# BIOLOGY

**Paper 9700/11**
**Multiple Choice**

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

## General comments

There was a good spread of scores. Two questions were answered correctly by more than 75% of candidates, **Question 13 and 18. Questions 5, 14 and 27** proved to be more difficult, with 30% or fewer candidates answering them correctly**.**

## Comments on specific questions

### Question 5

A minority of candidates realised that, since tRNA requires ATP to bind it to the appropriate amino acid, then mitochondria as well as rough endoplasmic reticulum and Golgi apparatus are all required in the formation of enzymes.

### Question 7

Although many weaker candidates continue to find it hard to recognise α-glucose and β-glucose, the majority of candidates answered this correctly.

**Question 11**

Stronger candidates had no difficulty with this question, but the majority of weaker candidates incorrectly thought that the properties of glycogen were dependent on hydrogen bonds.

**Question 12**

Whilst almost all candidates used the information to correctly identify collagen and haemoglobin, less than a half of candidates correctly identified the antibody.

**Question 14**

Although the strongest candidates answered correctly, only a minority realised that the mean calculated by candidate 2 is correct as the anomalous result of '8' is ignored.

**Question 20**

Stronger candidates had no difficulty with this question, although less able candidates were unable to link DNA uncoiling and separating with interphase.

**Question 21**

The majority of more able candidates were able to process this information to decide that nocodazole might work by stopping sister chromatids migrating to opposite poles.

**Question 24**

Whilst stronger candidates had no difficulty in converting from anticodon to codon to DNA sequence, this was challenging to the majority of weaker candidates.

**Question 27**

Whilst this was answered correctly by most of the more able candidates, there were many who did not fully understand the mechanics of transpiration.

**Question 28**

A minority of candidates thought that all three adaptations would be seen in halophytes. However, if the stomata were open most of the time the plants would lose too much water.

**Question 38**

Nearly two thirds of all candidates were able to use the information to determine the ecological relationships, showing good knowledge of the terminology.

**Question 39**

This proved straightforward for stronger candidates, who knew that only denitrifying bacteria require anaerobic soil conditions.

# BIOLOGY

**Paper 9700/12**
**Multiple Choice**

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

## General comments

There was a very good spread of scores. Eight questions were answered correctly by more than 75% of candidates, **Questions 2, 6, 7, 10, 18, 23, 26 and 33. Questions 14, 37, 38 and 39** proved to be more difficult, with 35% or fewer candidates answering them correctly**.**

## Comments on specific questions

### Question 1

Many candidates did not realise that the distance between the membranes does not change when the objective lens is changed.

### Question 4

Many of the less able candidates did not realise that the only feature in the list that allows an organism to be identified as a prokaryote was the circular DNA.

**Question 12**

The majority of more able candidates were able to process the information to obtain an approximate length of 1.2 nm.

**Question 17**

Whilst the majority of all candidates knew that the enzymes are released by exocytosis, fewer than half of less of less able candidates knew that ATP is required for this process.

**Question 24**

Whilst stronger candidates had no difficulty in converting from DNA triplet to codon to anticodon, this was challenging to the majority of weaker candidates.

**Question 31**

This posed no difficulty to most candidates. However, the Bohr effect is poorly understood by less able candidates.

**Question 35**

Whilst the majority of all candidates knew that the lymph glands would be swollen, just over half knew the alveoli would be damaged.

**Question 36**

Almost all of the stronger candidates answered correctly, but many of the less able candidates incorrectly think that TB is transmitted by sewage contaminated water.

**Question 37**

The majority of stronger candidates answered this correctly, but less able candidates found it difficult to use their knowledge of the immune system in an unfamiliar situation.

**Question 38**

Over half of all candidates incorrectly thought that nitrogen fixation is carried out by nitrifying bacteria.

**Question 39**

Almost half of all candidates did not realise that all energy eventually leaves ecosystems in the form of heat.

# BIOLOGY

**Paper 9700/13**
**Multiple Choice**

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

## General comments

There was a very good spread of scores. Three questions were answered correctly by more than 75% of candidates, **Questions 32, 35 and 38. Questions 12, 13, 15 and 39** proved to be more difficult, with 25% or fewer candidates answering them correctly**.**

## Comments on specific questions

### Question 5

The majority of candidates knew the correct sequence of the last two events. Less than a quarter of less able candidates knew the correct sequence of the first two events.

### Question 6

Whilst all the more able candidates knew the function of the smooth endoplasmic reticulum, the majority of less able candidates did not.

**Question 11**

Although the strongest candidates answered correctly, the majority of less able candidates incorrectly thought that the properties of glycogen were dependent on hydrogen bonds.

**Question 12**

Many candidates found this challenging and did not know that denaturation does not involve the primary structure.

**Question 13**

Only a minority of candidates were able to apply their knowledge of the properties of water correctly. Many did not realise that as water gets warmer, less oxygen can dissolve in it.

**Question 17**

Stronger candidates have a good understanding of terminology and answered correctly. However, less able candidates do not understand the roles of active transport, facilitated diffusion and phagocytosis compared with exocytosis.

**Question 18**

Whilst stronger candidates had no difficulty with this question, less able candidates continue to find 'less negative' and 'more negative' water potentials difficult to understand.

**Question 23**

Stronger candidates had no difficulty in converting from anticodon to codon to DNA sequence. However. This was challenging to the majority of weaker candidates.

**Question 25**

Whilst this was answered correctly by most of the more able candidates, there were many who did not fully understand the mechanics of transpiration.

**Question 29**

The majority of more able candidates could use the information provided and link this to their knowledge of the cardiac cycle.

**Question 31**

This posed no difficulty to the stronger candidates. However, the changes in the properties of haemoglobin as a result of the Bohr effect are poorly understood by less able candidates.

**Question 40**

The majority of more able candidates were able to interpret an unfamiliar representation of the flow of energy in a food web.

# BIOLOGY

**Paper 9700/21**
**AS Structured Questions**

## Key messages

- Candidates should be encouraged to plan their answers carefully before giving a written response, particularly where questions describe experimental investigations and provide the results in graphical or tabular form. For example the graphs in **Questions 3** and **6** needed to be studied carefully first, before attempting to answer **Questions 3(b)** and **6(c)**. There was a tendency in **Question 6(c)** to give data quotes that were inaccurate.

- Many questions require careful analysis before embarking on a written response. For example, **Question 6(b)** asked candidates for experimental evidence for the link between smoking and lung cancer. Many misread this as *epidemiological evidence*. In part **(c)** of the same question candidates should have spent some time studying the graph before writing out their answers. Following the changes in mortality rates in *each* country with a ruler moved from left to right across the graph would have helped the candidates in their analysis. They could also have used subheadings to help structure their answers on the similarities and differences between the mortality rates in the five countries.

- Responses to questions that ask about the transmission of a disease, such as in **Question 2(a)** should be clear about how the pathogen or disease-causing organism can be transferred from an infected individual to an uninfected individual. The response should show knowledge of

    - how the pathogen leaves an infected person, for example with measles, in droplets from coughing, sneezing or breathing out
    - how the pathogen gains entry into the uninfected individual, for example with measles, by inhaling the airborne droplets

- The distinction between antibiotics, covered in ***Section I*** of the syllabus and antibodies, from ***Section J*** is not clear for many candidates. Generally, when confusion is apparent, as in **Question 4(d)**, candidates incorrectly wrote 'antibodies' when they meant 'antibiotics'; the reverse has also happened in other papers. Candidates should ensure that they can differentiate clearly between antibiotics and antibodies.

## General comments

The paper discriminated well between the candidates, with some performing extremely well. **Question 3** was the most accessible for many, particularly part **(c)**. **Question 4(c)** proved challenging but more able candidates responded well with impressive use of technical terms. **Question 6(b)** was answered well only by those who noted that the question was about experimental evidence.

Careful consideration of command words can avoid misinterpretation of questions. In many cases, candidates explained rather than described and vice versa. Candidates need to fully understand that different command words, such as 'state', 'explain', 'describe', or 'suggest' require different approaches to answers. For example, in **Question 1(b)**, many candidates gave lengthy *descriptions* of the figures in **Table 1.1** rather than *explaining* the differences; in **Question 3 (b)** marks were lost as candidates *explained* the difference between the transpiration rates of the two groups of buttonwood trees rather than *describe* the changes in the rates of transpiration.

Many candidates used shorthand in their answers; for example, they used 'HB' for haemoglobin and 'conc' for concentration. The use of abbreviations for some technical terms is often accepted where it is made clear what these mean. Candidates should avoid using arrows for indicating increase or decrease and avoid using hash (#) to indicate number.

Answers to **Question 1(a)** suggested that candidates need more experience of interpreting electron micrographs. Candidates who performed well took much more care over the spelling of both technical and non-technical words. Where possible, good Biology was credited despite flaws in spelling but on occasion some words were not recognised as any acceptable biological term.

In **Question 1(b)** and **Question 5**, candidates wrote about movement of substances across capillary walls and across membranes. To improve their response, a number of candidates should have made it clear that they were writing about movement through or across these structures. Movement 'along' a capillary suggests longitudinal movement and not exchange between blood and tissue fluid. Movement into a membrane is not the same as movement across or through a membrane. In **Question 1(b)**, an understanding of how capillaries filter molecules and cells by size was essential for candidates to do well. For example, many explained that white blood cells are too big and glucose molecules are small enough to filter.

Candidates should be encouraged to read through the whole of a question before starting to answer the first part. In **Question 4** candidates often wrote about the different strains of HIV, something that they could also have written about in part **(c)**.

## Comments on specific questions

### Question 1

Candidates used knowledge and understanding from syllabus ***Sections A***, ***C*** and ***G*** to approach this question and many performed well. Most knew the correct formula to use for the calculation in part **(a)(ii)**. Those candidates who were clear about the meaning of 'Explain' were able to provide some good answers for part **(b).**

**(a) (i)** Many candidates correctly identified the cell labelled **A**. All three acceptable cell names, endothelial, epithelial and squamous were seen. Cell structure **B**, the nucleus, was also generally well known. Common incorrect answers were 'epidermis' for **A** and 'nucleolus' for **B**. The scale of the image was a useful indicator to help candidates. Some would have benefited from a more careful consideration of size: a misjudgement of the scale of the image produced responses such as red blood cell, white blood cell, phagocyte and alveolus for **A**.

**(ii)** The calculations were generally correct. The distance between **X** and **Y** to the nearest micrometre was 7 μm. Some candidates gained partial credit for not rounding down their answer from 7.02 μm. The most common error was conversion between units and there were many responses where mathematical notations (powers to the base 10) were used incorrectly.

**(iii)** Candidates were credited only where a structural feature correctly linked to a function. The most common credited answer was to state that capillary walls are thin, to give a short diffusion distance. The most common incorrect answer was to omit the word 'wall', so that 'capillaries are one cell thick' and 'capillaries are thin' did not gain credit. Some candidates gave two correct structural features, but did not give any correct functions and therefore only gained partial credit. Reference to 'easy diffusion' as a reason for a structural adaptation or simply a reference to '...allows substances to pass easily through the capillary' was not credited. The presence of endothelial pores was well known, as was the idea that capillaries are close to the cells.

**(b)** Table 1.1 gave information about the composition of blood, tissue fluid and lymph. The candidates were then asked to explain the differences between the figures for white blood cells, glucose and protein. Many candidates were able to relate the figures in the table to movement that occurs as blood flows through capillaries. The best answers explained that white blood cells are, in general, too large to leave capillaries, but that some can pass through their walls, as happens during inflammation. The high concentration of white blood cells in lymph nodes was given as a reason for the high number in the lymph. The difference in molecular size of glucose and protein was used to explain the differences in concentration of these two components between blood and tissue fluid. Many knew that glucose can be filtered from the blood through the walls of capillaries but most proteins cannot leave the blood owing to their large size. The production of proteins by cells that secrete into tissue fluid was cited occasionally, but not always made very clear. Many candidates simply listed data figures from the table without explanations and so gained no or little credit.

**(c)** There were many good answers to this question, which assessed knowledge of the transport of carbon dioxide in the blood. However, there were some common errors; for example, carbon dioxide was often described as being transported in combination with haemoglobin as 'carboxyhaemoglobin' rather than as 'carbaminohaemoglobin'. Descriptions of the action of carbonic anhydrase were often correct, but the movement of hydrogen carbonate ions out of red blood cells into plasma was not always described precisely. Formulae were often used in descriptions of the action of carbonic anhydrase and these were accepted. However, some candidates did not indicate the negative charge on hydrogen carbonate ions and were penalised once in their answers. There was no need for candidates to describe or explain the Bohr effect in this answer; for example references to the formation of haemoglobinic acid were common, but not relevant to the question posed. Some gave vague statements, such as 'carbon dioxide binds to red blood cells' while others lacked precision by describing the conversion of carbon dioxide to hydrogen carbonate by carbonic anhydrase without any reference to carbonic acid. Weaker responses commonly discussed the formation of carbon dioxide at respiring cells, transport of carbon dioxide in solution in the blood and then its diffusion out of the blood into the lungs.

A number of candidates described the structure of red blood cells and related this to the function of transporting gases. These answers gained no credit at all.

**Question 2**

The transmission of measles, from syllabus ***Section I***, was well known by some candidates. Antibody structure to function, from ***Section J*** was assessed in part **(b)**.

**(a)** Some candidates gave confident and correct answers about the transmission of measles, while others could have improved by providing a more detailed response. Some described the transmission of other diseases, for example transmission by between infected and uninfected people by direct contact or sexual contact, by sharing needles, or through 'dirty water'. Many candidates should have made it clear that the viral particles are transmitted in droplets. They also needed to highlight that infected people pass these out when they cough or sneeze and uninfected people inhale them. Most candidates, even with correct transmission, lost credit for not using the term 'uninfected*'.*

**(b) (i)** Answers to part **(i)**, concerning the variable region of the antibody depicted in Fig. 2.1 were the best in part **(b)**. Most knew that the shape of the variable region is complementary to the shape of the antigen so that they are able to bind together. The serrated edges of the variable region shown in Fig. 2.1 helped to point candidates to the right answer.

**(ii)** Label **B** in Fig. 2.1 is clearly pointing to the disulfide bridge between the two heavy polypeptides (long chains). Answers that explained that these bridges held the long chains together gained credit. Some candidates needed to make their statements more precise as the response they provided was too general, for example, 'the disulfide bonds hold the antibody together' or 'they maintain the shape and structure of an antibody'. Candidates also gained credit if they stated that these disulfide bridges hold the tertiary and/or quaternary structure of the antibody together. A number of candidates were unsure where B was pointing and made reference to the hinge region, which was not credited.

**(iii)** There were a number of excellent answers describing the function of the structure labelled **C** on Fig. 2.1. Most of these explained how the constant region binds to receptors on phagocytes, although there were also a few who gave good descriptions of opsonisation. Only the minority gained credit: **(b)(iii)** was, for many, the most challenging question on the paper. Some left this blank, while others thought that the constant regions are involved in agglutination.

**Question 3**

Topics from syllabus ***Section G*** were assessed in this question. Many candidates would have benefited from a greater knowledge of the syllabus learning outcomes, as only some were able to provide good responses to part **(a)**.

**(a)** Having been prompted by familiar wording from a learning outcome, a few candidates confidently gained full credit for part **(a)**. It was expected that candidates would refer to the gas exchange required for photosynthesis, explaining that stomata are open to allow carbon dioxide into the leaf for photosynthesis, and as a result water vapour diffuses out. Good responses made it clear that

transpiration was a consequence of gas exchange and not the other way round: many were under the incorrect impression that carbon dioxide diffusion was a consequence of transpiration. Some candidates simply gave lengthy descriptions of the process of transpiration, often including movement through the xylem. To gain credit for loss of water vapour there needed to be a reference to diffusion, which was not always given.

**(b)** The description of the graph showing rates of transpiration of buttonwood trees growing in two different habitats proved to be more accessible to candidates. Candidates generally described the trends in the rates shown in Fig. 3.1 very well. Data quotes, when given, were often correct. Some could have improved by stating clearly the times of day when peak rates occurred and by giving comparative data quotes. Units for transpiration rates were sometimes omitted and times were given as days. Candidates often described adaptations of the trees in the two locations as reasons for lower or higher transpiration rates. There were a number of responses that revealed some confusion between the lines on the graph, as some stated that the trees growing in the more exposed habitat had higher transpiration rates. A simple method to ensure that data quotes are correct is to look at the scale division on the axis and divide by the number of squares between two points, e.g. a gap of 50 units on the graph covered by 10 squares = 50 divided by ten, where each square = 5. Many candidates seemed unable to do this.

**(c)** There was a generous amount of space for candidates to describe the adaptive features of the leaves that reduce rates of transpiration. Some simply named their chosen features, others described them and many did both. Many explained how the features reduce water loss. Common answers were sunken stomata, rolled leaves, and hairs or trichomes over the surface of the leaf. 'Needle-like leaves' gained no credit as this feature is ruled out by the question. 'A waxy cuticle' was also not creditworthy since all leaves of terrestrial flowering plants have waxy cuticles; candidates who stated that the cuticles are *thick* or *thicker* gained credit. Candidates should note that there are hairs or trichomes around stomata that are sunken in pits, but guard cells do not grow hairs.

**Question 4**

Many candidates did very well on this question, which assessed syllabus ***Sections C, F*** and ***I***, with part **(a)** proving to be the most accessible question on the paper.

**(a)** The naming of parts in Fig. 4.1 was generally answered very well. Common errors were to give the wrong bases or misspell them. Phosphodiester bonds occasionally appeared instead of hydrogen bonds.

**(b)** Candidates were able to identify the drugs zidovudine and efavirenz as competitive and non-competitive inhibitors respectively. Fewer were able to explain in correct detail their mode of action. Many stated that zidovudine has a shape which is the *same* as that of the active site rather than referring to its complementary shape. Stronger responses also explained that efavirenz binds to an allosteric site, so changing the shape of the active site. Good answers often included information about the effect of increasing the substrate concentration on the activity of these two enzyme inhibitors. Candidates who performed well on this question were those using the scientific terms, such as complementary, allosteric, competitive and non-competitive.

**(c)** People who receive drug treatment for HIV/AIDS almost always take a mixture of drugs. Candidates were asked here to suggest the advantage of this. There were some very thoughtful suggestions about the different effectiveness of the drugs and changes that might occur in the target enzymes and HIV antigens. Candidates who made use of the data were able to explain that the drugs were inhibiting different enzymes. Many used the idea of synergy successfully, as related to potentiation effects seen in many drugs (particularly analgesics). Many candidates focused on the idea of 'drugs' rather than the 'mixture' of the drugs and so missed the main emphasis of the question. Some incorrectly referred to HIV as a bacterium or to viruses becoming 'immune' to drugs.

A number of candidates made reference to HIV's antigenic variability and different strains of HIV in the next part of the question, part **(d)**, but did not seem to appreciate the challenges these present when designing an effective drug treatment. This meant that pertinent points stemming from the idea of antigenic variability were not made in part **(c)**.

