BIOLOGY

Paper 9700/11
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 2

Most candidates answered correctly. A minority of the weaker candidates incorrectly thought that a bacterium contains rough endoplasmic reticulum and Golgi bodies.

Question 3

The majority of stronger candidates chose the correct answer. However, many of the weaker candidates incorrectly thought that the cell membrane cannot form vesicles.

Question 6

This question proved to be straightforward for stronger candidates, who were able to select the reducing sugar from the options. However, many of the weaker candidates incorrectly thought that the answer was sucrose. The question describes the test for reducing sugars, not non-reducing sugars.

Questions 7 to 10 inclusive

These questions were all answered correctly by at least half of the stronger candidates, whilst less than a third of the weaker candidates answered correctly.

Question 11

Many candidates found this question difficult, with a minority being able to process this information and realise that the RNA ribozymes do not contain the same bonds as found in protein enzymes.

Question 13

The majority of candidates found this question difficult and did not understand all of the properties of non-competitive enzymes.

Questions 15 and 16

These questions were answered correctly by a third of all candidates, with the majority of stronger candidates showing a good understanding of both topics. In **Question 16**, the weaker candidates chose all options equally.

Question 24

Many candidates did not realise that mass flow would occur in all four of the listed vessels, rather than only in the plant vessels.

Question 28

Many candidates found this question difficult, although the majority of high achievers answered correctly.

Question 30

Many candidates found this question difficult, with a third of all candidates able to identify reaction **C** as correct.

Question 32

Less than a quarter of all candidates were able to identify the correct two statements about the human gas exchange system. Some candidates chose option C, which is incorrect because alveoli have squamous epithelium, rather than cuboidal and the cartilage in trachea and bronchi are incomplete rings rather than circles.

Question 39

More than half of all candidates and almost all of the stronger candidates answered correctly.

BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 3 and 5

The majority of all candidates answered these questions correctly, although many weaker candidates did not know the structural features present in prokaryotes or mitochondria.

Question 7

Many candidates incorrectly thought that the results indicated that non-reducing sugars must be present. This cannot be the case because the Benedict's test gave a brick red colour when testing for reducing and non-reducing sugars.

Questions 8 to 13 inclusive

These questions were all answered correctly by the majority of all candidates. Of the stronger candidates, at least two thirds answered correctly, whilst minority of the weaker candidates answered correctly.

Question 15

Stronger candidates were able to process the information provided to determine that the acidic conditions had caused the tertiary structure to be lost.

Question 18

Many candidates answered this question correctly. However, there were a significant number of candidates who had difficulty in processing the information given. The graph shows the rate of entry into the cell for substance X. From the graph, diffusion is occurring since the rate increases and then levels off when there is no concentration gradient. Pathways 1 and 2 both allow diffusion or facilitated diffusion to occur.

Question 21

The majority of candidates found this question difficult. Telomeres start with a fixed number of DNA sequences and some of these are lost with each cell division. Cancer cells have the enzyme telomerase in order to replace the lost DNA sequences.

Question 22

Most candidates answered correctly, with stronger candidates having little difficulty. The majority of weaker candidates found this difficult and were unable to answer correctly. If the DNA contains 700 bases (350 base pairs), all of which were C–G, there would be 350 × 3 = 1050 hydrogen bonds.

Question 23

The majority of all candidates found this difficult. Any DNA nucleotide (e.g. an adenine nucleotide) is always different from the equivalent RNA nucleotide, since one contains deoxyribose and the other contains ribose.

Question 30

Most candidates answered correctly, with stronger candidates having little difficulty. Weaker candidates found it difficult to select the correct explanation and chose all options almost equally.

Question 32

Most candidates found it difficult to fully process the information in the graph. Many thought that both valves would be open and the majority incorrectly thought that at least one of the valves should be open.

Questions 33 to 36 inclusive

The majority of all candidates answered these questions correctly, with the majority of higher achieving candidates finding them straightforward. Of the weaker candidates, many found these questions difficult and chose all options almost equally.

Question 38

Most candidates had no difficulty with this question and the vast majority correctly calculated the percentage decrease as 39.6%.

BIOLOGY

Paper 9700/13
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Question 1

Although most candidates answered correctly, many weaker candidates did not realise that a bacterium measuring 0.2 μm in diameter is the same as measuring 200 nm in diameter, so this would not be visible if a light microscope has a resolution of 220 nm.

