BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 5, 7, 10, 13, 15, 18, 20, 21, 23, 25, 31, 34, 36, 37 and 38

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

Question 3

Many candidates found this question difficult. Most of the stronger performing candidates answered correctly, realising that both mitochondria and chloroplasts have circular DNA. The most common incorrect answer was option **B**, even though mature red blood cells contain no organelles and no DNA.

Question 4

Whilst the majority of stronger performing candidates answered correctly, some candidates incorrectly chose option **D**.

Question 8

Most candidates answered correctly and realised that the primary, secondary and tertiary levels of protein must be involved in forming the active site. Not all enzymes will have a quaternary structure.

Question 11

Many candidates found this difficult and incorrectly chose either option **B** or option **D**. Using the information provided in the question and noting that the *y*-axis is labelled as the rate of reaction, candidates should have realised that the rate must start high, and therefore option **C** must be correct.

Question 16

The majority of candidates found this question difficult. From the information supplied, candidates were required to identify that all three cell types would undergo many mitotic cell cycles.

Question 19

Whilst almost all candidates knew that statements 1 and 4 were correct, only the strongest candidates realised that statement 3 was also correct.

Question 27

Most candidates answered correctly. The most common incorrect answer was to select option **C**. Only a longitudinal section of a heart could contain both the right atrium and right ventricle.

Question 30

The majority of all candidates knew that all three tissues were present and so answered correctly. The most common incorrect answer was to select option **C**.

Question 32

A majority of candidates answered correctly. The weaker candidates mostly chose options where alveoli contain smooth muscle tissue.

Question 33

Whilst the vast majority of all candidates selected options that included statement 3 (the only correct statement), many also thought that statement 1 or statement 2 was also correct.

Questions 39 and 40

The vast majority of stronger candidates had little difficulty with these questions and most candidates overall answered correctly. Only a minority of the lower performing candidates answered correctly.

BIOLOGY

Paper 9700/22
AS Level Structured Questions

Key messages

One difference between phloem sieve tube elements and xylem vessel elements is the fact that the sieve tube elements are living while the vessel elements are dead. This comparative feature is not an example of a structural difference, as stated by some candidates in **Question 1(d)**. The structure of the living phloem cell would be the features of peripheral cytoplasm and the presence of some organelles, contrasting with the structure of the dead xylem vessel element, which would be hollow, with no cell contents (no cytoplasm or organelles).

When describing the different ways that an infectious disease can be transmitted, candidates should make clear that they understand the difference between the disease and the pathogen that causes the disease. For example, a common error in **Question 4**, which was about cholera, was to state that water is contaminated by the disease, rather than stating that water is contaminated by the pathogen or by *Vibrio cholerae*. In addition, it is important for candidates to know the type of pathogen that is represented by the named organism. In **Question 4**, a number incorrectly thought that *V. cholerae* was a virus.

When considering the structure of a phospholipid, it is important to include the phosphate group plus the glycerol (phosphate head) and the fatty acid residues that form part of the molecule. It is not sufficient to say that a phospholipid has a hydrophilic head and two hydrophobic tails, as was stated by a number of candidates in **Question 5(b)**. Although this provides information about the nature of the different parts of the molecule, it does not give enough structural detail.

General comments

All syllabus topics were assessed in this paper. All questions apart from **Question 6** required candidates to draw from more than one syllabus topic and highlighted the need for candidates to be able to think across the syllabus when tackling some questions. When completing the paper, many made good use of the spaces provided to respond to questions and took notice of the level of credit that could be allocated when deciding how many different ideas to incorporate into their response. A very high level of competence was shown by a good proportion of candidates: this included a good understanding of the command terms used in the question and an ability to look back at information provided to help formulate a response. At the other extreme, some candidates lacked the ability to use correct scientific terminology and did not compose their answers to take account of the number of different ideas that should be included to be eligible for maximum credit. There were a number of instances where some correct biological knowledge was used for an answer that did not address the question topic and could not be credited. Examples of this were references to cell signalling in **Question 2(d)** and a description of the symptoms of sickle cell anaemia in **Question 3(d)**.

In **Question 3(d)**, candidates needed to bring together ideas about haemoglobin from three syllabus topics to answer an extended response. Here, the best accounts showed a good understanding of the central dogma and levels of haemoglobin structure by clearly separating their ideas: differences between alleles were explained, then differences in transcription and translation were covered, followed by the effect of these on the polypeptide and then the complete protein molecule.

In **Question 4 (c)(ii)**, candidates had to interpret a graph with two *y*-axes, and some did get these the wrong way around. When quoting data from a graph, candidates should check whether the figures seem sensible, for example quoting 560 000 countries and 18 cases in 2008 should have alerted candidates that they had made a mistake.

Question 6 frequently highlighted that many candidates could recall the principals of experimental method when investigating the progress of an enzyme-controlled reaction, but not all could demonstrate complete understanding of the results of the investigation.

Comments on specific questions

Question 1

(a) Most candidates knew that **Fig. 1.1** showed a stem and a high proportion gained the credit by giving an acceptable reason, for example by stating that the vascular bundles, or xylem and phloem, were arranged around the periphery or by stating that the xylem and phloem were not located in the centre of the section. Stating only that the xylem and phloem were in a ring, or that they were not star shaped, was not credited without further qualification about the location of the transport tissue. Some drew a sketch of where the location would be in a root, and this was helpful to gain the credit. Some incorrectly stated that the vascular bundles were arranged around the edge of the cell. Others cited the lack of root hair (cells) as their rationale for identifying the figure as a stem; as root hair cells are not present in all parts of the root, this was not creditworthy.