**(d)** Antibiotics are not used to treat the infection with HIV. This is because there are no targets upon which antibiotics may act. Some candidates explained this very well. Others explained that secondary, or opportunistic, infections are often bacterial and antibiotics are used to treat them. Tuberculosis was often mentioned in this respect. Many were able to explain that HIV infection lowers immunity, so leading to secondary infections. Some candidates confused antibiotics with antibodies and wrote about immunity instead of drug treatment. Weak answers came from a basic lack of knowledge that antibiotics do not treat HIV because it is a virus. A number stated that HIV has no cure, with no further qualification or attempt to answer the question. Several saw the treatment as a method to improve the immune system

Many candidates discussed antigenic shift and the different strains of HIV, stating that HIV's antigenic variability is why the antibiotics were not effective. This variation was a point that would have gained credit in **(c)** but not in **(d)**. Some candidates confused the use of antibiotics with vaccinations and the difficulty in developing vaccines for HIV.

**Question 5**

Candidates found this question, based on topics from syllabus ***Section D*** to be very accessible initially and then to become progressively more challenging. Part **(a)** required factual recall of the structure of the cell surface membrane and the function of its components. In part **(d**), which required application of knowledge and understanding, stronger candidates were able to give good explanations using their knowledge of the syllabus.

**(a)** Many candidates performed well in this question, identifying the structures shown in the diagram of the membrane and giving a suitable function. There was no requirement to name the structures. Structure **P** was a carrier or channel protein, so any description of the movement of ions or polar substances across the membrane was accepted. Most candidates stated structure **Q**, a glycoprotein, was a receptor or was involved with cell recognition. There were good answers about the role of structure **R**, cholesterol, in regulating or maintaining the fluidity of the membrane. Some lost credit here by stating that cholesterol 'maintains the fluidity of the cell'.

**(b)** The correct answer to this question, 7.0 nm, was seen for approximately half of candidates. Some did not answer this question. Many candidates were clearly unsure about the width of the membrane in nanometres or did not know the correct unit for its measurement.

**(c)** A number of candidates clearly understood how the model of membrane structure became known as the fluid mosaic model and gained full credit with well-expressed accounts. Good answers referred to the movement of phospholipids and the scattered pattern of the protein components of the fluid mosaic membrane. Common errors were describing the orientation of the phospholipid molecules making up the bilayer rather than stating that they move within the membrane. Often candidates referred just to molecules moving rather than to phospholipid molecules; similarly, they referred to 'scattered molecules' rather than scattered protein molecules to explain the term *mosaic*. Some referred to molecules moving in and out of the membrane or bilayer, confusing it with movement of molecules across the membrane.

**(d)** There were two lines of argument that candidates could have followed in answering this question on aquaporins. They could have explained that water is polar and does not easily pass across the phospholipid bilayer. This explains the need for protein channels that are lined by amino acids with polar R groups. The uses of water in cells constituted the second line of argument. Some candidates supported this argument with references to places where there must be high concentrations of aquaporins, such as root hair cells for the uptake of water from the soil.

Common errors and misconceptions were:
- water is hydrophilic
- phospholipid heads are hydrophobic and tails are hydrophilic
- aquaporins allow movement of water soluble molecules, ions and glucose
- water moves by active transport.

Many referred to water potential gradients and the movement of water by osmosis but only the stronger responses explained why the aquaporins are required for this.

**Question 6**

This question assessed ***Sections E*** and ***H*** of the syllabus. There was a great contrast in the quality of response for part **(a)** compared to part **(b)**, with the latter being misread or misunderstood by a large number of candidates.

**(a)** Candidates gave some good answers to this question on cancer, explaining that a mutation or mutations had led to the lack of control over mitosis. Many referred to proto-oncogenes and oncogenes in the control of mitosis. The growth of tumours was often stated and some went on to describe the spread of these cells through the body.

**(b)** The description of experimental evidence for the link between smoking and cancer was answered well by a minority of candidates. Many referred to *epidemiological* evidence. Of those who did refer to the results of animal experimentation, few gave accurate details. Many candidates described how smoking causes cancer, with reference to carcinogenic substances present in cigarettes. Credit was awarded for references to the experimental work on dogs that were forced to smoke cigarettes, and to the application of tar to the skin of small mammals, such as mice. Many candidates simply described the effects of various components of cigarette smoke on the body, perhaps because they had practised past paper questions on this topic.

Several described how the data would be collected; in other words, they described an experiment rather than the information that was collected in the past.

**(c)** The graph in Fig. 6.1 showed the trends in mortality from lung cancer in five countries between 1950 and 2006. Candidates were asked to describe the similarities and differences between the trends for the different countries. The best answers to this question clearly stated the names of each country and the dates over which increases and decreases in mortality rates occurred. References to the dates of these and for the peak mortality rates had to be accurate. There was also credit for using a comparative data quote to support the answer. Often this was gained for comparisons of the peak mortality rates in two or more countries. Few candidates spotted that the maximum mortality rates were different for all the countries. There was a tendency for candidates to describe graphs for individual countries and not link the trends for all the countries, with many focusing on one or two countries. Several candidates did not understand the unit used for mortality.

# BIOLOGY

**Paper 9700/22**
**AS Structured Questions**

## Key Messages

- Candidates should be encouraged to plan their answers carefully before giving a written response, particularly where questions describe experimental investigations and provide the results in graphical or tabular form. For example, the graph of **Fig. 4.2** in **Question 4** was often misinterpreted and time spent understanding the experiment described could have benefited many candidates.

- Many questions require careful analysis before embarking on a written response. For example, a number of candidates seemed to read 'differences between cells that have been produced by mitosis compared to cells that have been produced by meiosis' as 'differences between cells undergoing mitosis and cells undergoing meiosis' in **Question 1(a)(i)**. Similarly, in **Question 2(a)**, some candidates seemed to read 'xylem tissue' instead of 'xylem vessels' and in part **(b)** of the same question gave advantages of an electron microscope instead of a light microscope.

- Responses to questions that ask about the transmission of a disease, such as in **Question 3(a)** should be clear about how the pathogen or disease-causing organism can be transferred from an infected individual to an uninfected individual. The response should show knowledge of

    - how the pathogen leaves an infected person, for example with tuberculosis, in droplets from coughing, sneezing or breathing out
    - how the pathogen gains entry into the uninfected individual, for example with tuberculosis, by inhaling the airborne droplets

- The distinction between antibiotics, covered in ***Section I*** of the syllabus and antibodies, from ***Section J*** is not clear for many candidates. Generally, when confusion is apparent, as in **Question 3(b)**, candidates incorrectly describe the action of antibodies when referring to antibiotics. Candidates should ensure that they can differentiate clearly between antibiotics and antibodies.

## General comments

The paper discriminated very well, with many candidates demonstrating extremely high levels of competency in responding to all types and difficulty of questions. These candidates demonstrated a range of skills and had a very good knowledge of the syllabus learning outcomes, producing responses that reflected careful thought and good planning. At the other end of the scale, there were a minority of candidates who were not ready to take an examination of this level and clearly struggled to interpret the requirements of all but the most basic part-questions. The majority of candidates, however, had revised well and made a good attempt at all but the most challenging part-questions.

It is good practice for candidates to become skilled at recognising questions requiring recall and questions requiring the application of knowledge and understanding. In addition, candidates should be able to draw together knowledge from different syllabus areas. For example, **Question 5(b)** required recall of one learning outcome from ***Section F***, whereas **Question 1(b)(ii)** was based on unfamiliar material and used knowledge of learning outcomes from ***Sections A*** and ***E.***

Some candidates could have improved their overall performance if they had addressed all aspects of the question. For example in **Question 2(a)** a number were able to describe in detail the structure of xylem vessels but gave little explanation of how this linked to function. Similarly, in **Question 6(b)** some only explained why the wall of the left ventricle was thick and failed to mention the comparison with the right ventricle. In **Question 3(b)**, which required an extended answer and was worth a good proportion of the overall marks, a very large number of candidates confused 'antibodies' with 'antibiotics', thus highlighting the

importance of reading the question carefully before formulating a response. In terms of overall questions, **Question 6** was most accessible to candidates and **Questions 3 and 5** were most challenging.

Candidates should be aware that credit cannot be given when a response lacks clarity. For example, in **Question 1(b)(ii)**, asking candidates to explain the presence of large numbers of mitochondria and rough endoplasmic reticula (RER), was a signal to many candidates that each organelle needed to be assigned its specific function. Hence, a response explaining that a cell undergoing uncontrolled mitosis requires the production of (more) ATP by the mitochondrion and protein production at the RER was given full credit. In contrast, other responses that stated 'for protein and ATP production', did not gain credit as this was not confirmation that the candidates knew which organelle was responsible for which product.

It is important for candidates to answer on the lines provided. The best answers are concise and direct and can be completed well within the lines provided. Almost all candidates attempted all parts of each question and there appeared to be sufficient time for candidates to complete the paper.

## Comments on specific questions

### Question 1

Candidates who were focused from the outset and ensured that they answered the question asked precisely, did very well on this question. A number of skills were assessed, including a calculation of actual size from an electron micrograph. The question assessed learning outcomes from syllabus ***Sections A*** and ***C***.

**(a) (i)** This was a straightforward exercise for many. Candidates were asked for differences between the cells produced by mitosis and meiosis, in the same organism. Those that gave differences between the two processes, such as ending up with two or four cells, or with one division compared to two divisions, gained no credit. Candidates were provided with a table to complete and each row should have shown differences for a particular feature, such as the ploidy of the cell, the number of chromosomes in the daughter cells or the nature of the DNA. Some weaker candidates did not do this. Only one difference per row should have been given: some candidates gave responses that contained a number of points per row while others created a third row of the table to complete, neither of which gained additional credit.

**(ii)** Almost all candidates were able to gain some credit for **(a)(ii)**, most appearing to understand that that cells with half the number of chromosomes would then allow for the full complement to be restored on fertilisation, but not all expressing themselves well enough to gain full credit. Those that gained full credit were clear in their explanation and some gave all the points considered. The strongest candidates also showed an understanding that reduction division not only produced cells with half the number of chromosomes, but also that the cells each had a complete set of chromosomes for the diploid number to be restored on fertilisation. Very few qualified a statement about genetic or biological variation with its importance in natural selection and evolution.

**(b) (i)** This posed no problems for many candidates, with the working shown clearly and the answer provided to the nearest micrometre. Almost all appeared to measure correctly the length of the line at **X**-**Y** and a good proportion of these knew the formula to use to calculate the actual width of the dividing cancer cell. At this step, the stumbling block for some was the conversion to give the answer in micrometres. A measurement in millimetres required a multiplication by 1000 and a measurement in centimetres required a multiplication by 100. Some candidates did not read the instruction to provide the answer to the nearest micrometre and so were unable to gain full credit.

**(ii)** Candidates producing high quality responses demonstrated an understanding that cancer cells undergo uncontrolled mitosis and that growth needed to occur for a cell to divide. The responses were also clearly linking each organelle to its particular function. Others were less precise. Many were careful in their handling of the term 'energy' and either just wrote about the production of ATP, or finished their sentence with 'so that energy can be provided to the cell'. Reference to the production or creation of energy by the mitochondrion, or 'makes energy', and 'energy for respiration' were not credited as they are biologically incorrect. Some weaker responses stated that ATP production occurred at the RER and some candidates forgot that they were being asked about RER and wrote only about ribosomes. Several gave functions of the Golgi body rather than RER.

**Question 2**

In this question, candidates were assessed on aspects of plant transport from syllabus **Section *G***, and also on their ability to apply their knowledge and understanding of the light and electron microscopes, from ***Section A***. There was considerable variation in the quality of response for part **(a)**.

**(a)** The best answers gave a large number of well-described, correct structural features of xylem vessels and then went on to explain for each how this linked to the function of transporting water and mineral ions. It should have been clear from the amount of credit that could be gained, and from the number of lines allocated, that a fairly extended response was required and that a range of structural features should be described. A number of responses were too short to gain much credit.

A proportion of candidates had not read the questions sufficiently carefully and gave details of the different cells types found in xylem tissue, a costly error. A common error was to assume that the wall of the xylem vessel was composed only of lignin, rather than of cellulose impregnated with lignin, which meant that fewer candidates correctly linked adhesion of water molecules to the hydrophilic cellulose lining. Although lignin contains some hydrophilic groups, its waterproofing nature given by the many hydrophobic groups would not support a column of water moving up a stem by adhesion. Strong candidates gave a succinct explanation of the prevention of collapse by the lignified wall, understanding that the tension would mean a lower hydrostatic pressure within the vessels. Others gave a more confused, slightly contradictory account which correctly noted the feature and mentioning its role in preventing collapse, but linking this with a high hydrostatic pressure within the vessels. On many occasions, candidates were able to gain credit, but responses inferring that the xylem vessels would burst gained none.

The fact that mature xylem vessels are dead is not a structural feature: astute candidates made sure that they qualified this with the structural consequence and mentioned features such as hollow or no cell contents. Some confused the lack of end walls with phloem and mentioned sieve plates. 'Pits' were referred to as 'piths' by quite a few candidates. A comment about the diameter of the lumen was credited only when the reference to 'narrow' or 'wide' was qualified with a valid explanation. References to 'capillary rise' were ignored as capillary action in xylem vessels with a narrow lumen would only be relevant for upward movement in small plants and 'adhesion' would be a more appropriate general term to use.

**(b)** The majority of candidates did very well on this question, although there were some vague responses which lost credit, such as referring to 'damage' caused by the electron microscope rather than referring to the (increased) possibility of artefacts. Some weaker responses referred incorrectly to the light microscope offering a higher resolution than the electron microscope. Others stated that the higher magnification with the electron microscope was a disadvantage as only a portion of the xylem tissue would be seen. These candidates had not noticed that the information given had stated 'same magnification'. Others misread the question and gave advantages of the electron microscope.

**Question 3**

This question, which included three sections of extended prose, discriminated well. Tuberculosis (TB), from syllabus ***Section I*** was a theme used to assess knowledge and understanding of infectious diseases and antibiotics. In addition, a link between TB and tobacco smoking allowed subject matter from ***Section H*** to be assessed.

**(a)** This question was not just asking for a definition of an infectious disease, so those who exemplified their definition using TB as an example were easily able to gain full credit. Well-revised candidates gave factually correct details about the type of organism involved and a clear explanation of the mode of transmission involved. Good answers named or explained clearly aerosol or droplet infection, demonstrating an understanding that that the transmission was from an infected individual to an uninfected one and not just simply stating that TB was from 'droplets in the air'. Some were imprecise in their terminology by referring to 'TB' as the organism and not the disease, while others stated 'the TB virus'.

**(b)** A small proportion of candidates were able to give a comprehensive account of the role of antibiotics in the treatment of infectious diseases, such as TB, to gain full credit. They clearly understood the difference between 'role' and 'mode of action' of antibiotics. Many gave descriptive

accounts of the action of different types of antibiotics and where it was clear that the end result was a bactericidal or bacteriostatic outcome, partial credit could be given. Candidates were not expected to know details of the action of antibiotics. A very large proportion gained no, or very little, credit for this question. Of these, a sizeable number of good candidates had clearly misread the question and gave accounts of the role of antibodies in infectious disease. Weaker responses stated that antibiotics were antibodies and described antibiotics binding to antigens or antibiotics stimulating phagocytosis. Others thought that antibiotics were drugs that contained antibodies.

**(c)** A minority of candidates were confident as to what was meant by epidemiological evidence and avoided confusion with experimental evidence. Although the term is in a learning outcome in ***Section H***, most did not appear to understand what was meant by 'epidemiological'. Some repeated word for word one or more of the information bullet points provided, while others gave a response that was more suited to part **(d)** and described the effects of smoking on the gas exchange system, or wrote about the effects of smoking on the cardiovascular system.

**(d)** Responses that gained full credit showed an understanding that TB is primarily a disease of the lungs and focused their response on explaining how the effects of smoking on the gas exchange system would make a smoker more prone to infection by the pathogen. Others that gained some credit understood the link between mucus trapping pathogens and paralysed cilia unable to move the mucus, but did not progress to explain that the increased exposure of respiratory tissue to pathogens (with increased numbers owing to population growth) would increase the risk of infection. Some gave an incomplete statement by mentioning less effective cilia but not linking this to mucus accumulating or stating that paralysed cilia could not remove pathogens. Also, some referred to increased production of mucus by cells, but did not go on to explain that this would not be removed by cilia or to explain that it would provide nutrients for the growth of the bacteria. Weaker candidates wrote about tar causing lung cancer or about the effects of carbon monoxide or nicotine on the cardiovascular system and so did not address the question.

**(e)** Many correctly listed heart transplant and coronary bypass surgery as the two treatments mentioned in the relevant syllabus learning outcome, while some gave angioplasty or the insertion of stents, which was acceptable. Although the question asked candidates to 'list', some gave descriptions, which was not required and descriptions of 'balloons' for angioplasty, or 'putting in rings' for stents, did not gain credit. A considerable number of candidates listed advice that doctors would give patients to avoid worsening their condition, such as avoiding saturated fats and taking more exercise.

**Question 4**

This question assessed ***Sections B, C*** and ***D*** of the syllabus. A number of part-questions required higher level skills to gain full credit. In **(b)** candidates were provided with enough information to be able to use knowledge and problem-solving skills to identify disaccharides. The description of the graph in part **(e)** could only be tackled correctly if candidates fully understood what the results of the investigation were showing.

**(a)** Almost all candidates knew that glycosidic bonds were formed when polysaccharides are synthesised, but not all were able to spell this correctly.

**(b)** Confident candidates were able to use their knowledge of the structure of α-glucose, β-glucose, sucrose and cellulose to work out which disaccharide was which. The most common correctly identified molecule was **D**, sucrose, followed by **C**, cellobiose. Some weak candidates did not seem to realise that the bullet points provided them with the names of the four disaccharides that they could match to the molecular structures. This meant that α-glucose, β-glucose and cellulose were also seen as names of disaccharides. Others wrote the name of the same disaccharide for more than one structure.

**(c)** Many gave a considered account of the importance of cell surface membranes and gained full credit. Others misinterpreted the question and gave a description of the fluid mosaic structure of membranes and how the components were involved in transport across the membrane.

**(d) (i)** Candidates who focused on explaining the mode of action of enzymes had no problems in giving sufficient points to gain full credit. Others gave an outline of the features of enzymes or described how enzymes catalysed a reaction and were generally able to gain partial credit. Hence a good response explained the specificity of enzymes and noted the ability of enzymes to lower activation energy, whereas one that simply stated 'enzymes have an active site where a substrate can bind to

form products' gained no credit. A number thought they were being asked to describe the denaturation of enzymes.

**(ii)** Many were able to suggest that the active site changed shape, although some were not precise and gave more vague answers such as 'the active site is affected' or 'the enzyme changes shape'. Fewer explained how the active site could lose its shape. Some of those candidates who did realise that R-group interactions would be affected did not suggest the types of bonds that could be broken or incorrectly suggested that disulfide bonds would be affected. A number of thoughtful candidates gave correct suggestions about the loss of the globular structure of the enzyme.