Question 9

Most candidates answered correctly, with the stronger candidates having little difficulty. Of the weaker candidates, a minority were able to correctly process the information and answer correctly.

Question 10

The majority of candidates found this question straightforward, although some incorrectly thought that the scientists were studying the tertiary level.

Question 13

The majority of all candidates were able to process the information provided in order to determine that immobilisation stabilises the enzyme against denaturation.

Question 16

Most candidates answered correctly, with stronger candidates having little difficulty. Weaker candidates found the question more difficult and chose each option almost equally.

Question 21

The majority of stronger candidates knew that tumour cells would undertake rapid uncontrolled divisions, which means that the time cells remain in interphase becomes shorter. The majority of weaker candidates incorrectly thought that only tumour cells would have mutated DNA.

Question 24

Many candidates incorrectly thought that four genes would be required. One gene would code for α-globin and one gene would code for β-globin. Each gene can be transcribed and translated to make many molecules of each globin.

Question 26

The majority of all candidates answered correctly, but many of the weaker candidates were unable to answer correctly. If the DNA contains 700 base pairs, all of which were A–T, there would be 700 × 2 = 1400 hydrogen bonds.

Question 28

Most candidates answered correctly, with stronger candidates having little difficulty. Weaker candidates found the question more difficult and chose each option almost equally.

Question 29

Many candidates did not realise that mass flow would occur in all four of the listed vessels, rather than only in the plant vessels.

Question 34

Many candidates found this question difficult. The reaction of carbon dioxide with haemoglobin to form carbaminohaemoglobin involves carbon dioxide molecules, not dissociated carbon dioxide.

Question 35

Most candidates answered correctly but some did not realise that Y was muscle and not cartilage.

Question 36

Most candidates answered correctly but many of the weaker candidates incorrectly selected option **B**. The accumulation of mucus does not cause infection, this only occurs when pathogens become trapped in the mucus.

Question 39

The majority of all candidates answered correctly, with stronger candidates having little difficulty.

BIOLOGY

Paper 9700/21
AS Level Structured Questions

Key messages

In **Question 1(c)**, some candidates were confused between tissue repair and cell repair. 'Repair of damaged cells' is not a correct role of mitosis: candidates were given credit for stating that damaged cells are replaced or that damaged tissue is repaired.

Candidates should understand the difference between the name of an infectious disease, the causative organism (pathogen) and the type of causative organism. For example, in **Question 3(b)(ii)**, when describing how the pathogen is transmitted, a statement such as 'when people drink water with cholera' would not be credited. In **Question 3(b)(i)**, when naming the pathogen that causes cholera, the species name was required. The spellings of the names must also be correct. The first letter of the genus name must be upper case and the first letter of the species name lower case.

In **Question 6(c)**, candidates needed to know that the mitochondrion is the organelle that carries out aerobic respiration and so is important in the synthesis (production) of ATP. It is not correct to describe a molecule of ATP as energy in the form of ATP, ATP energy or ATP (energy). ATP is a molecule and not a form of energy. Hydrolysis of ATP provides energy for cell activities and because of this it can be described as the energy currency of a cell.

General comments

A number of candidates displayed a very good grasp of the syllabus learning outcomes and were able to do well on straightforward questions that assessed knowledge and understanding. Some were also very confident in applying knowledge and understanding to new situations. Many could have improved their performance in the questions of this type by organising their response in the context of the information provided, rather than giving main ideas on the general subject matter concerned. This was most evident in **Question 4(b)**, where many gave correct information regarding globular protein structure and also needed to refer to the detail in **Fig. 4.1** and incorporate the necessary information in their answer.

There was evidence in **Question 1** that some candidates needed to read all of the questions carefully. **Question 1(a)** remained unanswered by some candidates. In **Question 1(c)**, some candidates wrote about mitosis in animals when the question specifies mitosis in plants. In **Question 2(b)(iii)** many wrote only about differences even though the question asked for similarities and differences. In **Question 3**, candidates who gave the best responses understood what was meant by antigen, antibody and antibiotic. They also knew the difference between bacteria and viruses and were able to use the explanation provided about bacteriophages to suggest properties of bacteriophages that made them useful in the treatment of cholera.

Candidates appeared to have sufficient time to complete the paper. Overall the part-questions most frequently left blank by candidates were **Question 4(e)** and **(f)** on enzyme kinetics. **Question 5** proved to be the most accessible question for candidates.