(b) It was not necessary to name the tissue concerned although many did identify the tissue as being of parenchyma cells. The role of the whole tissue or individual cells was accepted and many gained full credit. Most realised that the large central vacuoles of these cells were important and gave some good examples of storage of substances. Weaker responses gave incorrect reasons for support, such as thick cell walls. Some of the stronger responses explained how turgidity and storage of water in the vacuole would provide hydrostatic support for the stem, but this was not commonly seen. Reference to symplast and apoplast pathways were often given, sometimes following on from an incorrect identification of **Fig. 1.1** as a root.

(c)(i) Most knew the term to describe structure **B** and generally the spelling of vascular bundle was correct. 'Vesicle bundle' was the only relatively common mistake.

(ii) Candidates were knowledgeable of conversion factors and usually the correct answer was given. Some who did not gain credit could have benefited from studying their answer and making judgements about whether the size stated was a realistic estimate.

(d) The quality of response here was very varied. Some high-quality accounts used a sentence for each feature and made sure that the statement was comparative. A number gave most of the points expected and some constructed a comparison table where features compared were easy to identify. A very common error was to state that xylem vessel elements were dead and phloem sieve tube elements were living. Some did not go on to explain what this meant structurally. Care needed to be taken when comparing: stating that phloem had mitochondria but xylem did not was not enough to show understanding that xylem vessel elements had no contents at all. A misconception was to think that xylem did not have cellulose and only had walls made of lignin. Some candidates listed every organelle that they thought was found in the phloem: if this list included a nucleus then credit could not be given. Some suggested that having a companion cell was a structural difference, but as this is a separate type of cell, it cannot be considered part of a phloem sieve tube element.

Question 2

(a) Goblet cells were well known as structures associated with mucus. Fewer remembered that mucous glands were also present in the gas exchange system. Some were not precise enough and named main structures in the gas exchange system, such as the trachea and bronchus. Incorrect answers named cell structures such as the Golgi body or cilia.

(b) Information was provided in the question stem that mucin was present in vesicles ready for secretion from the cell. This allowed candidates to make links with the Golgi body and rough endoplasmic reticulum, and either structure was acceptable as a location of post-translational modification. Some named ribosomes but this was not credited, as it is only after the polypeptide has entered the lumen of the RER that glycosylation may occur. Others stated the cytoplasm.

(c) Deciding on the order of the stated processes was generally straightforward for all but those candidates who performed less well overall. Transcription and translation were usually stated in the correct sequence.

(d) The strongest responses used terminology stated in the syllabus, were concise when answering the question and gave a sequential account. Many candidates could have improved their response by:

- Avoiding use of the terms concentration of water or water concentration.
- Using the terms lower water potential and higher water potential rather than incorrectly stating lower water potential gradient or higher water potential gradient.
- Stating that water leaves the cell or crosses the cell surface membrane by osmosis rather than by diffusion.
- Stating clearly that water leaves the cell by osmosis, rather than just stating water moves to the area with the chloride ions by osmosis.

Some incorrectly suggested that the exit of chloride ions would cause water to move into the cell. There were a proportion of candidates who gave very good descriptions and explanations of the mechanisms by which chloride ions could leave a cell but were unable to gain credit as they did not answer the question posed. A number of candidates, some of whom did well overall, attempted to answer the question from the point of view of a cell signalling cascade triggered by chloride ions.

(e) Most candidates realised cells of the gas exchange system needed replacing, but to gain credit this idea had to be qualified with a reason. The importance of mitosis in tissue repair was well known but many candidates incorrectly stated that mitosis was important in repairing cells. Fewer referred to the need for the new cells to function in the same way as the cells they were replacing or to repair tissue so that it could still function effectively. Some were accurate in describing the importance of mitosis in producing genetically identical cells, although stating that mitosis produced identical cells was insufficient as this would mean that daughter cells would have exactly the same contents, which is not the case. Mitosis for growth was only credited when candidates showed a clear understanding that an increase in the size of the gas exchange system, by an increase in the number of cells, would only occur in childhood. Some referred to the role of mitosis in asexual reproduction, which had no links to this question. Others gave accounts of mitosis in immune system cells, or descriptions of the causes and types of damage sustained by the respiratory system, which were not relevant answers to this question.

Question 3

(a) Some candidates had no difficulty identifying the different blood cell types from the photomicrograph of a human blood smear. Although **E** was a monocyte, macrophage was accepted as a correct response. Macrophages have granular cytoplasm and mature from monocytes when these cells leave the blood stream to enter tissues.

(b)(i) Most candidates knew, or deduced, that leucocytes were formed in the bone marrow. Others understood that this meant that stem cells were present in the organ. Some candidates who understood that mutations were more likely to arise when a cell is replicating its DNA, added the information that cell division involving stem cells would be occurring. It was sufficient just to note that cell division would occur in the bone marrow. Statements referring to CLL and uncontrolled cell division of white blood cells were also credited.

(ii) Stronger responses made it clear that there were two very different causes of the increase in white blood cell count. When explaining the situation for measles, detailed explanations were given of how the immune response would lead to an increased number of lymphocytes as a result of clonal expansion. Stating that the immune system responds was not an alternative to using the key term 'immune response'. Others were too vague to be awarded credit, with statements such as 'the disease causes a lot of white blood cells to be produced'. For CLL, good answers explained that uncontrolled cell division occurs, rather than just stating that this was continued cell division. Fewer answers noted that the reason for uncontrolled mitosis was a mutation or gave other details such as an inability of cells to respond to cell signals.

