BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

The majority of weaker candidates did not know the definition of the magnification of a drawing of a leaf.

Question 4

Almost half of weaker candidates were unable to compare the measurements to determine that 0.001 mm and 1000 nm are equivalent to 1 μm.

Questions 6 and 8

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

Question 9

The majority of stronger candidates were able to process the information provided and deduce that the longer the chains of fatty acids, the more carbon-hydrogen bonds present, so the more energy available.

Question 12

Over half of weaker candidates incorrectly selected option **C**. This indicates that they did not understand the difference between hydrophobic and hydrophilic.

Question 14

The majority of weaker candidates were unable to determine the appropriate control for the investigation.

Question 17

The majority of candidates did not realise that only channel proteins possess a water-filled pore.

Question 24

Many candidates found this question difficult and did not know the correct definition of a mutation as being a change in the sequence of nucleotides. Therefore, the smallest unit of DNA that can change by mutation is the nucleotide.

Question 29

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

Question 30

The majority of candidates found this difficult. Whilst cell walls can be lignified, it is frequently the case that the lignin is arranged as rings, in spirals or in patches. Therefore, water can still pass through the cell wall, but not where it is lignified.

Question 37

The majority of stronger candidates answered correctly, appreciating that the ventilation of the lungs would maintain the concentration gradients by reducing the carbon dioxide concentration in the alveoli, whilst increasing the oxygen concentration.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 2

Over half of all candidates incorrectly selected options that included the detail that the DNA is in a double helix. Both eukaryotic and prokaryotic DNA is in a double helix.

Question 4

Whilst the majority of stronger candidates answered correctly, over half of the weaker candidates did not realise that since chloroplasts and mitochondria have DNA, they would need both 70S ribosomes and mRNA in order to synthesise proteins.

Question 12

Many of the weaker candidates did not understand how the Michaelis-Menten constant (K_m) is used.

Question 14

There was an approximately even spread of responses across each of the options here, demonstrating that candidates found it difficult to understand what is meant by a less negative water potential.

Question 15

Over half of weaker candidates found this difficult and did not identify **D** as the answer. All cholesterol molecules in the membrane are identical. Molecule 2 (glycoprotein) and molecule 3 (glycolipid) are not identical.

Question 17

The majority of candidates found this difficult. Whilst the role of histones is relatively new to the syllabus, candidates should know that during prophase each chromosome consists of two chromatids.

Question 18

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

Question 19

The majority of candidates found this difficult. The most suitable substances to be radioactively labelled would be ribose and uracil. This is because adenine and inorganic phosphate would be found in both DNA, mRNA and tRNA, which would not allow mRNA to be identified.

Question 27

Whilst most of the stronger candidates knew what systolic blood pressure is, the question was poorly answered by the majority of weaker candidates.

Question 28

The majority of the stronger candidates understood the significance of the increased red blood cell count at high altitudes.

Question 31

Many candidates found this question difficult. Prior experience of studying slides or photomicrographs of the various tissues in the gaseous exchange system should have helped candidates to recognise an artery and vein, as well as notice that the smaller structures did not have the characteristic ‘wavy’ inner lining of bronchioles.

Question 35

The majority of candidates found this difficult. Candidates should realise that both prokaryotic and eukaryotic cells require RNA polymerase, 70S ribosomes and DNA.

Question 36

The weaker candidates were unable to correctly process the information to determine that all three statements were correct.

Question 39

Whilst over three quarters of all candidates knew that statement 1 was correct, only half of all candidates knew that in addition statements 2 and 3 were also correct.

BIOLOGY

Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

The majority of weaker candidates incorrectly thought that mitochondria contain cisternae rather than cristae.

Question 3

The majority of weaker candidates did not link the absence of a Golgi body with an inability to form glycoproteins.

Question 5

Many candidates found this question difficult, with only a minority answering correctly. Candidates should know that, in the test for non-reducing sugars, the acid needs to be boiled (between steps 2 and 3) to hydrolyse the sucrose molecules to glucose and fructose molecules, so that, when boiled with the Benedict's solution (after step 4), there will be a positive test.

Question 8

A minority of candidates realised that the quaternary structure is described.

Question 9

Many weaker candidates did not show understanding of the meaning of hydrolysis.

Question 11

The majority of stronger candidates correctly determined that denaturation occurred before hydrolysis was complete.

Question 13

The majority of weaker candidates incorrectly indicated that facilitated diffusion requires ATP.

Question 18

Whilst the majority of stronger candidates answered correctly, very few weaker candidates knew the answer.

Questions 19 and 21

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

Question 20

The majority of the stronger candidates understood the process of semi-conservative replication.

Question 24

A minority of candidates knew that because the loading of sucrose into phloem sieve tube elements is an active process, they must contain the highest sucrose concentration.

Question 27

The majority of candidates did not know that the blood pressure in the veins is less than in the capillaries.

Question 28

The majority of candidates selected carbaminohaemoglobin. This transports only about 10% of carbon dioxide in the blood.

Question 34

The majority of candidates found this very difficult. The molecule of oxygen has to pass through the cell membrane on either side of a cell from the alveolus, then through the cell membrane on either side of a cell from the capillary in order to reach the plasma. This is four cell membranes. A molecule of carbon dioxide would follow the reverse journey from the plasma into the alveoli. This is also four cell membranes.

Question 39

Many candidates were familiar with slides of blood smears and correctly selected option **D**.

Question 40

A minority of candidates were able to process this information to correctly select option **D**.

BIOLOGY

Paper 9700/21
AS Level Structured Questions

Key messages

- **Question 1(a)** was about organelles. Some candidates confused the term 'organelle' with 'organ'. An organelle can be described as a structure within a cell that carries out a particular function.

- The Michaelis-Menten constant, K_m, is the affinity of an enzyme for its substrate. In **Question 2(a)**, some candidates stopped after finding half V_{max} and did not determine the substrate concentration at this value. The substrate concentration should be accompanied by the appropriate units. Candidates should be able to obtain V_{max} and K_m from a graph so that they can describe in words how to do this.

- Candidates should read the questions very carefully and plan their answers accordingly. Often answers included plenty of good biology, but not what was required to answer the question. **Question 3(c)(i)** on monoclonal antibody production attracted many detailed answers that dealt with the immune response in the small mammal and did not mention anything about the subsequent production process. In response to **Question 4(a)** candidates occasionally wrote about functional differences between mRNA and DNA instead of the structural ones required.

- The cotransport of sucrose by hydrogen ion flow proved to be a difficult concept for some candidates in **Question 5(b)**. They should realise that ATP is used for the active transport of hydrogen ions out of the companion cell (into the apoplast) and this creates a proton gradient that allows the passive flow of hydrogen ions back into the companion cell. The specialised membrane protein that facilitates this flow is a cotransporter, as the flow of protons drives the cotransport of sucrose into the companion cell. The movement of sucrose through the transporter is frequently not down a concentration gradient and cannot be described as facilitated diffusion. No ATP is required so the mechanism cannot be described as active transport.

General comments

There were many excellent answers to the questions on this paper and, even though some candidates wrote lengthy answers, none appeared to be short of time.

Many candidates wrote correctly about active sites in their answers about enzymes in **Question 2**, and should have avoided using the same term when describing the structure and function of antibodies in **Question 3** and receptors in **Question 6**. There was also some confusion with use of the term 'receptor'. Although this was required in answers to describe the ganglioside in **Question 6(b)**, it should not have been used to describe part of the toxin choleragen. 'Receptor' was also used incorrectly to describe the antigen-binding sites in antibodies and the antigens on the surface of pathogens in **Question 3(b)(i)**.

Question 1(a), candidates were asked to 'Identify the structure ...', indicating that they need to give only one answer. Candidates should be aware that providing additional suggestions risks giving an incorrect answer which then cannot gain full credit. **Question 5(c)** is another example of this, where some candidates tried to give more than two examples of sinks.

Candidates can use graphs or diagrams to help their descriptions or explanations. When describing how to determine the substrate concentration in **Question 2(a)**, many candidates drew the intercept on the graph and this helped to secure credit. This is good practice and is a skill that candidates should use in questions where they are asked to describe data from a graph and/or illustrate their answers with accurate data quotes.

In **Question 3(b)(i)**, descriptions of the antigen binding site needed to be precise, so that 'binding to pathogens' was not sufficient to gain credit. In relation to the role of antibodies, terms such as 'fighting disease' or 'fighting pathogens', rarely attract any credit.

In **Question 4(a)**, candidates confused the structure of polynucleotides and polypeptides. For example, some stated that DNA is composed of amino acids.

Some of the stronger answers to longer questions came when candidates took time to organise their thoughts and present their responses in an appropriately sequenced fashion, as in **Question 5(b)** for example. Many candidates would have produced more relevant responses if they had taken a little more time to read and consider the requirements of this question before formulating their answers. Many candidates did not pay enough attention to the fact that **Question 4(e)** was about the role of ribosomes and focused instead on an account of translation involving details of mRNA, tRNA, codons and anticodons.

A substantial number of candidates wasted time and space by repeating the question to start their answer: **Question 6(d)** had five lines available and three were often used up before the actual answer began.

Comments on specific questions

Question 1

This question assessed knowledge of cell structure from syllabus Topic 1.

(a) Many candidates identified chloroplasts and mitochondria as organelles that contain 70S ribosomes. Chromosome and chromatid were common correct answers to statement **B.** Chromatin was named by some candidates. As it is a complex of DNA and histone proteins, this was also accepted (although not usually described as thread-like). Many candidates gave gene as the answer, which was not accepted as histones are not part of a gene. Most candidates stated that Golgi bodies are the organelles that modify and package proteins. **D** was the structure that candidates found most difficult. The most common incorrect answers for **D** were rough endoplasmic reticulum and ribosome, instead of the nucleolus.

(b) Many candidates stated that peptidoglycan is the main component of cell walls of prokaryotes and cellulose is the main component of plant cell walls. Murein was a common alternative to peptidoglycan. Some wrote about fungi or described cell membranes instead of cell walls. Common errors were: to confuse the two main components; give chitin as an answer; and to state that pili are components of the prokaryotic cell wall. Some referred to functions of the walls rather than to the structures. For example, weaker responses compared permeability properties of the two types of wall.

Question 2

There were many excellent answers to all parts of this question, although there were also many weaker responses, especially for **Question 2(a)**. Some candidates merely defined K_m rather than describing how to determine it. Many, however, answered this part well by showing how they worked through the figures given in the question. Those who tried to answer solely by describing the method used, often had difficulty doing so clearly.

(a) There were two ways to answer this question. The majority of successful answers stated V_{max} from **Fig. 2.1** as 14 $\mu mol\,dm^{-3}\,min^{-1}$. The Michaelis-Menten constant (K_m) was stated as the concentration of the substrate at $^1/_2V_{max}$ and this was often shown by use of an intercept on the graph. The other way to derive K_m is to draw a double reciprocal plot and take the value from the intercept of the line with the *x*-axis. Candidates who described this method occasionally illustrated their answers with a sketch graph. This was useful, especially when some candidates did not state in their response what should be plotted on the axes. To gain full credit, responses should have explained how K_m is derived from V_{max}.

(b) Many candidates recalled the inverse relationship between K_m and the affinity of an enzyme for its substrate, by stating that the affinity of enzyme **B** is lower than that of enzyme **A**. Many candidates stated that the opposite relationship existed, with enzyme **B** having the higher affinity and requiring a lower concentration of substrate to reach V_{max}. Many candidates used the term efficiency here rather than affinity. Some candidates gained credit for suggesting that the active site of enzyme **B** was a less good fit for the substrate. Some candidates linked this idea to the induced fit and lock and key mechanisms, suggesting that one method takes longer than the other and that was the reason for the difference in K_m. This was incorrect. Very few wrote about the need for a higher concentration of substrate required to raise the rate of reaction of enzyme **B**.

(c) Some candidates saw that this was a question about competitive inhibition and wrote about the mechanism of action of these inhibitors in reducing the activity of an enzyme. They needed to explain the effects on V_{max} and K_m. Candidates who referred to graphs showing the effect of a competitive inhibitor on enzyme activity at different concentrations of substrate tended to write better answers, as they explained why K_m has a higher value even though V_{max} remains the same. Occasionally sketch graphs were used effectively to make these points. Some answers that described the graph included statements like 'it takes longer to reach V_{max}'. This was a common error as candidates implied that the *x*-axis of the graph is time rather than substrate concentration. However, many correctly indicated that the curve with the inhibitor is to the right of the one without or has a less steep gradient. Weaker candidates tended to explain the effect of competitive inhibitors without referring to the active sites of enzymes. Many simply stated that the inhibitor binds to the enzyme. There was also some confusion between competitive and non-competitive inhibitors. A few candidates linked the reduced rate of a reaction in the presence of a competitive inhibitor to low substrate concentrations, which showed recognition of the effect of substrate concentration on competitive inhibition. Others stated that competitive inhibition decreased the rate of a reaction and could have improved their response by referring to the differing effects at different substrate concentrations.

Question 3

This question covered three parts of the syllabus: antibody structure and function and monoclonal antibodies from Topic 11 and levels of organisation of proteins from Topic 2. In **Question 3(c)(i)**, some did not realise that the question was about an artificial process and instead described the immune response in some detail, with reference to clonal selection and clonal expansion and without any details of cell fusion. In **Question 3 (c)(ii)**, many thought that they should write about treatment rather than diagnosis and gave accounts of passive immunity that were not appropriate.

(a) Candidates gave a variety of answers to this question to explain why the antibody molecule shown in **Fig. 3.1** has quaternary structure. Many candidates stated correctly that it has more than one polypeptide or that it has four polypeptides. Incorrect answers included the following:

- the antibody has two polypeptides (it has four)
- there are two different types of polypeptide (proteins with two or more identical polypeptides have quaternary structure)
- there are more than two polypeptides (proteins with two polypeptides have quaternary structure)
- the antibody has many polypeptides or there are multiple polypeptides in an antibody molecule (many is much more than four)

Some candidates answered by explaining why the antibody molecule needs to have a quaternary structure for its functions instead of what makes it a quaternary structure.

(b) (i) Most candidates explained that the variable region of an antibody forms the antigen-binding site, which has a complementary shape to an antigen. Many then qualified these statements by referring to specificity. Fewer candidates used their knowledge of protein structure to explain that different sequences of amino acids give the variation in antigen-binding sites. Some candidates referred to active sites rather than antigen-binding sites. Many candidates wrote about the whole antibody, for example by describing the role of the hinge region.

(ii) While most candidates knew about the role of the variable region, fewer were aware of the role of the constant region. Successful answers referred to it binding to receptors on phagocytes.

(c) (i) High quality accounts outlining the production of monoclonal antibodies gave the main details of the process. Some candidates could have provided more main points to help improve their answer. A good answer was sequential in nature and began with the injection of antigen into a small mammal. A number realised that time was required to allow an immune response to occur before removal of plasma cells from the mammal and fusion with myeloma cells to form hybridoma cells. There was no need to explain why cell fusion is necessary. Candidates often could have stated more clearly that the cells are fused together. Simply 'mixing' or 'crossing' them together is insufficient. A few candidates correctly outlined that one stage of the process was to test hybridomas to find those that make the required antibody. Some candidates gave points that may not necessarily be considered part of an outline but were pertinent to the process and so one mark

was available for a correct point, such as using a fusogen or a named fusogen, such as polyethylene glycol, for the fusion stage. Weaker responses stated that a disease or a pathogen was injected into an animal or described that antibodies are extracted from animals, fused with cancer cells and cloned. These weaker answers often stated that antibodies release enzymes and divide and 'reproduce' by mitosis.

(ii) This question asked for the advantages of using monoclonal antibodies in diagnosis. Many candidates referred to their highly specific nature and also stated that suitably labelled monoclonal antibodies are used in locating the position of blood clots and infections in the body. In diagnosis, monoclonal antibodies are not injected to increase the body's own immune response to an infection. Well-prepared candidates qualified their statement about specificity to explain that this allowed different pathogens or strains of pathogen to be identified. Some candidates confused the terms 'disease' and 'pathogen'. Many misread the question and wrote answers about the use of monoclonal antibodies in treatment rather than in diagnosis.

Question 4

This question dealt with subject matter from Topic 6. In **Question 4(a)**, many wrote about adenine being a complementary base pair with thymine in DNA, but then stated that it forms a complementary base pair with uracil in mRNA. In a number of cases, elsewhere in the response these candidates stated that mRNA was single-stranded, and so would have benefited from re-reading their answer to spot their error.