**(e)** Before considering part **(e)**, pieces of information were provided to candidates to enable them to fully understand the investigation described. Immediately prior to part **(c)**, the nature of cryoprotectants was introduced. In part **(d)** candidates were told that freezing temperatures can stop enzyme activity and that this activity is not recovered when temperatures are increased to normal. In **(e)** trehalose and glycerol were named as cryoprotectants that could have a protective effect for a respiratory enzyme that had been subjected to a freezing temperature and then returned to optimum temperature. Using this information, and extracting data correctly from **Fig. 4.2**, some candidates gave a response that indicated full understanding of the investigation described, including responses such as '…. activity of the enzyme', 'trehalose allowed 100% of maximum activity to be restored' 'trehalose had a better protective effect on the enzyme than glycerol'.

Some candidates were imprecise in their wording, such as 'the activity of trehalose…' and 'at 10 mmol glycerol had only 10% maximum activity'. The best responses remembered to include the correct units when giving data quotes and gave relevant *comparative* data quotes for trehalose and glycerol. Incorrect references to time, such as 'fast' and 'slow(ly)' were avoided by stronger candidates who used terms such as 'increased steeply' and 'less steep'. Many candidates referred incorrectly to 'rate', while some referred to the plateaux or 'levelling off' but did not link this to 100% maximum activity. A good number did not appear to have digested the outline of the investigation and interpreted the axes of the graph as being standard for an enzyme investigation, with rate of reaction on the *y*-axis and substrate concentration on the *x*-axis. This meant that they thought that trehalose and glycerol were enzymes and that 'cryoprotectant' was the substrate for the reaction. Some of these included explanations in terms of enzyme-substrate complexes and interpreted 100 per cent of maximum activity as the saturation of active sites at high substrate concentration. On a different misinterpretation, a number of candidates thought that the *x*-axis values were temperatures.

**Question 5**

In this question, candidates were assessed on syllabus ***Sections F*** and ***J***, with knowledge of measles from ***Section I*** also required. In part **(a)** most candidates were able to complete a table so that differences in one particular feature appeared on the same row, rather than appearing in a non-random manner. Some candidates did extremely well on all sections of this question, giving full and detailed accounts, while others could have done as well if they had further qualified their responses. Weaker candidates only had a tentative grasp of the subject matter and gave imprecise and confused answers that also lacked the correct terminology.

**(a)** The completion of the table was a relatively easy task for well-revised candidates who were knowledgeable about each process and who gave simple but informative comparative descriptions. For others, responses such as 'DNA' versus 'mRNA' or 'DNA nucleotides' versus 'RNA nucleotides' were not sufficient to show an understanding of the processes, and would have been acceptable if qualified with words such as 'produced' and 'used' respectively. Some candidates gave a comparison such as 'DNA polymerase used' versus 'DNA polymerase not used', which was not credited as there was an equivalent enzyme, RNA polymerase involved for transcription, which should have been described. Candidates needed to know both processes: a number appeared to be stronger on DNA replication and others confused transcription for translation and gave descriptions that included reference to polypeptides.

**(b)** This question was based on a short definition-style learning outcome from ***Section F***. Those candidates who were well-prepared were easily able to gain credit by recalling the learning outcome, while others gave more rambling and vague responses. Some gave a mixed response, either describing the changed sequence of amino acids on the DNA molecule or noting that the

DNA was altered but matching this to amino acid substitution, deletion or insertion. A few gave descriptions of chromosomal mutation.

**(c) (i)** Knowledge of the specificity of the immune response was required for this question and candidates needed to give further explanation as to why a vaccine can become ineffective if the surface antigen of a pathogen changes. Many understood that the vaccine was the source of the original antigen. Good responses either described how the vaccine would invoke an immune response and result in antibodies and memory cells specific only to the original antigen or explained that existing antibodies, lymphocytes or memory cells would not be specific to the changed antigen. Answers that included ideas such as 'would no longer recognise', 'antibody is not complementary to the antigen' were acceptable ways to indicate an understanding of specificity. There was a sizeable minority that stated that the vaccines contained antibodies.

**(ii)** Approximately half of candidates correctly identified the type of immunity provided by a vaccination.

**(d)** There were a number of well-expressed reasons why measles is still common in many parts of the world, despite the availability of a measles vaccine. Some candidates were able to quote percentage cover values for measles to support their explanation that herd immunity had not been achieved in these areas. There were also some excellent outlines of how protein malnourishment could have impaired the immune response to the vaccine. A list of features associated with the measles vaccine was not required. The best responses answered in terms of how epidemics have failed to be prevented. For example some stated that boosters are needed, while others correctly indicated that some areas have a problem in giving boosters to children. Some responses were too vague to be given credit.

**Question 6**

This question, assessing parts of syllabus ***Section G***, was generally very well attempted.

**(a)** A high proportion of candidates gave the correct sequence of events. For many others, some credit was gained for knowledge that the sinoatrial node was the first event in the sequence and/or the atria contracted before the ventricles. Commonly, events 4 (Purkyne tissue conducts the wave of excitation) and 5 (ventricles contract) were the wrong way round.

**(b)** Many gained full credit for this question. Where no, or only partial credit was awarded, this was generally because a comparative term or statement was not given. For example, some gave details about the left ventricle and did not mention the right ventricle at all.

# BIOLOGY

**Paper 9700/23**
**AS Structured Questions**

## Key Messages

- Candidates should be encouraged to plan their answers carefully before giving a written response, particularly where questions describe experimental investigations and provide the results in graphical or tabular form. For example, the results shown in graphical form in Fig. 4.1 in **Question 4**, although straightforward, required an explanation rather than a description, and many candidates could have benefited from working through the graph first before attempting their written response.

- Many questions require careful analysis before embarking on a written response. For example, a number of candidates seemed to read 'Explain how water moves from the xylem into the leaves' rather than '….from the xylem in the leaf into these vacuoles' in **Question 1(d)**.

- Responses to questions that ask about the transmission of a disease, such as in **Question 6(b)** should be clear about how the pathogen or disease-causing organism can be transferred from an infected individual to an uninfected individual. The response should show knowledge of:

    - how the pathogen leaves an infected person, for example with measles, in droplets from coughing, sneezing or breathing out
    - how the pathogen gains entry into the uninfected individual, for example with measles, by inhaling the airborne droplets.

- The distinction between antibiotics, covered in ***Section I*** of the syllabus and antibodies, from ***Section J*** is not clear for all candidates. In **Question 6(c)**, some candidates, when referring to vaccination against measles, wrote about resistance to antibodies. Candidates should ensure that they can differentiate clearly between antibiotics and antibodies.

## General comments

Many candidates demonstrated proficiency when handling the most challenging part-questions and produced responses that reflected very good knowledge and understanding of the syllabus learning outcomes. In contrast, there were a number of candidates who were not ready to take an examination of this level and these struggled to interpret the requirements of all but the most basic part-questions, many of them leaving sections unanswered. For the majority, it was clear that a very good effort had been made at learning the syllabus and preparing for the examination, and generally these candidates tackled each question with consideration. In terms of overall questions, **Questions 1** and **6** were most accessible to candidates and **Question 2** was the most challenging.

It is good practice for candidates to become skilled at discerning between those questions requiring recall and understanding and those questions that require application of knowledge and understanding. It is also of great benefit for candidates to be familiar with the syllabus sections and learning outcomes within each section. For example, **Question 5(c)** was a straightforward question that required basic recall of a learning outcome from syllabus ***Section E***, whereas **Question 1(c)** introduced the tonoplast and then asked candidates to describe the structure of the membrane. By realising that the structure of the tonoplast is not required knowledge, well-prepared candidates knew that they were expected to use their knowledge of the fluid mosaic model of membrane structure, from syllabus ***Section D***, having also been 'prompted' so do to in the introduction. Less well-prepared candidates gave confused and irrelevant accounts of what they thought they were expected to know about tonoplast structure. In addition, candidates should be able to draw together knowledge from different syllabus areas. **Question 2** was based on unfamiliar material and used knowledge of learning outcomes from a number of syllabus sections: some candidates were more skilled than others at drawing together knowledge from different strands.

It is important for candidates to answer on the lines provided. The best answers are concise and direct and can be completed well within the lines provided. Although most candidates attempted all parts of each question, there were a number who did not attempt some sections: the most common parts that were left blank were **Question 2 (a)(iv)** and **Question 2 (c)**. Candidates appear to have had sufficient time to complete all questions.

## Comments on specific questions

### Question 1

Learning outcomes from syllabus ***Sections A***, ***D*** and ***G*** were assessed in this question. Almost all knew the formula to use to calculate the actual width of the vacuole in **(d)**. This was a straightforward question for well-prepared candidates.

**(a)** The most able candidates gained full credit by naming correctly all the features labelled in Fig. 1.1. Feature **A**, was well known, although some gave 'chlorophyll' instead of 'chloroplast' and a number thought that **A** was a mitochondrion despite the obvious presence of starch grains. Feature **B**, the (intercellular) air space, was not well recognised and this was left blank in a fairly high proportion of scripts, or subject to guesswork, for example, 'space', 'pith', 'vacuole', 'air sac', 'gap', 'cytoplasm' and 'xylem vessel'. Stronger responses named **C** correctly as the nucleolus: although the label pointed clearly to this structure, 'nucleus' was accepted to the benefit of candidates.

**(b)** Almost all candidates were able to measure correctly the length of line **X-Y**, but the challenge for many was the conversion that would allow the answer to be shown in micrometres. A measurement in millimetres required a multiplication by 1000 and a measurement in centimetres required a multiplication by 100, but many candidates forgot to do this or divided by 1000 or 100. Some did not notice that the magnification was given, or did not know that the magnification was required to make the calculation and simply converted their measurement to micrometres.

**(c)** The best responses included all the chemical components of a membrane and explained how these were arranged as part of the fluid mosaic model of membrane structure. Within their response a number of candidates included an explanation of how the structure could be considered a 'fluid mosaic'. Glycolipids and glycoproteins are only noticeably present in the cell surface membrane so inclusion of these in a description of the tonoplast, a membrane within a cell, was ignored. Others who were on the right lines tended to concentrate either on a description of phospholipids and the formation of a bilayer, or on a description of the different types of membrane protein. Many candidates did not address the question and attempted to give an account of the function of the tonoplast as a membrane, or explain how substances were transported across membranes.

**(d)** Candidates first needed to visualise the pathway that water would take from the xylem in the leaf to the vacuoles of the palisade mesophyll cells before embarking on a written explanation. Weaker responses used the term 'osmosis' very carelessly, unlike the stronger responses that correctly pointed out that osmosis only occurred where water crossed the cell surface membrane or tonoplast. Some did not notice that these were palisade mesophyll cells, or that they had been asked to provide an explanation where vacuoles were the final destination, so gave biologically correct but irrelevant accounts of evaporation from the cell walls of spongy mesophyll cells and diffusion of water vapour through stomata.

### Question 2

For many, this was the most challenging question on the paper in terms of understanding the information provided in the passage and working out what was required as a response to each part-question. Stronger candidates successfully applied their knowledge of the relevant syllabus sections and gave excellent answers. Strands from syllabus ***Sections A***, ***B***, ***C*** and ***F*** were assessed in this question, which required considerable concentration in order to stay focused on the method of *in vitro* translation described and produce the required responses.

**(a) (i)** Most candidates understood that scientists would be opting for cells that had high levels of protein synthesis as this would make it much more likely that an increased yield of the desired protein would be obtained. Far fewer went on to think about the process of protein synthesis and explain

that this would mean a greater availability of the relevant cell structures, enzymes and amino acids. Of these, some gave a comprehensive list of what would be required.

**(ii)** Approximately 60% of candidates did well on this question, with stronger responses realising that both the cell surface and internal membranes were broken down. Most gained credit from using the information in the passage to explain that the nucleic acids would be more prone to destruction, while others included explanations about the difficulty otherwise of introduced RNA gaining entry to the cell. Some had the wrong idea about the method and thought that the scientists were attempting to extract components for use elsewhere

**(iii)** Candidates needed to be precise when answering this question. For example, 'The cell's own mRNA needs to be destroyed so that the new protein can be made with the new RNA' was not given credit as the presence of the original mRNA theoretically would result in the production of both protein types.

However, those candidates who wrote '…….so that *only* the new protein can be synthesised…..' showed an understanding of the purpose of the method. Some good responses also referred to the desire to obtain the maximum yield or commented on the need to use the ribosomes and amino acids only for the production of the new protein.

**(iv)** This was understood by a few candidates, who explained the universal nature of both mRNA and the cell machinery to use mRNA to synthesise proteins. Many just explained that mRNA could be used for protein synthesis without showing an understanding of the universal nature of the process. Other weaker responses rewrote the last sentence from the introductory passage. Several candidates left this question blank.

**(b)** Candidates who were careful to read the question carefully generally responded from the point of view of ribosomes, usually gaining partial credit. Stronger candidates were able to give further detail to gain full credit. Some weaker candidates had read the question but gave a response that indicated they thought that translation was transcription. In these cases, explanations involving DNA were given. The majority of candidates misread the question and gave two differences between prokaryotes and eukaryotes. Sometimes they were fortunate if they included information about ribosomes as one of their two differences.

**Question 3**

This question, mainly assessing syllabus ***Section K***, included a part question, **(b)(ii)**, that proved to be quite challenging for many. Some stimulus had been provided in **(a)(ii)** and **(b)(i)**, and several candidates took advantage of this to produce a good explanation. A number of candidates left **(b)(ii)** blank.

**(a) (i)** Fig. 3.1 was a very straightforward diagram of the nitrogen cycle. Although naming the three labelled processes posed no problem to those who had revised the cycle, some gave the same process for each of **A**, **B**, and **C**, or just wrote three different processes in any order, in the hope of gaining some credit, without taking the time to try and logically work out the correct answer. Process **C**, denitrification, was, for example, given as, 'nitrogen release', 'nitrogen loss', and 'energy release'. 'Condensation', 'hydrolysis' and 'evaporation' were common incorrect responses. Nitrification was frequently seen as 'nitration'. Some candidates knew the processes involved but named them as if they were describing the bacteria involved, i.e. 'nitrifying', 'nitrogen fixing' and 'nitrifying'.

**(ii)** Fig. 3.1 should have prompted candidates towards decomposition or ammonification. Although detailed knowledge in this area, such as reference to proteases and deamination, was lacking, a number of candidates were able to provide enough information to gain full credit. Most of these did this by a reference to decomposition or decay by bacteria and fungi, together with a mention of protein breakdown or the production of ammonium ions. Many only wrote that the plant and animal material would decay. There was a clear correlation between those doing well in part **(i)** and those giving acceptable accounts in part **(ii)**.

**(b) (i)** Uses of nitrate were well known, usually linked to amino acids or proteins, but nucleotides or ATP was also commonly given for nitrates as well as phosphates. The use of phosphate was less well known, often incorrectly stated as being a component of amino acids. Listing the cell membrane as a use of phosphate was too imprecise, given that knowledge of phospholipids is a requirement of

the syllabus. Some knew that phosphates were an important part of bone structure and were given credit for this knowledge.

**(ii)** There were some thoughtfully-planned responses that explained clearly the statement given. The correlation between energy flow and feeding was noted, and the importance of both nitrates and phosphates in growth, and hence biomass for consumption by the next trophic level, was explained. Another relevant aspect, an increase in the importance of the decomposer food web, was also included by many candidates, and generally where partial credit was given, it was for this point. The best responses gave a range of examples of uses of nitrates and phosphates. Weaker responses assumed high growth rates and high rates of energy flow correlated with early death of organisms and rapid transfer of nitrogen and phosphate.

**Question 4**

Fig. 4.1 presented candidates with a familiar graph of an enzyme-controlled reaction for substrate concentration, using results from an experiment involving the enzyme catechol oxidase (phenol oxidase). Although this enzyme is mentioned in the published CIE Scheme of Work, it is not required knowledge for the syllabus, so the equation for the reaction catalysed by catechol oxidase was provided. In addition to assessing knowledge and understanding of syllabus ***Section D***, candidates were given the opportunity to use their skills of data extraction and interpretation.

**(a)** Of the candidates who gave an acceptable response, the majority suggested timing the appearance of a brown colour, with other credit-worthy examples being seen far less frequently. Some had not digested the information that quinone, the product of the reaction, was further oxidised to a brown-coloured substance and instead focused on the reaction. Vague suggestions that the rate at which quinone appeared were not credited. Some also suggested that the volume of oxygen used should be measured; presumably these had not noticed that the source of oxygen was exposure to air.

**(b)** The explanations required were standard for an enzyme graph. Fig. 4.1 showed the results of enzyme activity with an increase in substrate concentration. This meant that stronger candidates were easily able to produce high quality responses covering all the points. The problem for many others was the inability to distinguish between 'explain' and 'describe'. Good responses gave details of the mode of action of enzymes to explain how the shape of the curve in Fig. 4.1 was produced, whereas others gave a description of the shape of the curve and gained little or no credit. A number of candidates used the term 'active side' rather than 'active site'.

**(c) (i)** Most understood that an inhibitor would lower the initial rate of reaction, but far fewer realised that an increasing substrate concentration would begin to reverse the effects of inhibition and that the curve would reach or be approaching $V_{max}$. Although most sketched a curve onto Fig. 4.1, there were some candidates that left this blank. This highlights the importance of checking back and ensuring that all questions are answered.

**(ii)** This was well answered, with many explaining clearly how the competitive inhibitor would affect enzyme action. A few had not noticed that they had been told that PHBA was a competitive inhibitor and gave an 'either….or' response to cover both types of inhibition.

**(d)** A small proportion of candidates answered this with sufficient detail to gain full credit. Many realised that citric acid would alter the pH for enzyme action but only a few went on to explain that enzymes work in a limited pH range or explain the effect of an increase in hydrogen ions on the enzyme tertiary structure. This is a good example of how some candidates were able to apply very well their knowledge and understanding of factors affecting enzyme action, while others appeared not to have made any link to learning outcomes in the syllabus.

**Question 5**

Many showed a good grasp of mitosis from syllabus ***Section E*** and a number of candidates were able to give some thoughtful suggestions in part **(d)** as to the consequences of MPF not breaking down during anaphase.

**(a)** This was well answered, with many giving more than sufficient detail to gain full credit. The best responses made it clear that that mitosis was important for growth by increase in cell numbers and for repair of tissue by replacement of cells. Less convincing answers gave statements such as 'for

growth and repair of cells' or 'for cell growth and repair'. In these instances, some credit was given for 'growth' or 'repair' as stand-alone statements, while rejecting the idea of cell repair and cell growth. Where tissue repair or cell replacement was not mentioned, credit was given for statements referring to regeneration.

**(b)** Candidates should know that all globular proteins possess a primary, secondary and tertiary structure so should tick at least the first three boxes, then, realising that MPF was composed of two polypeptide chains, the final box for quaternary structure should also be ticked. Stronger candidates ticked all four boxes. Others focused on the information that MPF had two polypeptide chains and ticked the quaternary box only. Weaker candidates ticked only the secondary box, presumably in an attempt to explain two polypeptide chains.

