GP concentration would lead to less TP being made, and that this is needed for the production of other organic molecules for growth. Some responses gained credit for stating that less carbohydrate, lipid or protein would be produced, but rarely were these linked to growth or *Chlorella* cell division. Candidates should note than a question about a decrease in a parameter refers to a changed situation over time. The answer therefore should also use comparative terms like 'less / decreased' to explain the resulting change over time in other parameters.

Question 2

(a) Candidates found it difficult to express their ideas clearly. The point most often stated was that cross-pollination involves two parents, not one, although some lost credit by saying two *flowers* without making it clear that these must be on different plants. Some candidates also made correct references to inbreeding or outbreeding. Candidates needed to select the correct term 'alleles' for explanations of how genetic variation occurs. It was a common error for candidates to think that the offspring of self-pollination are genetically identical. They did not consider that meiosis also occurs to form gametes for self-pollination so independent assortment, crossing-over and random fusion of gametes all still occur.

(b) It was rare to find a candidate who clearly described DNA sequencing, rather than just an application of electrophoresis. A correct description of automated Sanger sequencing needed to refer to modified PCR using chain-terminating dideoxynucleotides, followed by electrophretic separation of the different length DNA copies, plus the use of a laser scanner to detect the fluorescently tagged dideoxynucleotides.

(c) Most candidates scored full credit for suggesting cross-breeding the old and new *Silene stenophylla* to see if the resulting offspring were themselves able to reproduce. Errors included mention of 'viable offspring' rather than 'fertile offspring' being produced by breeding within a species, and answers that suggested a molecular approach such as electrophoresis.

Question 3

(a) (i) The symbols AABBCC were usually given correctly.

(ii) Candidates were more successful in explaining why hybrid AB was sterile than in detailing the events that led to polyploidy at point **Y**. Many candidates realised that meiosis could not occur in AB due to not all the chromosomes having a homologous partner, so gametes cannot be produced. However, despite clearly stating this in the first part of their answer, many candidates then argued that at **Y** some type of fusion of gametes occurred. In fact the unequal chromosome division leading to polyploidy occurs during mitosis.

(b) (i) Few candidates achieved full credit on this interpretation of data question. Candidates' analysis of the data and the experimental design was generally very limited.

Credit was available for giving a comparative data quote in a question like this, but in order to score this credit, candidates must use the correct units. In this instance, however, the figures referred to numbers of aphids, so no units were required unless a percentage had been calculated. As there were different starting numbers of aphids in each experimental set-up, both the starting and finishing numbers needed to be stated, or else a percentage leaving or remaining should have been calculated.

As well as illustrating their argument with figures, candidates should clearly state the key trends shown in the results in words. Thus they needed to say that in the presence of Eβf many aphids move away, but in the absence of Eβf very few or no aphids leave.

Few candidates commented on the different volumes of air used in the two experiments, and most assumed that the concentration of Eβf was higher in **Experiment 2** although the correct inference was that the concentration of Eβf in **Experiment 1** was unknown. Few candidates commented on the key distinction between **Experiments 1** and **2**, that in **2** the Eβf was pure, but in **1** other chemicals were present in the leaves.

(ii) Many candidates scored most or all of the available credit here but many are poor at writing brief, clear, factual answers. The key points were that Eβf makes aphids leave, and also attracts the predators of aphids, so aphids eat less wheat.

Some candidates confused the predators of aphids with aphids themselves being 'predators' (rather than herbivores) on the wheat. Others thought that the significance of attracting ladybird predators was that these insects would enhance wheat pollination. Students should be aware that wheat is in fact wind-pollinated.

(iii) The focus of the answer should ideally have been why the GM wheat is acceptable, not the perceived problems with GM maize and cotton. Given the phrasing of the question, the ideal answer would begin 'This wheat might be acceptable because...' and would then list the positives about it. Any negatives about Bt maize or Bt cotton that candidates knew about should have been reversed into a positive for the GM wheat to fit this question. It is this sort of sophisticated manipulation of their knowledge that many candidates need to practise.

Positives for GM wheat are that it is non-toxic to humans and is not a new chemical in the human food chain as it already occurs in peppermint, an edible plant. It does not kill insects directly so the aphids that move away are still available for their predators and the food web is therefore not disrupted.

Question 4

(a) (i) Candidates were mostly able to identify the spermatogonium and primary spermatocyte stages as being 2n or diploid and the later three stages as n or haploid.

(ii) Growth or mitosis were correctly suggested by most for the first stage of development but the answer 'maturation' for the second stage was sometimes spoiled by the inclusion of an additional wrong answer.

(iii) Providing nutrients for spermatids was the best-known role of a Sertoli cell. A few candidates were mistaken in thinking Sertoli cells make testosterone.

(b) Candidates from some Centres were well-prepared and their answers focused on administering an FSH-type drug, development of multiple follicles, use of hCG and retrieval of oocytes with a fine tube and ultrasound. The credit available for retrieving the oocytes from the ovaries was negated if candidates mistakenly stated that ovulation was induced by LH. In fact ovulation is deliberately prevented with an LHRH antagonist. Problems for some candidates included discussing the fertilisation and implantation processes rather than the obtaining of mature oocytes asked about in the question, and stating that FSH causes superovulation rather than development of multiple follicles.

(c) (i) Data-handling skills tested many candidates as in **Question 3(b)(i)**. The main problem on this question was failure to read the question. Candidates were asked to describe the effects of adding the hormones **after 48 hours**. It was not appropriate therefore to reference figures after 24 hours as many candidates did. One of the skills tested on data questions is the ability of the candidate to select the correct information for discussion. A further problem was that the figures were percentages and candidates performed subtractions to find the numerical difference between one category of treatment and another but then called this a percentage increase or decrease, which it was not. The last problem candidates showed was a sense of perspective and ability to weed out small fluctuations and attribute them as insignificant, as in the treatment with testosterone only. Most candidates showed no awareness that changes from the correct baseline reference point (no hormones added, 21%) of 10 (FSH) and 23 (both hormones together) are significant increases but that a change by 2 (testosterone) is a slight effect that could be due to chance.

(ii) This was generally well answered with death of cells being the most frequent correct response.

(iii) The best answers linked the natural temperature of the scrotum outside the body with the experimental conditions chosen. Candidates who wrote that sperm die at 37 °C were obviously not considering the survival of sperm for up to three days in the female reproductive tract. The key issue is that the spermatogenesis differentiation and development process does not occur as well

at the higher temperature, with decreases in sperm quantity and quality resulting from temperatures above 35 °C (in man).

Question 5

(a) Many candidates gained full credit here. The most common mistake was to include deletion or addition as a form of mutation. Very few candidates mentioned the random or spontaneous nature of mutation.

(b) (i) A straightforward description of the relationship between altitude and the frequency of the haemoglobin alleles was required here. Unfortunately many candidates failed to read the question properly and made no reference at all to alleles, only to the haemoglobin polypeptides with their different amino acids.

(ii) Most candidates gained partial credit. The situation at either high or low altitude needed to be described, with those mice with a selective advantage clearly identified and reference made to their increased likelihood of reproduction and passing on the (specified) favoured allele. Candidates should be encouraged to clearly identify the selection pressure and the favourable genotype and phenotype in questions about natural selection. Errors included descriptions of allopatric or sympatric speciation.

Question 6

(a) The ion channels, membrane depolarisation and the effect of strength of stimulus on frequency of action potentials were the more frequent correct answers. Few candidates seemed familiar with the terms 'receptor' or 'generator potential', while slightly more correctly fitted the term 'threshold' into the passage.

(b) A widespread problem with this question was candidates' determination to focus on the establishment of resting potential and the creation and stages of an action potential, when the question was instead asking about the transmission of action potentials along a neurone. Some incorrect answers even went beyond the neurone and described events at the synapse. A typical answer was largely irrelevant, only considering the transmission of the action potential via local circuits in the last two or three lines of the answer. As ever, the advice is to encourage candidates to read the question properly.

Candidates who did focus on the correct part of the process generally scored particularly well if their descriptions included the role of the myelin sheath and salutatory conduction between nodes of Ranvier.