(a) Candidates often made very effective direct comparisons between DNA and mRNA, sometimes using a table. Some candidates were confused between the different types of RNA as they often referred to base pairing in part of the molecule, as occurs in tRNA. All of the expected points were seen. Some candidates stated that mRNA is a single helix, while DNA is a double helix: mRNA does not have a helical shape. No credit was given for referring to ribose as oxyribose, but credit was given to the different functional groups on C3 on ribose and deoxyribose.

(b) (i) This question concerned the first seven amino acids of the β chain of haemoglobin and the consequence of the deletion of the base pair G:C at position 6. Some realised that the codon formed by the deletion is TGA, a stop codon, so that the sequence of amino acids formed is shortened to just two: Val and His. Others thought that the third amino acid in the sequence would become threonine. Some wrote that a frameshift would occur.

(ii) Some candidates knew that the deletion of three base pairs does not cause a frameshift mutation, so the change is the loss of Leu from the sequence. Some candidates stated that 'Leu is not synthesised'. This is not correct as mutations in a gene for haemoglobin do not interfere with the synthesis of any of the amino acids. In many responses, candidates simply wrote about a mutation occurring and again many thought that this was a frameshift.

(c) Many candidates gained full credit by completing **Table 4.2** correctly. Some candidates did not complete both boxes in each row and some used crossed ticks which were usually too ambiguous to be credited. The most common incorrect answer here was thinking that no phosphodiester bonds are formed during transcription.

(d) Candidates often found it difficult to describe the function of telomeres. Some confused them with centromeres so wrote about holding chromatids together. There were some answers that described the structure of telomeres without stating their function and others that dealt with the action of telomerase rather than with telomeres themselves. A few candidates stated correctly that telomeres prevent the ends of chromosomes joining together. A large number of candidates referred to telomeres preventing the loss of genes or genetic material.

(e) Descriptions of ribosomes were usually very good. Some candidates wrote lengthy answers about details of translation, describing tRNA in some detail and the binding of codons and anticodons. These could have improved their response by selecting the appropriate information to answer more concisely the question posed, although some were able to gain full credit by referring to the relevant points about ribosomes within their more detailed answer. A number of candidates named peptide bonds as dipeptide or polypeptide bonds, which was not accepted. A few mentioned tRNA binding to the P and A sites in ribosomes.

Question 5

This question combined movement across cell surface membranes in Topic 4 and the loading of sucrose into sieve tube elements in Topic 7. Candidates would have benefited from using their knowledge of the histology of phloem while planning their answers to **Question 5(b)** so that they did not write about unnecessary aspects of sucrose transport.

(a) Many candidates recognised this question as testing the features of sugar molecules and cell membranes in transport. Most stated that sugar molecules are polar, or gave a suitable alternative, and then stated that these molecules are unable to pass through the phospholipid bilayer. Many explained that sugars are hydrophilic but the core of the membrane is hydrophobic and that explains why transport proteins are necessary. Many, however, stated that the whole of the bilayer was hydrophobic rather than just the core. Credit was not awarded to answers that stated the sugar molecules are too large since many lipid-soluble molecules are as large or larger than sugars and they pass easily through phospholipid bilayers.

(b) There were many excellent answers that explained how sucrose moves into companion cells and from there into sieve tubes. These candidates used **Fig. 5.1** to good effect to explain the role of the proton pump to create a proton gradient and the cotransporter protein to move sucrose against its concentration gradient into the companion cell. Some candidates could have made more use of the information in the diagram and tried to explain it without the correct terminology. Many candidates described cotransport as both sucrose and hydrogen ions diffusing through the cotransport protein. Candidates recognised the plasmodesmata in the diagram and explained that sucrose diffuses through these into sieve tube elements.

(c) Numerous plant structures could have been used as examples of sinks here. However, many candidates included ‘leaves’ in their answers and unless this was qualified by young, developing, maturing or infected, it could not be credited. Healthy, mature leaves carry out photosynthesis and are net exporters of assimilates, so they are sources, not sinks. Soil was given as a sink by some candidates.

Question 6

This question was set in the context of infectious diseases in Topic 10, but also covered material from Topic 4. **Question 6(e)** revealed some common misconceptions about antibiotic resistance. The two most common were stating that bacteria become ‘immune’ to antibiotics and that people develop antibiotic resistance.

(a) (i) Most candidates knew the causative organism of cholera but often misspelt it. Vibro cholera, Vibreo cholerae, Vibro cholerea, Vibrio cholera, Vibro cholerae were common misspelling and V. cholerae was also given. Candidates are expected to spell correctly the scientific names of the pathogens listed in the syllabus.

(ii) There were many correct descriptions of the transmission of cholera. Answers that could have been improved often referred to the consumption of contaminated food or water without explaining how the contamination occurred. Many referred to infected water and to infected food and some did not make it clear that the bacteria leave the infected host in faecal matter. Some thought transmission is by transfer through the air.

(b) Candidates seemed unsure about how the toxin choleragen interacts with gangliosides on intestinal cells. Many, however, used the diagram in **Fig. 6.1** to describe the gangliosides as receptors that are complementary to choleragen. Some candidates went further and described likely ways in which the two interact, for example by formation of hydrogen bonds, ionic bonds or hydrophobic interactions. Many focused on what would happen after binding and not the way the molecules interact with each other.

(c) Almost all candidates named the process by which choleragen enters the cell as endocytosis. Phagocytosis and pinocytosis were accepted as alternatives.

(d) Candidates knew the effect of cholera on the intestines so used the cue given in the question about the outward movement of chloride ions to describe water movement. Almost all candidates described the loss of water by osmosis and/or referred to water loss down a water potential gradient. Some referred to water moving down a 'concentration gradient' which did not gain credit.

(e) The antibiotic tetracycline is used in the treatment of severe cases of cholera and there were many good explanations given for the recommendation that its use is limited. Some candidates discussed the successful management of cholera with rehydration therapy and others considered the risks of antibiotic resistance. Explanations of the latter were often very detailed with mention of mutation, plasmids, and vertical and horizontal transmission. The dangers of antibiotic resistance were understood by a great majority of the candidates. Some candidates referred to 'cholera becoming resistant to antibiotics' rather than the pathogen becoming resistant. The term 'immune' was also occasionally used in the wrong context.

BIOLOGY

Paper 9700/22
AS Level Structured Questions

Key Messages

- **Question 1(a)** used the term organelle. Some candidates confused this term with organ. An organelle can be described as a structure within a cell that carries out a particular function.

- The cotransport of sucrose by hydrogen ion flow proved to be a difficult concept for some candidates in **Question 4(d)**. They should realise that ATP is used for the active transport of hydrogen ions out of the companion cell (into the apoplast) and this creates a proton gradient that allows the passive flow of hydrogen ions back into the companion cell. The specialised membrane protein that facilitates this flow is a cotransporter, as the flow of protons drives the cotransport of sucrose into the companion cell. The movement of sucrose through the transporter is frequently not down a concentration gradient and cannot be described as facilitated diffusion. No ATP is required so the mechanism cannot be described as active transport.

- Candidates should read the questions very carefully and plan their answers accordingly. Often, answers included plenty of good biology, but not what was required to answer the question fully. **Question 5(b)** on the mode of action of a macrophage attracted many detailed answers about antigen presentation by macrophages and the subsequent response of B-lymphocytes and T-lymphocytes, but frequently did not describe the mode of action of the phagocyte and so did not include the events occurring in phagocytosis. Similarly, in **Question 4(a)(ii)** many described in detail the process of semi-conservative replication but did not actually explain what the term meant.

General Comments

There were many candidates who gave consistently high performances in every question. Many of those who were extremely well prepared for this exam also showed an ability to apply knowledge and understanding to produce high quality responses to questions set in an unfamiliar context, such as in **Questions 1(b)** and **5(d)**.

All candidates attempted **Questions 1**–**5**, and almost all attempted **Question 6**, indicating that there was sufficient time to answer the questions and all questions were accessible.

Table 1.1, used in **Question 1(a)**, required candidates to use their knowledge from several different areas of the syllabus and to make deductions using the information provided. Some coped with this very well. Taking more time to understand how the table was constructed may have helped other candidates.

The graph in **Question 2(c)**, **Fig. 2.2**, was printed on a 2 mm grid. This meant that each small square for the *y*-axis, percentage activity, was the equivalent of a numerical value of 2, and not 1. Some candidates did not notice this and hence did not gain credit for correct comparative data.

In **Question 3(d)**, several candidates were out by one or more factors of 10 in their final calculated value. It would be helpful to the candidates to practise straightforward conversions between the different units of measurement used in biology. Measuring in millimetres and then multiplying by 1000 to obtain micrometres may be simpler than measuring in centimetres and remembering the additional requirement to multiply by 10.

The best responses seen in **Question 4** were consistent in focusing on meristematic cells found in plants, as in the theme of the question. Many candidates reverted back to subject matter with which they were most familiar: stem cells in animals and mitosis in animal cells, and did not apply their knowledge of these to the actual questions posed. All parts of a question should be read in context of the overall subject of the question.

Question 5(d) is a good example of application of knowledge and understanding. Many successful candidates used their knowledge of the features of cell surface receptors and cell signalling to link different parts of the information provided to the correct aspect of cell signalling.

In **Question 6(b)**, a common error, even for candidates who otherwise did well on the rest of the paper, was to give TGT as the tRNA anticodon sequence for the TGT of the DNA strand transcribed, instead of UGU. Candidates tend to know well that uracil replaces thymine in messenger RNA, but should also note that this rule applies to tRNA and rRNA.

Questions beginning with, for example, 'Suggest one...' or 'Name one...' set a limit to candidates, who should not go beyond this in the hope of increasing their chances of success. Candidates should be aware that an incorrect answer with a correct answer will most likely mean that no credit can be given. **Question 1(a)**, **Question 2(b)**, **(d)(i)** and **(ii)** and **Question 3(a)** were examples of this type of question.

Comments on Specific Questions

Question 1

Question 1(a) assessed candidate knowledge with understanding of learning outcomes from syllabus Topics 1 and 11 (knowledge of palisade mesophyll cells is also in Topic 7) and **Question 1(b)** linked to syllabus Topic 8.

(a) **Table 1.1** was set out so that only one piece of knowledge per row was required. In the first row, candidates could deduce the function of the cell either from knowing about the function of the palisade mesophyll tissue from studying leaf structure and function, or from knowing the function of the chloroplast, a plant cell organelle. Although most stated photosynthesis or gave a brief worded summary, a number stated only 'to absorb light'. Some gave gas exchange as the function. Candidates were not required to know about a Leydig cell or a pancreas acinar cell. The example of a required organelle in a Leydig cell could be deduced from knowing that steroids are synthesised in the smooth endoplasmic reticulum. In a pancreas acinar cell, knowing that enzymes are proteins and that the site of protein synthesis is the ribosome or rough endoplasmic reticulum would lead candidates to stating either of these as the correct answer. Some candidates had a poor understanding of the term organelle and stated pancreas as their answer. In a similar way, for the root hair cell, some stated channel or carrier protein (or transport or membrane protein), which is a molecule and not an organelle. Many knew that a plasma cell produced and released antibodies. As the column heading had 'type of cell' there were other correct answers, as stated in the mark scheme, but T-lymphocyte was rejected as this does not produce antibodies.

(b) The very best responses used the information provided, or had a good recall of the definition of an organ from previous studies, to produce a fluent response using correct scientific terminology. Tissues were correctly named and were considered within the overall function of the artery, which was clearly stated. Stating that blood was a tissue was only credited if it was in context of the vasa vasorum, as this can be considered to be part of the structure of an artery. Elastic muscle was a fairly common error. Some knew the function of an artery and could name some or all of the different tissues, but still stated that the artery was a tissue. Others needed to be able to distinguish between the different tissues and the three different layers, with quite a few naming the tunica intima, tunica media and the tunica externa as the tissues involved. Some of the weakest answers only named one type of tissue or one of the layers of the artery and stated that it was a tissue. A common error was to state that the function of the artery was to pump blood around the body, believing that contraction and relaxation of smooth muscle was similar to the action of the cardiac muscle in the ventricles. In some cases, stretch and recoil of the muscles was described, which is a feature of the elastic fibres.

Question 2

In this question, knowledge and understanding of lipids and enzymes was assessed, which is subject material from syllabus Topics 2 and 3.

(a) Many gained full credit. Partial credit was most commonly given for knowing the products of lipid hydrolysis. The gap in **Fig. 2.1** for the substrate was quite frequently left blank, or commonly had lipase, ethanol or fatty acids stated. Glycogen was seen on occasion instead of glycerol.

(b) Candidates showed excellent knowledge of the emulsion test for lipids and the positive result for the test. For those not gaining full credit, the positive result was generally well described. 'Precipitate' was not credited as this is different to an emulsion. Many, when stating the method, were unaware that an emulsion is not visible unless the ethanol-triglyceride mixture is added to water (or water added to the mixture). Some attempted to describe a method for the investigation that the researchers carried out. Hence, lipase was added to the mixture or the mixture was placed in a water-bath. A number, presumably who had mistakenly read 'bacteria' rather than 'bacterial lipase', added bacteria when describing the test. A few candidates described tests for lipids that are not stated in the syllabus: if correctly described, then credit was given but these tests are not required knowledge and candidates should only need to learn and understand the emulsion test.

(c) This question asked only for a description of the effect of pH on the activity of lipase and not for explanations. Almost all were able to gain credit for stating the optimum pH or describing an increase in activity up to pH 7 from pH 2 and then a decrease above pH 7 (to pH 10). Some candidates also noted that within this trend of 'increase then decrease in activity', as the pH increased from 2 to 10, there were differences in the gradient of the curve. Good accounts of these differences used terms such as 'steeper' or 'less steep', rather than incorrectly relating these to time with terms such as 'faster' and 'slower'. Extracting comparative numerical values from **Fig. 2.2** to support worded descriptions was generally quite accurate, although weaker responses frequently read the percentage activity at pH 2 as 72 rather than as 74.

(d) (i) Enzymes that are immobilised on or in a support medium frequently perform differently to the same enzyme reacting free in solution. Candidates were asked to suggest why the bacterial lipase immobilised to a polymer had a different optimum pH to the lipase free in solution. A range of suggestions were seen and credited, with most suggesting in some way that the support medium gave some protection from the hydrogen ions. Some stated that it prevented denaturation of the enzyme. These had not made the connection with the information provided in **Fig. 2.2** previously, which showed a percentage activity of the enzyme at pH 4 as 90.

(ii) Most gave a valid suggestion to gain credit.

Question 3

This question was based on the infectious disease malaria and assessed syllabus Topics 1 and 10. Many candidates performed well with the calculation. Knowledge of the transmission of *Plasmodium* was also good, but the ability to remember one species of *Plasmodium* that causes malaria was lacking for a large number of candidates.

(a) Generally, only candidates who performed well overall knew the name of a species of *Plasmodium* that caused malaria and could spell it correctly. The most common species given was *P. falciparum*, with *P. malariae* and *P. vivax* also seen less frequently. A range of incorrect answers were seen: these included versions of *Drosophila* and *Mycobacterium*. Some gave the correct type of causative organism and stated Protoctist, while weaker answers stated virus or bacterium or the *Anopheles* mosquito.

(b) The majority knew that the mosquito host of *Plasmodium* was *Anopheles*. A very large variation in spellings was seen. Some incorrectly stated *Aedes* as the host.

(c) Most candidates were able to gain some credit for knowledge that the electron microscope has a higher resolution than a light microscope. Many went on to gain full credit with knowledge that the image provided more detail or that it was possible to better distinguish between two (close) points. It was not enough to say that the image was clearer. Fewer were accurate in stating that the electrons used had a smaller wavelength than light, with many that tried to make this point stating that the microscope had a smaller wavelength. As it had been stated in the text that the magnification used could also have been obtained by the light microscope, it was not a valid answer here to state that the light microscope could not magnify the image to the same extent as the electron microscope.

(d) Many candidates were able to gain full credit here with a clearly presented formula and a neatly set out calculation to accompany the correct answer. It was clear that these candidates applied the formula by using only a correct measurement of the scale bar and the actual value stated below the

scale bar. Others arrived at the correct answer but attempted to use the image to obtain the magnification when this was not necessary.

(e) A large proportion gained full credit for this question. Generally, most knew that the transmission of malaria involved taking blood meals from human hosts. More candidates stated that infective stages were delivered in the saliva of the mosquito than stated that the mosquito acted as a vector. Although this question only asked for an outline of the role of the mosquito in the transmission of malaria, there were some very detailed answers seen and clearly a number of candidates possessed knowledge of the transmission of malaria that extended beyond the requirements of the syllabus. Some candidates gave good details of the life cycle within the mosquito but did not state how *Plasmodium* was taken up or passed on, while others did not refer at any stage to human blood. The weakest responses described modes of transmission of the other infectious diseases included in the syllabus.