(c)(i) Some candidates understood that this question was only about the passage of oxygen across the cell surface membrane of the red blood cell. These responses were likely to get full credit, noting that oxygen molecules were small enough to cross the bilayer, and were non-polar. Fewer gave correct details of the mechanism of transport, diffusion across the phospholipid bilayer, with quite a number writing about carrier or channel proteins. A proportion gave accounts of gas exchange between the alveolus and the red blood cell or gave a general statement of oxygen diffusing into

the red blood cell and describing oxygen uptake by haemoglobin, none of which answered the question posed.

(ii) The introduction to this question explained to candidates that the partial pressure of oxygen is lower at sea level than at a high altitude. The stronger candidates began their response by explaining the effect of this on the uptake of oxygen in the lungs, rather than unnecessarily stating that at high altitude the partial pressure of oxygen in the atmosphere is lower. Many were able to gain some credit for a statement concerning haemoglobin. There were a number who could have gained more credit by showing knowledge that red blood cells contain haemoglobin: here their responses were entirely about red blood cells not being saturated with oxygen or not being able to transport as much oxygen. Some candidates were careful to give unambiguous explanations, making it clear that they understood an increase in red blood cells would not improve the saturation of haemoglobin molecules, but would provide more haemoglobin to collectively transport the same quantity of oxygen as at sea level. Quite a few gained credit for this point by using the term 'compensate' or 'compensation'. There were many who did not gain credit by stating that more oxygen was carried when there was an increase in red blood cells. Some responses included descriptions of, or only wrote about, altitude sickness.

(d) There was a very wide range in quality of response here, with some extremely knowledgeable and clear, comprehensive accounts as well as some either very confused answers or answers that only addressed part of the question. Some could have made clearer the difference between the alleles and the amino acid change in the polypeptide. Statements such as 'The Hb^A allele has glutamic acid and is CTT but the Hb^S allele is valine which is hydrophobic' did not show evidence of understanding despite the use of some correct terminology. Most were able to give some detail about a change in amino acid and a change in the structure of β-globin or haemoglobin. Few candidates noted that: the substitution of one base for another resulted in different mRNA codons; the change was in the sixth amino acid or DNA triplet (or mRNA codon); haemoglobin molecules with the valine-for-glutamic acid change formed fibres (became sticky) with other molecules. Care was needed when describing the change to the levels of structure in the protein. A change in the quaternary level of protein structure could only occur with the whole haemoglobin molecule and not the single β-globin polypeptide. A good proportion knew that a change in structure decreased the solubility of the molecule and the ability to transport oxygen. A common error was to describe the molecule, rather than the red blood cell, becoming sickle shaped.

Question 4

(a) Candidates did not need to have prior knowledge of the structure of a *Vibrio cholerae* cell, but needed to apply their knowledge of prokaryotic cell structure to complete **Fig. 4.1**. Many completed the diagram with care and to a high standard. Credit was not awarded for the cell wall or cell surface membrane unless another line had been drawn in. Some candidates correctly labelled 'circular DNA' yet drew a number of unconnected lines or coiled shapes with a clear start and end. Others indicated that the main circular DNA of the cell was known as the plasmid. Maximum credit could not be awarded when a structure found only in eukaryotic cells was added to the diagram. It was quite common to see a nucleus or mitochondrion added to the cell. A number of candidates did not use the diagram provided as instructed, and drew their own version of *V. cholerae*, which could not gain full credit. Some weaker responses drew both bacterial and viral structures, usually by drawing the cell wall but labelling it as 'protein coat' or 'capsid'.

(b)(i) Most candidates completed a correct calculation, although not all gave the answer to the nearest 0.1%.

(ii) A number of candidates correctly focused their response on why some countries had high case fatality rates of cholera. Many wrote answers about high rates of transmission and number of cases of cholera and did not suggest explanations as to why proportionately more people with cholera were dying from the disease. Answers about improper treatment or lack of ability for individuals to pay for treatment did not gain credit: rehydration treatment is provided freely by non-governmental organisations and is effective and easy to administer.

(c)(i) Most had a good understanding of the relationship between a natural disaster such as an earthquake and a cholera outbreak. Some used the term 'polluted' rather than 'contaminated' when describing the supply of drinking water and others used the term 'waste' instead of 'sewage'. These could not be credited unless the response contained additional correct detail.

(ii) There were some excellent responses to this question, with many gaining full credit. It was far more common to see answers that described or compared trends for the two sets of results than commented on reasons for the trends seen, despite being provided with the information in the introduction. A few realised that the initial outbreak of cholera in 2010 had increased to epidemic proportions in 2011. Some candidates read off values from the wrong *y*-axis when attempting to provide numerical values to support a point. Good answers gave trends rather than describing year-to-year changes. Some candidates were too vague with their comparative statements: 'low number of cases' could not in this instance be considered the same as 'lowest (or least) number of cases' and similarly 'highest' or 'most' should have been used instead of 'high'.

Question 5

(a) Some candidates needed to check that all the examples of biological molecules given in **Fig. 5.1** had been included in the completed **Table 5.1**. Many did well to gain full credit. For most of the molecules listed, correct completion of the task was based on knowledge of the molecules and an understanding of the terms. Only glycine and α-globin required knowledge to be applied.