Question 7

(a) Most candidates could name the centromere, although the spelling was not always correct.

(b) Some candidates were unfamiliar with describing genetic change of this magnitude. The words genes and loci were missing from some answers, which instead discussed base changes, frameshifts and alleles rather than missing genes in a section of chromosome. Few candidates made the link between genes, polypeptides and the resulting phenotype.

(c) This was very well answered with most candidates gaining full credit. A few thought the normal male had two X chromosomes, or possessed a faulty X_1 or X_2 chromosome.

Question 8

(a) There were some confused responses which did not gain credit, as they did not make it clear which function was carried out by which organelle. DNA needed to be linked to transcription or the coding of mRNA, and the ribosomes to translation or synthesis of proteins or polypeptides. A few good responses gained credit for naming a protein that a mitochondrion would need to produce. There was some confusion between ATP synthetase (the enzyme on the stalked particles of the

cristae) and ATPase (enzyme that hydrolyses ATP to ADP and inorganic phosphate), which lost credit for candidates who put the wrong name.

(b) The majority of responses correctly listed 2, 3, 4 in the order S, U, W and 6, 7, 8 in the order Q, X, T. The most common mistake was to reverse X and T. T following directly after S and U was allowed minimal credit. This exercise was well done even by candidates who scored poorly on the rest of the question.

(c) Most candidates recognised the splitting of the ATP molecule into ADP and inorganic phosphate as hydrolysis or dephosphorylation. Others provided acceptable alternatives, such as catabolic or exothermic. A significant number of responses incorrectly stated the reverse reaction of condensation or phosphorylation.

(d) Most realised that this would involve anaerobic respiration with a net gain of 2 ATP. Few candidates were awarded marks for the idea of substrate level phosphorylation occurring while TP was being converted to pyruvate in glycolysis. Many responses gained further credit for detail of the formation of lactate when pyruvate gains hydrogen, or for the regeneration of NAD, allowing glycolysis to continue.

A common error was to confuse the lactate pathway found in animals with the ethanol pathway, which would not occur in a tapeworm. Another error was to substitute the term 'dehydrogenation' for its opposite, reduction (of pyruvate to lactate).

Section B

Question 9

(a) Very few candidates could clearly summarise the similarities and differences between different members of the kingdom Protoctista. Most did not realise that, apart from sharing eukaryotic features, they are a diverse group with many differences in their cell structure and mode of nutrition. Candidates gained credit for stating that the group included organisms with and without cell walls, means of motility, multicellularity and the ability to obtain food through photosynthesis or by capturing other unicellular organisms. Ideally candidates would at least know that *Amoeba* or *Plasmodium*, *Chlorella* or another unicellular alga, and seaweeds belong to this kingdom in order to write a good answer.

(b) Most candidates named a relevant species, (elephants, rhinos, polar bears and giant pandas were popular), and explained that endangered meant that numbers had reduced to a point where the species was in danger of becoming extinct. It was rare to see a reference to the species being listed on the IUCN red list.

Most candidates correctly referred to hunting, habitat destruction or a decrease in food supply, together with further detail of how these factors impact upon the species in question. Competition, predators and disease were also referred to, but usually failed to gain credit as a decrease or increase in the factor was not specified. References to pollution were usually too vague to be credited as the pollutant and habitat affected were not specified.

Candidates from some Centres were very well-informed about local examples of endangered species in their countries, showing excellent teaching tailoring the syllabus to local issues.

Question 10

(a) Many candidates wrote very clear answers about the action of penicillin on bacteria, gaining full credit. Some areas to highlight for improved understanding include stating that autolysins are produced by the bacteria themselves and the reason for this (allowing cell walls to stretch during growth), including the explanation 'by osmosis' when describing water entering cells, and making reference to turgor pressure as the reason why cells burst.

(b) Many very good answers gained full credit. Some weaker candidates, however, wrote about the advantages and disadvantages of bioleaching. Credit was lost for errors in writing the Latin name of a bacterium like *Acidithiobacillus ferrooxidans* (missing the capital letter for the genus), for failing

to name two metals obtained (other than iron whose oxidation and reduction is part of the process) and for talking about washing out the soluble sulfate product without saying that this liquid is kept in order to extract the metal by displacement.

Some candidates were let down by their knowledge of chemistry, with the terms oxidation and reduction frequently misused. Where biology candidates are not also studying chemistry it is important to ensure that they have a thorough grasp of the key chemical terms and concepts listed towards the front of the syllabus.

Really detailed descriptions including names of relevant sulfide ores and chemical detail of reactions were often from Centres in countries with an active mining industry, again showing excellent teaching tailored to local issues.

BIOLOGY

Paper 9700/42
A2 Structured Questions

Key messages

1. Candidates should take a note of the credit allocation for each question part as this is an indication of the number of points that are expected in order to gain full credit.

2. It is essential that when candidates use information from tables and graphs to illustrate their answers the figures should be accurate and include the correct units where appropriate.

General comments

There was no evidence of misinterpretation of the rubric. The vast majority of candidates attempted every section.

Generally, candidates appeared to find this paper very accessible, particularly **Questions 1, 2, 9** and **10** where even weaker candidates were able to score some credit. **Questions 3** and **4** proved to be the best discriminators.

Comments on specific questions

Section A

Question 1

(a) This question was generally answered well, with the majority of candidates correctly identifying the pigments as **X**. Slightly fewer named **Y** as the transport proteins.

(b) Many candidates did not mention that the DNA codes for proteins or enzymes, rather manufacturing them. Some were able to give an example of a protein or an enzyme, rubisco being the most popular. Few references to transcription or the production of mRNA were seen.

(c) Almost all candidates gave the correct indications for carbon dioxide and light intensity. The majority, however, incorrectly ticked photolysis and put a cross by Calvin cycle for temperature.

Question 2

(a) Many candidates were able to suggest an explanation for the increased muscle mass in racehorses with the *MSTN* CC genotype, most frequently stating that the myostatin protein would either not be produced or would be non-functional, meaning that the growth and differentiation of muscle tissue would not be slowed down. Some offered the reverse argument for the TT genotype. A few candidates attempted to explain the difference in terms of recessive or dominant alleles, or believed that myostatin would promote the growth of muscle tissue in the CC genotype.

(b) There were many good descriptions of the effect of the *MSTN* genotype on the ability of racehorses to win races of different lengths. Candidates generally started by stating that the CC genotype won mostly short distance races, while the TT genotype was more successful at long distances, often providing suitable data quotes to support both statements. Some candidates even explained the reasons for these observations, stating that horses with genotype CC would have greater power for shorter distances but would tire easily, whereas horses with genotype TT would have more stamina

for longer races. However, few commented that the CT genotype won at all race distances although many identified their best performance at 1.8 km.

(c) (i) The meaning of the term *artificial selection* was generally well explained with many candidates understanding that this would be applied by humans and that two organisms with the desired phenotypes would be interbred so that these chosen characteristics would also be manifested in the offspring. A number of candidates then went on to give examples. However, some neglected to state that the desired organisms would be interbred or referred to organisms of different species being selected to produce a hybrid.

(ii) Explanations as to how genetic tests for the *MSTN* genotype can help in the selective breeding of racehorses were variable and often confused. Better candidates appreciated that horses of known genotype could be chosen to produce horses for specific race distances, often giving examples. Weaker candidates believed that the *MSTN* gene could be isolated and then introduced into horses by genetic manipulation.

Question 3

(a) (i) Most candidates were able to provide at least one reason why sugars need molecules such as SWEET in order to enter or leave the cell, the most frequent being the hydrophilic or polar nature of the sugar. Many went on to explain that this would prevent the sugar from diffusing directly across the phospholipids bilayer, although some simply referred to the cell membrane. Others also commented that the sugar would be too large for simple diffusion. However, some candidates focussed on how the SWEET protein would allow the sugar to pass through its hydrophilic interior, for which no credit was awarded.