Question 4

This question was based on syllabus Topics 5, 6 and 7. For many, this was the most challenging of all the questions. Those who did well in parts **Question 4(a)(i)** and **(b)** remembered throughout their response that meristematic cells were plant cells.

(a) (i) Many were confident that stage **5** in **Fig. 4.1** depicted cytokinesis. Fewer went on to give two or more correct points to describe what happens in cytokinesis in a meristematic cell. Responses of a high standard avoided a common error of describing the aspects of cytokinesis pertinent only to animal cells, such as the formation of a cleavage furrow or other similar descriptions. Where credit was given, this was generally for knowledge of the formation of a cell plate and/or deposition of cellulose or cell wall formation, rather than for stating that the cytoplasm is divided into two. There were some very detailed answers from some candidates, who displayed extension knowledge of the formation of the phragmoplast.

(ii) Many knew that semi-conservative replication of DNA occurred in the **S** stage of the cell cycle shown in **Fig. 4.1**, although this was less well known than the stage for cytokinesis. The strongest answers defined semi-conservative replication, remembering to address both parts: 'semi-conservative' and 'replication'. While the majority who gained credit for this section of the question gave a fair explanation of 'semi-conservative', only a small minority explained that replication led to the production of two identical DNA molecules. Some candidates described the process of semi-conservative replication instead of defining it and gave some very good detailed biology that could not be credited as it was not answering the question. A few also wrote about the work of Meselson and Stahl, which is not a syllabus learning outcome. Some gave an outline of transcription.

(b) Although many candidates had an understanding of the role of a stem cell and could suggest the role of a meristematic cell, only some were able to express their answers well. The ability of the undifferentiated cell to divide continuously, and for some of these cells to differentiate, was often linked to a role in tissue repair, cell replacement and growth. A small number of candidates showed an understanding that there would be changes in gene expression for cell differentiation. Statements suggesting that meristem cells could become any cell, or could reproduce, or were found in growing regions, were not credited without further qualification. Commonly, candidates did not mention that the cells were able to divide (by mitosis) or switched to only writing about stem cell features and the role of stem cells in animals. Weaker responses suggested roles that are characteristic of differentiated cells, such as water uptake by root hair cells.

(c)(i) The meaning of the term sink was usually explained well enough to gain credit. It was not sufficient to state that a sink was an area that uses assimilates as this was not in the context of transport from the source. Some stated that the sink was an area of lower hydrostatic pressure, which is part of the process of translocation, but not a definition of a sink.

(ii) This proved to be a challenging question. Those that gained credit noted that the statement at the start of **Question 4(c)** was about meristematic cells so could suggest that strong sinks were highly active or had a high requirement for sugars / assimilates (for division). A number suggested that a strong sink is where a lot of sucrose is unloaded or an area where a lot of sucrose is stored, but this could apply to the sink simply being a large storage organ so was not credited.

(d) There were numerous excellent responses and some candidates had no difficulty in achieving full credit. Good answers included both descriptive and explanatory points and were sequential in nature to give a flowing account. A good understanding was shown of the cotransport mechanism. The cotransporter protein was also described by some candidates as the symporter and this was credited. Some candidates could have improved their answers by ordering their ideas and by stating one idea only in each sentence. Although candidates were only required to write about how sucrose was loaded into phloem sieve tubes, some took time to write about translocation in the phloem sieve tubes and mass flow, which was not relevant. Common misconceptions were often related to the movement of hydrogen ions: many thought that they are pumped out of phloem sieve tubes and move back, carrying sucrose with them, or that they enter the mesophyll cells to cotransport sucrose.

Question 5

Candidate knowledge and understanding of syllabus Topics 4, 9 and 11 was assessed in this question. Some candidates showed a good aptitude to apply knowledge in **Question 5(c)**, but many other responses suggested that many candidates did not have a good understanding of the concepts involved in cell signalling.

(a) (i) Trachea and bronchus were well known as structures that have a ciliated epithelial lining, but fewer stated that bronchioles also possess ciliated epithelial cells. The structures were not always spelled correctly. It was quite common to see 'alveolus' in the list but these structures do not have ciliated epithelial cells.

(ii) This proved to be the most accessible part-question of the paper and a high proportion gained credit. 'Mucous cell' was too general to gain credit and was ignored, as was 'mucous gland'. 'Cells of the mucous gland', which is not part of the ciliated epithelium, are also mucous cells. Candidates should remember that an additional incorrect structure stated with a correct structure will often result in loss of credit.

(b) Some of the best responses were concise but contained all the information required, and were frequently supported with clear annotated diagrams. There were some responses that were more detailed than required for an outline of the mode of action of an alveolar macrophage. These had no problems gaining full credit. Some knowledgeable candidates described antigen presentation and the mode of action of the activated lymphocytes and did not give sufficient attention to phagocytosis. Some of those who commented on antigen presentation did not appear to know that a macrophage was a phagocytic cell and went on to describe the action of a neutrophil. The role of the lysosome in phagocytosis was not always made clear and some incorrectly described the lysosome as killing the bacterial cell rather than outlining that this was achieved by the fusion of the lysosome to the phagocytic vacuole and the release of the hydrolytic enzymes into the vacuole. There were quite a few who confused a lysosome with the hydrolytic enzyme lysozyme.

(c) Candidates tended to know that in a person with emphysema, the breakdown of elastin in the alveolar wall would lead to the loss of recoil of the alveolus. Fewer were able to continue to give a good suggestion as to how this would lead to bursting of the alveolus and many simply repeated the information that they had been given in the introduction.

(d) There was a great variation in the quality of response for this question. For a high-quality response, candidates needed to be confident in their knowledge of cell signalling before they could apply the principles to the maintenance of the correct quantity of surfactant. Many candidates were quite knowledgeable about signal transduction, secondary messenger molecules, and activation of intracellular enzymes; details that were not required to gain full credit. Some did not realise that the glycoprotein GM-CSF was the signal, despite being told that the macrophage had receptors for GM-CSF, and a proportion of these thought that GM-CSF was produced to digest the surfactant. There were candidates who thought that surfactant was a signal. Others thought that there was a receptor on GM-CSF. The immune system was described as releasing GM-CSF, rather than cells of the immune system. A number wrote about nerve impulse transmission, while some thought the response of the macrophage was to produce antibodies to break down surfactant.

Question 6

Syllabus Topics 2, 6 and 11 were assessed in this short question.

(a) To gain credit for the first row of **Table 6.1**, candidates needed to realise that both the antibody molecule and the haemoglobin molecule were globular proteins. Most knew about haemoglobin but quite a few thought that antibodies were fibrous. Fibrous proteins should be linked to a structural function and globular proteins to a metabolic or dynamic function. The second row only required knowledge of haemoglobin, with the antibody given as an example. A common error was to state 'two alpha helices and two beta-pleated chains' or versions of this, showing confusion between secondary protein structure and quaternary haemoglobin structure. Many knew that the bonds holding the antibody polypeptides together were disulfide. 'Covalent' was not enough to gain the mark and 'sulfide' was not accepted. Some incorrectly stated ionic or hydrogen bonds.

(b) Not all candidates showed knowledge that thymine in DNA is replaced by uracil in all forms of RNA. UGU was given by the majority of candidates for the mRNA codon but the tRNA anticodon was often stated as TGT. ACA was also seen quite frequently. A number wrote an amino acid in the blank boxes, so combinations with Thr and Cys were also seen. Some did not state the triplet codes in the blank boxes but shaded them in, possibly as a result of misreading the question. Others had lightly written triplets in the shaded boxes, which usually appeared to be helpful in arriving at the correct answer to write into the blank boxes.

BIOLOGY

Paper 9700/23
AS Level Structured Questions

Key Messages

- **Question 2(e)(iii)** required knowledge and understanding of the Michaelis-Menten constant, K_m, which provides information about the affinity of an enzyme for its substrate and can be derived by noting the concentration of substrate that enables the enzyme to achieve half the maximum rate of reaction, or half V_{max}. Candidates should understand that when an enzyme has a low K_m, it has a high affinity for its substrate and needs a lower concentration of substrate to reach V_{max} than the same enzyme in the presence of a competitive inhibitor. Candidates can consolidate their understanding by obtaining V_{max} and K_m from a graph. By doing this, they will see that K_m is a substrate concentration and not a rate of reaction.

- In **Question 2(e)(i)**, a common misunderstanding demonstrated by a number of candidates is to think that a length of DNA, a gene, is the genetic code for a particular polypeptide. Hence responses such as 'DNA has the genetic code for the polypeptide systemin' were seen, which could not be credited. Candidates should understand that the genetic code is related to triplets of bases that specify a particular amino acid, often given as messenger RNA (mRNA) codons, but also as DNA triplets and that a gene is a length of DNA coding for a particular polypeptide (which is the sequence of amino acids).

- Candidates should read the questions very carefully and plan their answers accordingly. Some answers included correct material, but not what was required to answer the question fully. For example, in **Question 3(b)**, candidates were asked to comment on the effect of the introduction of the vaccine and antibiotics on the number of new cases and deaths from tuberculosis (TB). Many focused the majority of their answer on describing the patterns before the introduction, while others described the complete range from 1925 to 2010 but did not mention the years when the vaccine and antibiotics were introduced.

General Comments

Many candidates were extremely well prepared for this exam and were knowledgeable of the syllabus and demonstrating an ability to apply knowledge and understanding to questions set in an unfamiliar context, such as in **Question 2(e)(ii)** and **Question 5(c)**.

All candidates attempted **Questions 1**, **2** and **4**, and almost all attempted **Questions 3**, **5** and **6**. Candidates appeared to have sufficient time to answer the questions and those who left complete questions blank tended to be those that did not perform well overall. **Question 2(e)(iii)** was the most common part-question left blank. However, overall, very few part-questions were left blank.

In **Question 1(c)(ii)**, quite a number of candidates included information about the addictive effects of nicotine on the brain, when they were only asked to describe short-term effects on the cardiovascular system.

Question 2(e)(ii), was quite demanding for some candidates, often as they did not show understanding that proteases comprise a group of enzymes acting on proteins, which would mean that different proteases could act on different substrates and possess different shaped active sites.

Candidates were required to complete a diagram in **Question 4(b)** to show how a peptide bond forms between two different amino acids. Although there were many excellent answers to this question, some candidates tried to amend the diagram showing the two amino acids, despite there being a large space to encourage them to show the next step. When candidates are asked to complete diagrams of reactions, they should be discouraged from trying to modify the printed diagram that has been provided for them as a starting point.

In **Question 5(a)**, the extended responses were often detailed and of a very high standard. It was clear that many candidates had a good understanding of the process of semi-conservative replication. At the other extreme, there were some who wrote about transcription or translation. It may help to stress that replication in semi-conservative replication of DNA means identical copies, which rules out the synthesis of mRNA in transcription and the synthesis of a polypeptide in translation.

In **Question 6(a)**, several candidates did not pay attention to the instruction to show a hydrogen bond between two water molecules. This meant that only two water molecules should have been drawn and only one hydrogen bond shown.

Questions beginning with, for example, 'State one …' or 'Name two…', set a limit to candidates, who should not go beyond this in the hope of increasing their chances of success. Candidates should be aware that this may actually have the opposite effect if they include an incorrect answer. **Question 2(b)** and **(c)** and **Question 4(c)** were examples of this type of question.

Comments on Specific Questions

Question 1

Candidate knowledge of syllabus Topics 8 and 9 was assessed in this question. This was a straightforward question and many candidates performed very well.

(a) The best responses addressed the complete question and explained both parts of the term closed double circulation. Where only partial credit was given, this tended to be for a good explanation of double circulation. Quite a few described double circulation in terms of a complete circuit around the body and noted that this required the passage of blood twice through the heart. Alternatively, some knew that the double circulatory system comprised the pulmonary and systemic circulatory systems, while others secured credit by a good description of these two systems. Weaker responses stated that 'double' meant the circulation of oxygenated and deoxygenated blood. For 'closed', candidates needed to state that blood was contained in blood vessels or that it was contained within three from arteries, veins, capillaries and the heart. It was not sufficient to state that it meant that blood did not leave the system.

(b) Quite a number of candidates successfully worked out the correct sequence of blood flow through the heart in one circulation. These candidates tended to be those who did well overall. Some were able to gain partial credit if part of the sequence was correct: the aorta followed by the vena cava or the left ventricle after the pulmonary vein, with the right atrium as number 5 in the sequence. A common error was to think that the aorta was the artery leaving the right ventricle, therefore incorrectly placing this in sequence after the right atrium.

(c) (i) A high proportion of candidates knew that the arteries have thicker walls than veins in order to withstand the higher (hydrostatic) pressure of blood, but only some of these went on to explain that this prevented the rupture of the blood vessel. A few gained full credit by writing about withstanding higher pressure and then explaining that there was more smooth muscle and elastic tissue, or by naming one of these tissues and explaining their role. Frequently candidates stated that arteries contain blood at higher pressure than veins, and should then have gone on to relate this to the ability to withstand the pressure. Some confused the role of the artery with the role of the ventricles of the heart and stated that arteries had thicker walls to allow the blood to travel further distances.

(ii) There were some very good responses here. Many knew about the formation of carboxyhaemoglobin and some went on to explain that haemoglobin has a greater affinity for carbon monoxide than oxygen. Accurate details included the permanent nature of the binding, leading to less haemoglobin being available to bind oxygen. Stating that there was less oxygen in the blood should have been qualified further by explaining that this was because there was a lower percentage saturation of the haemoglobin carried by the red blood cells or even to state that this meant blood had a reduced oxygen-carrying capacity. The most common correct answers to the effect of nicotine were the increase in heart rate and the increase in blood pressure. Not many wrote about the increased risk of blood clotting owing to the increased adherence of platelets: 'makes platelets sticky' was credited.

Question 2

This question used the theme of plant cells to assess syllabus material in Topics 1, 3 and 6. A calculation was included in this question and many candidates performed well and set out their working clearly.

(a) Some candidates gained partial credit initially by setting out the formula that they would use to make this calculation very clearly, and went on to make the correct calculation to gain full credit. It was clear that they had measured the length of the scale bar and divided this by the printed actual length of 10 μm. Some did get the correct answer by calculating the magnification of the image in **Fig. 2.1**, having firstly calculated the actual diameter of the cell after measuring both the length of the scale bar and the diameter of the cell. This was a much lengthier process that made it more likely for errors to be introduced.

(b) Generally, those who correctly identified the vacuole as structure **X** went on to give a correct function. The most common incorrect answer was the nucleus.

(c) Almost all candidates could name at least one structure visible in the cell in **Fig. 2.1** that contained DNA. The most easily visible structures were the nucleus and the chloroplasts, but the much smaller mitochondria were also present.

(d) Some candidates realised that they needed to use their knowledge of the general structure of viruses and apply this to the plant virus in **Fig. 2.2**. Others seemed to have studied the diagram and tried to match **A** and **B** to other molecules or structures they had learned about in their studies, with much less success.

(e) (i) Many candidates stated that messenger RNA (mRNA) was synthesised, as a stage in the production of the polypeptide. Some also knew that the role of DNA, by consisting of a sequence of nucleotides, was to code for a particular polypeptide and so were able to state that DNA codes for systemin. In a well-organised response, this appeared as the first statement to reflect the flow of information from DNA to mRNA to polypeptide. Some spent time describing translation, which was not the focus of the question.

(ii) Good answers showed a sound understanding that there are different proteases that have active sites of different shapes and hence may be affected differently by a particular competitive inhibitor. Some stated that serpin had a similar shape to the active site of herbivore proteases, rather than a complementary shape, so could not be credited. Others could have improved their answer by providing greater detail, for example, stating that 'serpin fits the herbivore enzyme' is lacking the reference to the active site. Some wrote in detail about the mechanism of action of a competitive inhibitor and needed to address the actual question.

(iii) This proved to be a demanding question for many candidates and those producing high quality answers tended to be those that did very well overall and showed a good understanding of the meaning of K_m. Many candidates thought that a higher value meant that there was more inhibitor present.

Question 3

This question was based on the infectious disease tuberculosis (TB) and assessed Topics 10 and 11. The graph that was in **Question 3(b)** was quite detailed and some candidates made good use of the command term 'comment' to gain full credit.

(a) Generally, only candidates who performed well overall could correctly name and spell one of the two species of bacteria that caused tuberculosis. '*Micobacterium'* and '*Microbacterium*' were seen on a number of occasions. Some were close and should have written the name out in full, for example *M. bovis* should have been written as *Mycobacterium bovis*. Others stated 'bacterium', which is the type of causative organism. Some produced a name that was a mixture of the other infectious pathogens studied in syllabus Topic 10, such as *Myoplasmodium* and *Morbillibacterium*. Some very weak responses gave modes of transmission of the pathogen or named the lungs as organs of the body that were affected.