(b) Many candidates were able to establish that the phosphate head of the phospholipid molecule is hydrophilic in nature and that the fatty acid tails are hydrophobic. The strongest answers indicated how these properties allowed a bilayer to form naturally and noted both sides of the bilayer, with the phosphate heads facing both the external surroundings of the cell and the internal solution. It was not enough to state that the tails face away from water as this could just form a monolayer rather than a bilayer. A few very good answers included detail of the hydrophobic interactions between the fatty acid tails. Some included small labelled diagrams to support their response which enabled further credit to be awarded in some cases. There were candidates who described two heads per phospholipid molecule, used the term 'lipid tail' to mean 'fatty acid tail' or confused 'hydrophilic' with 'hydrophobic'.

Question 6

(a)(i) Many candidates had no problems with this question. For those who were not familiar with this practical, sufficient information was provided in the question stem. 'Amount' of oxygen was not credited. Although a graduated inverted cylinder was shown in **Fig. 6.2**, many suggested counting bubbles. This was not credited as the reaction would be very fast and bubbles would appear too quickly to be counted. In addition, when the reaction was at its most vigorous the bubbles would collect and bubble size would not be uniform. Some explained that the volume was measured by the decrease in the water level in the cylinder as it was being displaced by the oxygen, which was acceptable. As the equation was given in **Fig. 6.1**, 'gas' was accepted for 'oxygen'. Some candidates stated that hydrogen was produced. Some did not mention that the volume should be measured at timed intervals or over a period of time. A few suggested time intervals that were impractical, such as measuring every second. Some described the experiment, which was not required, but then gained credit when details of a graph that could be drawn were included. Only a handful of responses noted that the initial displacement of water would be air that had been displaced by the addition of the hydrogen peroxide solution.

(ii) Most responses indicated that cutting the same volume of potato as the first experiment into smaller pieces would mean that there would be an increase in surface area. There were quite a few, however, who thought the opposite. For maximum credit candidates needed to show an understanding that more enzyme would be available for the reaction. Many incorrectly stated that enzyme would only be on the surface of the potato tissue rather than being released from the damaged potato tissue and dispersed throughout the peroxide solution. Hence, suggestions that more hydrogen peroxide would be able to contact the enzyme remaining on the potato tissue surface were seen. Some indicated that the potato tissue was the substrate and the hydrogen peroxide the enzyme.

(b) Some candidates drew curves that were standard for how temperature affects the activity of an enzyme, reflecting a doubling in rate of reaction with every 10 °C rise in temperature until the optimum, with a steep decrease as denaturation occurs. Many drew bell-shaped curves that were more like the curves seen for the effect of pH on the rate of reaction. Frequently, candidates needed to show more clearly that the curve decreased more steeply at temperatures above the optimum than it increased at temperatures before the optimum. Some drew curves that were symmetrical about the optimum yet had labelled the curve beyond the optimum as denaturation. Very weak responses drew the curve for substrate concentration.

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 aware that the wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory. In **Question 1(c)(ii)**, when asked to suggest an explanation for the results between pH2 and pH6, the candidate needed to make clear in their answer that they had stated why something happens, such as referring to the shape of the active site of pepsin changing after pH2 leading to the substrate being unable to bind to the active site and fewer enzyme-substrate complexes being formed.

General comments

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.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to show how to carry out a serial dilution, stating the correct concentration below each beaker (10.00%, 1.00%, 0.10%, and 0.01%) and transferring 1 cm^3 of the previous concentration to the next beaker and adding 9 cm^3 of distilled water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger responses included the heading for percentage concentration of milk (**M**) and the heading for symbol or colour. The majority of candidates gained credit for recording the results for at least four concentrations of milk. Many candidates recorded results which showed that the higher the percentage concentration of milk the deeper the shade of purple. The strongest responses recorded the colours as symbols.

(iii) Most candidates correctly recorded a result for **X** using one of the symbols in the key.

(iv) Some candidates correctly estimated the concentration of protein in **X** from their results based on the fact that 100% **M** contained 12 g of protein in 100 cm^3.

(v) Most candidates correctly stated that a significant source of error was the difficulty of judging the exact shade of colour.

(vi) The majority of candidates were able to suggest three improvements to the investigation so that a more accurate estimate of the concentration of protein in **X** could be obtained. Many candidates correctly suggested preparing more concentrations of milk close to the estimate for **X** with narrower intervals between each concentration. Some candidates correctly suggested using a colorimeter and using the data to draw a graph. A few candidates noticed that the milk concentrations changed colour over time and suggested that carrying out the test for **X** at the same time as the milk concentrations would help give a more accurate estimate of the concentration of protein in **X**.

(b) Most candidates used the headings given in the table to correctly label the axes. Some candidates labelled the incorrect axis or gave incomplete headings. Most candidates drew bars of equal width and distance apart on the *x*-axis, used a scale of 1 to 2 cm for the *y*-axis and plotted each bar accurately. The strongest responses drew ruled lines for the bars so that the vertical lines joined with the horizontal lines precisely. The most common error was drawing lines which were not ruled.

(c) (i) Many candidates correctly described the trend shown in **Fig. 1.4** by stating that as the pH increased the percentage mass of the protein remaining increased.

(ii) Many candidates correctly explained that between pH2 and pH6 the activity of the pepsin gradually declined. They correctly suggested that, as a result of the active site changing shape, the substrate could no longer bind to the active site resulting in fewer enzyme-substrate complexes forming. Many candidates correctly suggested that the enzyme had become denatured. The most common error was to give a description of the graph rather than give an explanation of what was occurring to the pepsin as the pH increased.