(ii) There were some good suggestions as to how a SWEET is held within the membrane bilayer. Many candidates understood that the protein would have both hydrophilic and hydrophobic regions and that the latter would bond with the fatty acid tails of the phospholipid molecules. However, few mentioned that bonds would also form with the phosphate heads. Nevertheless, many candidates named an appropriate bond which might occur, although some made the mistake of referring to hydrogen bonding between the protein and the surrounding water molecules.

(b) (i) Explanations as to how the resistance of rice plants to Xoo bacteria might arise were often comprehensive. Many candidates began their account with how Xoo affected the wild type rice before going on to state what would happen in the resistant rice. Most appreciated that the chemical secreted by the bacteria would be unable to bind to the mutated promoter region of the SWEET gene so that the gene could not be expressed, while some believed that the promoter itself would not be switched on. Fewer candidates commented that the SWEET protein would not be produced, but many stated that glucose would not be secreted into the intercellular spaces so that the Xoo bacteria would be unable to multiply. There were, however, hardly any references to the resistant rice not developing bacterial leaf blight.

(ii) A few candidates received full credit for correct explanations of why it would be difficult to transfer the resistance into susceptible rice plants by genetic engineering. There were many comments about the expense of the process or the difficulty in isolating the required gene and inserting it into a plasmid. While some candidates recognised that the resistant allele was recessive and therefore would not be expressed in the presence of a dominant allele, others confused the terms allele with gene or stated that two dominant alleles would first have to be removed. More able candidates appreciated that the mutated promoter would also have to be transferred in order for the allele to be expressed.

(iii) Few candidates were able to gain full credit for explaining why the presence of large numbers of Xoo bacteria in the intercellular spaces of rice plants affects the ability of the plants to grow with their roots submerged in water. A common misconception was that the bacteria would metabolise the plant's supply of glucose thereby depriving the roots of a respiratory substrate. Other candidates stated that glucose would block the intercellular spaces, preventing gaseous exchange. More able candidates referred to the aerenchyma being occupied by the bacteria, preventing the diffusion of oxygen to the roots, as well as the bacteria using it for their own respiration. Some then went on to describe how the roots would respire anaerobically, producing ethanol which would

build up to toxic proportions. Hardly any candidates linked anaerobic respiration to the fact that less ATP would be available for growth.

Question 4

(a) Many candidates had a clear understanding of the use of electrophoresis as a tool for DNA analysis. Many gave a good account of the procedure for preparing DNA samples and running a gel. Weaker candidates, however, confused the direction of movement of DNA, and few acknowledged that separation of fragments is caused by an electric field/PD. Few candidates referenced the use of radioactive/fluorescent DNA probes.

The majority understood that a comparison of male and hatchling DNA needed to be made, but often did not refer to banding/sequencing patterns.

(b) *body length*
A significant number of candidates recognised that there was no relationship, and many attempted to give an indication that small/intermediate body length produced more offspring. Many quoted random figures over the whole range of body lengths which did not support their answer.

sprint speed
Most candidates identified the correct relationship between sprint speed and number of offspring. Many attempted to use figures to support their answers, although many quoted too many decimal places for speed, or in some cases grouped sprint speeds and quoted ranges of offspring.

(ii) Most candidates linked longer hind legs to the ability to run faster and concluded that they would have more offspring. Few went on to state that there would be a greater probability of passing on these alleles, many assuming that this would automatically occur. Many candidates referred to the number of offspring in a population having long hind legs rather than referring to a change within the species.

(c) This was generally very well answered, with most candidates gaining full credit. Many candidates referred to geographical isolation and explained what was meant by this term. They then went on to state that the two populations would have different environmental conditions. Many referred to mutations occurring and then gave a clear description of the main points of allopatric speciation.

Question 5

(a) Most candidates knew that FSH is secreted by the anterior pituitary, although quite a few attributed the hypothalamus or brain. The most frequent error was omission of 'anterior'.

(b) (i) Whilst it appeared that most candidates knew the answer, many did not state it. The majority were aware that the Graafian follicle develops from the secondary under the influence of FSH but did not link it with ovulation. Many did not state that the corpus luteum formed from the Graafian follicle or after ovulation.

(ii) The majority stated that FSH caused an increase in the number of sperm which were more active, but few made references to fertility or that FSH would bring about better or enhanced development.

Question 6

(a) (i) Very few candidates were able to explain what is meant by the term water potential. Those who did only described it with reference to the tendency of water molecules to move from one region to another. The majority of candidates referred to 'the concentration of water/amount of water molecules in a region' or made references to the difference in water concentration causing it to flow from an area of high to low water potential. Some candidates stated that it was the 'kinetic energy of water' rather than 'potential energy'.

(ii) Most candidates knew the effect of adding solute to a solution. Water potential decreasing and becoming more negative were both regularly seen.

(iii) Knowing precisely where ADH is released into the blood was not well known. A lot of candidates knew that it was from the pituitary gland, but did not qualify it, or gave the anterior instead of the posterior. A few candidates wrote the hypothalamus.

(iv) Generally candidates gave two correct ways of water loss. Sweat and urine were the most common answers. A common incorrect answer was excretion.

(b) Most of the answers to this question gained some credit, but few candidates scored full credit. Many answers included a lot of irrelevant information before getting to the fact that the ADH affects the collecting duct. A few gave the distal convoluted tubule. A few candidates incorrectly wrote about the proximal convoluted tubule or the loop of Henle. Despite knowing that the ADH binds to something, few named the cell surface membrane or included the enzyme controlled reactions in their answer. The idea of the vesicles moving to and fusing with the membrane usually scored well. The consequence of these vesicles fusing with the membrane was rarely stated. Few candidates scored credit for the walls becoming more permeable, or water moving down a water potential gradient. Some mentioned water moving out of the collecting duct but omitted to say it was going from the lumen.

(c) Symptoms of a person with diabetes insipidus were well known, although some lost credit by writing about frequency of urination rather than amount or concentration. Few candidates mentioned cramps or loss of salts.

Question 7

(a) Most candidates lost credit because they did not use the term allele. Other common errors were using a superscript for multiple alleles or XY for sex linked. The most able candidates showed NF with a dominant allele and went onto gain full credit. Most candidates were awarded credit for correct parental genotype and gametes. The most common error in offspring phenotypes was making one a carrier. This was a relatively straightforward question to answer if simple genetic cross rules were followed, but many candidates did not do this.

(b) Many candidates commented on it being a mutation but credit could not be awarded without reference to the mutation being in the allele or gene. The most able candidates stated that it was a random gene mutation and gained full credit. Many candidates gave examples of named mutagens or details of base mutations. Some candidates lost credit as they referenced radiation without stating that it was ionised. The candidates who tended to make the previous answer recessive and thought carriers were involved did not gain any credit as they referenced symptomless carriers being the cause and reason for no family history of NF.

(c) The majority of candidates found this question very challenging and were not able to gain any credit. They did not focus on the transmission of the nerve impulse. The most common answers when given were the setting up of local circuits being prevented or sodium ion channels not opening. Many candidates incorrectly referred to it interfering with synapse action, or, if they mentioned an effect on blocked blood supply, were non-specific about the effect for example referring to the effect on nutrients and no oxygen supply.

Question 8

(a) (i) Many candidates did not make their answer specific to blood temperature. Most recalled that it was a process of negative feedback, but without correct reference to receptors, effectors, responses and a return of the blood temperature to normal, were unable to gain full credit.

(ii) This was a very challenging question for the majority of candidates. The few who did earn credit gave the idea that babies have a larger surface area to volume ratio, and some went on to make the link that this meant they would lose more heat. Quite a large number of candidates recognised that there were more mitochondria present but then did not link this with heat energy release, but incorrectly with ATP production. Occasionally there was the incorrect mention of heat energy being produced.

(b) (i) Many candidates answered this question correctly. The main errors for **A** were reference to ATPase or it being a hydrogen ion channel. For **B**, common incorrect answers were intermembrane or phospholipid bilayer.

(ii) Some candidates did not attempt this question, or did not put their arrow on Fig. 8.1, or made the arrow head point upwards instead of downwards.