(b) Some candidates were able to study **Fig. 3.1** and produce a varied response that described accurately the changes occurring over the years, especially in the years leading up to the

introduction of the antibiotics and the vaccination, as well as make suggestions as to why these changes occurred. Others could have improved their response by:

- matching up the trends described to the corresponding years
- noting that there was little change in numbers of new cases for a short time after the introduction of the antibiotics and vaccination, and little change in numbers of deaths for a few years after the introduction of antibiotics
- noting that the trend of deaths was already decreasing before the introduction of the vaccination
- supporting ideas with comparative data extracted from **Fig. 3.1**
- noting that the number quoted for the *y*-axis was per 100 000 population
- checking that the year of introduction for the antibiotics was 1940 and the vaccine was 1948, rather than the other way round
- suggesting explanations for the effects seen after the introduction of antibiotics and the vaccination.

(c) There were some who knew and understood the difference between a person who has the status HIV+ and a person with HIV/AIDS. These pointed out that a proportion of HIV+ people shown in **Table 3.1** could have developed HIV/AIDS and so would have a weakened immune system. Many stated that an HIV+ person has a weaker immune system than an HIV– person, which is not accurate. While the question asked for suggestions as to why the number of deaths per 100 000 population of people who are HIV+ is much higher than that in people who are HIV–, candidates were told that they had to use the information in **Table 3.1**, which provided them with the link to TB. The best responses referred to TB when presenting their suggestions.

Question 4

Overall, this question was the most accessible of the six main questions. It was based mainly on syllabus Topic 2 and drew on some knowledge from Topics 4 and 6.

(a) **Table 4.1** was completed correctly by many candidates. Most paid attention to the instruction to place ticks and crosses in the table. Where only partial credit was gained, different candidates gained credit for different molecules, so no obvious pattern of difficulty was gauged.

(b) Many were confident in completing **Fig. 4.1** to show a structurally correct dipeptide, as well as the loss of the water molecule to indicate the condensation reaction that takes place in the formation of a peptide bond. Some drew a correctly formed dipeptide and should have remembered to show a water molecule as an additional product. Common errors in showing a peptide bond were to leave an oxygen atom, or an oxygen atom and a hydrogen atom between the carbon and nitrogen of the two amino acids.

(c) A high proportion of candidates were able to state at least one correct function for the glycoproteins in cell surface membranes. Some repeated their idea for the second function, for example, stating that the glycoprotein acts as an antigen, and then stating that it acts in cell recognition. Some could have improved their response by giving more detail. For example, stating that the glycoproteins supplied stability should have been further qualified by explaining that hydrogen bonds were formed with water. Quite a few did not read the question properly and stated a function involved with transport.

Question 5

Candidate knowledge and understanding of syllabus Topics 5 was assessed in this question, with knowledge of chromosome structure from Topic 6. Many found **Question 5(c)** to be quite challenging and overall this question was the second most demanding after **Question 6**.

(a) Some exceptional accounts of DNA replication were seen for this extended response, with some candidates proving to be knowledgeable beyond the requirements of the syllabus and having no problem in gaining full credit. Where DNA polymerase was mentioned, credit was given for knowing that it catalyses the polymerisation reaction and not for unwinding the DNA molecule, which involves DNA helicase. Stating that the molecule ‘unzips’ should be explained as the breaking of hydrogen bonds between the complementary bases of the two strands, and it should be made clear that each exposed strand acts as a template. The points least frequently seen were

a description that this is a step-wise process and that the entire lengths of the DNA template strands are copied. Some were unclear as to the complementary bases and a number paired adenine with uracil.

(b) Telomere, or a very close spelling of telomere, was correctly given by many candidates. The most frequently noted incorrect answers were chromatid and centromere.

(c) (i) Some candidates knew that both adenine and guanine are purines to gain credit.

(ii) Few candidates were aware of the main differences in structure between purines and pyrimidines or realised that the difference in structure meant that there would be a distortion in the section of the DNA molecule formed where the mutation had occurred. Some good responses also noted that the repair mechanism was more likely to spot a transversion event owing to this greater mismatch of paired bases. Most incorrect answers suggested that there were fewer bases that could take part in a transversion event than a transition event, so reducing the chances of the event occurring.

(d) The strongest answers began with details of the type of mutation that could occur in the development of a tumour cell and then went on to give some detail of the conversion of a healthy cell to a tumour cell. Most gave a description of a tumour cell and frequently gained most of the credit by stating that uncontrolled division occurred and stating one other feature of a tumour cell, such as no programmed cell death. Poorer responses commented on fast division rather than uncontrolled division, or gave unnecessary details of carcinogens, or wrote about tumours rather than tumour cells.

Question 6

Syllabus Topics 2 and 7 were assessed in this question.

(a) Candidates who gained full credit answered exactly the question asked and drew two water molecules linked by a hydrogen bond. Each water molecule had one oxygen and two hydrogen atoms, with δ^- by the oxygen atom and δ^+ by the hydrogen atom. Candidates could use various means to symbolise the hydrogen bond. Many drew out the two water molecules and showed how a hydrogen bond would be formed. These would have gained full credit if they had shown the slightly negative and slightly positive charges which lead to the formation of the hydrogen bond. Some did remember this feature but only showed them as – and + when they should have written δ before the symbols. A large number of candidates would have benefited from checking their drawing of a water molecule as it was not uncommon to see the molecule drawn as two oxygen atoms attached to a single hydrogen atom. Some drew more than two (some many more) water molecules and hydrogen bonds.

(b) (i) The force of attraction between water molecules within xylem vessels was fairly well known. The most common incorrect answers were hydrophilic and adhesion.

(ii) Candidates who gained this mark not only identified the feature of water as latent heat of vapourisation (or latent heat of evaporation), but also remembered that the cooling effect is due to the high heat of vapourisation. Some stated high specific heat capacity while others mixed the two features so that 'high specific heat of evaporation' or variations of these were seen. The most frequent incorrect answers were evaporation and transpiration.

BIOLOGY

Paper 9700/31
Advanced Practical Skills 1

Key messages

- Candidates should be given the opportunity to experience a variety of practical work throughout the course in order to develop the skills that can be applied to the requirements of the examination.
- Candidates should be given the opportunity to use an eyepiece graticule to measure different tissues and use these measurements to help draw plan diagrams of organs.
- Candidates should be given the opportunity to draw both line graphs and bar charts. In this case, a bar chart was required. The bars should be plotted accurately and drawn exactly along the horizontal lines with a fine ruled line. All of the lines, both vertical and horizontal, should be sharp and unbroken.

General comments

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

Comments on specific questions

Question 1

(a) (i) Many candidates were able to carry out a serial dilution, showing the correct concentration below each beaker (0.025%, 0.0125%, 0.00625 and 0.003125%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of vitamin C (**V**) and the heading for volume of DCPIP with units (cm^3). The majority of candidates gained credit for recording the volumes for at least four concentrations of vitamin C. Many candidates recorded results which showed that the higher the percentage concentration of vitamin C, the higher the volume of DCPIP added to reach the end-point.

(iii) Most candidates correctly stated that a significant source of error when carrying out steps 3 to 9 was the difficulty of judging the colour change/end-point.

(iv) The majority of candidates correctly stated a volume of DCPIP to reach the end-point for **X**.

(v) Many candidates estimated the concentration of vitamin C in **X** correctly according to their results. The stronger candidates stated that the estimated concentration was between two known concentrations or was the same as one of the known concentrations.

(vi) The stronger candidates stated that preparing more known concentrations of vitamin C, closer to the estimated concentration of solution **X**, would allow a comparison of the volume of DCPIP needed for the end-point to be reached for sample **X** compared to the times for the known concentrations. The stronger candidates correctly stated that the volumes for the known concentrations could be plotted on a graph and the concentration of sample **X** could then be read off using the volume of DCPIP to reach the end-point for **X**.

(b) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (vegetable) and the *y*-axis (vitamin C content / mg per 100 g). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *y*-axis, used a scale of 20.00 to 2 cm and for the *x*-axis, even widths for each of the six bars.

The stronger candidates plotted the six bars accurately, in the order of the table (**K**, **B**, **R**) and drew the bars with thin lines. The most common error was drawing lines which were too thick.

(ii) Most candidates correctly calculated the percentage loss of the vitamin in broccoli. The stronger candidates showed all the steps in their calculations.

(iii) Some candidates correctly explained that the cell membrane may be destroyed by heating and that this would result in vitamin C being released from the broccoli cells. The most common error was to restate the stem of the question.

Some candidates correctly explained that at 49°C there was sufficient kinetic energy for many successful collisions between substrate and enzyme molecules resulting in more enzyme-substrate complexes forming, and at 70°C the enzyme may have denatured so the substrate could no longer bind to the active site of the enzyme resulting in fewer enzyme-substrate complexes forming.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the areas of tissue to include part of the epidermis, only two small outer vascular bundles and only one large inner vascular bundle. Many candidates gained credit for drawing subdivisions of the vascular bundles and the epidermis as two lines. Most candidates used a label line to correctly identify the xylem.

(ii) The majority of candidates used the eyepiece graticule correctly to measure **L** and **T**. The stronger candidates recorded **L** as being at least three times larger than **T**.

(iii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four cells from the epidermis, each cell touching at least one of the other cells, with double lines representing the cell walls. The stronger candidates gained credit for using their eyepiece graticule measurements obtained in **Question 2(a)(ii)** to draw the cells in the correct proportions. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing some cells which had convex walls on their upper surface. Most candidates used a label line to show the cell wall of one cell.

(iv) The majority of candidates were able to suggest the presence of stomata or large air spaces as a feature which supports the conclusion that this plant exchanges gases through its stem.

(b) Many candidates correctly measured the scale bar line. The stronger candidates recorded their measurements with the correct units (mm). Most candidates showed the correct conversion into μm. Most candidates then showed the division of the measurements by the 1460 μm and displayed the correct answer to the appropriate degree of accuracy.

(c) Credit was awarded to candidates who annotated **Fig. 2.2** by drawing three label lines and describing next to each line how this feature was different to **J1**. The common errors included labelling more than three differences and drawing a comparison table instead of annotating the diagram.

BIOLOGY

Paper 9700/32
Advanced Practical Skills 2

Key messages

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

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

Candidates should be able to measure area using a grid, counting a half square or more within the grid as one whole square and not counting those squares that were less than half a square. When calculating the area of the xylem tissue or the area of the vascular bundle using a grid placed over a photomicrograph it is necessary to indicate on the grid each of the 1 cm × 1 cm squares included in the calculation.

General comments

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

Comments on specific questions

Question 1

(a) (i) Many candidates were able to carry out a serial dilution, showing the correct concentration below each beaker (0.03%, 0.003%, 0.0003% and 0.00003%) and transferring 1 cm^3 of the previous concentration to the next beaker and adding 9 cm^3 of distilled water to each beaker.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of **S** and the heading for time with units (seconds). The majority of candidates gained credit for recording the times for **W** (the control) and at least four concentrations of **S**. Many candidates recorded results which showed that the higher the percentage concentration of **S** the longer the time for the colour change. The stronger candidates recorded the times in whole seconds.

(iii) Most candidates correctly suggested that molecule **S** may have reduced the activity of the enzyme by acting as an inhibitor, preventing the substrate from binding to the active site of the enzyme and reducing the formation of enzyme-substrate complexes.

(iv) The majority of candidates correctly recorded a time for solution **X** to reach the end-point.

(v) Many candidates estimated the concentration of molecule **S** in solution **X** correctly according to their results. The stronger candidates stated that the estimated concentration was between two known concentrations or was the same as one of the known concentrations.

(vi) The stronger candidates described the significant source of error as the difficulty of identifying the colour change of the litmus paper.

(vii) The stronger candidates stated that preparing more known concentrations of **S** by proportional dilution, closer to the estimated concentration of solution **X**, would allow a comparison of the time

taken for the red litmus paper to change to blue for the sample **X** compared to the times for the known concentrations. The stronger candidates correctly stated that the times for the known concentrations could be plotted on a graph and the concentration of solution **X** could then be read off using the time taken for the red litmus paper to change to blue for **X**.

(b) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (organism) and the *y*-axis (mercury concentration in tissue samples / ppm). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *y*-axis, used a scale of 10.00 to 2 cm and for the *x*-axis, even widths for each of the five bars. The stronger candidates plotted the five bars accurately, in the order of the table (F, C, B, O and R) and drew the bars with thin lines. The most common error was drawing lines which were too thick.

(ii) The majority of candidates correctly calculated the mean mercury concentration in the five organisms as 19.1.

Question 2

(a) (i) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the areas of tissue directly beneath the epidermis and only three vascular bundles. Many candidates gained credit for drawing subdivisions of the vascular bundles and the epidermis as two lines. Most candidates used a label line to correctly identify the xylem.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four cells from the central tissue, each cell touching at least two of the other cells, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing a cell which had at least five sides. Most candidates used a label line to show the cell wall of one cell.

(b) (i) The stronger candidates organised the table into three columns, with one column for features, one headed **M1** and one headed **Fig. 2.1**. Many candidates listed at least three observable differences between **M1** and **Fig. 2.1** such as the overall shape of **M1** was triangular and the overall shape of **Fig. 2.1** was circular.

(ii) Many candidates showed on the grid in **Fig. 2.2** all of the 1 cm × 1 cm squares that were counted and stated the area of the xylem and vascular bundle, with the appropriate units (cm^2).

(iii) The majority of candidates were able to calculate the area of the xylem tissue as a percentage of the area of the vascular bundle by showing the area of the xylem tissue divided by the area of the vascular bundle, multiplied by 100. Most candidates stated the answer to the appropriate degree of accuracy.

BIOLOGY

Paper 9700/33
Advanced Practical Skills 1

Key messages

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

Candidates should be encouraged to learn the methods for the tests for biological molecules as specified in the syllabus, including the Benedict's test. The volume of Benedict's solution must be the same or more than the volume of the sample being tested and the temperature of the water-bath must be maintained at 80 °C or up to 100 °C. As this test was being used to compare concentrations of reducing sugar in **S1**, **S2**, **S3** and **S4** the same temperature needed to be maintained for all the tests.

Candidates should be given the opportunity to use an eyepiece graticule to measure different tissues and use these measurements to help draw plan diagrams of organs.

General comments

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

Comments on specific questions

Question 1

(a) To show the changes in the concentration of reducing sugar as the starch enters the mouth and passes to the small intestine, the majority of candidates drew a line on the graph that started at the origin and went up to meet the broken line where it levelled out. Many candidates then correctly drew a horizontal line which went up at the end of the existing broken horizontal line.

(b) (i) Most candidates decided on using iodine solution to test for starch and correctly stated a number of drops or volume of iodine to add to a stated number of drops or volume of sample.

The majority of candidates correctly stated that they would record the colour and would determine which solution had the highest concentration of starch by observing which solution had the most intense blue/black colour.

(ii) Many candidates decided on using Benedict's solution to test for reducing sugar and correctly stated a volume to add to a stated volume of sample.

The majority of candidates stated that they would measure the time taken to the first colour change and would determine which solution had the highest concentration of reducing sugar by observing which solution took the shortest time to show a colour change.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. For the starch test, the stronger candidates included the heading for colour and gained credit for recording the colour change for each of the four samples. For the reducing sugar test, many candidates included the heading for time and seconds and gained credit for recording the time taken to show a colour change for each of the four samples. The stronger candidates recorded the times as whole seconds.

(iv) Most candidates used their results from **Question (b)(iii)** to correctly identify **S2** as the sample that contained a starch suspension which a person was about to eat, **S1** or **S3** as the sample from the mouth two minutes after being eaten, **S1** or **S3** as the sample from the stomach ten minutes after being eaten and **S4** as the sample from the small intestine two hours after being eaten.

(v) Many candidates correctly explained that the sample identified as being from the small intestine contained no starch as it had all been hydrolysed.

(c) To obtain a quantitative estimate of the reducing sugar concentration in a sample the stronger candidates stated that five or more known concentrations of reducing sugar solution needed to be prepared by proportional dilution. Many candidates then correctly compared the times for the first appearance of a colour change for the known concentrations with the times for the first appearance of a colour change of the sample. Some candidates correctly described that the times for the known concentrations could be plotted on a graph and the concentration of the sample could then be read off.

Question 2

(a) (i) The majority of candidates used the eyepiece graticule correctly to measure **L** to **Q**, **L** to **M**, **M** to **N** and **N** to **Q**. The stronger candidates recorded **M** to **N** as the lowest measurement and the sum of the measurements for **L** to **M**, **M** to **N** and **N** to **Q** added up to the measurement for **L** to **Q**.