Question 2

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

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

(b) (i) The majority of candidates gained credit for measuring the scale bar and the line **Z** within an acceptable range. Many candidates measured the scale bar in millimeters and showed this figure multiplied by 1000 to convert into micrometres before dividing by 317. Many candidates correctly calculated the magnification of **Fig. 2.1** in this way then divided their measurement for **Z** by this magnification to calculate the actual width of the root and used the correct units.

(ii) The stronger candidates organised the table into three columns, with one column for features, one headed **K1** and one headed **Fig. 2.1**. Many candidates listed at least three observable differences between **K1** and **Fig. 2.1** such as **K1** had fewer layers of tissues than Fig**. 2.1**, **K1** had a smooth, continuous outer layer while **Fig. 2.1** had a rough discontinuous outer layer and cells of **K1** were larger than the cells of **Fig. 2.1**.

BIOLOGY

Paper 9700/34
Advanced Practical Skills 2

Key messages

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

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

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

General comments

In general, candidates demonstrated a good understanding of the skills required in this paper. The majority of candidates showed they were familiar with the microscope and demonstrated good drawing skills.

Comments on specific questions

Question 1

(a) (i) Some candidates were able to explain that using the higher magnification lens would allow them to observe the different states of plasmolysis more easily. Many appreciated the need for a large sample size from different fields of view so that enough cells were counted.

(ii) The majority of candidates organised their results by presenting a ruled table with correct headings. The candidates that displayed the numbers of cells in each of the four stages of plasmolysis for each sodium chloride concentration gained the most credit.

(iii) The majority of candidates correctly identified **S2**, **S3** and **S4**.

(b) Most candidates drew the required number of cells. Many used a sharp pencil to draw clear thin lines that were continuous. Some candidates correctly labelled the cell surface membrane of one cell. The most common error was to draw cells that were too small or with lines that were not continuous or to label the cell wall as the cell surface membrane.

(c) (i) Many responses referred to the pattern of water movement either into the potato tissue (below 0.4 / mol dm^{-3}) or out of the potato tissue (above 0.4 / mol dm^{-3}). A large number of candidates did not refer to the movement of water and just described the change in length of the potato tissue. The better answers also stated that there was no net movement of water at 0.4 / mol dm^{-3}.

(ii) Most candidates were able to explain that the water potential was higher in the sucrose solution than in the potato cells, so water moved into the potato cells by osmosis. The most common error was not to refer to the potato cells or the direction of water movement.

(iii) Most candidates were able to suggest three variables that needed to be standardised. Some candidates gained credit for describing how they were standardised by suggesting the apparatus they would use.

Question 2

(a) (i) Many candidates were able to describe an appropriate control. The most common error was to state variables that needed to be controlled instead of suggesting a control.

(ii) Many candidates suggested the use of a drying agent and gained credit for this. The most common error was to suggest the use of a fan which may reduce the humidity but also changes the movement of air.

(iii) Most candidates recorded their measurements of the water remaining and correctly calculated the water lost.

(iv) The majority of candidates answered this question correctly from their results.

(b) (i) Most candidates gained credit for showing their workings. Candidates also gained credit for not including the anomalous result in their calculation of the mean.

(ii) Most candidates used the headings given in the table to correctly label the axes. Some candidates labelled the incorrect axis or gave incomplete headings. Most candidates used a scale of 20 to 2 cm for the *x*-axis and 20 to 2 cm for the *y*-axis. The strongest responses plotted the points precisely using a small cross or dot in a circle and accurately connected the points with a ruled line. The most common error was drawing lines which were too thick or not ruled to the centre of the point.

(iii) Most candidates described the correct trend.

(iv) Most candidates answered correctly. A common error was to read the value off the incorrect axes.

(c) Many candidates drew a plan diagram that was an appropriate size and did not include any cells. The strongest candidates carefully followed the instructions and drew the appropriate amount of detail within the section in the correct proportions.

(d) The majority of candidates correctly counted the number of eyepiece graticule units and used these to calculate the actual width shown by the line **X**-**Y**. The better answers showed all of the steps in the working and used appropriate units.

BIOLOGY

Paper 9700/42
A Level Structured Questions

Key messages

- Candidates should consider the number of marks available when answering each question. This provides an indication of the number of separate points that a candidate will need to make or the level of detail that will be expected.
- Candidates should plan their use of time to ensure that they can engage effectively with all questions.

General comments

Most candidates were able to demonstrate sound knowledge and understanding of the syllabus when presented with familiar contexts. Many were also able to develop effective responses in novel contexts by making links with the underlying biological principles that are embedded in the syllabus. Candidates lacking confidence when presented with these less familiar situations were sometimes unable to apply the relevant knowledge and understanding to engage with the assessment.

Comments on specific questions

Section A

Question 1

(a) The structures in the cross section of a myelinated neurone were, in general, correctly named. Responses identifying **A** as myelin were not specific enough. A number of candidates incorrectly identified **B** as the nucleus or simply repeated the information already provided in the question and identified **B** as a neurone. Very occasionally, responses were the wrong way around.

(b) The meaning of saltatory conduction and its effect on the transmission of a nerve impulse were well understood by the majority of candidates. Most stated that the impulse, or action potential, would jump from node to node, thereby increasing the speed of transmission. Some also provided detailed accounts to explain why depolarisation is only possible at the nodes. Few candidates went on to consider effects on local circuits and how these effects would affect the speed of transmission.

(c) There were some excellent accounts as to how sea snail toxin would prevent the generation of an action potential in the postsynaptic neurone. Full responses outlined the step-by-step consequences of exposure to the toxin to develop a coherent explanation that linked the initial exposure to the inability to generate action potentials in the postsynaptic neurone.