Comments on specific questions

Question 1

This question assessed knowledge of mitosis from **Topic 5** and required candidates to apply knowledge and understanding of the light microscope and the electron microscope from **Topic 1**.

(a) Of those who placed a circle round a cell in **Fig. 1.1**, the majority were correct in identifying the one cell in the anaphase stage of mitosis.

(b) Many candidates were able to give at least one advantage of using the light microscope to study mitosis. Most of these knew that using the light microscope allowed the tissue to remain living. Fewer explained that this meant the process of mitosis could be observed. Some gave advantages of the light microscope that were more general in nature and could be credited if relevant. Some weak responses gave advantages of the electron microscope instead or incorrectly stated that the light microscope allowed a higher resolution of image to be obtained.

(c) Most candidates gained some credit here, usually with knowledge that mitosis is important for tissue repair and the replacement of dead or worn-out cells. Generally, those gaining full credit also correctly stated asexual reproduction. There were only a few who noted the importance in producing genetically identical cells. Some candidates stated growth as part of their response, despite being asked for three other ways in which mitosis is important in plants. Others wrote about animal cells and the importance of mitosis in the immune response. Weak responses appeared to have misunderstood the question and gave examples of growth in plants, such as more cells for photosynthesis or more cells to allow the root to grow into the soil.

Question 2

Candidates used knowledge and understanding from **Topic 8** in this question. Many found **Question 2(b)** to be particularly challenging.

(a) There were a number of features on **Fig. 2.1** that provided candidates with the evidence that the blood vessel was a capillary. Candidates who correctly identified the capillary usually went on to give two reasons for their identification. Good responses avoided being vague and used the correct terminology. For example, the scale bar was used to estimate the diameter of the vessel in the order of 7 μm rather than stating it was a small size and the vessel was described as having a single celled wall, rather than stating that there was a thin tunica media, which was incorrect. A large proportion of candidates incorrectly identified the vessel shown as either an artery or a vein.

(b) (i) A few candidates showed a good understanding of blood pressure changes in the cardiac cycle graphs and knew how to interpret the graph to find the time when the semilunar valve closes. It was important to also state the correct units. Those who did state a time that was not correct frequently gave either 0.08 s, just before the pressure in the right ventricle started to increase or 0.12 s, where the two curves crossed.

(ii) Generally, candidates who did well in **Question 2(b)(i)** also knew how to use the graphs to find the time when the right ventricle begins to contract.

(iii) This proved to be a good discriminator with a wide range in the quality of responses seen and the strongest tended to be from the candidates who did well overall. Where partial credit was given, this was usually for knowledge that the right ventricle pumps blood to the lungs and the left ventricle to the rest of the body. Very few were able to correctly state the similarities and differences that would be seen in the graph of left ventricle blood pressure during the cardiac cycle and many thought that the curve of the left ventricle would increase after that of the right ventricle. Some also described what would be seen with a curve for the aorta, which was not required.

Question 3

This question, based on subject material from **Topics 10** and **11**, had a number of parts that required candidates to apply knowledge and understanding to an unfamiliar situation. Many candidates had greater difficulty with these part-questions than those asking for straightforward recall of knowledge.

(a) (i) Some candidates were precise in naming plasma cells or B-lymphocytes as those producing antibodies. As the question asked for the type of cell, lymphocytes, leucocytes or white blood cells were also accepted. The most common incorrect answer was T-lymphocyte. Macrophage was also seen.

(ii) There were some good attempts at describing how the structure of an antibody molecule allowed it to be specific for one antigen. Although in the context of antigen **H** and antigen **N** of the influenza virus, some understood that they needed to think about features of antibody structure to function. The most common error was to use the term receptor, either stating that an antibody molecule had a receptor or stating that binding took place with the receptor on the antigen. Some included in their response reference to the hinge region and constant region of the antibody molecule. This was not relevant to the question.

(b) (i) The spelling of the name of the organism that caused cholera needed to be correct in order to gain credit, and many were able to do this. Some did not write out the full genus name, while others stated cholerae bacterium. *Escherichia coli* was also seen on a number of occasions.

(ii) There were some fluent accounts of the transmission of the cholera pathogen. These included taking care with the use of terms. The infected person was described as passing out faeces rather than using the term waste and terms such as 'dirty water' were avoided in favour of 'contaminated drinking water'. It was important to describe how the pathogen entered the body, so terms such as drinks, eats, ingests or takes in were used to help secure credit.