(ii) Many candidates correctly stated that the measurement for the length of the cortex across the diameter was calculated by adding the measurement for **L** to **M** and **N** to **Q**. Most candidates correctly showed the calculation of the length of the cortex as a percentage of the diameter of the root by showing the measurement for the length of the cortex divided by the measurement for the length of the root multiplied by 100. The answer was stated to the appropriate degree of accuracy.

(iii) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the shaded area as shown in **Fig. 2.2**. Many candidates gained credit for drawing at least two layers of tissue. Credit was given to those candidates who had drawn the width of the stele in the correct proportion to the width of the root. Most candidates correctly drew the outline of the xylem and correctly identified and labelled the xylem.

(iv) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent cells from the central tissue, each cell touching at least two of the other cells, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing a cell which had at least five sides. Most candidates used a label line to show the cell wall of one cell.

(b) (i) Most candidates correctly used the heading given in the table to correctly label the *x*-axis (height / m). The stronger candidates, for the *x*-axis, labelled the origin 50 and used a scale of 10.00 to 2 cm. Many candidates plotted the five points as a line of best fit with a thin line. The most common errors were not labelling the scale every 2 cm and drawing lines which were too thick.

(ii) The majority of candidates correctly explained that water is transported through the xylem vessel elements by adhesion (the attractive force between water molecules and the cellulose of the walls of xylem vessel elements) and by cohesion (the attractive force between water molecules) whereby a column of water, as a result of transpiration pull, is transported upward.

BIOLOGY

Paper 9700/34
Advanced Practical Skills 2

Key messages

- Candidates should be given the opportunity to experience a variety of practical work throughout the course in order to develop the skills that can be applied to the requirements of the examination.
- Candidates should be given the opportunity to draw both line graphs and bar charts during the course. In this case, a line graph was required. All plots should be plotted accurately and the plots joined with a fine ruled line or curve. The line should be sharp and unbroken.
- Candidates should be given the opportunity to use an eyepiece graticule to measure different tissues and use these measurements to help draw plan diagrams of organs.

General comments

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

Comments on specific questions

Question 1

(a) (i) Most candidates were able to carry out a simple/proportional dilution, showing the correct volumes of both **M** and **W** to make the concentrations they had stated. Most candidates ensured there were at least four further concentrations making the total number of different concentrations at least five.

(ii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of **M** and the heading for time with units (seconds). The majority of candidates gained credit for recording the times for at least four concentrations of **M**. Many candidates recorded results which showed that the lower the percentage concentration of **M** the longer the time for the colour change. The stronger candidates recorded the times in whole seconds.

(iii) The majority of candidates correctly recorded a time in whole seconds for sample **U** to reach the end-point.

(iv) Many candidates estimated the concentration of molecule **M** in sample **U** correctly according to their results. The stronger candidates stated that the estimated concentration was between two known concentrations or was the same as one of the known concentrations.

(v) The stronger candidates stated that preparing more known concentrations of **M**, closer to the estimated concentration of solution **U**, would allow a comparison of the time taken for potassium manganate(VII) to change from pink to colourless for the sample **U** compared to the times for the known concentrations. The stronger candidates correctly stated that the times for the known concentrations could be plotted on a graph and the concentration of sample **U** could then be read off using the time taken for the potassium manganate(VII) to change to colourless for **U**.

(b) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (concentration of solution **M** / $\mu g\,cm^{-3}$) and the *y*-axis (inhibition area / mm^2). Some candidates,

however, labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *x*-axis, labelled the origin 0 and used a scale of 20 to 2 cm and for the *y*-axis, labelled the origin 0 and used a scale of 20 to 2 cm. Many candidates plotted the six points accurately and joined the points with a thin line. The most common errors were not using the correct scale and drawing lines which were too thick.

(ii) Most candidates used the graph correctly to estimate the inhibition area for a concentration of 46 $\mu g\,cm^{-3}$ of molecule **M** and they included the correct units.

(iii) Many candidates stated that there was a larger area of inhibition as the concentration of molecule **M** increased, however, some did not give any further detail. The stronger candidates explained that this area of inhibition was as a result of molecule **M** inhibiting the growth of the bacteria or killing the bacteria.

(iv) Many candidates made a correct reference to synthesis of the cell wall being affected and this could result in the bacterial cells lysing or bursting. Some candidates gained credit for suggesting that molecule **M** may have some effect on protein synthesis or DNA replication or may act as an enzyme inhibitor. The most common error was for candidates to restate their answer to **Question 1(b)(iii)**.

Question 2

(a) (i) The majority of candidates used the eyepiece graticule correctly to measure **T**, **L1**, **P**, **Q** and **L2**. The stronger candidates recorded **L1** and **L2** as the lowest measurements, **T** as the highest measurement and the sum of the measurements for **L1**, **P**, **Q** and **L2** added up to the measurement for **T**.

(ii) Many candidates correctly used the measurements of **T** and **P** or **Q** (whichever was the smallest). Most candidates correctly showed the ratio as a larger number to a smaller number to the lowest common denominator. The most common mistake was to express the final answer as one number and not a ratio; also, many candidates used **P** as the palisade layer regardless of the orientation of their slide on the microscope.

(iii) Credit was awarded to candidates whose drawings did not include any cells and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and only drawing the shaded area as shown in **Fig. 2.2**. The stronger candidates gained credit for using their eyepiece graticule measurements obtained in **Question 2(a)(i)** to draw the tissues in the correct proportions. Most candidates used a label line to correctly identify the palisade layer.

(iv) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four cells from the epidermis, each cell touching at least one of the other cells, with double lines representing the cell walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing some cells which had convex walls on their upper and lower surface, and inclusions present. Most candidates used a label line to show the cell wall of one cell.

(b) Credit was awarded to candidates who annotated **Fig. 2.3** by drawing three label lines and describing next to each line how this feature was different to **N1**. The common errors included labelling more than three differences and drawing a comparison table instead of annotating the diagram.

BIOLOGY

Paper 9700/35
Advanced Practical Skills 1

Key messages

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

Candidates should be given the opportunity to use an eyepiece graticule to measure different tissues and use these measurements to help draw plan diagrams of organs.

Candidates should be aware that the wording of questions often indicates how the candidate should respond. The word 'explain' may imply reasoning or some reference to theory, depending on the context. For example, when the question states to 'explain the difference in the absorbance of light between 49 °C and 70 °C', the candidate needs to explain why this happens, such as referring to kinetic energy and the formation of enzyme-substrate complexes at 49 °C. At 70 °C, candidates should refer to the shape of the active site changing, leading to the substrate being unable to bind and fewer enzyme-substrate complexes being formed.

General comments

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

Comments on specific questions

Question 1

(a) (i) Many candidates correctly stated the volume of water used to cover the Visking tubing.

(ii) Many candidates were able to carry out a serial dilution, showing the correct concentration below each beaker (0.50%, 0.25%, 0.125% and 0.0625%) and transferring 10 cm^3 of the previous concentration to the next beaker and adding 10 cm^3 of distilled water to each beaker.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for percentage concentration of reducing sugar (**R**) and the heading for time with units (seconds). The majority of candidates gained credit for recording the times for at least four concentrations of reducing sugar. Many candidates recorded results which showed that the higher the percentage concentration of reducing sugar, the shorter the time for the colour change. The stronger candidates recorded the times in whole seconds.

(iv) Most candidates correctly stated that a significant source of error when carrying out steps 12 and 13 was the difficulty of judging the first appearance of any colour change.

(v) The majority of candidates correctly recorded the time for the first colour change for the sample **X** and stated the appropriate units as seconds.

(vi) Many candidates completed **Fig. 1.3** by correctly showing the position of each of the percentage concentrations of reducing sugar solution that had been prepared in step 11.
Most candidates were able to show on **Fig. 1.3**, using the letter **X**, the estimated concentration of reducing sugar in the sample **X** according to their results.

(vii) The stronger candidates stated that preparing five or more known concentrations of reducing sugar solution, closer to the estimated concentration of the sample **X**, would allow a comparison of the time for the first appearance of a colour change when carrying out the Benedict's test on the sample **X**, compared to the times for the known concentrations. The stronger candidates correctly stated that the times for the known concentrations could be plotted on a graph and the concentration of the sample **X** could then be read off using the time for the first appearance of a colour change.

(b) (i) Most candidates correctly used the headings given in the table to correctly label the *x*-axis (temperature / °C) and the *y*-axis (absorbance of light by the coloured solution / arbitrary units). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates, for the *x*-axis, labelled the origin 30 and used a scale of 10.00 to 2 cm and for the *y*-axis, labelled the origin 0.6 and used a scale of 0.20 to 2 cm.

Many candidates plotted the five points accurately and joined the points with a thin line. The most common errors were not using the correct scale and drawing lines which were too thick.

(ii) Some candidates correctly explained that at 49 °C there was sufficient kinetic energy for many successful collisions between substrate and enzyme molecules resulting in more enzyme-substrate complexes forming, and at 70 °C the enzyme may have denatured so the substrate could no longer bind to the active site of the enzyme resulting in fewer enzyme-substrate complexes forming.

Question 2

(a) (i) Most candidates used the eyepiece graticule correctly to measure the depth of the leaf at **Y** and the depth of the vascular bundle at **Y**.

(ii) Many candidates correctly calculated the depth of the vascular bundle as a percentage of the depth of the leaf by showing the measurement for the depth of the vascular bundle divided by the measurement for the depth of the leaf, multiplied by 100. Most candidates stated the answer to the appropriate degree of accuracy.

(iii) Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing the shaded area as shown in **Fig. 2.2**. Many candidates gained credit for drawing at least three layers of tissue and showing the correct shape and proportion of the vascular bundle in relation to the depth of the leaf. Most candidates used a label line to correctly identify the vascular bundle.

(iv) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent xylem vessel elements from the xylem tissue with each element touching at least one of the other elements, with double lines representing the walls. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing a xylem vessel element which had at least five sides. Most candidates used a label line to show the lumen of one xylem vessel element.

(b) The stronger candidates organised the table into three columns, with one column for features, one headed **L1** and one headed **Fig. 2.3**. Many candidates listed at least three observable differences between **L1** and **Fig. 2.3** such as the shape of the vascular bundle on **L1** was curved and the vascular bundle in **Fig. 2.3** was oval.

BIOLOGY

Paper 9700/41
A Level Structured Questions

Key messages

- Scientific terminology should be used where possible to ensure credit can be awarded. Good examples are water potential for discussing osmosis in **Question 1(c)** and correct ecological terms such as habitat, niche and species in **Question 8(a)**.
- Candidates should be strongly discouraged from writing and partially erasing a pencil draft and then rewriting their answers over the top of this in ink. This can make parts of their answers illegible.
- Candidates should be aware that they cannot gain credit for writing about topics irrelevant to the question. For example, **Question 1(c)** was about osmoregulation, so answers about thermoregulation, although it is another example of homeostasis, were not creditworthy.

General comments

There were many very good scripts. Well-prepared candidates who read the questions carefully and were able to convey facts and ideas clearly achieved a high standard. Weaker candidates generally wrote with insufficient accuracy about what they were describing.

For example, some candidates did not make the crucial distinction between resistant poppies and normal red poppies in **Question 5(a)** and instead used the general term 'poppies'. Similarly, many did not appreciate that daisies and poppies are both weeds (as stated in the question introduction) so could not answer **Question 5(b)(iii)** effectively. Few candidates followed the instruction to give three decimal places in their answer for **Question 8(b)(iii)**.

The extended response questions were generally well answered. Knowledge of the operation of the glucose dipstick was particularly good, while many candidates had a thorough understanding of action potential transmission.

Candidates performed particularly well on **Question 7** and most also scored highly on **Question 4** and **Question 6**.

Comments on specific questions

Question 1

(a) Most candidates correctly defined homeostasis. Some missed out either the idea of constancy or the location, the internal environment.

(b) (i) Many answers were correct but a common error was to name the pelvis area, **A**, as the medulla.

(ii) Knowledge of the locations of functions and structures in the kidney varied so that the full range of available credit was awarded.

(c) Candidates who correctly differentiated between the roles of the hypothalamus in detecting changes in water potential and producing ADH, and the posterior pituitary gland in secreting ADH, often went on to achieve full credit.
Nearly all candidates mentioned aquaporins, although these were commonly misspelt as 'aquaporine'. A common misapprehension is that ADH causes pre-existing in-situ aquaporins to

open, rather than that ADH causes more aquaporins to be added to the cell surface membranes on the collecting duct (or distal convoluted tubule).

Since osmoregulation involves changes, any situation should be described as compared to the pre-existing situation before the event (such as ADH binding). Therefore, comparative statements were needed about ADH increasing cell membrane permeability and causing more water reabsorption.

The shrinking of osmoreceptors when blood water potential is low, and the nature and role of neurosecretory cells, were not well known. Those who attempted to describe the nervous communication between the hypothalamus and posterior pituitary often did not gain credit by referring to 'signals' and 'messages' being sent, instead of action potentials or impulses.

Question 2

(a) Most candidates correctly suggested that the coral polyps would produce carbon dioxide in respiration, resulting in a higher concentration available for photosynthesis by the algae. Some responses showed confusion between the animal coral and the photosynthesising alga. Plausible suggestions to do with higher temperature or increased availability of mineral ions were also credited. This question was comparative (between algae in polyps and free-living algae) and the suggestions needed to be clearly comparative too. For example, some responses did not explain that the concentration of carbon dioxide inside the coral polyps was higher than that available to free living algae.

(b) Chromatography was named as the method by most candidates. Many answers described making the pigment extract but did not give sufficient relevant detail about carrying out the chromatography process. Omissions included not placing the extract on a pencil baseline, and not ensuring that the solvent was below the baseline or pigment spot on the paper. Few candidates showed how an R_f value is calculated. Those who suggested spraying with a dye did not realise that pigments are themselves coloured. Stronger answers mentioned comparing the results with known R_f values.

(c) Good responses made use of both tables and noted that chlorophyll a and peridinin were the most abundant pigments, as well as stating that most pigments absorbed light best in the violet-blue range of the light spectrum. Weaker candidates did not relate the figures in **Table 2.2** to pigment molecules absorbing light. The strongest answers made it clear that the light absorption of the pigments affects the rate of photosynthesis in the algae, and that this affects growth of the coral hosts. However, the majority of answers made no distinction between the symbiotic algae and the corals involved.

Question 3

(a) Most candidates linked herbicide use on a resistant crop to increased crop yield due to less competition as weeds are killed. Errors included using the term 'herbs' or 'pests' for weeds. Some answers focused on the resistant crop surviving but did not explain the purpose of using the herbicide to kill or control weeds.

(b) (i) Most candidates could describe a plasmid as a small circle of DNA. Errors included thinking that plasmid DNA is single-stranded or describing the plasmid as a membrane-bound organelle.

(ii) Some candidates could supply further detail about plasmids, relating their features to their use in genetic modification. The commonest points were that plasmids have restriction sites and marker genes and that their small size allows them to be taken up by bacteria.

(iii) Candidates showed good knowledge of the role of a promoter sequence. Errors included referring to DNA polymerase binding instead of RNA polymerase, and stating that the promoter is a separate protein or nucleic acid sequence that attaches to the DNA.

(c) (i) Most candidates calculated 28 correctly. The most common wrong answer was 56, where candidates omitted to divide the original diploid chromosome number by two to obtain haploid gametes for forming the hybrid.

(ii) Few candidates stated the most pragmatic method: spraying the plants with glufosinate ammonium and seeing which ones survived (these being the plants that had the bar gene).

Many answers partially described a molecular technique. Unexplained references to microarrays, marker genes and electrophoresis did not gain credit. Credit was available for a molecular method that was described in enough detail to potentially work.

(iii) Candidates found it difficult to relate sterility in the GM crop to the research results in **Table 3.1**. Many realised that sterile hybrids would not produce pollen but did not link this with inability to pass on the bar gene to wild relatives. Many candidates discussed the type 1 and type 2 hybrids without appreciating the relevance of the differences between the two in terms of competition with wild radish or with crops. The strongest responses focused on GM crop sterility preventing the formation of the type 2 hybrids, which had invasive characteristics of increased height and seed production, compounded by some inheriting the bar gene and resisting herbicide treatment.

Question 4

(a) Most candidates showed a good understanding of ATP generation during respiration and scored credit here. Some candidates did not follow the instructions and placed ticks and crosses or the number of ATP molecules in the table.

(b) Candidates performed well here and were able to integrate their knowledge of oxidative phosphorylation and chemiosmosis at the inner mitochondrial membrane to the question context of membrane ratios in the two groups of mice. Weaker responses either did not follow the line of logic through to its conclusion, or wrote an account of these processes that did not relate to the context of epicatechin. Repetition of the question stem 'exercise for longer', while in context, did not score credit, but saying that the extra ATP could be used so that muscles could contract for longer did gain credit. This indicated difficulty in moving from the biochemical to the physiological level of explanation.