(iii) Many candidates did not use Fig. 8.1 and the process numbers listed, trying instead to name the processes which used up much more than the one line available for the answer.

(iv) Most candidates knew that the correct answer was water, but also listed other possible products. It was clear that they did not understand the term by-product.

(v) This question was answered well with most candidates gaining credit for fatty acids or equivalent.

Section B

Question 9

(a) This was a question that required the candidates not only to recall the main features of an organism belonging to the plant kingdom, but also to be specific regarding those features. Most answers included reference to the facts that plants have eukaryotic cells, which carry out autotrophic nutrition, with structural features including chloroplasts, cellulose cell walls and a large vacuole. Marking points were often lost for not stating that the cell wall is made of cellulose, nor that the vacuole was either large or central. Reference to vascular tissue and motility was less common, with meristematic tissue and motility either of plants or gametes in mosses and ferns rarely seen.

(b) This question required candidates to give a description of methods used to conserve endangered species and most were fully aware of the methods used. Many candidates gained full credit. Placing animals in zoos or national parks with captive breeding programmes and assisted reproduction were almost universally appreciated, as were most of the other methods. Several included species such as the Bengal tiger in which many had a particular interest. There were some very well-structured answers

Question 10

(a) Many candidates were unaware that *Penicillium* is a fungus rather than a bacterium, and only a few gave penicillin as a secondary metabolite. Penicillin was often described as being produced when the organism was 'under stress' rather than the more precise scientific description, namely after the growth phase or when nutrients were running out. Most candidates, even the less able, made reference to needing to maintain pH and temperature. The mixing of nutrients with a paddle and aeration were given less often. With regard to nutrients, there was some confusion about addition. It was often not clear when the nutrients were added in the batch culture. Often, candidates mentioned the fed batch culture then proceeded to describe regular addition of glucose/ammonia for the batch culture, seeming to have forgotten the fed batch culture. Better candidates included harvesting and the cleaning of the fermenter at the end of the answer.

(b) A comparison of the batch and continuous culture methods were required in this answer. Points that were well appreciated for the batch culture, were that it needed minimum attention, that only one batch was wasted if there was contamination and that the fermenter can be used for different processes. Less chance of blockage was not generally given. For continuous culture the use of small vessels, high productivity and cost effectiveness were the points most frequently made. With the exception of the most able candidates, many answers were unsystematic with points for the batch and continuous method confused. Overall, this part tended to be less well answered than part **(a)**.

BIOLOGY

Paper 9700/43
A2 Structured Questions

Key messages

1. Candidates should be reminded to interpret question command words correctly. A glossary of terms is to be found in an appendix towards the back of the syllabus. 'Describe' and 'explain' are most frequently confused.

2. Candidates should practise combining their own biological knowledge with the contextual information provided in an exam question. There are many occasions when a memorised text book answer does not fully answer the question.

3. Candidates need more practice in interpreting and making sense of tables of data. They should use past paper questions and mark schemes to learn how to gain credit for quoting data and for describing trends in words as well as figures.

4. Candidates should be alerted to notice questions that ask for a comparison between two entities or processes, or a comparison between a situation at one time (such as the beginning of a process or experiment) and another. In these cases answers should be comparative, often using words like more/less, lower/higher, increased/decreased, etc. Examples such as these can be seen in **Questions 1(a)(ii)**, **1(b)**, **4(c)(i)**, **5(b)(ii)** and some marking points on **9(b)**.

General comments

There were many excellent scripts this year, with well-prepared candidates scoring highly. The candidates who did best were able to combine their factual knowledge with an ability to interpret the demands of the question and to understand and use new information from the question context. Careful reading of the whole question was needed for this.

Generally candidates were most successful on **Questions 1** (photosynthesis recall), **7** (genetics cross) and **8** (respiration recall). Questions that involved data handling (**Questions 3** and **4**) were lower-scoring. Both essays were done well by prepared candidates but in **Question 9** there was a tendency for candidates to be more knowledgeable about endangered species than about protoctists.

Comments on specific questions

Section A

Question 1

(a) (i) The precise location in the chloroplast of RuBP and GP was clearly given as the stroma by many candidates, although incorrect responses frequently referred to the thylakoids.

(ii) Most candidates correctly linked the change in concentration of RuBP to the reduced concentration of carbon dioxide over the time period. Further explanation needed was the idea of less carbon fixation or less RuBP converted to GP. A few responses noted that RuBP was also being reformed from TP. Candidates needed to refer to concentration changing rather than to 'amounts' or 'levels' to gain full credit.

(iii) The calculation frequently produced the correct answer of 0.01 arbitrary units per second. Incorrect responses were usually due to not noticing the instruction to give the answer to two decimal places.

(b) Few candidates explained that a decrease in GP concentration would lead to less TP being made, and that this is needed for the production of other organic molecules for growth. Some responses gained credit for stating that less carbohydrate, lipid or protein would be produced, but rarely were these linked to growth or *Chlorella* cell division. Candidates should note than a question about a decrease in a parameter refers to a changed situation over time. The answer therefore should also use comparative terms like 'less / decreased' to explain the resulting change over time in other parameters.

Question 2

(a) Candidates found it difficult to express their ideas clearly. The point most often stated was that cross-pollination involves two parents, not one, although some lost credit by saying two *flowers* without making it clear that these must be on different plants. Some candidates also made correct references to inbreeding or outbreeding. Candidates needed to select the correct term 'alleles' for explanations of how genetic variation occurs. It was a common error for candidates to think that the offspring of self-pollination are genetically identical. They did not consider that meiosis also occurs to form gametes for self-pollination so independent assortment, crossing-over and random fusion of gametes all still occur.

(b) It was rare to find a candidate who clearly described DNA sequencing, rather than just an application of electrophoresis. A correct description of automated Sanger sequencing needed to refer to modified PCR using chain-terminating dideoxynucleotides, followed by electrophretic separation of the different length DNA copies, plus the use of a laser scanner to detect the fluorescently tagged dideoxynucleotides.

(c) Most candidates scored full credit for suggesting cross-breeding the old and new *Silene stenophylla* to see if the resulting offspring were themselves able to reproduce. Errors included mention of 'viable offspring' rather than 'fertile offspring' being produced by breeding within a species, and answers that suggested a molecular approach such as electrophoresis.

Question 3

(a) (i) The symbols AABBCC were usually given correctly.

(ii) Candidates were more successful in explaining why hybrid AB was sterile than in detailing the events that led to polyploidy at point **Y**. Many candidates realised that meiosis could not occur in AB due to not all the chromosomes having a homologous partner, so gametes cannot be produced. However, despite clearly stating this in the first part of their answer, many candidates then argued that at **Y** some type of fusion of gametes occurred. In fact the unequal chromosome division leading to polyploidy occurs during mitosis.

(b) (i) Few candidates achieved full credit on this interpretation of data question. Candidates' analysis of the data and the experimental design was generally very limited.

Credit was available for giving a comparative data quote in a question like this, but in order to score this credit, candidates must use the correct units. In this instance, however, the figures referred to numbers of aphids, so no units were required unless a percentage had been calculated. As there were different starting numbers of aphids in each experimental set-up, both the starting and finishing numbers needed to be stated, or else a percentage leaving or remaining should have been calculated.

As well as illustrating their argument with figures, candidates should clearly state the key trends shown in the results in words. Thus they needed to say that in the presence of Eβf many aphids move away, but in the absence of Eβf very few or no aphids leave.

Few candidates commented on the different volumes of air used in the two experiments, and most assumed that the concentration of Eβf was higher in **Experiment 2** although the correct inference was that the concentration of Eβf in **Experiment 1** was unknown. Few candidates commented on the key distinction between **Experiments 1** and **2**, that in **2** the Eβf was pure, but in **1** other chemicals were present in the leaves.

(ii) Many candidates scored most or all of the available credit here but many are poor at writing brief, clear, factual answers. The key points were that Eβf makes aphids leave, and also attracts the predators of aphids, so aphids eat less wheat.

Some candidates confused the predators of aphids with aphids themselves being 'predators' (rather than herbivores) on the wheat. Others thought that the significance of attracting ladybird predators was that these insects would enhance wheat pollination. Students should be aware that wheat is in fact wind-pollinated.