**(c)** There were some clear descriptions that contained all factually correct information. This contrasted with sentences that had correct biology mixed with vague or incorrect statements. Stronger responses also used appropriate scientific terminology, for example describing the movement of centrioles to opposite poles, rather than the ends, of the cell. Also, the distinction between chromosomes and chromatids was made clear, although for many candidates the terms were used interchangeably as if they were the same entity. Descriptions of the nuclear envelope disappearing during prophase were accepted, but stronger candidates were clear to explain that the nucleolus or nucleoli, owing to condensation of chromatin into visible chromosomes, disappeared whereas the nuclear envelope disassembled (as the nuclear membranes fragmented into vesicles). Many candidates described the replication of the centrioles during prophase, which is not the case. However, they were not penalised if they then went on to describe the movement of the centrioles to opposite poles.

**(d)** Prior to part **(c)**, candidates were told that the presence of MPF is known to cause prophase to start. They needed this information to make valid suggestions in part **(d)**. A few candidates gained full credit while others suggested that tumours or cancers would appear but did not explain the reasons for this. Quite a number of candidates seemed to read '…stop functioning during anaphase' without noticing that the sentence began with 'MPF normally begins to break down ….', so thought that the MPF not breaking down would mean that the cell would stop at anaphase and would not be able to continue to divide. Some candidates did not appear to understand the difference between normal cells that were able to divide continuously by mitosis, such as epithelial cells, and cells that undergo uncontrolled division to form tumours.

**Question 6**

This was a short question touching upon syllabus ***Sections H*** and ***I*** of the syllabus. Although most gained full or partial credit for part **(a)**, the information required for **(b)** was far less well known. Approximately half the candidates gave a sensible, full suggestion for the rise in measles cases in **(c)**.

**(a)** This was well done, with most understanding that 'lifestyle' entailed an element of choice or habit, and hence, for many, lung cancer could be considered an avoidable disease. Weaker responses suggested that 'lifestyle' meant that the person with lung cancer would have a big change in their lifestyle compared to healthier days, or that it meant that the person would have lung cancer for life.

**(b)** Measles as a disease was well understood by a few candidates, who could easily state that the pathogen was a virus and that the (main) mode of transmission was droplet or aerosol infection. Good descriptions of droplet transmission were acceptable but responses that were more vague, such as 'airborne' or 'in the air' were not. The name of the pathogen was not required; however where Morbilli virus was provided as an answer, this was accepted. Many candidates thought that measles was a bacterial disease and some thought that they were being asked for the name of a causative organism and either made one up that sounded like 'measles' or gave other names they knew, such as *Vibrio.*

**(c)** There were a range of different, equally acceptable suggestions in response to this question. Where credit was not given, it was generally for a more vague statement that did not convey full understanding that the disease was considered eradicated before the outbreak, or for an explanation of how measles spread without indicating the initial cause of the problem. A number of candidates were not clear about the distinction between antibiotics and antibodies or were careless in their use of terminology. Some wrote about vaccines resulting in the production of antibodies and then stated that some people would be resistant, others referred to antibiotics in vaccines and a few thought that taking antibiotics would stimulate an immune response.

# BIOLOGY

**Paper 9700/31**

**Advanced Practical Skills 1**

## Key Messages

Candidates should be encouraged to learn the methods for the tests for biological molecules as specified in the syllabus. For the non–reducing sugar test, after the sample has shown a negative result for reducing sugar, a fresh sample should be boiled with an acid, usually hydrochloric acid, to hydrolyse any non-reducing sugar into reducing sugar, e.g. sucrose into glucose and fructose. The sample should then be cooled and neutralised with an alkali such as sodium hydrogen carbonate powder. Then the reducing sugar test should be repeated, where 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 maintained at 80 °C or up to 100 °C.
For the protein test, the syllabus specifies Biuret reagent or potassium hydroxide and copper sulfate solution. This test does not require heating.

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills required for the examination. They should also be given opportunities to reflect on this work in order to modify a particular procedure for studying a different variable by keeping the previous independent variable constant and then changing the required independent variable in the question. In this Question Paper this should have been by suggesting at least five concentrations obtained by serial or simple dilution.

Candidates should be given the opportunity to draw graphs from a variety of different data so that the selected scales use most of the grid and take into consideration the value of half a square (1 mm), this being the most accurate value from which a reading or plot can be made. When deciding how to draw the line, the data must be considered. In this Question Paper, a curve was not appropriate as the *x*-axis was 'time of day' and the transpiration rate may have been very different between the times recorded, due to varying weather conditions. Without more data the plotted points could only be joined with ruled lines exactly to the intersection of a cross or centre of a dot within a circle.

## 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.

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who

requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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 who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

## Comments on Specific Questions

### Question 1

**(a) (i)** Many candidates correctly showed that glucose was tested before sucrose and also showed a good knowledge of the methods of testing for glucose as a reducing sugar and then for sucrose as a non-reducing sugar. Many candidates also showed a good knowledge of the method for testing for proteins. Better candidates used the information provided, so that once a molecule in a solution was identified, this solution did not need to be tested again.

**(ii)** Many candidates identified **S2** (containing sucrose) as the solution most likely to be an extract from the phloem.

**(b)** The better candidates correctly realised that, in order to find the concentration of reducing sugars in the two plant extracts, a range of at least five known concentrations of reducing sugar should be made. These should be tested with Benedict's solution, along with the two unknown solutions and then the colours are compared to obtain the unknown concentrations. Some candidates incorrectly tested only the two unknown solutions and compared them to see which was most concentrated. However, this would not enable them to find the actual concentration.

### Question 2

**(a) (i)** The better candidates used the information provided to measure the four layers along the drawn line and used the eyepiece graticule scale to obtain measurements, which added up to the total length of 30 eyepiece graticule divisions as shown in Table 2.1.

**(ii)** Those candidates who were familiar with using an eyepiece graticule to help draw proportions when observing microscope slides performed well. These candidates observed the vascular bundle carefully and completed the outline using a sharp pencil, then drew in the lines to show the shape of the four layers, using the number of eyepiece graticule divisions to draw the correct proportions.

**(iii)** Better candidates showed clearly on Fig. 2.2 which squares were counted, i.e. whole 1 cm by 1 cm squares and those that were more than half a square. The figures collected were clearly displayed for the whole vascular bundle and the xylem. These figures were then compared by showing the ratio as the larger whole number to the smaller whole number, to the lowest common denominator.

**(b) (i)** The majority of candidates drew the graph correctly, using the headings given in the table, with time of day/hours on the *x*-axis and rate of transpiration/g $cm^{-2}$ $hr^{-1}$ on the *y*-axis.

The better candidates used scales of 2 cm to times of day 5.00 hours apart and 2 cm to 0.5 for rate of transpiration, 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.

As a general rule, lines should not be extrapolated. The most common errors were not including a full axis label or/and units for each axis, not using time of day (05:00, 10:00, etc.) on the *x*-axis, omitting to label the origin when it had a value other than zero, using an unsuitable scale on the *x*-axis which meant that the points at 12:30 and 18:30 could not be plotted, 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)** Most candidates who had used the correct scale of 2 cm to 05:00 time of day were able to use the reading from the graph at 14:30 and obtain a correct reading with the correct units of g $cm^{-2}$ $hr^{-1}$.

**(c)** Those candidates who had experience of drawing cells as part of their course 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 the space provided without drawing over the text of the question. The majority of candidates gained credit for carefully following the instructions, selecting three complete touching cells from each region and drawing these cells with double lines for the cell walls so that where the cells touched there were three lines. Better candidates used the eyepiece graticules to help them draw well-proportioned drawings which showed the difference in size observed between each group of cells.

Candidates should be encouraged to draw what they observe on the particular slide provided.

**(d)** The better candidates recorded only observable differences using the most appropriate organisation, which included a headed column for features and one headed column for **J1** and one headed column for Fig. 2.3. The majority of candidates were able to gain full credit for recording appropriate differences. The most common errors were to incorrectly identify the tissues or to include similarities.

# 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 required for the examination. They should also be given opportunities to reflect on this work in order to be able to identify where parts of a procedure could be improved to increase the confidence in the results. The selection of improvements should involve consideration of whether an error caused any variation in the trend of the results. Candidates should carefully consider the variables and procedure of the investigation so that any suggested improvement should reduce the effect of the error and be relevant to their investigation so improving the confidence in their results, for example by repeating the experiment more than once, by using a gas syringe to measure the volume of the oxygen produced, or by controlling the temperature of the reaction using a thermostatically-controlled water-bath.

Candidates should be familiar with how to use the microscope provided in the examination and how to draw plan diagrams with no cells. When asked to draw cells candidates should follow instructions carefully to draw the required number of the correct cells, using a suitable pencil to obtain clear sharp lines. They should label only the structure or structures specified.

Candidates should be given the opportunity to draw graphs from a variety of different data so that the selected scales use most of the grid and take into consideration the value of half a square (1 mm) which is the most accurate value from which a reading or plot can be made. When deciding how to draw the line, the candidate should consider the information provided about the collection of the data. In this case the plotted points could be joined with ruled lines exactly to the intersection of a cross or centre of a dot within a circle or joined as a smooth curve of best fit going through most of the plotted points and to within half a square of the remaining points.

## 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.

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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 who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

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 showed a water level in **W** between the level of **Y** in the small beaker and the top of the small beaker.

**(ii)** The better candidates correctly stated that the position of the tubing could be standardized by making a mark either on the delivery tube or the small test tube so that the end of the delivery tube could be kept 1 cm below the water surface.

**(iii)** Those candidates who are familiar with carrying out investigations presented their results most clearly and gained most credit.

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 (either time/s or temperature/°C) and the dependent variable (number of bubbles). The majority of candidates gained credit for recording eight results for each temperature as whole numbers, and recording the correct pattern of results with more bubbles produced during the first interval compared to the last 30s interval in both cases. Many candidates also recorded a higher temperature of 40-45 °C as instructed.

The most common errors were to include units (°C or s) in the cells under the headings, or to omit 'number of' in the 'bubbles' heading.

**(iv)** Many candidates identified a reason for finding it difficult to count the number of bubbles accurately. The better candidates were also able to specify variation in bubble size, or temperature of the reaction mixture, as another significant source of error. The most common mistakes were to state the error as 'counting bubbles' without giving a reason for this causing variation in the results and to identify temperature change of the water-bath, rather than the reaction mixture in **A**.

**(v)** Many candidates were able to identify one important improvement which would increase the confidence in the results. Only the better candidates could identify more than one improvement. The most common errors were to indicate the importance of repeating the experiment without specifying that this should be more than once, to indicate the importance of controlling temperature using a water-bath without specifying that this should be thermostatically controlled, and to indicate that another person should be used without specifying what job they should perform.

**(b) (i)** The majority of candidates were able to identify the two anomalous results in the table as the 6% value in trial 3 and the 12% value in trial 4.

**(ii)** Better candidates were able to calculate the missing mean value correctly, by omitting the anomalous result and quoting the answer to a whole number: 13.

**(iii)** The majority of candidates drew the graph correctly, using the headings given in the table, with percentage concentration of hydrogen peroxide on the *x*-axis and the time taken to collect 20 $cm^3$ of oxygen/s on the *y*-axis.

Better candidates used scales of 2 cm to 5% for concentration of hydrogen peroxide and 2 cm to 10s for the time taken, plotted the points exactly with a small cross or a dot in a circle and drew a sharp, clear, ruled line which accurately connected each pair of points.

The most common errors were not including a full axis label or/and units for the y-axis, using a scale of 2 cm for 4% on the *x*-axis, plotting points which were too large, and drawing lines which did not pass exactly through the points. As a general rule, lines should not be extrapolated.

**(iv)** The better candidates were able explain the faster rate of reaction at higher concentrations as resulting from the formation of more enzyme-substrate complexes. Only the best candidates explained the slower increase in rate at higher concentrations as being due to all the active sites being occupied. The most common error was to describe the change in rate as shown by the graph, rather than to explain it scientifically.

**Question 2**

**(a) (i)** Most candidates used a label line to show the position of the pith correctly and some had used the eyepiece graticules to help them draw well-proportioned drawings. The better candidates produced drawings made using a sharp pencil to produce clear, sharp lines which joined up neatly, did not include any shading and used the space provided without drawing over the text of the question. They included at least seven lines to delineate different areas in the specimen, drew the large corner vascular bundle divided into at least three regions, and labelled the central pith correctly.

The most common errors were lines drawn that did not meet up precisely or were too thick, insufficient detail in the corner vascular bundle, and incorrect identification of the pith.

**(ii)** Those candidates who had experience of drawing cells as part of their course 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 the space provided. The majority of candidates gained credit for carefully following the instructions, selecting three complete, touching cells from each region and correctly identifying the cell wall. Better candidates used the eyepiece graticules to help them draw well-proportioned drawings which showed the difference in size observed between each group of cells and drew each of these cells with double lines for the cell walls, so that where the cells touched there were three lines.

The most common errors were drawn lines which were too thick, insufficient difference in size between the two sets of cells, and cell walls drawn as single lines. Candidates should be encouraged to draw what they observe on the particular slide provided.

**(iii)** Those candidates who had experience of measuring using an eyepiece graticule were able to show at least three measurements of each type of cell in whole numbers and including eyepiece graticule units with their measurements.

The better candidates showed the addition of these measurements, division to produce a mean, and a final ratio as whole numbers with the larger number first.

**(iv)** The majority of candidates correctly suggested that the thick cell walls supported the conclusion that the cells in the corner carried out the function of support.

**(b)** The majority of candidates were able to gain partial credit for recording appropriate differences. Better candidates recorded observations using the most appropriate organisation, which included one column for features and two additional columns, one for **M1** and the other for Fig. 2.2. The most common errors were to not specify the tissue in which differences were being described and to incorrectly identify tissues.

# BIOLOGY

**Paper 9700/33**

**Advanced Practical Skills 2**

## Key Messages

Candidates should be encouraged to learn the methods for the tests for biological molecules as specified in the syllabus. For the non–reducing sugar test, after the sample has shown a negative result for reducing sugar, a fresh sample should be boiled with an acid, usually hydrochloric acid, to hydrolyse any non-reducing sugar into reducing sugar, e.g. sucrose into glucose and fructose. The sample should then be cooled and neutralised with an alkali such as sodium hydrogen carbonate powder. Then the reducing sugar test should be repeated, where 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 maintained at 80 °C or up to 100 °C.

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills required for 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 and then changing the required independent variable in the question. In this Question Paper this should be by suggesting at least five temperatures maintained using a thermostatically-controlled water-bath.

Candidates should be given the opportunity to draw graphs from a variety of different data so that the selected scales use most of the grid and take into consideration the value of half a square (1 mm), this being the most accurate value from which a reading or plot can be made. When deciding how to draw the line, the data must be considered. In this Question Paper, a curve was not appropriate as the *x*-axis was 'time of day' and, for example, there was no data collected for the flow rate between 9.00 and 17.00, so the maximum flow rate may have been between these times or 17.00 and 22.00. Without more data the plotted points could only be joined with ruled lines exactly to the intersection of a cross or centre of a dot within a circle.

## 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.

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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 who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

## Comments on Specific Questions

### Question 1

**(a)** Many candidates correctly showed that glucose was tested before sucrose and also showed a good knowledge of the methods of testing for glucose as a reducing sugar and then for sucrose as a non-reducing sugar. Better candidates used the information provided, so that once a molecule in a solution was identified, this solution did not need to be tested again.

**(b) (i)** Many candidates correctly decided that glucose could not be hydrolysed.

**(ii)** Better candidates tested only **S1** and **S2** with the enzyme and understood that to test the products for hydrolysis of either sucrose or starch required testing for reducing sugar (glucose). The majority of candidates organised their results clearly by presenting a fully ruled table and appropriately detailed headings for the independent variable (solution) and the dependent variable (observation of colour change). Most candidates recorded a colour change of green or yellow or orange or red for **S2**.

Those candidates who are familiar with carrying out investigations presented their results most clearly and gained most credit. The most common errors were to give no heading for the solution, to include method details in the cells of the table or to record 'positive' or 'no change' rather than a colour for the result.

**(iii)** Using these results the better candidates stated that **S2** was the solution hydrolysed and explained that the reason that, as **S2** was starch, after 5 minutes it had been hydrolysed to glucose so the reducing sugar test gave a positive colour change.

**(c)** The better candidates correctly modified this procedure to investigate the effect of temperature on mixtures of $2\,cm^3$ of the enzyme and $2\,cm^3$ of **S2**, using at least five temperatures maintained by thermostatically-controlled water-baths or by mixing hot and cold water and using a thermometer to check that the temperature was maintained. Some candidates incorrectly altered the temperature of the water-bath for the Benedict's test or used all three solutions.

### Question 2

**(a) (i)** The better candidates used the information provided to measure the four layers along the drawn line and used the eyepiece graticule scale to obtain measurements which added up to the total length of 20 eyepiece graticule divisions as shown in Table 2.1.

**(ii)** Those candidates who were familiar with using an eyepiece graticule to help draw proportions when observing microscope slides performed well. These candidates observed the vascular bundle carefully and completed the outline using a sharp pencil, then drew in the lines to show the shape of the four layers, using the number of eyepiece graticule divisions to draw the correct proportions.

**(iii)** Better candidates showed clearly on Fig. 2.2 which squares were counted, i.e. whole 1 cm by 1 cm squares and those that were more than half a square. The figures collected were clearly displayed for the whole vascular bundle and the xylem. These figures were then compared by showing the ratio as the larger whole number to the smaller whole number, to the lowest common denominator.

**(b)** Candidates who were familiar with how to use the microscope provided in the examination and who followed the instructions carefully drew a plan diagram with no cells.

The better candidates produced drawings 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 without drawing

over the text of the question. Many were able to draw the epidermis as two lines which were joined where there was a stoma, three small vascular bundles and one large vascular bundle. Within each vascular bundle the better candidates had used the higher power of the microscope to identify and draw the different tissues. Some candidates had used the eyepiece graticules to help them draw well-proportioned drawings.

The most common errors were to draw lines that did not meet up precisely or were too thick, not showing all the different tissues and their correct distribution, which would be observable using the microscope. Another common error was to draw the stomata as open ended lines instead of showing the tissues either side of each stoma as closed off.

**(c)** The better candidates recorded observations using the most appropriate organisation, which included one column for features and at least one additional column for **K1**. The majority of candidates were able to gain full credit for recording appropriate differences. The most common errors were to include similarities or to incorrectly identify the tissues.

**(d) (i)** The majority of candidates drew the graph correctly, using the headings given in the table, with time of day/hours on the *x*-axis and flow rate in xylem tissue/mg $min^{-1}$ on the *y*-axis.

The better candidates used scales of 2 cm to times of day 5.00 hours apart and 2 cm to 0.100 for flow rate, 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.

As a general rule, lines should not be extrapolated. The most common errors were not including a full label or/and units for each axis, not using time of day (05:00, 10:00, etc.) on the *x*-axis, omitting to label the origin when it had a value other than zero, not labelling the scale every 2 cm, plotting points which were too large or too small (point not visible when line drawn through it), and drawing lines which were too thick or not ruled exactly to the centre of the point.

**(d) (ii)** Most candidates who had used the correct scales were able to read the flow rate from the graph at 10.00 and 0.455 mg $min^{-1}$ to describe that the trend increased between 10.00 and 17.00.