(c) (i) The strongest responses focused on the structural features of the bacterial cells that would be damaged sufficiently to result in lysis. Many, however, speculated on how a virus might infect the cell and alter the metabolism of the cell but did not link these with weakened bacterial structures and cell lysis.

(ii) Strong responses showed an understanding that a treatment for cholera needed to be specific to the causative organism and hence not affect commensal bacterial species or human cells. Others were more vague and repeated the information provided in a slightly different way, stating that bacteriophages needed to kill the pathogen. Some suggested that a feature of a bacteriophage should be that the phage would be destroyed after infecting the cell, which would only allow a proportion of the infective bacterial cells to be eliminated.

(iii) Many knew that antibiotics were effective against bacterial cells and so would not be effective against the virus that causes measles. Some weak responses answered from the point of view of difficulties faced in developing vaccines and suggested that *Morbillivirus* had changing antigens. Others considered antibodies and suggested that viruses were inside cells and were out of reach of the immune system.

Question 4

Question 4 mainly assessed application of knowledge and understanding to subject material from **Topics 2**, **3** and **6**. Both of the extended responses in this question required candidates to use AO2 skills (handling information and solving problems). **Question 4(d)**, using graphical data, appeared to be more accessible than **Question 4(b)**, where candidates had difficulty in describing how the three R groups in **Fig. 4.1** contribute to the globular structure of a protein.

(a) A very wide range of definitions of a STOP codon was seen. Some gave good explanations of the term, generally gaining credit by referring to the termination of translation. Some candidates suggested that the STOP codon prevented the synthesis of amino acids or that it meant the polypeptide chain would terminate prematurely. Others wrote about termination of transcription or preventing mutations from occurring.

(b) Stronger responses gained full credit by describing features of a globular protein and by making correct reference to the three R groups in **Fig. 4.1** of the named amino acids. These recognised the hydrophilic nature of the R groups of Asp and Gln and the hydrophobic nature of the R group of Ile and so could show how these would contribute to the globular structure of a protein. Some mentioned R groups but made general points, such as explaining that they were important for the tertiary structure of a protein, or by naming bond types and did not focus on globular proteins.

(c) This question was generally well answered and many knew that glycosidic bonds are present in starch. Where credit was not given, this was usually for stating peptide or hydrogen bonds.

(d) Many of the points required candidates to be accurate in extracting values from **Fig. 4.2** and generally candidates did give the correct data. Some did not give the units for temperature. Some did not read the scale on the *y*-axis correctly and so gave 8.1 au and 7.25 au for the activity of each

enzyme at the optimum temperatures, or 1.2 au at 20 °C for the immobilised enzyme. The best responses made comparative statements and supported these with the extracted data. A number tried to explain the results in **Fig. 4.2**, which was not required. For example, reference was made to an increase in kinetic energy with an increase in temperature and the decrease in activity of both enzymes after the optimum temperature was frequently described as denaturation having occurred, despite both enzymes showing activity. Most responses concentrated only on differences between the results for the free and immobilised enzyme and only a few noted that both showed activity over the range of temperatures tested and a peak of activity at the optimum temperature.

(e) Some candidates gave precise responses to earn credit. Others realised that the Michaelis-Menten constant was referring to the substrate but did not state that this was the substrate concentration that gives ½V_{max}. Others gave responses relating to enzyme activity and not substrate concentration.

(f) Those candidates who gained full credit showed an understanding that an enzyme with a lower K_m value has a higher affinity for its substrate and explained that a lower concentration of substrate would be required to reach V_{max}. There were few who gave suggestions as to how immobilising the enzyme may affect the reaction and hence affect the K_m value. Most of those who gave incorrect answers equated a high value with high activity.

Question 5

Many candidates did very well on **Question 5**, much of it based on syllabus material from **Topics 1** and **4**. The question included a magnification calculation. Although many knew the formula to use to calculate magnification, only some of these were able to apply this formula to arrive at the correct calculated value.

(a) (i) The majority correctly identified the organelle in **Fig. 5.1** as the Golgi body/apparatus/complex. Responses naming two organelles were not credited with the exception of those who wrote Golgi body and Golgi vesicles, as these could be seen arising from the main organelle. The most common incorrect answers were endoplasmic reticulum and rough endoplasmic reticulum.