(iii) The focus of the answer should ideally have been why the GM wheat is acceptable, not the perceived problems with GM maize and cotton. Given the phrasing of the question, the ideal answer would begin 'This wheat might be acceptable because...' and would then list the positives about it. Any negatives about Bt maize or Bt cotton that candidates knew about should have been reversed into a positive for the GM wheat to fit this question. It is this sort of sophisticated manipulation of their knowledge that many candidates need to practise.

Positives for GM wheat are that it is non-toxic to humans and is not a new chemical in the human food chain as it already occurs in peppermint, an edible plant. It does not kill insects directly so the aphids that move away are still available for their predators and the food web is therefore not disrupted.

Question 4

(a) (i) Candidates were mostly able to identify the spermatogonium and primary spermatocyte stages as being 2n or diploid and the later three stages as n or haploid.

(ii) Growth or mitosis were correctly suggested by most for the first stage of development but the answer 'maturation' for the second stage was sometimes spoiled by the inclusion of an additional wrong answer.

(iii) Providing nutrients for spermatids was the best-known role of a Sertoli cell. A few candidates were mistaken in thinking Sertoli cells make testosterone.

(b) Candidates from some Centres were well-prepared and their answers focused on administering an FSH-type drug, development of multiple follicles, use of hCG and retrieval of oocytes with a fine tube and ultrasound. The credit available for retrieving the oocytes from the ovaries was negated if candidates mistakenly stated that ovulation was induced by LH. In fact ovulation is deliberately prevented with an LHRH antagonist. Problems for some candidates included discussing the fertilisation and implantation processes rather than the obtaining of mature oocytes asked about in the question, and stating that FSH causes superovulation rather than development of multiple follicles.

(c) (i) Data-handling skills tested many candidates as in **Question 3(b)(i)**. The main problem on this question was failure to read the question. Candidates were asked to describe the effects of adding the hormones **after 48 hours**. It was not appropriate therefore to reference figures after 24 hours as many candidates did. One of the skills tested on data questions is the ability of the candidate to select the correct information for discussion. A further problem was that the figures were percentages and candidates performed subtractions to find the numerical difference between one category of treatment and another but then called this a percentage increase or decrease, which it was not. The last problem candidates showed was a sense of perspective and ability to weed out small fluctuations and attribute them as insignificant, as in the treatment with testosterone only. Most candidates showed no awareness that changes from the correct baseline reference point (no hormones added, 21%) of 10 (FSH) and 23 (both hormones together) are significant increases but that a change by 2 (testosterone) is a slight effect that could be due to chance.

(ii) This was generally well answered with death of cells being the most frequent correct response.

(iii) The best answers linked the natural temperature of the scrotum outside the body with the experimental conditions chosen. Candidates who wrote that sperm die at 37 °C were obviously not considering the survival of sperm for up to three days in the female reproductive tract. The key issue is that the spermatogenesis differentiation and development process does not occur as well

at the higher temperature, with decreases in sperm quantity and quality resulting from temperatures above 35 °C (in man).

Question 5

(a) Many candidates gained full credit here. The most common mistake was to include deletion or addition as a form of mutation. Very few candidates mentioned the random or spontaneous nature of mutation.

(b) (i) A straightforward description of the relationship between altitude and the frequency of the haemoglobin alleles was required here. Unfortunately many candidates failed to read the question properly and made no reference at all to alleles, only to the haemoglobin polypeptides with their different amino acids.

(ii) Most candidates gained partial credit. The situation at either high or low altitude needed to be described, with those mice with a selective advantage clearly identified and reference made to their increased likelihood of reproduction and passing on the (specified) favoured allele. Candidates should be encouraged to clearly identify the selection pressure and the favourable genotype and phenotype in questions about natural selection. Errors included descriptions of allopatric or sympatric speciation.

Question 6

(a) The ion channels, membrane depolarisation and the effect of strength of stimulus on frequency of action potentials were the more frequent correct answers. Few candidates seemed familiar with the terms 'receptor' or 'generator potential', while slightly more correctly fitted the term 'threshold' into the passage.

(b) A widespread problem with this question was candidates' determination to focus on the establishment of resting potential and the creation and stages of an action potential, when the question was instead asking about the transmission of action potentials along a neurone. Some incorrect answers even went beyond the neurone and described events at the synapse. A typical answer was largely irrelevant, only considering the transmission of the action potential via local circuits in the last two or three lines of the answer. As ever, the advice is to encourage candidates to read the question properly.

Candidates who did focus on the correct part of the process generally scored particularly well if their descriptions included the role of the myelin sheath and salutatory conduction between nodes of Ranvier.

Question 7

(a) Most candidates could name the centromere, although the spelling was not always correct.

(b) Some candidates were unfamiliar with describing genetic change of this magnitude. The words genes and loci were missing from some answers, which instead discussed base changes, frameshifts and alleles rather than missing genes in a section of chromosome. Few candidates made the link between genes, polypeptides and the resulting phenotype.

(c) This was very well answered with most candidates gaining full credit. A few thought the normal male had two X chromosomes, or possessed a faulty X_1 or X_2 chromosome.

Question 8

(a) There were some confused responses which did not gain credit, as they did not make it clear which function was carried out by which organelle. DNA needed to be linked to transcription or the coding of mRNA, and the ribosomes to translation or synthesis of proteins or polypeptides. A few good responses gained credit for naming a protein that a mitochondrion would need to produce. There was some confusion between ATP synthetase (the enzyme on the stalked particles of the

cristae) and ATPase (enzyme that hydrolyses ATP to ADP and inorganic phosphate), which lost credit for candidates who put the wrong name.

(b) The majority of responses correctly listed 2, 3, 4 in the order S, U, W and 6, 7, 8 in the order Q, X, T. The most common mistake was to reverse X and T. T following directly after S and U was allowed minimal credit. This exercise was well done even by candidates who scored poorly on the rest of the question.

(c) Most candidates recognised the splitting of the ATP molecule into ADP and inorganic phosphate as hydrolysis or dephosphorylation. Others provided acceptable alternatives, such as catabolic or exothermic. A significant number of responses incorrectly stated the reverse reaction of condensation or phosphorylation.

(d) Most realised that this would involve anaerobic respiration with a net gain of 2 ATP. Few candidates were awarded marks for the idea of substrate level phosphorylation occurring while TP was being converted to pyruvate in glycolysis. Many responses gained further credit for detail of the formation of lactate when pyruvate gains hydrogen, or for the regeneration of NAD, allowing glycolysis to continue.

A common error was to confuse the lactate pathway found in animals with the ethanol pathway, which would not occur in a tapeworm. Another error was to substitute the term 'dehydrogenation' for its opposite, reduction (of pyruvate to lactate).

Section B

Question 9

(a) Very few candidates could clearly summarise the similarities and differences between different members of the kingdom Protoctista. Most did not realise that, apart from sharing eukaryotic features, they are a diverse group with many differences in their cell structure and mode of nutrition. Candidates gained credit for stating that the group included organisms with and without cell walls, means of motility, multicellularity and the ability to obtain food through photosynthesis or by capturing other unicellular organisms. Ideally candidates would at least know that *Amoeba* or *Plasmodium*, *Chlorella* or another unicellular alga, and seaweeds belong to this kingdom in order to write a good answer.

(b) Most candidates named a relevant species, (elephants, rhinos, polar bears and giant pandas were popular), and explained that endangered meant that numbers had reduced to a point where the species was in danger of becoming extinct. It was rare to see a reference to the species being listed on the IUCN red list.

Most candidates correctly referred to hunting, habitat destruction or a decrease in food supply, together with further detail of how these factors impact upon the species in question. Competition, predators and disease were also referred to, but usually failed to gain credit as a decrease or increase in the factor was not specified. References to pollution were usually too vague to be credited as the pollutant and habitat affected were not specified.

Candidates from some Centres were very well-informed about local examples of endangered species in their countries, showing excellent teaching tailoring the syllabus to local issues.