A number of candidates incorrectly referred to the exocytosis of vesicles, rather than the neurotransmitter, or stated that ions would enter the presynaptic or postsynaptic membranes. Although the stem of the question stated that the synapse was cholinergic, some candidates did not identify acetylcholine as the neurotransmitter.

A small minority of candidates simply described the process of neurochemical transmission, rather than addressing the question by considering the effect of the toxin.

Question 2

(a) (i) The responses of some candidates referred to types of speciation, rather than patterns of variation.

(ii) The majority of candidates correctly answered this question. Some candidates provided responses that were contradictory.

Incorrect responses often referred to mutation. While mutation does generate variation, mutation is non-directional and cannot explain, on its own, improved survival. Some candidates did not name a process, instead giving lengthy descriptions about how to improve tank conditions.

(b) Many candidates referred to the environmental conditions in the tank without linking these to how the phenotype of fish would be affected. Others linked relevant environmental features of the tank to differences in phenotypes of captive fish, without describing what these differences were. With no further explanation, such responses were too vague.

A significant number of candidates incorrectly interpreted this as a question about speciation and gave answers relating differences between the two environments to different selection pressures on allele frequencies. These candidates did not address the requirements of the question.

(c) (i) Overall, candidates were able to describe the process of microarray analysis quite well. A good number of candidates showed a clear understanding of the steps involved and many of these candidates were able to describe specific details of experimental technique.

Some candidates incorrectly referred to extraction of DNA, rather than mRNA, and a number of these described a role for restriction enzymes in the process.

When considering the application of the microarray analysis, the majority of candidates did not relate the process that they described to the context of this question: a comparison of gene expression between the two samples. Many responses implied that the microarray analysis described here reveals differences in the presence of genes in the genome, rather than differences in the pattern of gene expression.

(ii) Responses were of variable quality, with the majority of candidates confusing the processes of eukaryotic gene control and prokaryotic gene control. The prokaryotic *lac* operon was frequently used as an example, although this question specifically related to control of gene expression in eukaryotes.

Some candidates knew the term transcription factor but were unable to describe its role correctly, or its interactions with promoters and the binding of RNA polymerase.

A number of candidates incorrectly referred to gibberellins and DELLA proteins, although this question was about fish.

Some students misunderstood the context completely and, instead, wrote about dominant and recessive alleles or artificial selection. A minority of candidates did not attempt the question.

(d) (i) Few candidates were able to address this question effectively. Most candidates did not recognise the significance of keeping the two groups of fish in the same environmental conditions.

(ii) The majority of candidates did not specifically take into account the information in the question about wound healing. Better responses that did consider changes in wound healing and the immune response often did not go on to say how these were better for the fish.

Question 3

(a) This question required candidates to use their syllabus knowledge and understanding to outline the general principles of genetic engineering in an unfamiliar context. Relatively few candidates considered the source of the gene or how the gene could be introduced to the soybean genome. Few explained the final outcome in terms of gene expression.

Several candidates described the process of selective breeding, which was not directly relevant for GTS 40-3-2.

(b) Candidates generally found this question to be demanding. Where data was interpreted correctly, candidates recognised that GM soybean had the potential to increase overall yield. Good responses demonstrated higher order thinking by describing the social implications of increased or decreased yields in terms of food supply and cost, effects on potential profit, or on future herbicide use.

The information provided in the table was often misinterpreted. Many answers concentrated on trying to explain the figures, rather than providing an interpretation of the social and ethical implications of growing GM soybeans. Other answers largely ignored the data and gave general discussions on the topic.

Question 4

(a) The majority of candidates completed genetic diagrams in which parents and their gametes were correctly identified. Offspring phenotypes were usually correctly shown and linked to the expected genotypes.

Several candidates expressed the final answer as a ratio rather than as a probability.

A very small number of candidates incorrectly attempted to provide a genetic explanation based on a dihybrid cross or a sex-linked cross.

(b) (i) Many candidates were able to explain the difference between the product of a missense mutation and the product of a nonsense mutation. Overall, the effect of a nonsense mutation was better understood.

(ii) Many candidates were able to provide effective explanations.

(c) Candidates were able to provide a variety of valid reasons. Some incorrectly referred to inbreeding depression.

Question 5

(a) (i) Many candidates correctly labelled the glomerulus. The position of the lumen was less clearly appreciated, with some candidates labelling the surrounding convoluted tubules.

It was not always clear to which structure the candidates' label lines were pointing.

(ii) Most candidates were able to name the structure as the basement membrane. A few incorrectly suggested the basal membrane. Podocyte was a fairly frequent incorrect response.

(b) This question required a good understanding of the effect of the differing diameters of afferent and efferent arterioles on the process of ultrafiltration. Few candidates understood that a decrease in the lumen diameter of the afferent arteriole, or an increase in the lumen diameter of the efferent arteriole, would both lead to a decrease in the glomerular filtration rate.

(c) The mechanism of reabsorption of glucose in the proximal convoluted tubule was well explained only by the stronger candidates. Most candidates recognised the roles of facilitated diffusion and co-transport in the reabsorption of glucose, but fewer considered the link to the sodium-potassium pumps. Specific details were often lacking. For example, references to GLUT proteins were rare.

Less able candidates often suggested that sodium ions were pumped into the lumen of the proximal convoluted tubule.

(d) Most candidates were able to provide at least one of the features of a proximal convoluted tubule cell that adapt it to its function. The presence of microvilli to increase the surface area for reabsorption was the most frequent correct response.