Question 5

(a) Candidates who gained full credit gave an overview of the data rather than simply describing the graph one year at a time without summarising the overall trends. The two key facts required were that the percentage frequency of normal red poppies and daisies decreased while the percentage frequency of biotype X red poppies increased. Credit was available for quoting data. Many candidates did not distinguish between the two different types of poppy so had limited chances to gain credit as most of their statements were factually incorrect. Reading from the graph was not always accurate.

(b) (i) Many candidates recognised that the mutation changed the primary structure and thus the tertiary or 3D structure of the enzyme. Some recognised that the change in 3D structure meant that the herbicide could no longer inhibit the enzyme. Fewer candidates realised that the enzyme could form enzyme-substrate complexes normally in order to synthesise the amino acids required for growth.

(ii) Many candidates reiterated answers from the previous question and stated the effect on the enzyme rather than on the whole organism (biotype X red poppies). The candidates with the best understanding stated that the biotype X poppies were resistant to the herbicide.

(iii) This was a low-scoring question. The majority of candidates compared biotype X poppies to weeds and wheat, without acknowledging that the biotype X poppies were also weeds. Very few candidates understood from the relative percentage frequency figures in **Fig. 5.1** that as well as displacing daisies and normal red poppies in relative terms, the absolute number of weeds would increase with biotype X poppies growing unchecked. Hence the overall proportion of weeds would increase and the overall proportion of wheat would decrease. Weak answers included biotype X poppies competing for food, nutrients or unnamed resources with the wheat, and re-quoting figures from the graph. Some answers placed greater emphasis on the survival of the biotype X red poppies than in the growth of the wheat, which suggested limited appreciation of the importance of crop growth in providing food for the human population.

(c) Almost all candidates realised that a change of herbicide would decrease the abundance of biotype X red poppies. Some observed that the selection pressure which had favoured biotype X poppies had been changed or removed. Some candidates predicted that a new mutation could occur, but did not state that the mutation would be in a gene coding for a different enzyme. A few

candidates made the serious mistake of indicating that the new herbicide had a causal role in making a mutation happen.

Question 6

(a) (i) While many candidates could describe the role of tropomyosin accurately, others confused the roles of tropomyosin and troponin, or tropomyosin and actin. Candidates should use the names actin and myosin rather than thin and thick filament.

(ii) Descriptions of the role of myosin were variable. Errors included wrongly relating the sequence of events involving ATP to the stages of interaction between actin and myosin, not specifying myosin heads where necessary, referring to the active site of actin rather than the myosin-binding site, and referring to ATP synthase at the myosin head instead of ATPase.

(b) (i) This was well answered, with most candidates mentioning glucose and some also specifying glycolysis.

(ii) This was very well answered, with most referring to oxygen and aerobic respiration.

Question 7

(a) Most responses gave the correct phenotypes, pink and green.

(b) Most candidates answered this question well. Credit was lost for omitting to state the parents' phenotypes or a final reduced ratio of specified offspring phenotypes. Some candidates did not clearly show which genotype corresponds to which phenotype.

(c) Stronger candidates knew that the genes would be linked and some knew that independent assortment would not occur. Few worked out that the ratio would be different, with only two classes of phenotype. Those who mentioned crossing-over mostly said that it would be less likely than before, not realising that when genes are unlinked crossing-over is impossible (but that all the possible permutations of alleles are produced anyway by independent assortment).

Question 8

(a) There were many marking points available here, but many candidates did not gain high levels of credit as they did not use subject-specific words like habitat, niche, species, adapt and selection pressure. Candidates who linked biodiversity to the syllabus list of three ways of considering the concept produced the best responses. Genetic diversity was often mentioned but not always within the context of a single species.

(b) (i) Most candidates stated the null hypothesis that there would be no difference between the two sites. Answers stating there was no relationship, correlation or significance did not gain credit.

(ii) Credit was scored by most candidates here, although some reversed the figures for genera and species, or quoted large abundance numbers from **Table 8.1**.

(iii) Most candidates had some idea of how to use the formula to calculate Simpson's Index of Diversity, although some omitted the last step, subtracting from 1. The commonest errors were not to follow the instruction in the question and to use more or less than three decimal places, or to round to three decimal places incorrectly.

(iv) Most candidates deduced from their calculation that grazing increases diversity. Few candidates considered species evenness as well as richness.

Question 9

(a) This question was answered very well with the majority of candidates achieving full, or close to full, credit. The enzymes involved and the reactions that they catalysed were well known and the structure to the answers was generally clear and concise. The only detail not known was that the test is specific and only detects glucose, while few mentioned the problem of the dipstick urine test not giving the current blood glucose concentration.

(b) This was also well answered. Most referred correctly to the beta cells in the pancreas or the islets of Langerhans detecting high glucose. There was some confusion amongst candidates about the exact roles of muscle, liver, fat and brain cells in reducing blood glucose concentration.

Candidates need to take great care with spellings in this topic. A common error was to confuse glucagon and glycogen. Another common mistake was to use the word 'produce' when the correct term is 'secrete'. Insulin is produced in beta cells most of the time but when glucose concentration rises the stored hormone is then released or secreted into the blood. Some candidates confused glycogenesis and gluconeogenesis. Candidates sometimes gave a lot of detail on the role of secondary messengers which was not needed here.

Question 10

(a) Generally, candidates were able to describe the nucleus in a cell body, a long axon and the myelin sheath. The term 'dendrites' was often misapplied to the synaptic termini at the muscle end of the motor neurone, rather than just to the extensions on the cell body. Diagrams proved helpful, though were not essential. Where diagrams were included, the points they showed tended to be repeated again in the text.

A few candidates wrote about sensory neurones instead of motor neurones. Not all candidates were able to correctly name the cell body. Those who mentioned the inclusion of mitochondria or rough endoplasmic reticulum in the cell frequently did not state that these are present in large quantities.

(b) The strongest answers described the key ion channel and ion movements during the action potential. Candidates who did not make clear that they were describing charged ions of sodium and potassium lost credit, as did those with a poor understanding of the sequence of opening and closing of the sodium and potassium ion channels, or the direction of ion movements. A mistake that occurred fairly frequently was to describe ions as moving 'into the membrane' as opposed to into the cell or axon.

Some answers focused on the role of the myelin sheath in lengthening local circuits and enabling saltatory conduction. Understanding of hyperpolarisation, the refractory period and the unidirectional nature of impulse transmission was good.

Some candidates spent time unnecessarily writing at length about establishing or maintaining resting potential or about the events at a synapse.

BIOLOGY

Paper 9700/42
A Level Structured Questions

Key messages

In questions where candidates are required to apply their knowledge and understanding to give an explanation, candidates should be aware that copying introductory material in an answer will not be appropriate or sufficient for credit.

When a question is set in a context such as in **Question 3(c)**, candidates should take extra care and reread their response to ensure that they have answered the question.

General comments

Questions 4(b), **4(c)**, **7(b)** and **10** proved to be the most challenging on the paper. However, there were a reasonable number of high scoring candidates and a good range of credit was awarded.

Comments on specific questions

Section A

Question 1

(a) (i) This was frequently answered well, with a high proportion of candidates able to name pyruvate and carbon dioxide. The most common incorrect response was acetyl CoA, with oxaloacetate also occasionally appearing.

(ii) Most candidates were aware that NAD was involved in carrying hydrogen (or H^+ and e^-) which was released at the site of the ETC for oxidative phosphorylation resulting in the oxidation or dehydrogenation of NAD, and managed to gain full credit. A few candidates incorrectly associated reduced NAD with one of the stages of the Krebs cycle.

(b) There were many good answers here, and many candidates achieved maximum credit. Such answers referred to both carbon dioxide and lactic acid, and gave clear and correct descriptions of how these are removed from the blood, via the alveoli and liver respectively. However, irrelevant material frequently appeared, particularly descriptions of the processes in anaerobic and aerobic respiration that generate the waste products. This often took up all of the space provided for the answer before the actual question was addressed below the answer space. Other candidates wrote at length about urea and how it is excreted by kidneys.

Question 2

(a) This question was rarely answered well. Many candidates did not demonstrate detailed knowledge of this topic.

Example 1 – although most candidates were correctly aware of the increase in the rate of photosynthesis, only a minority succeeded in linking it to both the presence of chlorophyll or chloroplasts and the light dependent reaction.

Example 2 – candidates showed an awareness that the rate of photosynthesis would decrease, but many did not make the link between both the absence of chlorophyll, chloroplasts or thylakoids and failure of the light dependent reaction to take place.

(b) Some candidates gave excellent answers to this question, suggesting that they had first-hand experience of the technique, and presented good detail in a concise answer. However, the majority gave some incorrect descriptions of sequences – for example, putting the chromatography paper into the solvent first, and then drawing the pencil line on the paper, or marking the solvent front before even putting the pigment samples onto the paper. Some stated that a locating agent such as ninhydrin would be needed to see the pigment spots. Some thought that water could be used as the solvent.

Many could give the formula for calculating R_f values, but few candidates described how they would obtain the two values to put into this formula, by measuring the distances travelled by the solvent front and the pigments.

Some candidates showed confusion with other techniques. A few described electrophoresis. It was also quite common for answers to begin with a long description of how the pigments would be extracted, which was not relevant to the question.

(c) This was a challenging question, which required candidates to use higher order thinking skills to synthesise information provided in the text at the start of the question and in this section, together with the information presented in the graph and their own knowledge and understanding of photosynthetic pigments. Only a very small minority of candidates could do this. Few understood what was being shown in the graph, with many thinking that the solid line represented absorption of red light and the dashed line absorption of fluorescent light. This suggested that they had not carefully read, or had not understood, the information given in the introduction to this question part. Very rarely, candidates appreciated that the cyanobacteria had produced different pigments during their prior exposure to these two types of light, and this explained their different absorption spectra. Of the small number who did refer to pigments, many believed that red pigments absorb red light.

Question 3

(a) (i) Most candidates gained the credit here but there was a significant number of candidates who wrote an incorrect answer or used incorrect terms, like contract. A small number did not write any answer.

(ii) It was common for those candidates who gave the correct answer in **Question 3(a)(i)** to write the correct answer here.

(b) Many candidates had correctly learnt the whole sequence from the sarcoplasmic reticulum becoming depolarised to the power stroke of muscle contraction. Knowledge of voltage-gated calcium ion channels was demonstrated and few candidates made the error of incorrect use of Ca^{+} instead of Ca^{2+}. Only a small number of candidates used the term diffusion to describe the movement of the calcium ions or explained that the movement is down a concentration gradient to be awarded credit. Most candidates knew that the calcium ions bind to troponin, which changed shape and moved tropomyosin, which revealed the binding sites, to allow the myosin head to form a cross bridge and carry out the power stroke, which achieved maximum credit for this question. A few candidates confused the ions involved and some related the sequence for a synapse and outlined how the action potential arrived. A significant few referred to the active sites, rather than binding sites.

(c) Most candidates did not answer this question in the context as asked. Many stated correct biology as to how ATP was used but then did not go on to say how the lack of ATP therefore had an effect. On occasion candidates described three ways ATP was used, but then only one of these uses was explained to stop when ATP was absent, so the candidate gained little credit despite understanding the biology.

Question 4

(a) (i) A good number of candidates achieved full credit for this question, giving correct data quotes. Only a minority of candidates noted the general trend that there was no resistance to any of the herbicides at the start of use. The main reason, that was seen quite often, for credit not being awarded in this question was an incorrect figure used as the data quote. Candidates should be reminded that when quoting data, they need to quote accurately.

(ii) Many candidates effectively used the terms 'random' or 'spontaneous' when referring to mutation, thus gaining credit. Most candidates knew that the herbicide acted as the selection pressure with resistant weeds surviving, passing on their resistance allele to the offspring, causing an increase in the frequency of this allele, which must have happened over many generations. Some candidates were not clear that it was a resistant or mutant individual / allele and wrote in generic terms about advantageous individuals or alleles. Some weaker candidates incorrectly wrote that it was the resistant allele that survived. Unfortunately, many candidates mentioned mutations but incorrectly implied that the herbicide caused the mutations. Many candidates also referred to genes rather than alleles.

(b) (i) Many candidates did not state the correct numbers of base pairs as being 668 amino acids given in the question multiplied by three for the triplet code to give 2004. A minority of candidates also knew to take into account to add a stop codon to give a total of 2007. Some candidates incorrectly quoted the number of amino acids in the protein.

(ii) Many candidates deduced that it was the folding of the protein that needed explaining but did not give enough detail. Many wrote neutral statements that the tertiary structure would be affected but did not explain how. A number recognised that a shape change would prevent the binding of the inhibitor but did not say whether it was to the active site or an allosteric site. Only a minority of candidates said that after folding the substituted amino acids would be brought together. A good number of candidates mentioned that bonding would be different and some went on to add which bonds would be affected.

(c) This was a poorly answered question across all ability levels. The most common successful answer was that method 1 was an easier or cheaper method. A few candidates mentioned hybrid vigour or reduction in inbreeding depression and an increase in heterozygosity. Even fewer referred to an increase in genetic variation. Some of these candidates did not indicate an increase but stated a 'change in', which did not gain credit. For method 2 it was common for no credit to be awarded. Quite often candidates mixed up the sections and wrote the advantages for method 2 as disadvantages for method 1.

Question 5

(a) This question proved to be very demanding of candidates, who were required to interpret inheritance of dominant alleles with the data provided in the pedigree (family tree) that displayed presence of faulty *BRCA2* alleles and incidence of cancer. As such, gaining more than minimal credit was generally only open to candidates capable of high-level data interpretation as this required an acknowledgement that the data displayed evidence that both supports and does not support the hypothesis that a dominant faulty *BRCA2* allele increases the risk of cancer. Most candidates reported that individuals with cancer in the third generation had a parent with either the *BRCA2* allele or diagnosed with cancer. Many candidates acknowledged that there were two individuals in the second generation who had been tested and found to have the faulty *BRCA2* allele, but did not explicitly state that they did not go on to be diagnosed with cancer. Similarly, many assumed that all the individuals diagnosed with cancer must have the faulty *BRCA2* allele, despite being told that they had not been tested, therefore only a few candidates recognised that cancer in these individuals was not definitively linked to the faulty *BRAC2* allele, and this coincidence was only explicit in individual 15. Many candidates failed to gain credit by not making clear references to individuals in the pedigree to verify the points they were claiming. Few candidates realised the evidence provided a mixed picture and that the overall hypothesis is inconclusive.

(b) (i) Most candidates described the genome as representing all the genes or alleles, with very few recognising that the genome represents all the DNA of an individual, both coding and non-coding, and as such only a small number of candidates earned credit here.

(ii) Candidates had to state a type of cell found in the blood that contains DNA, and state that this cell contains DNA. Frequently, candidates stated either red blood cells or a cell type not found in the blood, and many candidates did not explain their reasoning if they did state white blood cells.

(iii) Many candidates had some appreciation of how a gene expression microarray could be used to detect the types of allele expressed. Most frequently candidates described the sample DNA being denatured into single stranded form to enable it to bind to the probes on the microarray, and good answers stated that this binding must be through complementary base pairing. A common error

was that candidates believed the probes to be fluorescently labelled rather than the sample DNA prior to hybridisation. Only stronger candidates described the detection phase using UV laser light, and so this recall question discriminated well between candidates across ability levels. Several candidates did not provide an answer to this question.

(iv) Most candidates were able describe both an advantage and a disadvantage for genetic screening for the *BRCA2* allele to earn full credit. Most stated that identification of the *BRCA2* allele would enable the patient to make a proactive choice, either by a lifestyle change or preventative treatment such as mastectomy, or to undergo more frequent screening for cancer. As a disadvantage, the dominant answer indicated fear, stress or worry anticipating that cancer would develop if found to be positive for the faulty *BRCA2* allele, and some candidates developed this line of thinking to state that cancer may not develop despite testing positive, as demonstrated by the pedigree. Some candidates also stated that genetic testing is expensive, and linked this to a potential negative result, although testing algorithms would prevent unnecessary screening. Several candidates did not understand the screening process however, believing that it would cause mutations and therefore cancer, as though the individual being diagnosed was subjected to UV radiation, rather than a sample taken from them.

Question 6

(a) This question was generally well answered with most candidates gaining maximum credit. The most frequent error was a mislabelling of the efferent arteriole, where candidates had to recognise it as the arteriole with the narrower diameter. Some poor labelling, particularly with respect to the location of the podocytes, often did not earn credit due to lack of clarity; candidates should be reminded of the need to provide precise labelling in these instances.