Question 10

(a) Many candidates wrote very clear answers about the action of penicillin on bacteria, gaining full credit. Some areas to highlight for improved understanding include stating that autolysins are produced by the bacteria themselves and the reason for this (allowing cell walls to stretch during growth), including the explanation 'by osmosis' when describing water entering cells, and making reference to turgor pressure as the reason why cells burst.

(b) Many very good answers gained full credit. Some weaker candidates, however, wrote about the advantages and disadvantages of bioleaching. Credit was lost for errors in writing the Latin name of a bacterium like *Acidithiobacillus ferrooxidans* (missing the capital letter for the genus), for failing

to name two metals obtained (other than iron whose oxidation and reduction is part of the process) and for talking about washing out the soluble sulfate product without saying that this liquid is kept in order to extract the metal by displacement.

Some candidates were let down by their knowledge of chemistry, with the terms oxidation and reduction frequently misused. Where biology candidates are not also studying chemistry it is important to ensure that they have a thorough grasp of the key chemical terms and concepts listed towards the front of the syllabus.

Really detailed descriptions including names of relevant sulfide ores and chemical detail of reactions were often from Centres in countries with an active mining industry, again showing excellent teaching tailored to local issues.

BIOLOGY

Paper 9700/51
Planning, Analysis and Evaluation

Key Messages

It is important to read the question carefully before starting to answer. In this particular paper there were many important pieces of information to absorb which would have allowed full and relevant answers to be produced.
Candidates also need to be clear about the meaning and relevance of statistical terms and how they are used in investigations.

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 was less evidence of learning from practical experience than previously and there were some areas of statistical analysis that candidates found confusing. Most candidates found that they were able to answer within the space provided.

Comments on Specific Questions

Question 1

This question focused on gel electrophoresis. Overall it seemed to be a technique that was not always familiar to candidates.

(a) (i) The detailed stem of the question provided much of the information needed to answer this question. Many responses covered the key idea that complementary base pairing between the RNA probe and the DNA sticky end made selection possible. Surprisingly few mentioned that the RNA probe was single stranded - perhaps thinking this was too obvious. Very many candidates did not go further than this and so missed out on the selecting of the DNA fragments. This needed a clear statement of the idea that different probes would allow the pairing up with different sticky ends thus selecting the various different DNA fragments.

(ii) Candidates found this question difficult to answer. The question asks for ideas related to genetic variation within species, but answers commonly talked about variation between species. The stem of the question gives some information which the better responses correlated and indicated that they were aware that genetic variation or mutation could be caused by as small a change as one or a few nucleotides. Examples to illustrate this, which were credited, included types of changes such as deletion or inversion (point mutations), or description of how such changes could affect the organism in terms of altering the amino acid sequence in a protein and thus giving variation. A number of answers described the electrophoretic method or its uses in crime forensics or paternity cases.

(b) Not all the responses showed that the candidates realised that this question required a practical approach to carrying out the gel electrophoresis. Many included a detailed account of the theoretical background as to why it worked as a separation technique or started by copying out much of the introduction to the question on how DNA fragments were produced and amplified. The key points were that an agarose gel was used with wells at one end, into which the DNA samples were placed then it was set up in a buffered situation with the cathode at the end where the samples were situated and a potential difference was applied. Detail as to how the samples would be added to the wells to get valid and reliable results was credited. There needed to be a way of showing up the fragments once separated. This could be via staining and using a UV light, staining with dyes that are visible in daylight or by ensuring all the fragments were radioactive at the start and making an autoradiograph. These ideas were rarely mentioned in the correct context. As a practical exercise, there needed to be some mention of safety and precautions. Appropriate ones

here include the risk with electrical apparatus and a precaution for the harmful nature of dyes or radioactive labels.

Many of the responses mentioned radioactive probes or fluorescent markers in the wrong context by describing them as a way of identifying specific DNA fragments rather than showing up the whole genetic fingerprint. Many responses did not mention wells and were too vague as to where on the gel the samples would be placed. In some cases it seemed they were placed near the middle, as fragments were described as moving either to the cathode or anode.

(c) Candidates focusing on preparation of fragments or their identification missed the point of variables such as volume of DNA sample, voltage difference, type of gel, time of running and others related to the actual electrophoresis. Instead they suggested things like invertebrate used or type of probe. There was also a focus on DNA fragments in some responses, e.g. same number, mass, length. There was a tendency in some responses to use the vague term 'amount' rather than a more precise term like volume of gel or DNA sample.

(d)(i)(ii) The majority of candidates were able to identify a suitable band on all three electrophoretograms, although sometimes very faint ones were chosen or the band was drawn over. These were credited provided it was possible to tell that it was a suitable band. In part **(ii)** most identified varieties 1 and 2 and described in some way that the bands all matched up. They do in fact match up very closely and that was looked for in the answer, so answers like 'similar' rather than very similar or the same did not gain credit. Very occasionally bands other than 1 or 2 were selected and it sometimes proved possible to award some credit if it was clear that the candidate understood that they were looking for matching bands. A small proportion misunderstood the question and instead of choosing varieties chose two of the groups of RNA probes **A**, **B** and **C**. This could not gain any credit as there is no valid explanation of this. Careful reading of the question and Figure 1.1 would have avoided that slip.

Question 2

This question contained some important material to read through. The data tables needed careful study to ensure that the legume fertiliser and the parts of the *Sorghum* were not confused. The question also allowed candidates to show their understanding of statistics and to draw conclusions from given information.

(a) (i) Many responses gained credit here. Some responses incorrectly gave two variables that should have been standardised. This would have been avoided with careful reading of the question. Some other responses were too vague to credit, e.g. 'time' unqualified was not sufficient as it needed to be time before *Sorghum* was planted. Some answers indicated that the question was not read carefully enough, e.g. 'time for *Sorghum* to grow', 'the same type of plant' and 'same type of *Sorghum*'. The whole investigation is on *Sorghum bicolor* so it cannot be a standardising variable. However, same type of legume used as fertiliser was accepted. Size of plot was credited but not size of field.

(ii) Some candidates confused biotic and abiotic factors and talked about microorganisms or the mass of legume. For those who did focus on abiotic factors good responses were usually in terms of light intensity or temperature. Rainfall, wind and abiotic aspects of the soil were also commonly credited. Credit was not given for general references to light or sunlight without the qualification of intensity.

(iii) There were some good answers about why the plots were left for 1 month before sowing the *Sorghum*. These clearly explained that it gave time for the green manure to decompose or to fertilise the soil. However, there was confusion in many responses which suggested it was to give time for the legume to grow or even for the *Sorghum* to grow, despite the stem of the question stating they were left for a month before sowing the grain. There were also a number of rather general responses on the lines of 'letting everything equilibrate' or 'let the nutrients spread evenly' which were not sufficient to gain credit.

(iv) Responses about the reliability of experimental design needed to make it clear that there was more than one replicate of each plot type or treatment. Some did, but there were many generalised answers with unqualified mention of repeats or large sample or large number of seeds. Others repeated the variables that were standardised or mentioned the control or random numbers.

(b) (i) Many responses did well on the calculation of percentage increase and gained full credit for a correct response to an appropriate number of decimal places. A few did not understand how this was done or chose a column of figures other than the whole plant column. In some cases it was possible to award credit for some correct working.

(ii) There were plenty of accurate responses giving 3:1 as the ratio, which is the way a ratio is usually displayed. Overall this calculation was less well approached than the percentage increase. Some gave 1:3 which was accepted provided it was clear which referred to legume roots and which to legume shoots. The figures do allow the ratio to be expressed as 3:1 and thus figures like 384:128 were not acceptable for full credit. But there was some credit for showing in the calculation that the figure 384 (782 - 398) was that to which the given figure of 128 was compared.

(c) (i) The suggested null hypotheses were not always accurate enough, seemingly due to candidates not reading all the information carefully enough. Thus the *t*-tests were not comparing one type of green manure against another type of green manure; they were comparing each type against the control, i.e. against the dry mass increase with no green manure. Thus the null hypothesis would be that there is no significant difference in the dry mass of *Sorghum* grown with green manure and that with no green manure. It is important that the word 'significant' appears in the statement.