# 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 required for the examination. They should also be given opportunities to reflect on this work in order to be able to identify where parts of a procedure could be improved to increase the confidence in the results. The selection of improvements should involve consideration of whether an error caused any variation in the trend of the results. Candidates should carefully consider the variables and procedure of the investigation so that any suggested improvement should reduce the effect of the error and be relevant to their investigation so improving the confidence in their results, for example by use of a colorimeter which removes the variability of the subjective colour assessment.

When carrying out practical work candidates should be encouraged to gain experience in deciding which variables have been standardized and how to standardise other variables to provide accurate results. If key variables are changed during an investigation the results may not produce a trend.

Candidates should be given the opportunity to draw graphs from a variety of different data so that the selected scales use most of the grid and take into consideration the value of half a square (1 mm) which is the most accurate value from which a reading or plot can be made. When deciding how to draw the line, the data must be considered. In this case, a curve was not appropriate, as there were many uncontrolled variables so the intermediate values are not certain. Without more data the plotted points could only be joined with ruled lines exactly to the intersection of a cross or centre of a dot within a circle.

## 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.

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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 who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

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)** Some candidates correctly stated that the variables that needed to be standardised were the volume of water and the number of drops of indicator solution (**P**).

**(ii)** Many candidates correctly described how to standardise the colour by adding the same number of drops of alkali solution (**A**) to each of the five test-tubes.

**(iii)** Many candidates correctly stated that the position of the tubing could be standardised by making a mark either on the tubing or on the test-tube so that the end of the tubing was at the same position below the surface of the indicator for each test-tube.

**(iv)** Most candidates stated that the smallest unit of time on their timer or clock was a second.

**(v)** Better candidates completed Table 1.1 and Table 1.2 with the raw data by recording the time when the tubing was put into the indicator and the time when the end-point was reached for all ten readings. These candidates also recorded the time correctly from the stop clock or stopwatch as minutes and seconds, as shown on the display, and recorded all readings to the same precision. Those who followed the procedure correctly recorded a later time for the start of the next reading compared to the end-point of the previous reading. Transferring the tubing into the next test-tube takes a short time and this delay results in the start time of the next reading being later than the end-point of the previous reading.

**(vi)** Most candidates completed Table 1.3 and correctly showed the calculation to find the time taken to reach the end-point in the first test-tube. The most common error was to omit the units (seconds) in the calculation.

**(vii)** Those candidates who are familiar with carrying out investigations presented their results most clearly and gained most credit. 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 (reading) and the dependent variable (time/s). The most common errors were to omit the heading for the independent variable or to include 'seconds' in the cells of this column or row.

The majority of candidates gained credit for recording ten processed times as whole numbers. The better candidates recorded times showing the same trend when comparing times from the first five readings with readings after 10 minutes.

**(b)** Most candidates gained credit for stating that the end-point was difficult to determine, the degree of shaking was not the same for each test-tube and the volume of alkali (**A**) was not the same for each test-tube.

**(c)** The better candidates correctly improved the investigation by describing how to prepare a stock solution by mixing water, indicator (**P**) and alkali (**A**) in a beaker and then using this solution for each set of five test-tubes. Some candidates correctly suggested that a colorimeter could be used and replicates could be carried out to obtain at least three sets of data.

**(d)** Many candidates correctly stated whether their results supported the hypothesis and further explained that the end-point time became shorter or longer when comparing the end-point times for the first five readings with the readings after 10 minutes.

**Question 2**

**(a)** Candidates who were familiar with how to use the microscope provided in the examination and who followed the instructions carefully drew a plan diagram with no cells. The better candidates produced drawings 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 without drawing over the text of the question. Many were able to draw the layers of different tissues within the leaf section and the position of the ring of cells around the vascular bundle. Within the vascular tissue several regions were observable which the better candidates had viewed by using the higher power of the microscope to identify the different tissues. 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 epidermis correctly.

The most common errors were drawn lines that did not meet up precisely or were too thick and not showing all the different tissues and their correct distribution, which would be observable using the microscope. Another common error was drawing the stomata as open ended lines instead of showing the tissues either side of each stoma as closed off.

**(b)** Those candidates who had experience of drawing cells as part of their course 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 without drawing over the text of the question. The majority of candidates gained credit for carefully following the instructions by selecting four complete touching cells that make up the ring of large cells around the vascular bundle and by drawing the thin cell walls.

The most common errors were to draw lines that did not join up or draw the cell walls as single lines instead of double lines so that where the cells touched there would be three lines. Candidates should be encouraged to draw what they observe on the particular slide provided.

**(c)** The better candidates showed the measurement of the diameter of the vascular bundle, including the ring of cells, and the measurement of the width of the xylem tissue as whole numbers and included eyepiece graticule units with their measurements.

Most candidates presented the ratio of the diameter of the vascular bundle to the width of the xylem correctly as a larger whole number to the smaller whole number. This might have required showing multiplying both figures by the same number to return to whole numbers, e.g. 1.6 :1 (x 5) becomes the ratio 8 : 5.

**(d)** The majority of candidates were able to gain partial credit for recording appropriate differences. Better candidates recorded observations using the most appropriate organisation, which included one column for features and two additional columns, one for **N1** and the other for Fig. 2.1. The most common errors were to include similarities or to incorrectly identify the tissues.

**(e)** The majority of candidates drew the graph, using the headings given in the table, with time of day/hours on the *x*-axis and water potential in the leaf cells/MPa on the *y*-axis. Better candidates used scales of 2 cm to 5.00 hours for time of day and 2 cm to -1.0 MPa for water potential in the leaf cells, plotted the points exactly with a small cross or a dot in a circle and drew a sharp, clear, ruled line, accurately connecting each pair of points.

As a general rule, lines should not be extrapolated. The most common errors were not including a full axis label or/and units for each axis, not using units of time (05:00, 10:00, etc.) on the *x*-axis, omitting to label the origin when it had a value other than zero, not labelling the scale every 2 cm, plotting points which were just too large or too small (point not visible when line drawn through it), and drawing lines which were too thick or not ruled.

**(ii)** Many candidates correctly described that between 12:00 hours and 22:00 hours the rate of transpiration decreased and water potential increased. The better candidates were able to suggest how transpiration explained the difference in the water potential in the leaf cells between 12:00 hours and 22:00 hours.

# BIOLOGY

**Paper 9700/35**

**Advanced Practical Skills 1**

## Key Messages

Candidates should be given the opportunity to experience a variety of practical work throughout the course, in order to develop the skills required for the examination. They should also be given opportunities to reflect on this work in order to be able to identify where parts of a procedure could be improved to increase the confidence in the results. The selection of improvements should involve consideration of whether an error caused any variation in the trend of the results. Candidates should carefully consider the variables and procedure of the investigation so that any suggested improvement should reduce the effect of the error and be relevant to their investigation so improving the confidence in their results, for example by use of a colorimeter which removes the variability of the subjective colour assessment.

When carrying out practical work candidates should be encouraged to gain experience in deciding which variables have been standardized and how to standardise other variables to provide accurate results. If key variables are changed during an investigation the results may not produce a trend.

Candidates should be given the opportunity to draw graphs from a variety of different data so that the selected scales use most of the grid and take into consideration the value of half a square (1 mm) which is the most accurate value from which a reading or plot can be made. When instructed to plot a chart, candidates should look carefully at the nature of the data to decide if the categories of data are discrete or continuous. If the categories of data are discrete, for example types of plant tissue, then a bar chart should be used to display the data and a gap is left between the bars on the *x*-axis since the *x*-axis represents different categories and has no scale. If data represents continuous categories, for example the height of candidates in a class, then a histogram is appropriate, where there are no gaps between the columns representing the different categories.

## 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.

Centres are reminded that they should contact CIE if any problems are encountered when supplying the materials or apparatus. To ensure that candidates do not have difficulty in meeting the skills criteria, there should be no changes to either the materials or the apparatus provided to them without prior consultation with CIE. Any necessary checks on the materials prior to the examination will be included in the Confidential Instructions.

It is important that each candidate receives fresh supplies of materials and clean apparatus where applicable. Extra supplies of solutions and materials should be made available to any candidate who requests them. It is important that these solutions and materials are labelled only as specified in the Confidential Instructions.

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 who had read the whole of each question before attempting it were more able to plan their time carefully and answer the specific questions accurately.

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

## Comments on Specific Questions

### Question 1

**(a) (i)** The majority of candidates were able to correctly complete Table 1.1 with the volumes of glucose solution and distilled water required to make up four different concentrations of glucose solution.

**(ii)** Most candidates stated that the smallest unit of time on their timer or clock was one second.

**(iii)** Many candidates were able to correctly state that one variable to standardise would be the volume of sulfuric acid or the volume of any of the other solutions provided.

**(iv)** Some candidates gained credit for stating that the variable volume of solutions could be standardised by using a syringe. Most candidates completed Fig. 1.4 with their raw data recording the time when they started observing tubes **U1** and **U2** and recording the time when the end-point was reached for both tubes. The better candidates recorded the time correctly from the stop clock or stopwatch as minutes and seconds as shown on the display. Those candidates who followed the procedure correctly recorded an earlier start time for **U1** than **U2**. The better candidates recorded all the readings to the same precision.

**(v)** Most candidates completed Table 1.2 and showed correctly the calculation to find the time taken to reach the end-point for the 6% glucose. The most common error was to omit the units (seconds) in the calculation.

**(vi)** Those candidates who are familiar with carrying out investigations presented their results most clearly and gained most credit. 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 glucose) and the dependent variable (time/s). Most candidates gained credit for recording six processed times as whole numbers. Many candidates correctly recorded a shorter time for the for the known glucose solution with the highest concentration.

The most common errors were to omit the heading for the independent variable or to include “seconds” in the cells of the ‘time’ column or row.

**(b)** Most candidates who had recorded results in **Question 1(a)(vi)** were able to use these results to correctly identify solution **U2** as the ‘glucose tolerance test’ solution.

**(c) (i)** Many candidates were able to identify determining the end-point as a significant source of error in their investigation.

**(c) (ii)** The better candidates gained credit by suggesting the use of a colorimeter, repeating the investigation more than once or using a wider range of concentrations. Common improvements such as standardizing pH using a buffer or controlling temperature through use of a thermostatically controlled water bath may not be applicable suggestions for the investigation they have completed.

**Question 2**

**(a) (i)** The better candidates used the information provided to measure the four layers of tissue along the drawn line and used the eyepiece graticule scale to obtain measurements which added up to a total length of 43 eyepiece graticule divisions as shown in Table 2.1.

**(ii)** Those candidates who were familiar with using an eyepiece graticule to help draw proportions when observing microscope slides performed well. These candidates observed the vascular bundle carefully and used a sharp pencil to complete the outline, then drew in the lines to show the shape of the four layers, using the number of eyepiece graticule divisions to draw the correct proportions.

**(iii)** Better candidates showed clearly on Fig. 2.2 which squares were counted, i.e. whole 1 cm by 1 cm squares and those that were more than half a square. The figures collected were clearly displayed for the whole vascular bundle and the xylem. These figures were then compared by showing the ratio as the larger whole number to the smaller whole number to the lowest common denominator. This might have required showing multiplying both figures by the same number to return to whole numbers, e.g. 1.5 :1 (x 2) becomes the ratio 3 : 2.

**(b)** Those candidates who had experience of drawing cells as part of their course 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 without drawing over the text of the question. The majority of candidates gained credit for carefully following the instructions by selecting three complete touching cells from each region and drawing the thin cell walls with double lines, so that where the cells touched there were three lines. Candidates should be encouraged to draw what they observe on the particular slide provided.

Some candidates had used the eyepiece graticules to help them draw well-proportioned drawings which showed the difference in size observed between each group of cells. Most candidates correctly used a label line to label a cell wall. The most common errors were to draw lines that did not join up or to draw the cell walls as single lines.

**(c)** The majority of candidates were able to gain partial credit for recording appropriate differences. Better candidates recorded observations using the most appropriate organisation, which included one column for features and two additional columns, one for **L1** and the other for Fig. 2.3. The most common error was to incorrectly identify the tissues.

**(d) (i)** The majority of candidates drew a bar chart using the headings given in Table 2.2, with type of plant tissue on the *x*-axis and concentration of glucose/arbitrary units on the *y*-axis.

Better candidates used scales of 2 cm to 2.0 arbitrary units for glucose concentration and drew separated blocks of even width for plant tissue type with blocks plotted in the order of the table. As a general rule when drawing blocks, horizontal lines should not extend beyond vertical lines.

The most common errors were drawing a line graph rather than a bar chart, not including a full axis label or/and units for each axis, not labelling the scale every 2 cm, drawing lines which were too thick or not ruled and solidly shading blocks.

**(d) (ii)** Some candidates used the readings from the chart to describe how the concentration of glucose is different for each type of plant tissue. The better candidates were able to suggest how active transport allows glucose to be absorbed against a concentration gradient.

# BIOLOGY

**Paper 9700/41**
**A2 Structured Questions**

## Key messages

- Candidates should be clear what the command word means in a question. For example a description will not be credited if the question asks for the name of a process.
- It is essential that candidates read the stem of the question carefully to enable them to use their own biological knowledge, in conjunction with the information provided, in an unfamiliar situation.

## General comments

Generally, candidates showed evidence of factual learning, although application of this knowledge was often poor. This particularly applied to questions where candidates needed to use both their own knowledge and new information supplied by the question, as in **Question 2**. Candidates need to carefully read, assimilate and use the information provided in order to work out sensible answers to the questions posed. Often there was too much reliance on standard learned ideas. In some cases candidates seemed unprepared for parts of the syllabus and unconfident in applying their knowledge where synoptic links were required. Both free response questions were popular as choices and were generally high scoring.

## Comments on specific questions

### Question 1

**(a)** Most candidates were able to identify at least two of the labelled parts. It was necessary to identify **A** as the palisade cells, not just mesophyll cells alone and for **B** to be recognised as the guard cell. Candidates should know that the stoma refers to the gap between the guard cells, not the cells themselves around the pore.

**(b) (i)** How carbon dioxide enters the leaf was described by the majority of candidates. A number of them gave too much detail, such as how carbon dioxide enters cells or a description of the mechanism controlling stomatal opening.

**(ii)** Many candidates correctly identified ribulose bisphosphate as the compound combining with carbon dioxide. RuBP alone did not qualify as this is not the actual name.

**(iii)** The role of reduced NADP as a reducing agent was described by many candidates. A few mentioned it carrying hydrogen but did not describe this being donated to GP. The best responses clearly described reduced NADP as reducing GP to TP.

### Question 2

**(a)** The emphasis in this question was on transmission of disease but very few candidates clearly explained that male mosquitoes do not bite humans so cannot transmit disease. An alternative was to state that *only* females bite, feed on blood or transmit disease.

**(b)** Most candidates gained partial credit here by explaining why fluorescent markers are often used in preference to antibiotic resistance genes. This question was comparative, so candidates needed to say not just that fluorescence was easy to identify, but that it was easier than the alternative method described. Candidates raising the issue of the safety of using antibiotic resistance genes as markers needed to clearly outline the risks of transmission of these genes from mosquitos to *bacteria*. Answers such as 'antibiotic resistance can be passed on to other organisms' was not credited.

**(c) (i)** Candidates gained credit for either a clear definition of positive feedback in general terms or by making reference to the figure, explaining that production of some tTA stimulated the production of more tTA.

**(ii)** Most candidates identified that the promoter initiates transcription or switches on a gene. Some correctly stated that it initiates gene expression. Few candidates could offer any further detail about the binding of RNA polymerase or a relevant comment about the positioning of gene and promoter in eukaryotes.

**(iii)** This question proved challenging as very few candidates realised that the GM larvae would not die immediately, giving a longer time for tTA build up or that there would be competition for food and space with non-GM larvae.

**(d) (i)** The commonest correct suggestion for how **A** prevents mosquito death was that it binds to the DNA binding site therefore preventing tTA from binding. Few candidates took their reasoning any further, for instance, to say that a small quantity of tTA does not kill, although a small number of references to it stopping positive feedback were seen. Many candidates suggested that **A** would bind to something acceptable but did not explain how this would affect the tTA.

**(ii)** Correct answers included cloning or breeding the GM males, though few suggested feeding the breeding stock with chemical **A**. Incorrect answers often outlined genetic engineering processes.

**(iii)** Good candidates recognised that GM males would die without **A** and that the offspring of GM males would also die. Fewer mentioned that they only mate with their own species, and errors using the term species were apparent, for example, saying that 'male species mate with female species', or using the word 'organisms' instead of 'species', such as 'males cannot breed with other organisms'.

**Question 3**

**(a)** Many candidates said that nutrients were added continuously but some did not mention the continuous removal of products, so were not credited. Some realised that in continuous culture the microorganisms are kept in a phase of exponential growth. The idea of maintaining a constant volume within the fermenter was unfamiliar to most candidates.

**(b)** Candidates had to think creatively to apply their knowledge to this question, and the commonest correct idea expressed was that mutants might be toxic. Decrease in yield was also mentioned frequently. Some candidates correctly visualised that pipes might become blocked and a few commented on changed texture or taste in the mycoprotein product. High RNA content as a risk in mycoprotein production was rarely mentioned.

**(c)** A number of candidates, after calculating the mass of protein harvested as 864, omitted the kg units and so did not gain credit. A minority worked out the mass harvested in 1 hour or 12 hours rather than in 24 hours.

**Question 4**

**(a) (i)** The question specified that events occurring inside the mitochondrion should be used in order to explain the faster rate of oxygen consumption. Most candidates referred to ATP being made in the electron transfer chain or by oxidative phosphorylation but many included unnecessary detail about processes such as glycolysis, with only a brief mention of the electron transfer chain. Often no further detail was provided. This could include how energy released from electron transfer is used to pump hydrogen ions creating a gradient, so that ATP could be synthesised as protons returned down the gradient through ATP synthase. It should be emphasised that the enzyme involved is not ATPase. The link between the numbers of electrons passing along the chain and oxygen consumption was rarely mentioned.

**(ii)** Many candidates knew that molecules would have more kinetic energy when the temperature increased, so there would be more collisions, and better responses included reference to faster reactions, such as during respiration.

**(b) (i)** A few candidates referred correctly to using the mass of the lizard in order to calculate the oxygen debt. Very few had any clear idea how the debt was calculated, with many confused accounts of when oxygen consumption should be measured in relation to exercise. Few explained that the oxygen consumed was the oxygen inhaled minus the oxygen exhaled or knew that the oxygen consumption should be measured at rest and after exercise stops. The difference between the oxygen consumption at rest and after exercise needed to be calculated as the debt.

**(ii)** Many good responses were seen comparing the debts and quoting comparative figures. Only a few candidates realised that the difference in oxygen debt between the two lizards becomes greater at higher temperatures.

**(iii)** Linking the oxygen debts in the table to the mode of life of *Varanus* proved difficult for most candidates. A few noted that it would enable them to run for longer and use less anaerobic respiration but it was rare for this to be linked to their increased chance of catching their prey.