(b) Most candidates earned some credit on this question by describing various features of the epithelial cells in the proximal convoluted tubule that enable selective reabsorption. Marking points most commonly stated were the presence of microvilli, the cells containing many mitochondria, and tight junctions or descriptions thereof. Imprecise answers often quoted the presence of transport proteins and/or cotransporters, but did not recognise their increased presence in this cell type and location. Some answers merely provided a description of selective reabsorption at the Bowman's capsule, rather than the cellular features, and few answers gave sufficient features, such as the presence of aquaporins, to gain maximum credit.

(c) Most candidates earned some credit on this question. In general, candidates recognised that maintenance of a constant water potential is a homeostatic mechanism controlled by negative feedback, and either of these terms was credited. Similarly, most candidates correctly identified the key hormone as anti-diuretic hormone. Fewer candidates knew that this was detected by osmoreceptors, with many stating osmoregulators or a generic reference to the endocrine system. Where candidates knew the site of release of anti-diuretic hormone, they generally made specific reference to the posterior pituitary, although some again made vague references to the endocrine system.

Question 7

(a) Most candidates scored well on this question, correctly calculating the necessary genotype from the given phenotype, and proceeding to fill in a correct Punnett square. Some, however, did not give the phenotypes of the offspring, or count the required ratio. There were several candidates who did not state the correct parental genotypes, and thus gained little credit. Some candidates did not interpret the question correctly, and suggested some new gametes, and subsequent coat colours (or occasional bald cats or cats with no fur colour).

(b) Many candidates found this difficult, and just stated that allele **A** was dominant, sometimes bringing in the idea of linkage. Stronger candidates gave the idea of coding for a repressor protein, although a few suggested that the allele itself was the repressor. Those with this correct idea usually continued the argument to achieve full credit.

Question 8

(a) Most candidates could describe the use of quadrats in both areas. However, many incorrectly described systematic rather than random sampling. Few described the calculation of percentage

cover, most simply described the identification and counting of all the species found in the quadrats.

(b) (i) Many were not able to give 'family' as the correct taxonomic level. Incorrect answers were very variable, such as Eukarya, Animalia and worm.

(ii) Generally, this was a well-answered question. Most correctly used the phrase 'no significant difference' but a few referred to 'no significant correlation'.

(iii) Many candidates found it difficult to keep to three decimal places throughout this question. However, the value for Simpson's Index of Diversity was frequently credited.

(iv) Many candidates found this difficult. Most incorrectly stated that the diversity was greater under the bracken rather than mentioning that both areas had a similar value of Simpson's Index. More candidates were able to say that abundance was greater under bracken.

Section B

Question 9

Many well-prepared candidates were able to score highly in this question. However, few candidates achieved the maximum credit available for both parts.

(a) Many candidates provided good explanations of the mechanism by which guard cells open the stomata. Most understood that hydrogen ions would be pumped out of the guard cells although few mentioned the location of the pumps in the cell surface membrane, or just stated the cell membrane. Many recognised that the efflux of hydrogen ions would increase the negativity of the guard cell resulting in the opening of potassium ion channels and influx of potassium ions. Most stated that this would lower the water potential inside the cells causing water to enter by osmosis down a water potential gradient, resulting in the guard cells becoming turgid.

However, there was little mention of potassium ions entering the guard cell by facilitated diffusion, the influx of chloride ions or the role of aquaporins. While some explained that the volume of the guard cell would increase and the cell would expand, or swell, some incorrectly stated that the cell wall would expand. Some commented on the unequal thickening of the guard cell wall, although there were some inaccurate references to thick inner walls and thin outer ones.

(b) Explanations as to how and why the stomata respond to changes in the external environment were frequently less precise. Some simply listed the factors responsible for stomatal opening or closure without further clarification. These factors were often inaccurately expressed, such as increased temperature or wind speed resulting in stomatal closure, rather than high temperature or high wind speed. Nevertheless, most candidates explained that stomatal closure was necessary to reduce water loss by transpiration.

The effect of light intensity was sometimes poorly understood, with candidates stating that high light intensity would close the stomata to prevent transpiration and vice versa. There were also several references to day and night without any mention of light intensity. However, more able candidates were able to explain that the stomata would open in high light intensity to allow transpiration and gaseous exchange, with carbon dioxide diffusing into the leaf for photosynthesis and oxygen diffusing out. Hardly any candidates linked the increase in transpiration to the uptake of minerals and water for photosynthesis or turgidity.

Question 10

(a) Many candidates provided separate accounts of the roles of the endocrine and nervous systems in control and co-ordination in mammals, while stronger responses compared them. Most candidates understood that the endocrine system releases hormones into the blood whereas the nervous system transmits impulses along neurones. Many continued to add that the response is faster in the nervous system although short-lived compared with the slower, but longer-lasting, effect of hormone action. Fewer commented on the difference in transmission speed or that hormonal stimulation is more widespread.

Some candidates appreciated that nervous communication is electrical in nature whereas that of the endocrine system is chemical, although hardly any stated that nervous stimulation results in a response in either a muscle or gland. However, many were aware that hormones act on target organs or cells.

Few correct references to the location of hormone receptors being either on the cell surface membrane or within the cell were seen, although some candidates mentioned the neurotransmitter receptors on the postsynaptic membrane.

Most responses did not mention any similarities between the two systems: comments on both using chemicals or cell signalling were rare. Hardly any candidates mentioned a signal molecule binding to a receptor in both systems.

(b) Candidates were often confused as to the role of the chemoreceptor cell in the human taste bud in detecting stimuli. Only a minority stated that chemicals acted as stimuli or commented on the specificity of chemoreceptors. Few mentioned microvilli or papillae, or the role of the chemoreceptor as an energy transducer.

Some candidates understood that chemical stimulation would result in the diffusion of sodium ions into the cell leading to depolarisation, although reference to the membrane was often omitted. However, credit was frequently gained for recognising that the receptor potential would stimulate the opening of calcium ion channels and that the influx of calcium ions would trigger the movement of neurotransmitter vesicles towards the presynaptic membrane. Many also went on to describe the exocytosis of the neurotransmitter and its subsequent binding to receptors on the postsynaptic membrane to initiate an action potential in the sensory neurone.

Less able candidates described the effect of sodium ion influx in the initiation of an action potential in a sensory neurone directly, with no mention of the chemoreceptor cell.

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Paper 9700/43
A Level Structured Questions

Key messages

- Scientific terminology should be used where possible to ensure credit can be awarded. Good examples are water potential for discussing osmosis in **Question 1(c)** and correct ecological terms such as habitat, niche and species in **Question 8(a)**.
- Candidates should be strongly discouraged from writing and partially erasing a pencil draft and then rewriting their answers over the top of this in ink. This can make parts of their answers illegible.
- Candidates should be aware that they cannot gain credit for writing about topics irrelevant to the question. For example, **Question 1(c)** was about osmoregulation, so answers about thermoregulation, although it is another example of homeostasis, were not creditworthy.

General comments

There were many very good scripts. Well-prepared candidates who read the questions carefully and were able to convey facts and ideas clearly achieved a high standard. Weaker candidates generally wrote with insufficient accuracy about what they were describing.

For example, some candidates did not make the crucial distinction between resistant poppies and normal red poppies in **Question 5(a)** and instead used the general term 'poppies'. Similarly, many did not appreciate that daisies and poppies are both weeds (as stated in the question introduction) so could not answer **Question 5(b)(iii)** effectively. Few candidates followed the instruction to give three decimal places in their answer for **Question 8(b)(iii)**.

The extended response questions were generally well answered. Knowledge of the operation of the glucose dipstick was particularly good, while many candidates had a thorough understanding of action potential transmission.

Candidates performed particularly well on **Question 7** and most also scored highly on **Question 4** and **Question 6**.

Comments on specific questions

Question 1

(a) Most candidates correctly defined homeostasis. Some missed out either the idea of constancy or the location, the internal environment.

(b) (i) Many answers were correct but a common error was to name the pelvis area, **A**, as the medulla.

(ii) Knowledge of the locations of functions and structures in the kidney varied so that the full range of available credit was awarded.

(c) Candidates who correctly differentiated between the roles of the hypothalamus in detecting changes in water potential and producing ADH, and the posterior pituitary gland in secreting ADH, often went on to achieve full credit.
Nearly all candidates mentioned aquaporins, although these were commonly misspelt as 'aquaporine'. A common misapprehension is that ADH causes pre-existing in-situ aquaporins to

open, rather than that ADH causes more aquaporins to be added to the cell surface membranes on the collecting duct (or distal convoluted tubule).

Since osmoregulation involves changes, any situation should be described as compared to the pre-existing situation before the event (such as ADH binding). Therefore, comparative statements were needed about ADH increasing cell membrane permeability and causing more water reabsorption.

The shrinking of osmoreceptors when blood water potential is low, and the nature and role of neurosecretory cells, were not well known. Those who attempted to describe the nervous communication between the hypothalamus and posterior pituitary often did not gain credit by referring to 'signals' and 'messages' being sent, instead of action potentials or impulses.

Question 2

(a) Most candidates correctly suggested that the coral polyps would produce carbon dioxide in respiration, resulting in a higher concentration available for photosynthesis by the algae. Some responses showed confusion between the animal coral and the photosynthesising alga. Plausible suggestions to do with higher temperature or increased availability of mineral ions were also credited. This question was comparative (between algae in polyps and free-living algae) and the suggestions needed to be clearly comparative too. For example, some responses did not explain that the concentration of carbon dioxide inside the coral polyps was higher than that available to free living algae.

(b) Chromatography was named as the method by most candidates. Many answers described making the pigment extract but did not give sufficient relevant detail about carrying out the chromatography process. Omissions included not placing the extract on a pencil baseline, and not ensuring that the solvent was below the baseline or pigment spot on the paper. Few candidates showed how an R_f value is calculated. Those who suggested spraying with a dye did not realise that pigments are themselves coloured. Stronger answers mentioned comparing the results with known R_f values.

(c) Good responses made use of both tables and noted that chlorophyll a and peridinin were the most abundant pigments, as well as stating that most pigments absorbed light best in the violet-blue range of the light spectrum. Weaker candidates did not relate the figures in **Table 2.2** to pigment molecules absorbing light. The strongest answers made it clear that the light absorption of the pigments affects the rate of photosynthesis in the algae, and that this affects growth of the coral hosts. However, the majority of answers made no distinction between the symbiotic algae and the corals involved.

Question 3

(a) Most candidates linked herbicide use on a resistant crop to increased crop yield due to less competition as weeds are killed. Errors included using the term 'herbs' or 'pests' for weeds. Some answers focused on the resistant crop surviving but did not explain the purpose of using the herbicide to kill or control weeds.

(b) (i) Most candidates could describe a plasmid as a small circle of DNA. Errors included thinking that plasmid DNA is single-stranded or describing the plasmid as a membrane-bound organelle.

(ii) Some candidates could supply further detail about plasmids, relating their features to their use in genetic modification. The commonest points were that plasmids have restriction sites and marker genes and that their small size allows them to be taken up by bacteria.

(iii) Candidates showed good knowledge of the role of a promoter sequence. Errors included referring to DNA polymerase binding instead of RNA polymerase, and stating that the promoter is a separate protein or nucleic acid sequence that attaches to the DNA.

(c) (i) Most candidates calculated 28 correctly. The most common wrong answer was 56, where candidates omitted to divide the original diploid chromosome number by two to obtain haploid gametes for forming the hybrid.

(ii) Few candidates stated the most pragmatic method: spraying the plants with glufosinate ammonium and seeing which ones survived (these being the plants that had the bar gene).

Many answers partially described a molecular technique. Unexplained references to microarrays, marker genes and electrophoresis did not gain credit. Credit was available for a molecular method that was described in enough detail to potentially work.

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(a) Most candidates showed a good understanding of ATP generation during respiration and scored credit here. Some candidates did not follow the instructions and placed ticks and crosses or the number of ATP molecules in the table.

(b) Candidates performed well here and were able to integrate their knowledge of oxidative phosphorylation and chemiosmosis at the inner mitochondrial membrane to the question context of membrane ratios in the two groups of mice. Weaker responses either did not follow the line of logic through to its conclusion, or wrote an account of these processes that did not relate to the context of epicatechin. Repetition of the question stem 'exercise for longer', while in context, did not score credit, but saying that the extra ATP could be used so that muscles could contract for longer did gain credit. This indicated difficulty in moving from the biochemical to the physiological level of explanation.

Question 5

(a) Candidates who gained full credit gave an overview of the data rather than simply describing the graph one year at a time without summarising the overall trends. The two key facts required were that the percentage frequency of normal red poppies and daisies decreased while the percentage frequency of biotype X red poppies increased. Credit was available for quoting data. Many candidates did not distinguish between the two different types of poppy so had limited chances to gain credit as most of their statements were factually incorrect. Reading from the graph was not always accurate.

(b) (i) Many candidates recognised that the mutation changed the primary structure and thus the tertiary or 3D structure of the enzyme. Some recognised that the change in 3D structure meant that the herbicide could no longer inhibit the enzyme. Fewer candidates realised that the enzyme could form enzyme-substrate complexes normally in order to synthesise the amino acids required for growth.

(ii) Many candidates reiterated answers from the previous question and stated the effect on the enzyme rather than on the whole organism (biotype X red poppies). The candidates with the best understanding stated that the biotype X poppies were resistant to the herbicide.

(iii) This was a low-scoring question. The majority of candidates compared biotype X poppies to weeds and wheat, without acknowledging that the biotype X poppies were also weeds. Very few candidates understood from the relative percentage frequency figures in **Fig. 5.1** that as well as displacing daisies and normal red poppies in relative terms, the absolute number of weeds would increase with biotype X poppies growing unchecked. Hence the overall proportion of weeds would increase and the overall proportion of wheat would decrease. Weak answers included biotype X poppies competing for food, nutrients or unnamed resources with the wheat, and re-quoting figures from the graph. Some answers placed greater emphasis on the survival of the biotype X red poppies than in the growth of the wheat, which suggested limited appreciation of the importance of crop growth in providing food for the human population.

(c) Almost all candidates realised that a change of herbicide would decrease the abundance of biotype X red poppies. Some observed that the selection pressure which had favoured biotype X poppies had been changed or removed. Some candidates predicted that a new mutation could occur, but did not state that the mutation would be in a gene coding for a different enzyme. A few

candidates made the serious mistake of indicating that the new herbicide had a causal role in making a mutation happen.

Question 6

(a) (i) While many candidates could describe the role of tropomyosin accurately, others confused the roles of tropomyosin and troponin, or tropomyosin and actin. Candidates should use the names actin and myosin rather than thin and thick filament.

(ii) Descriptions of the role of myosin were variable. Errors included wrongly relating the sequence of events involving ATP to the stages of interaction between actin and myosin, not specifying myosin heads where necessary, referring to the active site of actin rather than the myosin-binding site, and referring to ATP synthase at the myosin head instead of ATPase.

(b) (i) This was well answered, with most candidates mentioning glucose and some also specifying glycolysis.

(ii) This was very well answered, with most referring to oxygen and aerobic respiration.

Question 7

(a) Most responses gave the correct phenotypes, pink and green.

(b) Most candidates answered this question well. Credit was lost for omitting to state the parents' phenotypes or a final reduced ratio of specified offspring phenotypes. Some candidates did not clearly show which genotype corresponds to which phenotype.

(c) Stronger candidates knew that the genes would be linked and some knew that independent assortment would not occur. Few worked out that the ratio would be different, with only two classes of phenotype. Those who mentioned crossing-over mostly said that it would be less likely than before, not realising that when genes are unlinked crossing-over is impossible (but that all the possible permutations of alleles are produced anyway by independent assortment).

Question 8

(a) There were many marking points available here, but many candidates did not gain high levels of credit as they did not use subject-specific words like habitat, niche, species, adapt and selection pressure. Candidates who linked biodiversity to the syllabus list of three ways of considering the concept produced the best responses. Genetic diversity was often mentioned but not always within the context of a single species.

(b) (i) Most candidates stated the null hypothesis that there would be no difference between the two sites. Answers stating there was no relationship, correlation or significance did not gain credit.

(ii) Credit was scored by most candidates here, although some reversed the figures for genera and species, or quoted large abundance numbers from **Table 8.1**.

(iii) Most candidates had some idea of how to use the formula to calculate Simpson's Index of Diversity, although some omitted the last step, subtracting from 1. The commonest errors were not to follow the instruction in the question and to use more or less than three decimal places, or to round to three decimal places incorrectly.

(iv) Most candidates deduced from their calculation that grazing increases diversity. Few candidates considered species evenness as well as richness.