Descriptions of relevant features were often too vague. For example, many candidates who appreciated the need for mitochondria or transport proteins in membranes, referred only to their presence rather than the need for large numbers.

Similarly, explanations often lacked specific details. For example, ATP synthesis was frequently omitted when considering mitochondria, and transport proteins were not always linked to specific molecules or ions.

Many candidates described the tight junctions between proximal convoluted tubule cells as a feature to prevent leakage of filtrate. Some incorrectly stated that these would prevent fluid or molecules from entering the cells.

Question 6

(a) Very few candidates were able to state the general theory of evolution. Many candidates used the term evolution in their answers and, as a result, simply restated the question.

(b) The strongest candidates were able to use the information provided to develop effective responses within the given context. Many candidates described general principles of evolution, often in detail, that were not related to the example given. Others simply repeated the information provided. Such responses did not fully address the requirements of the question.

(c) This question was answered fairly well. The majority of responses identified similar selection pressures and the need to find food. Some made a link to avoiding predators. A very small percentage of candidates correctly referred to convergent evolution.

A number of candidates referred only to one organism, usually the octopus, and so did not address the requirements of the question.

Some candidates wrote that octopuses and mammals were closely related, despite the information in the question stating that this was not the case. Some of these suggested that octopuses were mammals.

(d) (i) Most candidates were able to use correct terms to state a correct answer. A number of candidates considered that 600 million years ago could be considered to be recent.

(ii) Many candidates were able to make relevant comments, but few complete answers were given. Most candidates recognised the link between similarities in amino acid sequences and a close evolutionary relationship but not all expressed this in clear terms. Very few answers commented on comparing sequences or relating sequence divergence to the passage of time (e.g. molecular clock).

Some candidates discussed DNA and comparison of nucleotide sequences instead of amino acids.

Question 7

(a) Most candidates understood that there is a level of interaction within ecosystems. Many referred to the presence of a community of organisms and the importance of biotic and abiotic factors. Not all candidates recognised that an ecosystem includes all of the organisms present.

Few candidates were able to provide a full and coherent definition of the term ecosystem.

(b) Many candidates were able to recall the correct scientific term for each of the definitions provided.

Habitat was occasionally given incorrectly as the term matching both the first and third descriptions. Some candidates confused biotic factors and abiotic factors.

Question 8

(a) The process of oxidative respiration was well understood, with the majority of candidates being able to place each stage in the correct sequence.

The most frequent error was to reverse the order for the production of ATP and the formation of water.

(b) Many candidates were able to state all of the correct locations.

Some candidates stated that the cytoplasm was the correct location for pyruvate, despite being asked for the location in the mitochondrion. Other candidates could not recall the correct term for the intermembrane space. A small number of candidates incorrectly made reference to chloroplast structures.

Section B

Question 9

(a) Candidates found it difficult to develop complete and coherent responses. Details provided were often insufficient. For example, many responses omitted to refer to a suitable range of temperatures or considered how temperature could be controlled, although this was central to the investigation. A number of candidates described the use of a lamp at different distances from the plant as a means to control temperature, suggesting confusion with a practical investigating the effect of light intensity.

Few candidates considered control of factors other than temperature, such as how to maintain constant light intensity or carbon dioxide concentration.

Candidates often did not indicate how a suitable variable could be measured to assess the rate of photosynthesis, such as oxygen production. Where measurement was described, this was not always related to time. Without relating measurements to time, a calculation of rate is not possible.

Not all candidates considered the need to repeat the experiment and to calculate mean rates at different temperatures to increase the validity of the results.

(b) Candidates were aware of what gives rise to degraded habitats but most were unable to provide suggestions for the actions needed to restore them. Answers often incorrectly focused on measures for preserving threatened species of animals or plants in terms of zoos or national parks, or banning the activities which gave rise to the degraded habitats.

Valid suggestions were narrowly focused on replanting trees and, very rarely, the removal of alien species or litter. Few responses included named examples. The most frequently mentioned were the Amazon Forest, the mangroves of the Sundarbans or the waters of the Arabian Sea.

Question 10

(a) This was a well-answered question. The majority of candidates were fully aware of the inhibitory effects of progesterone and oestrogen on the release of FSH and LH from the anterior pituitary gland, with fewer responses stating that this was a negative feedback mechanism. Inhibition of the development of the Graafian follicle was not always identified but prevention of ovulation was well understood, as were the thickening of cervical mucus and the reduced development of the endometrium. Some candidates correctly referred to the use of synthetic hormones, since these act for longer and give rise to a high concentration in the blood.

(b) Most candidates appreciated the flow of events leading to speciation that follows geographical separation of a species into separate populations. Responses were frequently detailed. Examples of geographical barriers were often omitted.

BIOLOGY

Paper 9700/52
Planning, Analysis and Evaluation

Key messages

- Candidates are advised to read through the whole question prior to answering.
- When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow.
- When planning investigations, it is not necessary to copy out all the information given in the question paper. The information provided should serve as the basis for developing the particular method asked for in the question.
- Conclusions need to be more than just a descriptive re-statement of the results provided. When looking for trends in data, the whole range of data should be considered rather than just raw data quotes alone.

General comments

The responses covered the full range of credit available and there was no evidence that the candidates were short of time on this paper. There was evidence that many candidates had an understanding of statistical ideas.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to identify at least one reason why Method 2 was the most suitable, with the most common answer being that it was easy to explain to subjects or easy for subjects to carry out. Credit was given for answers stating that some subjects might not be able to catch a ruler or cannot move easily; this is not the same as subjects do not have to catch a ruler or do not have to move easily. Candidates need to be clear of the distinction between the terms accurate, reliable and error. These terms were used interchangeably by some candidates and as such, some did not receive credit. Fewer candidates were able to provide two separate reasons, with many repeating their first answer.