(ii) The reasons for using the *t*-test were generally well presented. A few responses suggested that the test allowed you to find the mean rather than to compare means. Some answers were along the lines of 'to see if the data was significant', which effectively just paraphrases the question.

(iii) Although there were some responses that indicated a grasp of the fundamental ideas behind statistical tests, many more were confused and wrote out all the statistical terms they knew without making it clear that they understood their meaning or relevance. Thus 'error', 'confidence limits', 'critical value', deviation' often featured in answers without any explanation as to their relevance, if any, to the question

statistically significant: the best responses understood that this meant the results were caused by a factor other than chance. In this case it would be the green manure treatment. Many candidates gained credit here. Less good responses tended to go round in a circle and effectively say that 'statistically significant means that the results are significant'

$P < 0.05$: Many simply said that the probability was less than 0.05, which was just restating the question. The first requirement was to indicate that this equated to a 5% or less chance. Then this needed qualifying as either a 5% chance that the results gained were due to chance, or a 95% certainty that the results obtained were caused by an outside effect - in this case the green manure treatment.

(d) Many candidates were able to pick out a number of key conclusions from the tabulated data. There was some confusion between the parts of the legume plant used for green manure and the parts of the *Sorghum* plants showing changes in their dry mass. Responses such as 'manure applied to legume roots' were not uncommon, but it was sometimes possible to follow the meaning. Such responses do underline the need for clear unambiguous answers to this type of question. Many responses gave figures. Whilst these could sometimes back up a conclusion, they do not replace a clearly stated conclusion in words derived from a consideration of the figures. There is a general conclusion that can be seen in Table 2.1 that green manure always increases the dry mass. Table 2.1 also allows some comparative conclusions to be drawn regarding the different treatments. Such conclusions are that shoots cause a greater increase in dry mass than roots and that shoots and roots together cause the greatest increase in dry mass. Table 2.2 focuses on significance and thus conclusions from here needed to do the same. Some responses still refer to degrees of significance suggesting something is more or less significant. In a statistical sense this is not valid - a result is either 'significant' or 'not significant'. The term 'insignificant' should not be used. From Table 2.2 it is possible to conclude that roots as green manure do not have a significant effect on the increase in dry mass of any part of *Sorghum* plants whilst roots and shoots together have a significant effect on all plant parts. Shoots alone only have a significant effect on the grain and whole plant.

BIOLOGY

Paper 9700/52

Planning, Analysis and Evaluation

Key messages.

It is essential that candidates read the information provided. Good responses to questions often depend upon the use of this information. Candidates also need experience of practical work to become familiar with techniques used in this subject.

Candidates should be clear about the distinction between standard deviation and standard error and how they are used to assess the results of an investigation.

General comments

There was a good range of marks although there was some evidence that candidates found the context of **Question 1** quite challenging. The limited practical experience of some candidates was evident in this question. Candidates did not seem to be short of time and were able to use the space provided for their responses. Better responses showed the ability to select and use relevant data and weaker responses showing limited skills in interpreting complex data.

Comments on specific questions

Question 1

This question was about DNA extraction, gel electrophoresis of DNA and interpretation of results. Candidates did not seem to be as familiar with these techniques as might be expected. The introduction to the question gave a detailed description of extracting DNA from peas and its subsequent digestion by restriction enzymes. The questions that followed tested the understanding of the various stages of this process.

(a) (i) Very few candidates were able to state a reason for using detergent. There was considerable confusion between detergents and biological washing liquids containing enzymes. Incorrect responses included digesting the cell wall or cell membrane and causing an alkaline pH, both of which suggest some enzyme action. Other responses referred to disinfecting or cleaning the surface of the peas, suggesting that these candidates had not read the information carefully enough as the peas were already ground before adding the detergent. Candidates need to understand that detergents interact with fatty acids and aid their dispersal in water, so they disrupt membranes.

(ii) Better responses showed an understanding that enzymes would be denatured and thus prevent the action of the lytic enzymes released by cell damage during grinding. Some weak responses stated this was the optimum temperature for the enzymes. Others stated that the DNA strands would separate, suggesting some confusion with the polymerase chain reaction.

(iii) Few candidates were able to give a clear description in the context of the question. Better responses realised that filtration separates solid cell debris from the filtrate containing DNA. Weaker responses showed little understanding of filtration and stated that it removes a variety of incorrect substances such as salt, detergent or cell organelles. Other responses were too vague for credit, such as ‘filters the residue and ‘removes the peas’.

(iv) The majority of candidates gave a general definition of a protease in the context of ‘removing any remaining proteins’. Better responses showed an understanding that eukaryotic DNA has a number of associated proteins that must be removed to obtain DNA molecules.

(b) Many responses did not address the question as candidates wrote in terms of the theoretical background as to why electrophoresis works as a separation technique or wrote about restriction enzymes and DNA amplification. The main points required were that an agarose gel was used with wells at one end into which DNA samples were placed, then the gel was placed in a buffer and a potential difference applied for a period of time. Credit was also available for some detail of how the samples are added to the gel to ensure reliable results and the orientation of the gel so that a cathode was placed on the same side as the DNA fragments. Further credit was given for a suitable method of making the DNA fragments visible after separation. Acceptable methods included staining and using ultraviolet light, staining with dyes that are visible in daylight or using DNA that had been made radioactive before separation and making an autoradiograph. Candidates who had experience of electrophoresis gave good descriptions of how to set up and run an electrophoresis gel, although very few used a suitable method of visualising the DNA. Most responses referred to the use of probes or fluorescent markers to identify specific genes, rather than showing the entire fragmentation pattern. Weaker responses rarely mentioned wells, buffer or the type of gel used. In some cases these responses stated that the DNA samples were placed at the centre of the gel and that separation occurred in both directions. Since this was about a practical procedure candidates also needed to refer to safety issues, such as when using electrical apparatus and a precaution for potentially toxic or irritant dyes. Descriptions of safety were uncommon and frequently vague, such as 'take care with electricity'.

(c) (i) Most candidates gave a correct response, most commonly the distance moved by DNA fragments.

(ii) Candidates were expected to respond in the context of electrophoresis as the introduction to the question specified the details of the sample preparation necessary to ensure comparability. Many candidates however focused on the use of the restriction enzymes and so missed variables such as the volume of the DNA samples, the potential difference, the type of gel, the time of running the gel and others related to the actual electrophoresis. Instead they gave same species of pea, same enzymes, and same number of DNA fragments or quoted bullet points from the question introduction. There was also a tendency, even in better responses to use vague terms such as 'amount' rather than volume.

(d) Responses to this part of the question suggested that candidates were uncertain about interpreting the results of electrophoresis. A common misconception was that DNA fragments at the same distance along the gel were same fragments, even when produced by different restriction enzymes.

(i)(ii) Most candidates gave a correct response about the number of restriction sites in *Eco* R1 in comparison to *Hin* dIII. Some weak responses showed confusion between the restriction sites and the DNA fragments produced, for example 'more restriction sites show on the DNA fingerprint for *Eco* R1.

To respond to the question about *Eco* R1 restriction sites within the DNA fragments produced by *Hin* dIII candidates needed to compare the fragments produced by the combined action of these restriction enzymes to the fragments produced by the individual enzymes. Only better responses showed this understanding. Weaker responses compared the fragments produced by *Eco* R1 and *Hin* dIII to each other. A common incorrect response was that fragments produced by these enzymes travelled the same distance, or that *Hin* dIII produced more big fragments than *Eco* R1. Neither of these responses provides information other than the relative sizes of the fragments.

(e) (i) (ii) Candidates who understood that the smallest fragments at the anode were the start of the sequence and that this would be the 3' end, usually gave the correct response in part **(i)** and gained at least partial credit in part **(ii)**. The most common errors in part **(i)** were to start from the cathode end of the sequence (TTAGA…) or to write the base pairs of the actual sequence (GGCTT…). Some weaker responses did not appear to understand that the abbreviations CTP, GTP, ATP and TTP, used in Fig. 1.2, referred to the tri-phosphorylated nucleotides used during DNA synthesis. Consequently sequences had base pairs to the nucleotide and the 'T' in the abbreviation.