Question 9

(a) This question was answered very well with the majority of candidates achieving full, or close to full, credit. The enzymes involved and the reactions that they catalysed were well known and the structure to the answers was generally clear and concise. The only detail not known was that the test is specific and only detects glucose, while few mentioned the problem of the dipstick urine test not giving the current blood glucose concentration.

(b) This was also well answered. Most referred correctly to the beta cells in the pancreas or the islets of Langerhans detecting high glucose. There was some confusion amongst candidates about the exact roles of muscle, liver, fat and brain cells in reducing blood glucose concentration.

Candidates need to take great care with spellings in this topic. A common error was to confuse glucagon and glycogen. Another common mistake was to use the word 'produce' when the correct term is 'secrete'. Insulin is produced in beta cells most of the time but when glucose concentration rises the stored hormone is then released or secreted into the blood. Some candidates confused glycogenesis and gluconeogenesis. Candidates sometimes gave a lot of detail on the role of secondary messengers which was not needed here.

Question 10

(a) Generally, candidates were able to describe the nucleus in a cell body, a long axon and the myelin sheath. The term 'dendrites' was often misapplied to the synaptic termini at the muscle end of the motor neurone, rather than just to the extensions on the cell body. Diagrams proved helpful, though were not essential. Where diagrams were included, the points they showed tended to be repeated again in the text.

A few candidates wrote about sensory neurones instead of motor neurones. Not all candidates were able to correctly name the cell body. Those who mentioned the inclusion of mitochondria or rough endoplasmic reticulum in the cell frequently did not state that these are present in large quantities.

(b) The strongest answers described the key ion channel and ion movements during the action potential. Candidates who did not make clear that they were describing charged ions of sodium and potassium lost credit, as did those with a poor understanding of the sequence of opening and closing of the sodium and potassium ion channels, or the direction of ion movements. A mistake that occurred fairly frequently was to describe ions as moving 'into the membrane' as opposed to into the cell or axon.

Some answers focused on the role of the myelin sheath in lengthening local circuits and enabling saltatory conduction. Understanding of hyperpolarisation, the refractory period and the unidirectional nature of impulse transmission was good.

Some candidates spent time unnecessarily writing at length about establishing or maintaining resting potential or about the events at a synapse.

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Key messages

- It is important that candidates read the questions carefully to take in the range of information provided. Highlighting key parts of the information can be one way of reinforcing the key points. The context of the questions will often be new to candidates but the principles tested will be familiar.
- Candidates should be given opportunities to practice aspects of investigation design and analysis of unfamiliar data throughout the course.

General comments

There was no evidence of any time pressure and the paper discriminated well.

Comments on specific questions

Question 1

This question was based around planning an investigation with associated ideas on analysis and evaluation.

(a) Many candidates understood that the reason for not telling the test subjects which drink was caffeinated was so that bias was not introduced subconsciously by the subjects, thus affecting the results. This was successfully expressed in a variety of ways. A few responses suggested it was to stop subjects from deliberately generating the wrong results, which was not appropriate.

(b) (i) The majority of candidates identified the variables correctly from the information given although a few wrote them the wrong way around or missed a second dependent variable. Given the nature of the information provided there were a range of ways the independent variable could be expressed provided it related appropriately to caffeine.

(ii) Many answers included irrelevant material, which may have been avoided with more careful reading of the material provided in the question. The hypothesis under test was that caffeine decreases reaction time and increases heart rate, and the method requested was to be based on one of the drinks in the information. Thus, details of a range of concentrations was not relevant and nor was comparison of different drinks.

Many candidates did not realise that in this type of investigation the size of the sample is important. It was expected that a minimum of 10 subjects (for each condition – with or without caffeine) would be used. Few responses indicated a method of making sure the candidates did not know which drink they were receiving. Various approaches to carrying out the procedure were acceptable in detail, but the underlying ideas credited were that the subject should not have taken any caffeine for at least 5 hours before the start of the whole investigation, that the investigation should be carried out with the subjects at rest and in isolation and that the measurements should be taken before taking caffeine and again no sooner than 45 minutes after taking the caffeine (and no later than 120 minutes).

In this investigation, there were important control variables and some candidates needed to be more selective and include only those relevant in this case. Thus, controlling the pH of the drink with a buffer or keeping its temperature constant in a water bath were not appropriate. The volume of the drink should be constant and the subjects should be as standardised as possible with regard

to age, mass, fitness and previous caffeine habits. Subjects should also all be of the same sex or there should be an equal balance of sexes.

Many mentioned calculating a mean but it was not always clear what data they were using for the calculation. Any investigation is likely to include some risk. In this sort of health study, it would be appropriate to ask subjects to fill in a health-related questionnaire and exclude those with certain conditions like caffeine allergy or possible epilepsy due to the flashing lights, amongst others.

(c) (i) Many candidates appreciated that there are various criteria that indicate the suitability of Pearson's correlation test for this data. Approximately normally distributed data which seems to show a linear correlation were commonly seen and credited.

(ii) The given value indicated that it was a negative correlation, and this again was well understood by the majority. A description of the negative correlation was equally acceptable.

(iii) Candidates generally appreciated the basic principles behind calculating degrees of freedom and a variety of approaches were credited. The answers needed to indicate how it might be calculated, not just give a figure. Errors included referring to number of subjects rather than number of pairs of data, as the figure they would subtract from. With *n* keyed in the table as the number of pairs of data it was best to subtract from *n* as most did.

(iv) The standard in this question was often good. Candidates showed understanding that in biological work the key probability level is 0.05 or 5% and that comparing the calculated value with the critical value in the table shows that the calculated value is significant if the calculated value for *r* is greater than the critical value from the table. For Pearson's linear correlation test it is the correlation value that is significant. References to significant differences or observed and expected were not correct.

(d) The responses here were not always precise enough. There were answers which indicated that only a small number of people were tested but did not make it clear that only one person was tested for each concentration. With only one person for each concentration, candidates needed to go on to explain that the variation in an individual's response to caffeine would not be accounted for.

(e) Some link between knowledge of synapse transmission and the information in the question was expected. There was some confusion between reaction time and response with candidates stating that if reaction time decreased then the rate of response would be slower. Good answers clearly stated that the effect of caffeine would be that acetylcholine levels remained high and linked this correctly to the data showing reduced reaction time.

Question 2

This question involved assessing an ecological sampling investigation and drawing conclusions from unfamiliar data.

(a) (i) This was successfully answered either by stating what the variable was that had been standardised or by describing how a given variable was standardised. Thus 'the number of times the populations were sampled' or 'the populations were sampled the same (10) times' were equally creditworthy. Successful answers required precision with language, for example, 'same time' needed to refer to number of times sampled, time of year or time of day.

(ii) An outline of the mark, release and recapture method was expected and often given. Ideas of counting beetles in quadrats or along transects is unsuitable for mobile animals.

(b) (i) The calculations were generally correct. A few candidates included decimals. Calculated figures should match others in the table.

(ii) Candidates needed to match two sets of data for this and the following question. Both questions were about the size of beetles and not population size. Thus, the key row in **Table 2.2** was the percentage row. The other two rows were raw numbers and thus were population size. Many candidates did understand this and were able to match the general trend of cooler temperatures, as shown in **Table 2.1**, matching higher percentages of large beetles (or the reverse).

c) The other conclusions asked for in the question were still related to beetle size and not population size and thus responses needed to be in that context. It required that candidates went deeper into **Table 2.1** to link the various rows of temperatures given to the percentage of large or small beetles.

(d) This question was about populations and asked for a prediction as to how climate change might affect populations. Many thought climate change is just global warming and thus only mentioned the change without linking it precisely to warmer (or cooler or wetter, etc.). The stated change needed to be comparative (e.g. 'warmer' rather than 'warm') and then linked to a possible population outcome in terms of changes in total number of beetles or changes in the proportion of the sizes.

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Key messages

- Candidates must ensure that they have read the questions carefully in order to understand the basis of the question. Although contexts may be unfamiliar the underlying principles are not.
- Candidates need to understand scientific method so they can apply this to devising a method for an experiment or identifying variables.
- Candidates need to know how to process the different statistical tests and how to formulate a null hypothesis for any of these tests from the information given.

General comments

Candidates appeared to have sufficient time to complete the examination paper. Most candidates were able to confine their answers to the space provided and few candidates omitted any part of a question. Candidates should take care to avoid the use of imprecise language when describing scientific measurements, for example in **Question 1(b)(iii)** 'same amount of drops' or 'leave for some time', rather than the more precise 'same number of drops' or 'leave for the same time.' If figures are used then candidates need to consider carefully what is appropriate for the context of the question, for example making 100 cm^3 of a solution when only a very small volume will be used.

Comments on specific questions

Question 1

This question was about measuring the effect of caffeine on the heart rate of *Daphnia*. Candidates were expected to explain how to make a standard solution of caffeine and then dilute this to give a suitable range of concentrations to test by modifying the basic experimental design given in the question. Identification of sources of error and evaluation of experimental results were also tested.

(a) Almost all candidates gave a correct answer. A few candidates reversed the independent and dependent variables.

(b) (i) A great many candidates gave a correct description of making the standard caffeine solution. There were, however, candidates who did not read the information carefully enough and so crushed the caffeine tablets and then weighed 100 mg of caffeine from the powder. Weaker answers also showed uncertainty in the use of units, for example, adding 1 dm^3 of water to the caffeine tablets, or using 100 cm^3 of water to make a 100 mg dm^{-3} dilution.

(ii) Many candidates appeared not to have realised that a mobile organism needs some way of being kept still on a microscope slide. Many of the suggestions were not creditworthy, for example 'keeping the *Daphnia* warm or comfortable' and 'absorbing the caffeine'.

(iii) Candidates were expected to produce a workable method that would give reliable results. Stronger answers showed logical sequencing so that dilutions were made, followed by the placing of *Daphnia* on a cavity slide and addition of the test solutions to different test organisms. These included a control, allowed time for *Daphnia* to acclimatise and then measured the heart rate. The best answers also included a method of recording the heart rate of *Daphnia* and suitable descriptions of standardising variables, although very few candidates knew that a cavity slide has a

very small volume, usually 0.4 mm^3. A stated volume of 1 cm^3 was allowed, but volumes of 10 cm^3 were quite common. Weaker answers often stated a method of dilution that did not match the concentrations quoted or referred to using the formula $c_1v_1 = c_2v_2$, which is not acceptable without any further information. These responses often omitted a control and chose inappropriate ways of standardising variables, for example, measuring the mass of a single 5 mm crustacean on a microscope slide, or in some cases in a tank of water. Candidates needed to think carefully about the information given about an investigation in order to suggest a feasible method, for example, as the *Daphnia* are immobilised on a slide, a graticule could be used to measure the length.

Very few candidates suggested a way of recording the heart rate, for example using a counter or a recording that could be replayed slowly. The majority of candidates counted the heart rate for one minute, which was the maximum allowed. Only a few candidates realised, from the information in **Table 1.2**, that keeping count for the high number of beats would be very difficult and suggested counting for 15 or 20 seconds.

Most candidates realised this was a low risk experiment, although credit was allowed for caffeine allergy and a suitable precaution. Relatively few candidates referred to any ethical considerations of using live animals. Credit was allowed for descriptions of suitable handling, but there were more examples of inappropriate methods, for example forceps and gloves, rather than suitable methods for a small crustacean, such as a dropping pipette.

Candidates who mentioned replicating the experiment did not always gain credit as they did not specify the minimum of three replicates or referred to an 'average' rather than a 'mean'. Candidates are expected to know the different types of average, in this case an arithmetic mean.

There were also a number of candidates who ignored the context provided and described methods for testing humans or small mammals using a caffeine containing drink.

The majority of answers, however, were lists of variables with descriptions and so could gain only limited credit. An answer in the style of a practical schedule was required that identifies the apparatus, with instructions on what to do in order to test the independent variable, standardise important variables and measure the independent variable.

(iv) Very few candidates suggested an acceptable source of error. The most common answers were related to human error in using equipment or controlling variables. Many referred to difficulty in counting the heart rate but did not explain why this might be a source of error, for example 'too fast to keep count', or counting and watching a timer simultaneously. The improvement for this was almost always 'repeat and take a mean' which would not address the source of error. Many candidates also referred to the drops as a source of error, but in the context of number of drops, rather than the size of a drop being inconsistent. The most common improvements were 'use the same number of drops' which does not remove the source of error and 'use a syringe to give the same volume', which would be acceptable if the error had been identified as the variable drop size. A common misconception was that the heart beat would be easier to count using high power magnification instead of low power.

(c) Many candidates answered in terms of human responses to caffeine, instead of commenting that the data was all from *Daphnia* and so could not be reliably applied to humans.

(d) (i) Almost all candidates gave a correct answer.

(ii) The majority of candidates gained some credit for this question. The most common correct answers referred to the narrow range of concentrations and the limited number of concentrations tested. Stronger answers noted that there was overlap in the data for two of the concentrations tested and in some cases used the figures to show that the increase in heart rate was not proportional to the increase in concentration of caffeine.

Question 2

This question was about the effect of temperature on the distribution of cyanogenic clover and using Spearman's rank correlation to find out the significance of any apparent relationship.

(a) The majority of candidates did not give creditworthy answers as they gave a null hypothesis more suited to the *t*-test such as 'no significant difference between the number of cyanogenic clover and

the temperature'. Candidates who did write a null hypothesis in terms of 'no correlation between' or 'no relationship between' were not credited as they did not include the word 'significant'. Some weaker answers did not appear to understand what is meant by a null hypothesis so their answers were often statements such as 'temperature does not affect the distribution of cyanogenic clover'.

(b) (i) While many candidates gained maximum credit for this question, there were also a large number who did not appear to know how to complete a Spearman's rank correlation table. Some of these candidates did correctly rank column three of the table, but did not gain credit for column six as the minus signs were omitted, making it uncertain whether the candidates had worked backwards from column seven. There were also candidates who had worked backwards from column seven, ending up with an incorrect rank order in column three of 8,2,7,6,7,3,3,8,9.

(ii) Most candidates completed the calculation correctly. A few used eight pairs instead of nine.

(iii) The majority of candidates gave a correct answer. It was not necessary to quote the critical value, but it needed to be for n=9, so some candidates lost credit by quoting the values for n=8. Some weaker answers showed confusion between significance and correlation as their answers stated that r_s must be significant because it was closer to 1.

(iv) Very few candidates gave a suitable suggestion for this question. The answer needed to be comparative and use the information given. The majority of candidates answered in terms of photosynthesis and enzyme activity, but did not then link this to greater growth of the cyanogenic clover. Some stronger answers made the connection between herbivore grazing being more common at higher temperatures so the production of cyanide would reduce grazing so more of these plants survived. A common misconception was that non-cyanogenic clover could not grow at higher temperatures.

Question 3

This question was about trapping voles in order to estimate the frequency of heterozygous voles in a population.

(a) The majority of candidates gave at least two creditworthy answers. The most common correct answers were the time of the study, the spacing of the traps and the number of traps. A few candidates misinterpreted the question and listed what should have been standardised, for example the size of the trap.

(b) Answers to this question showed a wide range of approaches from excellent, gaining maximum credit, to random sets of numbers and letters gaining no credit. Some candidates were clearly familiar with using the Hardy-Weinberg equation and had no problems, but the majority of candidates seemed uncertain about the main stages in the calculation. The three main errors which resulted in some loss of credit were:

- using the frequency of the homozygous brown voles as q, instead of the square root, causing the the value of p and $2pq$ to also be incorrect
- converting q^2 to a percentage and using this as q, again making p and $2pq$ incorrect
- using the correct value for q to obtain $2pq$ but then multiplying by 100 or 50 or 1000 to obtain the number of voles.

Other common errors which were not creditworthy were to use the genotype ratio of 1 homozygous dominant:2 heterozygous:1 homozygous recessive, or the phenotype ratio of 3 dominant:1 recessive.

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Key messages

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- Candidates should be given opportunities to practice aspects of investigation design and analysis of unfamiliar data throughout the course.

General comments

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Comments on specific questions

Question 1

This question was based around planning an investigation with associated ideas on analysis and evaluation.

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(b) (i) The majority of candidates identified the variables correctly from the information given although a few wrote them the wrong way around or missed a second dependent variable. Given the nature of the information provided there were a range of ways the independent variable could be expressed provided it related appropriately to caffeine.

(ii) Many answers included irrelevant material, which may have been avoided with more careful reading of the material provided in the question. The hypothesis under test was that caffeine decreases reaction time and increases heart rate, and the method requested was to be based on one of the drinks in the information. Thus, details of a range of concentrations was not relevant and nor was comparison of different drinks.

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to age, mass, fitness and previous caffeine habits. Subjects should also all be of the same sex or there should be an equal balance of sexes.

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