(ii) Almost all candidates identified the dependent variable as reaction time. Candidates need to be clear that the independent variable is something that is manipulated by the person conducting the experiment, in this case the age of the subjects. A few candidates had the same answer for both the independent and dependent variables and therefore, could not gain credit for either.

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

Good answers started by making it clear how they would choose subjects of different ages by placing them into age categories or by testing one person of each age from 5 to 80. Less creditworthy were rather more nonspecific responses which repeated the information provided in the question to test a sample of people aged from 5–80. Some candidates suggested placing subjects into age categories, such as ages 20–30 and 30–40. This resulted in a person aged 30 being in two age categories and therefore, did not receive credit.

When considering things that should be standardised, candidates should appreciate which are the significant factors to control in any given investigation rather than give a long list of anything that

might be controlled, regardless of whether it is really relevant to the investigation in question. Creditworthy responses were common and included ideas about standardising the type of computer or colour change and not using subjects who had taken drugs / caffeine / alcohol prior to the test. Those candidates who did not gain credit were not specific enough in their response, referring to subjects not drinking, rather than what specifically the drink may contain. The important idea about gaining consent when using human subjects was not often mentioned; when it was, excellent suggestions about subjects signing consent forms were seen. Many candidates appreciated the importance of selecting subjects without specific medical conditions that might affect reaction time in the stated conditions, such as poor sight, or neurological disorders.

Many responses mentioned replicating the test a suitable number of times, but this was sometimes linked to calculating an average. It is better to use the term 'mean' in scientific work.

This was a low risk investigation. A few candidates gained credit by mentioning that bright light from the computer screen may damage eyes and suggested a suitable precaution against this.

(b) (i) Most candidates gave a correct answer. Careful reading of the instructions was essential as although some used the correct values and processed them using the correct calculation, they did not then give the answer to the nearest whole number, meaning that full credit could not be awarded.

(ii) To gain full credit, it was necessary for candidates to study the graph carefully and consider the whole range of data in order to make conclusions about the trends shown. Successful responses referred to reaction time being higher in females than in males for most ages. Many candidates discussed the reaction time decreasing up to age 20 years or increasing after this age. To improve answers, candidates should include what happens before and after a change in direction to receive credit. Relatively few candidates made reference to the standard deviation bars and if they overlapped or not. Candidates need to make use of all the information provided in a question in order to gain full credit. A few candidates commented on faster or slower time, which did not gain credit.

(iii) Many candidates gave a correct answer, stating that a *t*-test should be used. Correct reasons gaining credit were that the data is continuous or to compare two means. A few candidates also correctly stated that the standard deviations were approximately the same. Credit was also given if reference was made to the data being normally distributed.

(iv) The majority of answers showed a good understanding of the null hypothesis. A few answers gave a description of the results rather than a null hypothesis. Common errors were to state there is a relationship or a significant difference – in other words to state the alternative hypothesis. Another common error was not specifying what 'no significant difference' was between.

Question 2

(a) (i) There were some good responses here which showed a thorough understanding of the use of haemocytometry with reference to systematic counting of cells. The very best answers included detail such as only including sperm cells which were touching the top and left line and excluding those touching the bottom and right line. Less successful attempts made reference to the area of each square rather than the volume. A few did not appreciate that they were dealing with sperm cells which needed to be viewed under a microscope and made reference to capture, mark and recapture techniques.

(ii) Many candidates were able to multiply the number of sperm by the dilution factor provided in the stem of the question in order to estimate the number in the undiluted semen sample. Fewer candidates were able to describe how they would estimate the number of sperm per mm^3. Candidates needed to use the dimensions provided in the question to calculate the volume of 1 square on the grid and then divide the number of sperm in that square by the volume.

(iii) Many candidates were able to identify a reason why counting sperm using a grid may not represent the actual number of sperm in the undiluted sample. The most frequently seen successful answer was that the sperm cells may not be evenly distributed in the grid. Other common answers included that the sperm were moving; in order to gain credit for this point, reference also needed to be made that since the sperm were moving, this made it easy to miscount them. Fewer candidates made the link that the semen on the grid was only a sample of that produced.

(b) (i) Most candidates had read the information provided and were able to gain some credit for this question. A few candidates described what should have been standardised rather than what had been standardised. A few gave generic answers of standard variables that might apply to many different experiments. Some referred to only males being tested. Candidates need to ensure that they apply their answers to the specific question being asked.

(ii) The majority of candidates gave a correct answer, commonly for a control or for comparison.

(iii) Candidates needed to include detail about the type of infertility the men were suffering from and the levels of both FSH and LH to gain credit. Candidates could improve on their responses when asked to write a conclusion by using all the information provided, especially if a key is included in a chart. The most successful responses addressed the specific question asked and were supported with careful analysis of the data.

(c) There were two parts to this question. Firstly, to provide a method for counting the number of live and dead sperm cells. Secondly, to use the information provided in the question about what viability meant and suggest how this could be found. Successful responses identified that the live and dead sperm would be stained different colours and therefore, could be counted separately. Expanding on this to suggest a method to calculate the proportion of live to dead sperm, and so gain full credit, was seen in fewer responses. The most common method provided was to divide the number of live sperm by the total number of sperm. Candidates should use the terminology provided in the question when faced with information from an unfamiliar context.