**(iv)** Many candidates were able to suggest that a larger surface area would be created and this would enable more oxygen uptake into the blood. Few noted that this would supply the muscles with more oxygen.

**Question 5**

**(a)** Only a few candidates knew that the oocytes had undergone meiosis 1, so were suitable because they were haploid.

**(b) (i)** This was usually a very well answered question with movement of water by osmosis being described correctly, often with correct references to water potential.

**(ii) (ii)** Most candidates correctly chose **B** as the better solution and made a clear comparison with **A**, such as that it had allowed more survival of thawed eggs or more successful fertilisations. Few were awarded the supporting figures mark however, because just one figure for **A** and **B** for survival after thawing or number of successful fertilisations was given. This was insufficient, as a meaningful ratio was needed taking into account the different starting numbers of oocytes in each case.

**(iii)** Advantages of freezing and thawing oocytes as part of IVF were not well known. Many candidates did refer to deferring fertilisation but weaker candidates just mentioned deferring 'it' till later without explaining what process was being deferred. Some candidates were aware that this could be used when medical treatment might damage the ovaries, so oocytes could be stored for later fertilisation or that this would remove the need for repeated rounds of oocyte retrieval.

**Question 6**

**(a) (i)** Most candidates correctly identified calcium ions as entering the pre-synaptic neurone at **A** and sodium ions the post-synaptic neurone at **B**. Candidates needed to state ions or to give correct chemical symbols with correct charges.

**(ii)** Most candidates stated exocytosis. A description did not gain credit since the instruction was to name the process.

**(iii)** Most candidates correctly stated depolarisation or action potential as the effect of **B**.

**(iv)** There were many incorrect lines of reasoning and cases where candidates misread acetylcholinesterase as acetylcholine. Well-prepared candidates achieved all three marks for the splitting of acetylcholine, stopping continuous depolarisation and recycling choline into the presynaptic neurone. The products of the hydrolysis of ACh, acetate and choline, were less well-known. Many candidates named acetyl or acetyl coenzyme A in error.

**(b)** This required candidates to suggest and explain what happens at the synapse in the presence of phenothiazine. While a few candidates thought that phenothiazine would bind to pre-synaptic transporter proteins, most correctly suggested that it would bind to the dopamine receptors. Only a few pursued this reasoning to say it would prevent depolarisation and reduce the effects of dopamine. A common error was to think that dopamine concentration would be reduced.

**(c)** To suggest why the 13 base-pair deletion would have the most serious effect candidates needed to have a clear appreciation of the relationship between genes and protein structure, together with the ability to use technical vocabulary like 'tertiary', 'frameshift' and 'silent mutation'. Errors confusing base and amino acid sequences were fairly common, along with vague answers referring to a shape change without qualifying this as 3D or tertiary. Most candidates gained partial credit and some gained full credit.

**(d)** Many candidates realised that this was a natural selection scenario but few used the term itself or language like 'selective advantage'. The commonest mark awarded was for the allele being passed on to the next generation. There were few correct suggestions that people with the allele would survive or reproduce *more than* people lacking the allele.

**Question 7**

**(a)** Many candidates referred to the sex-linked gene being present on one of the sex chromosomes but usually did not clearly indicate that the gene would not be on the other sex chromosome. While some candidates knew that a gene was a section of DNA coding for a polypeptide, many vague responses were seen here where candidates did not know the straightforward definition.

**(b)** If candidates had carefully noted the information in the stem of the question, they appreciated that coat colour in cats is sex-linked. As a result, they were able to correctly indicate the X and Y chromosomes and use the appropriate alleles for coat colour to gain full marks. A number of candidates omitted X and Y so were unable to gain credit for the alleles alone. The commonest error, where the cross was completed correctly, was to list the offspring phenotype colours but without reference to male or female. A few candidates added letters for alleles on the Y chromosome showing a misunderstanding of the basis of sex linkage.

**(c)** Most candidates were able to explain that males cannot be tortoiseshell since male cats only have one X chromosome or one copy of the gene present.

**Question 8**

**(a)** Many candidates did not know how to calculate the percentage rise in the small squirrel population. Those who did divided the difference, in the figures between the two dates, by the original figure (before logging) resulting in a rise of 550%.

**(b)** Few references to limiting factors, such as the availability of food, water or nesting sites, were seen. Some candidates gained credit for correctly stating that population members would compete for food, but did not link this to the carrying capacity being the upper limit that these factors place on population size. Candidates also referred to predation or spread of disease but did not always appreciate that the effect of these would only be significant when the population was large.

**(c)** A number of candidates realised that the small number of marbled cats and small-clawed otters before logging might make the population unsustainable and would be a factor in them dying out completely. It was not appreciated that these two species were carnivores, so would have less prey or that they would have a slower reproductive rate. A few references to them migrating elsewhere were given credit.

**Question 9**

**(a)** Where candidates were well prepared for this, they were able to explain the need for maintaining biodiversity and so gained credit. Aesthetic or ethical reasons were given, along with the need for resources from the tropical rainforest and the economic benefits of encouraging tourism. A few references were seen to potential future uses, such as for the development of new medicines but the role of the rainforest in maintaining food webs or recycling nutrients was less commonly described. Weaker candidates wrote at length about one or two roles only, instead of realising that the value of the rainforest biodiversity is in its ability to carry out a wide range of essential roles.

**(b)** Many candidates had incorrectly assumed that the question was based on the general advantages and disadvantages of keeping animals in captivity, whereas the question concentrated on the captive breeding programmes for mammals. As a result many responses included the general idea of trying to preventing extinction and only briefly referred to breeding, so did not gain full credit. Candidates correctly reading the question described monitoring of the mother and fetus, along with

the storage of gametes, artificial insemination, IVF or the use of surrogate mothers. A few references were seen to the idea of international cooperation or that genetic records are kept. Many candidates were able to describe the disadvantages as being the unnatural environment causing stress and behavioural changes, along with disruption of reproductive cycles and the rejection of mates. Most responses also referred to there being problems with releasing the animals back into the wild, but this did not always gain marks as the problems experienced by the returned animals were not often explained.

**Question 10**

Candidates who chose this question were generally well-prepared, with some candidates gaining full credit. Some candidates, however, knew only general xerophytic rather than biochemical adaptations of C4 plants and many did not know the details of chemiosmosis in the context of photophosphorylation.

**(a)** This section required candidates to explain how the physiology of C4 plant leaves adapted them for carbon fixation at high temperatures. Many candidates demonstrated that they understood the organisation of the tissues in a C4 plant and the reasons for this. They were usually able to identify where rubisco and RuBP were stored and their role in the plant. These candidates gave very good explanations of the roles of PEP, PEP carboxylase and malate, linking these with the transfer of $CO_2$ from the mesophyll into the bundle sheath cells, preventing photorespiration and enabling the Calvin cycle to continue. Good candidates noted the difference in optimum temperature between the C4 enzymes and those in C3 plants. All candidates were able to access this question to gain either full or partial credit.

**(b)** Most candidates could describe light absorption by photosynthetic pigments, the excitation of electrons and their emission from chlorophyll, together with the passage of electrons down a chain of electron carrier molecules. However most candidates then linked the energy released from the electron transport chain directly to the production of ATP. A description of the energy released being used for the pumping of protons into the thylakoid space was essential here. Those candidates who knew about the setting up of the proton gradient and chemiosmosis gained the most credit in this part of the question, describing the role of ATP synthase and ultimately leading to ATP production.

# BIOLOGY

**Paper 9700/42**
**A2 Structured Questions**

## Key messages

- Candidates should be clear what the command word means in a question. For example a description will not be credited if the question asks candidates to explain a process.
- It is essential that candidates read the stem of the question carefully to enable them to use their own biological knowledge, in conjunction with the information provided, in an unfamiliar situation.

## General comments

Generally, candidates appeared to find this paper quite difficult, particularly **Questions 4** and **5**, although candidates found **Questions 1**, **6** and **7** reasonably straightforward. The best discriminators were **Questions 2** and **4**.

Many candidates did not always realise that the amount of credit available and the number of lines allocated is indicative of the length and detail of the response that should be given. This was very apparent in **Question 2(a)(ii)** and **Question 5**.

## Comments on specific questions

### Question 1

**(a) (i)** Most candidates correctly answered this, giving the correct changes in volume for temperature at high and low light intensities. Appropriate units for volume and temperature were also given in most cases.

**(ii)** The denaturation of enzymes beyond 30°C was appreciated by many and it was the most commonly given answer. Many referred incorrectly to factors other than temperature being the limiting factor, or referred to enzyme and substrate 'no longer' being able to bind, thus not realising that oxygen production never went as low as zero at any temperature recorded during the experiment. Some candidates incorrectly identified the light independent part of photosynthesis as being affected rather than photolysis.

**(b) (i)** Photolysis was given by the majority of candidates.

**(ii)** Photosystem II was the most frequent correct answer to this, with P680 also accepted. The most common error was to give Photosystem I as the answer.

**(iii)** The idea that oxygen was used for respiration was understood by all but the weakest candidates. Experimental error in some form seemed to be the alternative reason given for the volume of oxygen released not giving a true rate of photosynthesis. Some referred incorrectly to oxygen being lost to the environment rather than to respiration.

### Question 2

**(a) (i)** There was a mixed range of responses and most candidates had the idea of transference of resistance genes to other bacteria and its effect on the use of antibiotics. The fact that DsRed was easier to identify, safer and more economical was also correctly given by many candidates.

**(ii)** Almost all candidates were aware that a promoter was necessary to initiate transcription and a many had the idea that a coral promoter was needed to switch on a coral gene. The binding of RNA polymerase appeared only rarely.

**(b) (ii)** The majority of candidates had a clear idea of the principles involved, with sufficient relevant detail given to gain credit. The loading into wells at the negative end, use of buffer and the impedance of the gel, were given less frequently. Although candidates realised that the DNA fragments moved towards the anode, the reason for them carrying a negative charge in terms of a phosphate group was not given in many cases. In a noticeable number of weaker responses, a large part of the answer was taken up by irrelevant detail of procedures carried out after the electrophoresis had been completed which were not asked for and gained no credit.

**(ii)** The idea of comparison with a standard or fluorescence in UV was largely understood, but often not expressed fully to enable credit to be awarded, e.g. a comparison of the band/fragments made without reference to DNA, or fluorescence without mentioning UV light.

**(c)** Many candidates found this question challenging. Answers were often vague, referring to the effects of wild moths compared to sterile moths. Some referred to the need to keep count of the two varieties or estimating the degree of success of the method. A few candidates referred to data collection and to checking the success of the experiment.

**(d)** Answers to this question tended to be too vague and was missing the precise information about the factors that might be looked for, in terms of naming the effects of DsRed. Many answers revolved around the 'effect' on predators or on other insects or on the food chain, without giving exactly what the effect was that they might be looking for.

**Question 3**

**(a)** Many candidates correctly mentioned that nutrients and products were added and removed continuously. That the organism should be kept at the exponential phase of growth was given by the better candidates, but few included keeping internal conditions constant.

**(b) (i)** Some candidates misunderstood the question and simply wrote down the figures from the table. A good answer would have compared the growth at different temperatures for each of the carbon concentrations in turn and backed them up with figures, including units.

**(ii)** Most candidates were aware of the potential uses of carbon and nitrogen sources to gain partial credit. The production of amino acids/proteins and carbohydrates were commonly given.

**Question 4**

**(a) (i)** Most candidates correctly named cristae or inner membrane as the part of the mitochondrion in which the ETC is found. The most common error was 'intermembrane' or 'intermembrane space' or, more rarely, 'matrix'.

**(ii)** Many candidates demonstrated a good knowledge of respiration and were able to identify the origin of the electrons, usually referring to hydrogen, reduced NAD, and one of the correct stages of respiration. A few also linked these processes of respiration with their location in the mitochondria. However, some wrote at some length about the earlier stages of respiration and the role of the co-enzymes NAD and FAD but never quite answered the original question.

**(iii)** A large number of candidates were clear that oxygen is the final electron acceptor in the ETC and that it combines with $H^+$ to form water. However, many tried to combine both these ideas into one statement, thereby losing clarity in their answers. A significant number wrote an ionic equation to show their understanding of the formation of water. Only a few candidates mentioned that this allowed the ETC electrons to keep flowing, and that oxidation of the NAD or FAD allowed it to be reduced again. Answers that lacked precision lost credit due to vague statements like 'keeping respiration going', or 'oxygen-accepting electrons in the ETC' (rather than specifically at the end of it).

**(b) (i)** This question proved challenging to many candidates and showed a clear lack of understanding. Many wrote about their understanding of the stages involved in the passage of an action potential rather than answering the specific question about the role of the $Na^+/K^+$ pump.

The most common correct point was the knowledge that the pump maintained the resting potential. A number of candidates recognised that $Na^+$ ions would diffuse into the membrane. Few mentioned $K^+$ correctly. There was a rare reference to non voltage-gated channels, with most candidates referring to voltage-gated channels. There was considerable confusion about potential, potential difference, voltage and charge. Very few were able to state clearly that resting potential involves a difference in charge or potential across the membrane or that the potential difference values they had correctly learnt were relative to the outside. Similar confusion reigned with depolarisation, many being unclear as to whether this applied to the membrane or the neurone/cell itself.

**(ii)** Although this question required candidates only to show that they were correctly able to identify the sequence of events given to them in the question and to apply their biological understanding, there were many unclear answers given.

Good candidates understood that the voltage-gated channels opened allowing calcium ions to diffuse in. Weaker candidates did not understand the process and just quoted from the stem of the question, so did not state that the calcium ions diffused in or moved down the electrochemical/concentration gradient. Some simply described the role of $Ca^{2+}$ ions in releasing acetylcholine at a synapse.

The majority of candidates knew that the $Ca^{2+}$ channels opened but many did not gain credit as they did not state that they were voltage-gated channels.

**(c) (i)** Many candidates were able correctly to link the information about turtles with the flow chart given in the previous part of the question and to correctly point out that no calcium ions could enter the neurone if the ion channels were closed, then usually linked this with the enzymes not being activated to destroy the cell. Better candidates also grasped the idea of sodium and potassium ions not moving across the membrane, so there is no depolarisation. Only a few correctly explained that ions would not move through the membrane but many did not state which ions.

**(ii)** This question was poorly understood by the majority of candidates. A few better candidates realised that transcription would stop and even fewer linked this with less ATP. Only a tiny minority mentioned that the gene required would be switched off or expressed less.

**Question 5**

**(a)** Most candidates made a correct reference to hormones being administered to the woman and most gave a suitable example of a hormone. For weaker candidates it was often unclear whether the hormones were given to the woman or produced naturally by the body. A minority were unclear about the site of any injections, suggesting the pituitary gland or ovaries. The most common errors were to refer to drugs being given, not hormones, or to name oestrogen as the hormone.

**(b)** There seemed to be very little understanding of the development of the sperm and the maturation process. Many candidates incorrectly referred to sperm acquiring the ability to move during the hour rather than gaining the energy to swim more vigorously. Capacitation and the acrosome reaction were mentioned rarely, and then not usually sufficiently detailed.

**(c) (i)** In general this was very poorly answered with most candidates concentrating on the idea that babies would be born healthy but not being precise enough to gain much credit. Good candidates were able to identify a clear advantage, most commonly that only one embryo would need to be transferred or that there might be less chance of miscarriage or of the problems associated with multiple births. Surprisingly few worked out that fewer IVF cycles would be needed. However, a significant number wrote about genetic abnormalities at some length which was not relevant to the context of the question.

**(ii)** This was not answered at all well with the idea of embryos being destroyed the only point regularly awarded credit. It was rare to see a link between the need to wait before transplanting the embryo to the uterus and the difficulty in keeping the embryos in ideal conditions during this time. Weaker candidates sometimes suggested that this could lead to mutation.

**Question 6**

**(a) (i)** Most candidates were able to locate and use the correct figures to produce the answer 17.9 for the percentage of plasma that passes into the renal capsules. Some did not use the correct number of decimal places, which lost credit. A significant minority did not use the appropriate figures from the question and so produced wildly inaccurate percentages.

**(ii)** This was poorly answered with very few gaining full credit. Candidates tended to write about the differing widths of the arterioles causing high pressure, which did not gain any credit, since the question was about the structures of the capillaries and podocytes. They then often did not mention either endothelium or the basement membrane.

Some candidates recognised that there were gaps in the capillary wall but did not mention the endothelium. A few knew that the basement membrane acted as a filter. Many candidates stated that proteins did not filter through but did not include reference to being more than 68 000 MM. Many knew that cells did not get through.

With regard to the podocytes, most did not say that the podocytes have projections with gaps between them, often implying that the podocytes themselves were the projections. Descriptions of the filtration slits were often confused and some thought they were part of the cells rather than between them.

**(b) (i)** Most candidates were able to identify correctly the microvilli from the micrograph. Some lost credit, however, by referring to villi, cilia or brush border. A minority wrote about the structures being some form of cell (e.g. basal cell) even though the nuclei of the cells of which the structures form a part are clearly visible.

**(ii)** Most candidates stated that the mitochondria made ATP which was used in the active transport of $Na^+$ ions, though there was confusion for some about the fate of the sodium ions once they had left the proximal convoluted tubule epithelial cell.

**(iii)** Naming two substances that are reabsorbed into the blood from the proximal convoluted tubule proved straightforward for most candidates. Some did not realise that not all urea is reabsorbed here and others referred to ions, minerals or mineral salts without being more specific, so lost credit. A few candidates named two different ions rather than providing a second distinct response, thereby gaining only partial credit.

**Question 7**

**(a)** The completion of the genetic diagram to show how two resistant rats can produce warfarin-susceptible offspring proved to be difficult for many candidates. The symbols used for the alleles were often unclear or identified simply as dominant or recessive, rather than resistant or susceptible. Some candidates also believed the allele for warfarin susceptibility to be dominant and that for resistance to be recessive. Many candidates linked the alleles to sex chromosomes although they were still able to gain credit for correctly predicting the offspring phenotypes. Nevertheless, good candidates were able to gain full credit.

**(b)** Most candidates were able to suggest why rats that are homozygous for warfarin resistance have a low survival rate in the wild, predominantly by stating that the large amount of dietary vitamin K required to prevent internal bleeding would not be available in the wild.

**(c)** The type of inhibition that warfarin has on vitamin K epoxide reductase was correctly identified as competitive, or reversible, by the majority of candidates. Very few suggested it might be non-competitive or permanent. However, few of these gave a suitable reason, so were unable to gain any credit. Many gave a general description of competitive inhibition rather than making their response specific to the question. Most did not link an increase in the dose of warfarin to a decrease in the rate of blood clotting.

**(d)** Many candidates quickly accrued maximum credit for a good explanation as to how a single base substitution may affect the phenotype of an organism. There were frequent references to a change in the codon or triplet code leading to the incorporation of a different amino acid into the polypeptide chain. Many then stated that this could result in a change in primary, secondary or tertiary structure which would then alter protein function. However, some gave descriptions of the

degenerate code and silent mutations or gave vague descriptions of the change in protein structure. Nevertheless, many understood that a stop codon might be produced, the consequence of which would be a shortened polypeptide chain.