In part **(ii)** most candidates realised that base pairing was involved. Better responses also gave a correct start point and described how the key could be used to identify the nucleotides on the template DNA. Weaker responses tended to copy the key without linking it to finding the nucleotide sequence. Very few candidates explained that the antiparallel organisation of the two strands

forming a DNA molecule meant that the sequence given in **(i)** had to be written in reverse from the anode end of the gel.

Question 2

This question was about the effect of nitrogen supply on the activity of enzymes involved in photosynthesis in different varieties of *Sorghum bicolor.* The question tested evaluation of experimental design and statistical analysis of data.

(a) (i) Most candidates correctly identified at least one of the independent variables. Weaker responses were often too vague, such as 'the nutrient medium' or 'nitrogen' and in some cases confused, such as 'high and low nitrogen plants'. In other cases candidates did not appear to have read the question carefully and referred to 'different species' of *Sorghum*.

(ii) Many candidates gave a correct response. Some responses referred to eight or many replicates, but did not mention that this was for all the varieties tested.

(b) (i) Many candidates gained maximum credit for the calculation of percentage, although some lost credit by not rounding to the nearest whole number, as required by the question. A few candidates did not know how to do a percentage calculation for figures that included standard error values. Other candidates chose the wrong set of figures. In some of these cases it was possible to gain credit for correct working.

(ii) A variety of definitions of standard error were acceptable. The best responses usually defined standard error (S_M) as an estimate of the mean of a population and then went on to say that smaller S_M values indicate that a sample mean is close to actual mean of the population, or the mean is more reliable. The responses of very many candidates showed confusion between standard error and standard deviation. There were examples of correct definitions which were then illustrated by statements more appropriate to standard deviation, for example S_M shows the reliability of the mean, so the data from PEP carboxylase is reliable because there is a small spread from the mean.

(c) (i) Most candidates were able to identify **X** and **Z** although their reasons were often expressed in terms of error bars. This was not acceptable as the data was not presented in graphical form. Candidates need to understand that S_M is an indication of the range of values and look to see whether these overlap. Some stated that the mean overlapped, which was not accepted as it is the lower limit of the range of mean values of **Z** that overlap with the upper limit of the mean values of **X**. Many candidates did not follow the instruction in the question to underline their selected test(s) and lost thus credit.

(ii) Almost all candidates gave a correct response. Credit was given for a formula using the correct numbers of samples. The only common error was to state that the number of samples was 15 and then subtract 1.

(d) The majority of candidates identified **W** as anomalous but only the best responses gave an acceptable explanation. Candidates were expected to notice that NADP-malate dehydrogenase or PEP carboxylase showed an opposite pattern of response to the other varieties in high and low nitrogen. Acceptable reasons were that in low nitrogen the activity of NADP-malate dehydrogenase decreases and the other varieties increase, or the activity of PEP carboxylase in low nitrogen increases while the other varieties decrease in activity. Weaker responses said little more than '**W** does not follow the trend'. Candidates should be encouraged to explain how an anomalous result differs from the trend.

BIOLOGY

Paper 9700/53
Planning, Analysis and Evaluation

Key Messages

It is important to read the question carefully before starting to answer. In this particular paper there were many important pieces of information to absorb which would have allowed full and relevant answers to be produced.
Candidates also need to be clear about the meaning and relevance of statistical terms and how they are used in investigations.

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 was less evidence of learning from practical experience than previously and there were some areas of statistical analysis that candidates found confusing. Most candidates found that they were able to answer within the space provided.

Comments on Specific Questions

Question 1

This question focused on gel electrophoresis. Overall it seemed to be a technique that was not always familiar to candidates.

(a) (i) The detailed stem of the question provided much of the information needed to answer this question. Many responses covered the key idea that complementary base pairing between the RNA probe and the DNA sticky end made selection possible. Surprisingly few mentioned that the RNA probe was single stranded - perhaps thinking this was too obvious. Very many candidates did not go further than this and so missed out on the selecting of the DNA fragments. This needed a clear statement of the idea that different probes would allow the pairing up with different sticky ends thus selecting the various different DNA fragments.

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(b) Not all the responses showed that the candidates realised that this question required a practical approach to carrying out the gel electrophoresis. Many included a detailed account of the theoretical background as to why it worked as a separation technique or started by copying out much of the introduction to the question on how DNA fragments were produced and amplified. The key points were that an agarose gel was used with wells at one end, into which the DNA samples were placed then it was set up in a buffered situation with the cathode at the end where the samples were situated and a potential difference was applied. Detail as to how the samples would be added to the wells to get valid and reliable results was credited. There needed to be a way of showing up the fragments once separated. This could be via staining and using a UV light, staining with dyes that are visible in daylight or by ensuring all the fragments were radioactive at the start and making an autoradiograph. These ideas were rarely mentioned in the correct context. As a practical exercise, there needed to be some mention of safety and precautions. Appropriate ones

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(d)(i)(ii) The majority of candidates were able to identify a suitable band on all three electrophoretograms, although sometimes very faint ones were chosen or the band was drawn over. These were credited provided it was possible to tell that it was a suitable band. In part **(ii)** most identified varieties 1 and 2 and described in some way that the bands all matched up. They do in fact match up very closely and that was looked for in the answer, so answers like 'similar' rather than very similar or the same did not gain credit. Very occasionally bands other than 1 or 2 were selected and it sometimes proved possible to award some credit if it was clear that the candidate understood that they were looking for matching bands. A small proportion misunderstood the question and instead of choosing varieties chose two of the groups of RNA probes **A**, **B** and **C**. This could not gain any credit as there is no valid explanation of this. Careful reading of the question and Figure 1.1 would have avoided that slip.

Question 2

This question contained some important material to read through. The data tables needed careful study to ensure that the legume fertiliser and the parts of the *Sorghum* were not confused. The question also allowed candidates to show their understanding of statistics and to draw conclusions from given information.

(a) (i) Many responses gained credit here. Some responses incorrectly gave two variables that should have been standardised. This would have been avoided with careful reading of the question. Some other responses were too vague to credit, e.g. 'time' unqualified was not sufficient as it needed to be time before *Sorghum* was planted. Some answers indicated that the question was not read carefully enough, e.g. 'time for *Sorghum* to grow', 'the same type of plant' and 'same type of *Sorghum*'. The whole investigation is on *Sorghum bicolor* so it cannot be a standardising variable. However, same type of legume used as fertiliser was accepted. Size of plot was credited but not size of field.

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(iii) There were some good answers about why the plots were left for 1 month before sowing the *Sorghum*. These clearly explained that it gave time for the green manure to decompose or to fertilise the soil. However, there was confusion in many responses which suggested it was to give time for the legume to grow or even for the *Sorghum* to grow, despite the stem of the question stating they were left for a month before sowing the grain. There were also a number of rather general responses on the lines of 'letting everything equilibrate' or 'let the nutrients spread evenly' which were not sufficient to gain credit.

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(c) (i) The suggested null hypotheses were not always accurate enough, seemingly due to candidates not reading all the information carefully enough. Thus the *t*-tests were not comparing one type of green manure against another type of green manure; they were comparing each type against the control, i.e. against the dry mass increase with no green manure. Thus the null hypothesis would be that there is no significant difference in the dry mass of *Sorghum* grown with green manure and that with no green manure. It is important that the word 'significant' appears in the statement.

(ii) The reasons for using the *t*-test were generally well presented. A few responses suggested that the test allowed you to find the mean rather than to compare means. Some answers were along the lines of 'to see if the data was significant', which effectively just paraphrases the question.

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$P < 0.05$: Many simply said that the probability was less than 0.05, which was just restating the question. The first requirement was to indicate that this equated to a 5% or less chance. Then this needed qualifying as either a 5% chance that the results gained were due to chance, or a 95% certainty that the results obtained were caused by an outside effect - in this case the green manure treatment.

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