**Question 8**

**(a)** There were many comprehensive descriptions as to how new species of pupfish might have evolved as a result of the reduction of the extensive lake system to just a few pools. Many candidates understood that allopatric speciation would take place as a result of the different populations becoming isolated in different pools by a geographical barrier which would then prevent any interbreeding between these populations. Most also pointed out that each pool would be subject to different selection pressures due to the different environmental conditions and the effect that this would have on allele frequency. There were often references to mutations giving rise to advantageous alleles which would confer a selective advantage on the fish and would therefore be passed on to offspring. However, comments on genetic drift or a change in the chromosome number were comparatively rare.

**(b)** Few candidates were able to state how environmental factors could act as stabilising forces of natural selection in the isolated pools, although some recognised that the better adapted fish would survive while the extreme phonotypes would be selected against.

**(c)** This question was often poorly answered, with candidates not giving creditworthy suggestions as to the consequences of an increase in water levels re-establishing an extensive lake system. Few recognised that, initially, the populations all species might increase as a result of an increase in resources, such as food or breeding spaces. Although many commented that competition between the pupfish might arise, it was often unclear that this competition would be between the different species. Better candidates understood that interspecies competition could lead to a reduction in the population of some or all of the species, possibly resulting in one or more becoming extinct. While some appreciated that all species would be subjected to new selection pressures, they frequently went on to state that this would either give rise to further speciation, or that all four species would merge to become a single species again due to interbreeding. Hardly any references to different species occupying different niches within the ecosystem were seen.

**Question 9**

**(a)** The main features of a bacterial cell were well documented by a good proportion of candidates. Many drew a well-labelled diagram and good candidates recognised that there would be no membrane-bound organelles, often giving suitable examples, such as rough endoplasmic reticulum or mitochondria, and that the ribosomes would be 70S, or smaller than those found in eukaryotic cells. There were many references to the peptidoglycan cell wall as well as other bacterial structures, such as flagella, pili or capsules. Although many candidates understood that bacterial DNA would not be enclosed by a nuclear membrane, nor would it be associated with histone proteins, a common error was to state that the circular DNA was in the form of a plasmid. The dimensions of a bacterial cell were rarely stated, although when given, were usually correct.

**(b)** Some excellent accounts of the use of bacteria in the extraction of metal from ores were seen. Many appreciated that the metal ores were in the form of insoluble sulphides which would make the extraction difficult, often going on to state that these sulphides could be oxidised into soluble sulphates allowing bioleaching to take place. A number of candidates also gave examples of the metals which could be extracted using this method, with references to iron being most frequent, although some mentioned copper and uranium. Relatively few candidates named a suitable bacterial species, although *Acidothiobacillus ferrooxidans* was occasionally seen. The requisite bacterial properties for the extraction process, such as an ability to survive a wide range of temperatures and acidic conditions, were rarely touched upon. Nevertheless, many candidates stated a number of advantages of bacterial extraction over conventional mining methods. While weaker candidates were also able to identify the benefits of this process, they often did not supply any further detail.

**Question 10**

**(a)** The structure of a chloroplast was well described by more able candidates, many of whom achieved maximum credit with ease. The vast majority stated that the chloroplast is a double membrane bound organelle and offered suitable dimensions, although occasionally the units were

in nanometres rather than micrometres. Again, many drew diagrams to illustrate their answer. There was frequent mention of the internal membrane system, with thylakoids being named or described although the grana were sometimes inaccurately referred to as groups, or collections, of thylakoids rather than a stack. Occasionally, having stated that photosynthetic pigments or ATP synthetase would be found in the membranes of the grana, candidates then gave a description of the arrangement of pigments into photosystems and their function in the light-dependent reaction.

Most candidates named the stroma, or ground substance, often going on to state what would be found within, such as 70S ribosomes, circular DNA, enzymes and starch grains. However, weaker candidates confused the chloroplast with a plant cell, describing the presence of a cell wall and mitochondria.

**(b)** More able candidates offered good explanations as to how rice is adapted to growing in flood fields. Many began their response by stating that the submerged parts of the plant, in particular the roots, would undergo anaerobic respiration producing ethanol, although surprisingly few then went on to state that the roots could tolerate *high* concentrations of ethanol, simply stating that they were ethanol tolerant. While some mentioned the presence of ethanol dehydrogenase, again few appreciated that this enzyme would be in abundance. References to alcohol were not credited although candidates were not penalised for the error carried forward.

Many candidates commented that ethene (or ethylene) would be produced by the plant in order to stimulate the production of gibberellin which would, in turn, stimulate cell elongation or division, allowing the stem of the plant to grow above the surface of the water. Some understood that the leaves and flowers would then also be above water, although references to the significance, such as enabling photosynthesis or pollination, were relatively scarce. However, better candidates went on to state that leaves which remained submerged would be adapted to trap a layer of air over their surface. The presence of aerenchyma tissue in the stem was frequently mentioned, although weaker candidates were unable to explain its precise function in gaseous diffusion to submerged parts of the plant, often stating that it would be for the storage of air.

# BIOLOGY

**Paper 9700/43**
**A2 Structured Questions**

## Key messages

- Candidates should be clear what the command word means in a question. For example a description will not be credited if the question asks for the name of a process.
- It is essential that candidates read the stem of the question carefully to enable them to use their own biological knowledge, in conjunction with the information provided, in an unfamiliar situation.

## General comments

Generally, candidates showed evidence of factual learning, although application of this knowledge was often poor. This particularly applied to questions where candidates needed to use both their own knowledge and new information supplied by the question, as in **Question 2**. Candidates need to carefully read, assimilate and use the information provided in order to work out sensible answers to the questions posed. Often there was too much reliance on standard learned ideas. In some cases candidates seemed unprepared for parts of the syllabus and unconfident in applying their knowledge where synoptic links were required. Both free response questions were popular as choices and were generally high scoring.

## Comments on specific questions

### Question 1

**(a)** Most candidates were able to identify at least two of the labelled parts. It was necessary to identify **A** as the palisade cells, not just mesophyll cells alone and for **B** to be recognised as the guard cell. Candidates should know that the stoma refers to the gap between the guard cells, not the cells themselves around the pore.

**(b) (i)** How carbon dioxide enters the leaf was described by the majority of candidates. A number of them gave too much detail, such as how carbon dioxide enters cells or a description of the mechanism controlling stomatal opening.

**(ii)** Many candidates correctly identified ribulose bisphosphate as the compound combining with carbon dioxide. RuBP alone did not qualify as this is not the actual name.

**(iii)** The role of reduced NADP as a reducing agent was described by many candidates. A few mentioned it carrying hydrogen but did not describe this being donated to GP. The best responses clearly described reduced NADP as reducing GP to TP.

### Question 2

**(a)** The emphasis in this question was on transmission of disease but very few candidates clearly explained that male mosquitoes do not bite humans so cannot transmit disease. An alternative was to state that *only* females bite, feed on blood or transmit disease.

**(b)** Most candidates gained partial credit here by explaining why fluorescent markers are often used in preference to antibiotic resistance genes. This question was comparative, so candidates needed to say not just that fluorescence was easy to identify, but that it was easier than the alternative method described. Candidates raising the issue of the safety of using antibiotic resistance genes as markers needed to clearly outline the risks of transmission of these genes from mosquitos to *bacteria*. Answers such as 'antibiotic resistance can be passed on to other organisms' was not credited.

**(c) (i)** Candidates gained credit for either a clear definition of positive feedback in general terms or by making reference to the figure, explaining that production of some tTA stimulated the production of more tTA.

**(ii)** Most candidates identified that the promoter initiates transcription or switches on a gene. Some correctly stated that it initiates gene expression. Few candidates could offer any further detail about the binding of RNA polymerase or a relevant comment about the positioning of gene and promoter in eukaryotes.

**(iii)** This question proved challenging as very few candidates realised that the GM larvae would not die immediately, giving a longer time for tTA build up or that there would be competition for food and space with non-GM larvae.

**(d) (i)** The commonest correct suggestion for how **A** prevents mosquito death was that it binds to the DNA binding site therefore preventing tTA from binding. Few candidates took their reasoning any further, for instance, to say that a small quantity of tTA does not kill, although a small number of references to it stopping positive feedback were seen. Many candidates suggested that **A** would bind to something acceptable but did not explain how this would affect the tTA.

**(ii)** Correct answers included cloning or breeding the GM males, though few suggested feeding the breeding stock with chemical **A**. Incorrect answers often outlined genetic engineering processes.

**(iii)** Good candidates recognised that GM males would die without **A** and that the offspring of GM males would also die. Fewer mentioned that they only mate with their own species, and errors using the term species were apparent, for example, saying that 'male species mate with female species', or using the word 'organisms' instead of 'species', such as 'males cannot breed with other organisms'.

**Question 3**

**(a)** Many candidates said that nutrients were added continuously but some did not mention the continuous removal of products, so were not credited. Some realised that in continuous culture the microorganisms are kept in a phase of exponential growth. The idea of maintaining a constant volume within the fermenter was unfamiliar to most candidates.

**(b)** Candidates had to think creatively to apply their knowledge to this question, and the commonest correct idea expressed was that mutants might be toxic. Decrease in yield was also mentioned frequently. Some candidates correctly visualised that pipes might become blocked and a few commented on changed texture or taste in the mycoprotein product. High RNA content as a risk in mycoprotein production was rarely mentioned.

**(c)** A number of candidates, after calculating the mass of protein harvested as 864, omitted the kg units and so did not gain credit. A minority worked out the mass harvested in 1 hour or 12 hours rather than in 24 hours.

**Question 4**

**(a) (i)** The question specified that events occurring inside the mitochondrion should be used in order to explain the faster rate of oxygen consumption. Most candidates referred to ATP being made in the electron transfer chain or by oxidative phosphorylation but many included unnecessary detail about processes such as glycolysis, with only a brief mention of the electron transfer chain. Often no further detail was provided. This could include how energy released from electron transfer is used to pump hydrogen ions creating a gradient, so that ATP could be synthesised as protons returned down the gradient through ATP synthase. It should be emphasised that the enzyme involved is not ATPase. The link between the numbers of electrons passing along the chain and oxygen consumption was rarely mentioned.

**(ii)** Many candidates knew that molecules would have more kinetic energy when the temperature increased, so there would be more collisions, and better responses included reference to faster reactions, such as during respiration.

**(b) (i)** A few candidates referred correctly to using the mass of the lizard in order to calculate the oxygen debt. Very few had any clear idea how the debt was calculated, with many confused accounts of when oxygen consumption should be measured in relation to exercise. Few explained that the oxygen consumed was the oxygen inhaled minus the oxygen exhaled or knew that the oxygen consumption should be measured at rest and after exercise stops. The difference between the oxygen consumption at rest and after exercise needed to be calculated as the debt.

**(ii)** Many good responses were seen comparing the debts and quoting comparative figures. Only a few candidates realised that the difference in oxygen debt between the two lizards becomes greater at higher temperatures.

**(iii)** Linking the oxygen debts in the table to the mode of life of *Varanus* proved difficult for most candidates. A few noted that it would enable them to run for longer and use less anaerobic respiration but it was rare for this to be linked to their increased chance of catching their prey.

**(iv)** Many candidates were able to suggest that a larger surface area would be created and this would enable more oxygen uptake into the blood. Few noted that this would supply the muscles with more oxygen.

**Question 5**

**(a)** Only a few candidates knew that the oocytes had undergone meiosis 1, so were suitable because they were haploid.

**(b) (i)** This was usually a very well answered question with movement of water by osmosis being described correctly, often with correct references to water potential.

**(ii) (ii)** Most candidates correctly chose **B** as the better solution and made a clear comparison with **A**, such as that it had allowed more survival of thawed eggs or more successful fertilisations. Few were awarded the supporting figures mark however, because just one figure for **A** and **B** for survival after thawing or number of successful fertilisations was given. This was insufficient, as a meaningful ratio was needed taking into account the different starting numbers of oocytes in each case.

**(iii)** Advantages of freezing and thawing oocytes as part of IVF were not well known. Many candidates did refer to deferring fertilisation but weaker candidates just mentioned deferring 'it' till later without explaining what process was being deferred. Some candidates were aware that this could be used when medical treatment might damage the ovaries, so oocytes could be stored for later fertilisation or that this would remove the need for repeated rounds of oocyte retrieval.

**Question 6**

**(a) (i)** Most candidates correctly identified calcium ions as entering the pre-synaptic neurone at **A** and sodium ions the post-synaptic neurone at **B**. Candidates needed to state ions or to give correct chemical symbols with correct charges.

**(ii)** Most candidates stated exocytosis. A description did not gain credit since the instruction was to name the process.

**(iii)** Most candidates correctly stated depolarisation or action potential as the effect of **B**.

**(iv)** There were many incorrect lines of reasoning and cases where candidates misread acetylcholinesterase as acetylcholine. Well-prepared candidates achieved all three marks for the splitting of acetylcholine, stopping continuous depolarisation and recycling choline into the presynaptic neurone. The products of the hydrolysis of ACh, acetate and choline, were less well-known. Many candidates named acetyl or acetyl coenzyme A in error.

**(b)** This required candidates to suggest and explain what happens at the synapse in the presence of phenothiazine. While a few candidates thought that phenothiazine would bind to pre-synaptic transporter proteins, most correctly suggested that it would bind to the dopamine receptors. Only a few pursued this reasoning to say it would prevent depolarisation and reduce the effects of dopamine. A common error was to think that dopamine concentration would be reduced.

**(c)** To suggest why the 13 base-pair deletion would have the most serious effect candidates needed to have a clear appreciation of the relationship between genes and protein structure, together with the ability to use technical vocabulary like 'tertiary', 'frameshift' and 'silent mutation'. Errors confusing base and amino acid sequences were fairly common, along with vague answers referring to a shape change without qualifying this as 3D or tertiary. Most candidates gained partial credit and some gained full credit.

**(d)** Many candidates realised that this was a natural selection scenario but few used the term itself or language like 'selective advantage'. The commonest mark awarded was for the allele being passed on to the next generation. There were few correct suggestions that people with the allele would survive or reproduce *more than* people lacking the allele.

**Question 7**

**(a)** Many candidates referred to the sex-linked gene being present on one of the sex chromosomes but usually did not clearly indicate that the gene would not be on the other sex chromosome. While some candidates knew that a gene was a section of DNA coding for a polypeptide, many vague responses were seen here where candidates did not know the straightforward definition.

**(b)** If candidates had carefully noted the information in the stem of the question, they appreciated that coat colour in cats is sex-linked. As a result, they were able to correctly indicate the X and Y chromosomes and use the appropriate alleles for coat colour to gain full marks. A number of candidates omitted X and Y so were unable to gain credit for the alleles alone. The commonest error, where the cross was completed correctly, was to list the offspring phenotype colours but without reference to male or female. A few candidates added letters for alleles on the Y chromosome showing a misunderstanding of the basis of sex linkage.

**(c)** Most candidates were able to explain that males cannot be tortoiseshell since male cats only have one X chromosome or one copy of the gene present.

**Question 8**

**(a)** Many candidates did not know how to calculate the percentage rise in the small squirrel population. Those who did divided the difference, in the figures between the two dates, by the original figure (before logging) resulting in a rise of 550%.

**(b)** Few references to limiting factors, such as the availability of food, water or nesting sites, were seen. Some candidates gained credit for correctly stating that population members would compete for food, but did not link this to the carrying capacity being the upper limit that these factors place on population size. Candidates also referred to predation or spread of disease but did not always appreciate that the effect of these would only be significant when the population was large.

**(c)** A number of candidates realised that the small number of marbled cats and small-clawed otters before logging might make the population unsustainable and would be a factor in them dying out completely. It was not appreciated that these two species were carnivores, so would have less prey or that they would have a slower reproductive rate. A few references to them migrating elsewhere were given credit.

**Question 9**

**(a)** Where candidates were well prepared for this, they were able to explain the need for maintaining biodiversity and so gained credit. Aesthetic or ethical reasons were given, along with the need for resources from the tropical rainforest and the economic benefits of encouraging tourism. A few references were seen to potential future uses, such as for the development of new medicines but the role of the rainforest in maintaining food webs or recycling nutrients was less commonly described. Weaker candidates wrote at length about one or two roles only, instead of realising that the value of the rainforest biodiversity is in its ability to carry out a wide range of essential roles.

**(b)** Many candidates had incorrectly assumed that the question was based on the general advantages and disadvantages of keeping animals in captivity, whereas the question concentrated on the captive breeding programmes for mammals. As a result many responses included the general idea of trying to preventing extinction and only briefly referred to breeding, so did not gain full credit. Candidates correctly reading the question described monitoring of the mother and fetus, along with

the storage of gametes, artificial insemination, IVF or the use of surrogate mothers. A few references were seen to the idea of international cooperation or that genetic records are kept. Many candidates were able to describe the disadvantages as being the unnatural environment causing stress and behavioural changes, along with disruption of reproductive cycles and the rejection of mates. Most responses also referred to there being problems with releasing the animals back into the wild, but this did not always gain marks as the problems experienced by the returned animals were not often explained.

**Question 10**

Candidates who chose this question were generally well-prepared, with some candidates gaining full credit. Some candidates, however, knew only general xerophytic rather than biochemical adaptations of C4 plants and many did not know the details of chemiosmosis in the context of photophosphorylation.

**(a)** This section required candidates to explain how the physiology of C4 plant leaves adapted them for carbon fixation at high temperatures. Many candidates demonstrated that they understood the organisation of the tissues in a C4 plant and the reasons for this. They were usually able to identify where rubisco and RuBP were stored and their role in the plant. These candidates gave very good explanations of the roles of PEP, PEP carboxylase and malate, linking these with the transfer of $CO_2$ from the mesophyll into the bundle sheath cells, preventing photorespiration and enabling the Calvin cycle to continue. Good candidates noted the difference in optimum temperature between the C4 enzymes and those in C3 plants. All candidates were able to access this question to gain either full or partial credit.

**(b)** Most candidates could describe light absorption by photosynthetic pigments, the excitation of electrons and their emission from chlorophyll, together with the passage of electrons down a chain of electron carrier molecules. However most candidates then linked the energy released from the electron transport chain directly to the production of ATP. A description of the energy released being used for the pumping of protons into the thylakoid space was essential here. Those candidates who knew about the setting up of the proton gradient and chemiosmosis gained the most credit in this part of the question, describing the role of ATP synthase and ultimately leading to ATP production.

# BIOLOGY

**Paper 9700/51**

**Planning, Analysis and Evaluation**

## Key Messages

Candidates should be encouraged to make use of information provided in questions to inform their answers. Candidates need to identify key stages in an investigation and select the appropriate information to use. Direct copying from the question is not creditworthy, particularly when planning an experimental procedure.

Candidates should have a clear idea of the role of a control experiment and on precisely what a dependent variable is.

## General Comments

The writing and grammar were often good and there was no evidence that candidates were short of time. Although it is good practice for Centres to use past papers and mark schemes to prepare candidates, candidates should avoid repeating previous mark schemes in the context of a new question, without considering whether it is appropriate. New questions often test different knowledge and skills to that in past questions.

## Comments on Specific Questions

### Question 1

For this question, it was important that the candidates read the information provided carefully before starting to answer.

**(a) (i)** Most candidates were able to give the independent variable as the concentration of gibberellin. The dependent variable caused more problems, with 'activity of amylase' being a frequent answer. Candidates need to understand that the dependent variable is what is actually measured in an investigation. In this case the area around the grain that is clear or brown or starch free is what was actually measured. This can then be related to the activity of amylase which cannot be measured directly.

**(ii)** The key to producing a good answer here was to appreciate the instruction that the account should be precise enough for another person to follow and to base the account on the method used in the preliminary investigation. Some responses indicated that this method had not been fully understood.

A number of accounts unnecessarily restated the variable given in **(a)(i)** or described what the results might show.

Some candidates went into great detail on how to carry out a serial dilution and then gave a very brief outline of the main part of their method rather than an account that someone else could follow. Better answers stated that serial dilution (or some other suitable method) would be used to produce at least five different concentrations. The range should not be above 3 mmol $dm^{-3}$ and should ideally encompass something in the range given in the information as being found in plants. It should be clear that a control should be included which should be water. Once into the actual method good candidates gave clear and precise instructions using the information provided. Thus a stated soaking time in gibberellin and a stated incubation temperature and time were expected. Control variables given and credited included having the same number of grains, the same volume of soaking solution, the same concentration of starch and volume of agar. Many candidates realised that an incubator or water-bath would allow the plates to be kept at the stated temperature,

but there were still a few who mentioned an 'air conditioned room' which is not acceptable. Weaker responses just quoted the ranges in the information or prefaced their remarks with 'about'. Some candidates muddled the pre-soaking with water with the soaking in gibberellin or soaked them in gibberellin whilst on the agar plates. All of these errors suggest that practice at fully understanding information provided would be beneficial. When describing the actual measuring of the area of digested starch the responses were generally incomplete. Just 'measure the area' is not a full enough instruction for someone else to follow – a suitable method such as using a grid with squares of known size or measuring the diameter with calipers or a ruler and using a suitable formula to work out area, was needed. The safety and reliability aspects were often well covered. Weaker responses on safety either considered it a 'no risk' investigation or were too general regarding the particular risk and precaution. Weaker responses suggested only one replicate or did not link this to taking a mean or identifying anomalies.

**(b)** This was generally well done though a few got the axes the wrong way round or did not give units. Occasionally incorrect units were given, such as $mm^3$ for area or mol in place of mmol. Activity of amylase was allowed for the *y*-axis but the units would be au (arbitrary units) – a number of candidates put something suggesting a rate.

**(c) (i)** Candidates found the assessment of limitations a difficult concept. Many answers focused on things that might be wrong with the way that the method was carried out such as that the temperature was not constant or there were not enough repeats. A number showed a misunderstanding of the role of starch/iodine on the plates and discussed problems in terms of rate of colour change or rate of reaction. The diagram made it clear that the area stained brown was not regular but surprisingly few saw this as a limitation. Perhaps more practical experience with this technique would have alerted candidates to these limitations.

**(ii)** It was not always clear which of the limitations given in **(c)(i)** the candidate was referring to in this section. Many who suggested a difficulty related to the difficulty of deciding the colour boundary suggested improvements involving colorimetry which could not be applied to this method.

**Question 2**

**(a)** Most candidates were able to describe the trends in the two types of bacteria as soil depth increased. They were also able to explain the trend in terms of the decrease in oxygen with depth after six months. Not all were able to follow up this general explanation with detail in terms of the anaerobic bacteria replacing the aerobic ones as the oxygen ran out. Although not asked to comment directly on the data after one month, the large numbers of aerobic bacteria at depth after one month would suggest that the new soil heap had oxygen at depth at this time which had run out after six months. This would lead to the anaerobic bacteria replacing the aerobic ones. Some candidates spent time describing the data in great detail which lost sight of the trends.

**(b) (i)** Most candidates were able to see that the lowered activity of dehydrogenase supported the fact that sample **B** came from a greater depth.

**(ii)** Temperature and pH were the commonest correct responses. Some said time without qualifying it as the time the activity was determined over. Common errors were to suggest oxygen or the mass of soil which was given in the question as standardised.

**(iii)** Many seemed confused between controlled variables and setting up a control. What is required is an equivalent soil sample but with no active bacteria which could be most easily achieved by heating the soil to kill the bacteria. Some wanted the soil replaced by inert material such as glass beads. Others suggested a soil sample from the top or some other specified depth. These responses underline the need for a clear understanding of what a control is.

**(c) (i)** Good responses showed a clear understanding that the length of the error bar relates to the reliability of the data, with longer bars indicating less reliable data. Thus the data for years 2 and 6 are less reliable. Many got confused between reliability and significance and talked about overlaps here. Centres need to continue to stress the various aspects of statistics in relation to the context.

**(ii)** Candidates who understood the difference between reliability and significance were able to spot the two data sets likely to be significant due to the lack of overlap. Many candidates chose two data sets which showed a large time gap and suggested this as a reason, indicating a lack of confidence or understanding in this type of question.

**(d)** Relatively few understood the idea that if you plotted the given data on a graph you could then read off the dehydrogenase activity of the new sample on the graph to give a bacterial estimate. Some got part way there by comparing the new value to the table values and getting an idea of what the number might be. There were a lot of complex mathematical suggestions including taking averages and ratios which were not valid. The data is clearly not proportional. The idea of a calibration curve should not be a new one, although some candidates found it difficult to put it into a novel context. There were some candidates who suggested 'doing a stats test' on the data or ignored the given data altogether and suggested counting the bacteria under a microscope.

# BIOLOGY

**Paper 9700/52**

**Planning, Analysis and Evaluation**

## Key messages.

Candidates should be encouraged to make use of information provided in questions to inform their answers. For instance, basic information necessary to plan an investigation is usually provided. Candidates need to identify key stages in an investigation and select the appropriate information to use. Direct copying from the question is not creditworthy.

Candidates should be familiar with the purpose of a control and how data from a control should be used to process results.

## General comments

There was no evidence that candidates were short of time although the quality of the answers was variable. Candidates need to answer concisely, particularly in answers that require extended writing. Good answers showed that candidates were able to apply practical experience and their understanding of biological principles to answer the question asked. Less good responses often reflected uncertainty about practical techniques and limited application of knowledge. Mathematical skills followed a similar pattern, with better answers showing clear understanding of how to manipulate data and poorer answers often lacking basic knowledge.

## Comments on specific questions

***Section A***

**Question 1**

This question was about the effect of gibberellin on the germination and early growth of barley. Candidates were expected to use the information given about the germination of barley to devise a method of testing the effect of different concentrations of gibberellin from an external source on barley germination and early growth. The question tested skills of planning, data processing and statistical testing of results.

**(a)** Most candidates were able to sketch a suitable curve. A variety of curves were acceptable provided it showed an increase followed by a plateau or decrease at higher concentrations. Candidates were expected to label the *x*-axis with the independent variable and *y*-axis with the dependent variable. The dependent variable should be a measurable feature of either germination or early growth. The majority of candidates copied the wording of the hypothesis. On this occasion credit was allowed for this label. Bar charts were allowed, although they are not the most appropriate type of graph for the expected results. Poorer answers reversed the axes or did not label the axes.

**(b) (i)** Most candidates correctly identified the independent variable. Only the best answers gave a measurable feature for the dependent variable. The most common were 'length of the young root or shoot and the number of barley grain germinated. Rate of germination and early growth of young plants was not credited as neither of these can be measured directly.

**(ii)** There were a great number of different approaches to this question. Candidates must read all the information given before they start to answer and keep in mind the main stages of the investigation they are planning. This should help them to keep a focus on the whole plan and avoid writing too extensively on one part of the overall plan. Many candidates had clearly practiced using a previous paper that required an explanation of how to make a specific set of solutions and wrote the same

level of detail for this paper, which was not appropriate, since this question needed only the general principal of diluting. Candidates should also remember that they are providing a plan that can be followed by another person. Some answers were effectively a list, organised like the mark schemes for this paper.

Better answers to this question gained maximum credit. These candidates were able to give a suitable method of dilution and an appropriate range of μmol $dm^{-3}$ concentrations. They also gave a clear sequence of the investigation, including specified temperatures and times for both soaking and germinating the barley grains, descriptions of how appropriate variables were controlled and chose a suitable dependent variable that could be measured. The most common choices of variable were the volume of soaking solution, the number of barley grains and the germination temperature. The common choice for the dependent variable was the length of the young root or shoot, measured using a ruler or calipers. These candidates also explained the importance of a control. Relatively few candidates realised that to germinate, seeds needed to be planted in soil or another support medium. Most left the seeds in the soaking solutions.

Poorer answers showed a tendency to copy sections from the information given. For example, most candidates stated that the temperature could be controlled using a water-bath, but instead of choosing a specific temperature, stated the range given in the information. These candidates usually soaked the seeds in water for 24 hours as they did not connect the information given about the use of the gibberellin solution and the information about the requirements of barley germination. Most of these answers also indicated a suitable feature of a germinated seed that could be measured, for example the length of the shoot, without stating how the measurement would be made. Other poorer answers described a dilution process in great detail often ending up with too few concentrations or a range of concentration that had incorrect units, for example, mol $dm^{-3}$. In some cases the solutions showed an increase in concentration from the stated 3 mmol $dm^{-3}$ as candidates described adding a different number of packets to 1 $dm^3$ of water.

The majority of candidates commented on the low risk nature of this investigation, although this was often qualified by a reference to allergic responses to both gibberellin and barley. Poorer answers tended to contradict the idea of a low risk investigation by stating gibberellin is toxic. Candidates should be aware that any investigation using potential toxins cannot be classified as low risk.

Most candidates commented on improving reliability by taking a mean. Better answers made it clear that this was obtained from the results of three separate investigations and also referred to identifying anomalies. Candidates should be encouraged to refer to 'replicates', rather than 'repeats'. Poorer answers showed some confusion about the data used for obtaining a mean, in many cases this was the result of three measurements of root length from a single investigation.

**(c) (i)** Many candidates were able to carry out a correct calculation. The only common error was to divide the difference between the treated and control plants by the value of the treated plants. Poorer answers were often the results of candidates memorising the method of calculating percentage increase that has been tested in previous papers.

**(ii)** Most candidates were familiar with the idea that percentage values are often used to make comparisons. The role of the control however, which is critical for this particular investigation, was largely ignored. Candidates should be encouraged to consider the purpose of controls and whether data obtained from control experiments has to be taken into account with the results of an investigation.

**(d) (i)** Most candidates gave a correct answer. Imprecise use of language, for example 'it is a continuous variable' meant that some candidates were not credited.

**(ii)** Well-prepared candidates gave clear answers. Weaker answers tended to miss out the word 'significant' or used a generic statement, for example, 'There is no significant difference between the expected results and the actual results'. A common imprecise answer was 'there is no significant difference between plants grown in GA and the plant grown in water'. When writing a null hypothesis, candidates should identify a specific feature of the dependent variable and include this in their stated null hypothesis. For this investigation were a number of features that candidates could choose, for example the length of the root, the number of seeds germinated. Ideally, a null hypothesis should also specify the conditions being compared. In this case, barley treated with

gibberellin and untreated or control barley. Null hypotheses that stated 'there was no significant difference in the percentage difference' were not credited.

**Question 2**

This question was about the effect of oxygen on the growth of a population of bacteria and tested the evaluation of experimental design, estimating population size using a counting grid and the interpretation of data.

**(a)** Most candidates correctly identified oxygen as the independent variable. Poorer answers tended to be a paraphrase from the description of the procedure 'period of time that air was passed through the culture'.

**(b)** Better answers were able to give an explanation for all three precautions. Poorer answers were often too generalised. To gain credit for pH, candidates needed to make a link to enzyme activity and explain how this could be influenced by changes in pH, so answers that only stated 'to keep an optimum pH' were insufficient. For 'sterile medium', answers that only stated 'to prevent contamination' were not credited. A specific reference to other microorganisms was required. Some poorer answers showed a misunderstanding of the question as they answered in terms of nutrient supply. For 'stirred at low speed' an understanding of even distribution of the nutrients, bacteria and products of metabolism was expected. The answers 'to mix well' or 'to mix properly' were insufficient. A common misconception was that bacteria are damaged by stirring.

**(c)** Answers to this question showed great variation in the familiarity of candidates with the use of counting grids. Part of the credit for this question was for describing how to use a counting grid. Most candidates gained credit for counting the cells, better answers also described a method of systematic counting. The best answers also referred to uniform sample. Candidates did not seem to be aware that a culture of bacteria would need to be diluted before counting.

The remaining credit for the question was for showing how to calculate the number of cells per $cm^3$. Candidates who were familiar with counting grids usually gained full credit by dividing the number of cells by the calculated volume $4x10^{-6}$ $cm^3$. In some cases the conversion from $mm^3$ to $cm^3$ was incorrect. If an actual number of cells was used in the calculation, this had to be one that could be obtained by a recognised way of counting using a grid. Many candidates used a more complex proportional calculation which was credited if all the stages in the calculation were shown. Often this was not the case. Candidates should be encouraged to write all the stages of a calculation, as credit is given for showing what to do (data processing), even if the answer is not correct.

Other candidates were clearly unfamiliar with this technique so they did not realise that the volume of the grid could be calculated, or that the triple line border delineated a standard volume. Many candidates calculated inappropriate volumes or areas, for example a 5 x 4 x 0.05 mm x 0.1 mm, 0.5 mm x 0.5 mm x 0.5 mm, 16 x 0.5 mmx 0.05 mm.

**(d)** Candidates who read the table headings carefully realised that there was only one set of data. Weaker answers included 'there should be a mean', 'the bacteria are too many to count', 'there are no results before 100 min' and 'the increase in population is uneven'.

**(e)** There were very few good answers to this question. In many cases it appeared that the candidates had not understood the basis of the investigation, so their answers were in terms of the flow of air increasing from 100 min after inoculation until it was exhausted at 340 min. Others described the stages of population growth in bacteria.

Candidates were expected to identify the time at which oxygen was introduced by observing the sudden increase in population between the times 220 and 250 min. Candidates who did notice this change did not always gain credit as they stated that oxygen was added *at* 220 min or *at* 250 min. Credit was allowed for the answer *after* 220 min. From this deduction, candidates were then expected to explain the growth of the population in terms of energy availability from anaerobic and aerobic respiration. Some of the better answers identified the anaerobic and aerobic phases and linked this to ATP synthesis. Poorer answers that identified these phases were not credited if they referred to energy production rather than energy release. Only the best answers linked rate of population growth to energy supply.

There were many candidates who described, rather than explained the results in Table 2.1.

# BIOLOGY

**Paper 9700/53**

**Planning, Analysis and Evaluation**

## Key Messages

Candidates should be encouraged to make use of information provided in questions to inform their answers. Candidates need to identify key stages in an investigation and select the appropriate information to use. Direct copying from the question is not creditworthy, particularly when planning an experimental procedure.

Candidates should have a clear idea of the role of a control experiment and on precisely what a dependent variable is.

## General Comments

The writing and grammar were often good and there was no evidence that candidates were short of time. Although it is good practice for Centres to use past papers and mark schemes to prepare candidates, candidates should avoid repeating previous mark schemes in the context of a new question, without considering whether it is appropriate. New questions often test different knowledge and skills to that in past questions.

## Comments on Specific Questions

### Question 1

For this question, it was important that the candidates read the information provided carefully before starting to answer.

**(a) (i)** Most candidates were able to give the independent variable as the concentration of gibberellin. The dependent variable caused more problems, with 'activity of amylase' being a frequent answer. Candidates need to understand that the dependent variable is what is actually measured in an investigation. In this case the area around the grain that is clear or brown or starch free is what was actually measured. This can then be related to the activity of amylase which cannot be measured directly.

**(ii)** The key to producing a good answer here was to appreciate the instruction that the account should be precise enough for another person to follow and to base the account on the method used in the preliminary investigation. Some responses indicated that this method had not been fully understood.

A number of accounts unnecessarily restated the variable given in **(a)(i)** or described what the results might show.

Some candidates went into great detail on how to carry out a serial dilution and then gave a very brief outline of the main part of their method rather than an account that someone else could follow. Better answers stated that serial dilution (or some other suitable method) would be used to produce at least five different concentrations. The range should not be above 3 mmol $dm^{-3}$ and should ideally encompass something in the range given in the information as being found in plants. It should be clear that a control should be included which should be water. Once into the actual method good candidates gave clear and precise instructions using the information provided. Thus a stated soaking time in gibberellin and a stated incubation temperature and time were expected. Control variables given and credited included having the same number of grains, the same volume of soaking solution, the same concentration of starch and volume of agar. Many candidates realised that an incubator or water-bath would allow the plates to be kept at the stated temperature,

but there were still a few who mentioned an 'air conditioned room' which is not acceptable. Weaker responses just quoted the ranges in the information or prefaced their remarks with 'about'. Some candidates muddled the pre-soaking with water with the soaking in gibberellin or soaked them in gibberellin whilst on the agar plates. All of these errors suggest that practice at fully understanding information provided would be beneficial. When describing the actual measuring of the area of digested starch the responses were generally incomplete. Just 'measure the area' is not a full enough instruction for someone else to follow – a suitable method such as using a grid with squares of known size or measuring the diameter with calipers or a ruler and using a suitable formula to work out area, was needed. The safety and reliability aspects were often well covered. Weaker responses on safety either considered it a 'no risk' investigation or were too general regarding the particular risk and precaution. Weaker responses suggested only one replicate or did not link this to taking a mean or identifying anomalies.

**(b)** This was generally well done though a few got the axes the wrong way round or did not give units. Occasionally incorrect units were given, such as $mm^3$ for area or mol in place of mmol. Activity of amylase was allowed for the *y*-axis but the units would be au (arbitrary units) – a number of candidates put something suggesting a rate.

**(c) (i)** Candidates found the assessment of limitations a difficult concept. Many answers focused on things that might be wrong with the way that the method was carried out such as that the temperature was not constant or there were not enough repeats. A number showed a misunderstanding of the role of starch/iodine on the plates and discussed problems in terms of rate of colour change or rate of reaction. The diagram made it clear that the area stained brown was not regular but surprisingly few saw this as a limitation. Perhaps more practical experience with this technique would have alerted candidates to these limitations.

**(ii)** It was not always clear which of the limitations given in **(c)(i)** the candidate was referring to in this section. Many who suggested a difficulty related to the difficulty of deciding the colour boundary suggested improvements involving colorimetry which could not be applied to this method.

**Question 2**

**(a)** Most candidates were able to describe the trends in the two types of bacteria as soil depth increased. They were also able to explain the trend in terms of the decrease in oxygen with depth after six months. Not all were able to follow up this general explanation with detail in terms of the anaerobic bacteria replacing the aerobic ones as the oxygen ran out. Although not asked to comment directly on the data after one month, the large numbers of aerobic bacteria at depth after one month would suggest that the new soil heap had oxygen at depth at this time which had run out after six months. This would lead to the anaerobic bacteria replacing the aerobic ones. Some candidates spent time describing the data in great detail which lost sight of the trends.

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