(ii) Most knew that animal and plant cells contain Golgi bodies. The most common incorrect response was to tick only the animal cells box.

(b) Although candidates were asked to find the magnification of the image in **Fig. 5.1**, they only needed to use the scale bar provided. Many candidates realised that the length of this bar is the equivalent of an image length and as the actual length of the scale bar was given, there was only one step needed to obtain the correct magnification. Some candidates gave the correct formula but then used a much longer method to attempt the calculation. Here, measurements were taken from a variety of lengths within **Fig. 5.1**, with some measuring the length of the bracket **X**. Some candidates made errors in converting measurements of mm or cm to µm.

(c) Candidates generally did well and most named only two organelles, as requested. Where full credit was not achieved, this was usually for naming the mitochondrion, with the other organelle only possessing a single membrane, such as rough endoplasmic reticulum or Golgi body.

(d) (i) There was considerable variation in the quality of response here. The clearest answers were concise and explained *fluid* in one short sentence and then *mosaic* separately in the next sentence to gain full credit. Candidates who gained partial credit usually knew that *fluid* represented the phospholipids moving within their own layer, but were more vague with *mosaic*, often suggesting that it meant all the different components in the membrane. Some repeated the information and just stated that the membrane was fluid, while others thought that fluid meant that substances could be transported across the membrane.

(ii) The best responses gave only an outline of each of the roles of the cell surface membrane, covering different aspects to gain full credit. This contrasted with some who gained little credit by making a statement about a role and then elaborating on that one role. This was frequently for the idea of the selection of substances that enter and leave the cell. Once this was stated, some candidates gave detail about the different types of transport protein and a number also wrote about facilitated diffusion and active transport. Others explained about the differences in the passage across the membrane between hydrophilic and hydrophobic substances. Some candidates

showed a misunderstanding of the difference between a self-antigen and a receptor, for example using the term receptor when referring to cell recognition and stating that antigens, rather than cell signalling molecules, bind to cell receptors.

Question 6

This question assessed learning outcomes in **Topics 7** and **8**.

(a) The best responses gave a short, accurate description of a structural feature of xylem and then a relevant explanation of the way in which the structure was suited to the overall function of xylem in transporting water and mineral ions. The presence of lignin in the walls was linked correctly by some to its waterproofing qualities, but fewer were able to explain that thickening of the wall with lignin would prevent the inward collapse of the xylem vessels: most just noted that the wall was strong and did not qualify this further. More were able to suggest that the lack of contents of the vessels allowed unimpeded flow of water. Few noted the lack of end walls of xylem vessels or the presence of the cellulose lining. Weak responses gave mixed xylem and phloem statements.

(b) Many candidates did well, with the most common points made tending to be those where a feature was present in only one of the two different types of transport tissue. Where candidates did less well, it was because they concentrated on describing the features of roles of the circulatory system of blood in mammals and wrote about the heart or the carriage of oxygen, for example.

(c) Well expressed responses made clear links between the role of the root hair cell in the active uptake of mineral ions and the presence of many mitochondria to synthesise ATP for the process. Some candidates explained the function of the mitochondrion but did not explain why there were more mitochondria than in other cells. Weak responses suggested that ATP was for the active uptake of water. Stating that mitochondria produced energy was not credited.

BIOLOGY

Paper 9700/22
AS Level Structured Questions

Key messages

Question 4 showed that candidates should understand the difference between the name of an infectious disease and the causative organism (pathogen) involved. For example, 'cholera can mutate and become resistant to antibiotics' would not be credited for '*V. cholera* can mutate and become resistant to antibiotics'. It is also important to understand the difference between the name and the type of causative organism. The spellings of the names must be correct. The first letter of the genus name is upper case and the first letter of the species name is lower case.

Facilitated diffusion is a passive process. In **Question 4(b)**, some candidates described the movement of sodium ions through the cotransporter protein as facilitated diffusion but then explained that this required ATP or energy. The movement of sodium ions through the sodium-potassium pump does require ATP, as the mechanism of movement is active transport. Also, in **Question 3(d)**, some candidates suggested that an old mitochondrion would 'produce less energy', which is not correct, rather than 'produce less ATP'. The following terms should not be used to describe a molecule of ATP: 'energy in the form of ATP', 'ATP energy' or 'ATP (energy)'.

In **Question 5(c)**, there were some responses that confused evaporation and transpiration. Transpiration can be defined as the loss of water vapour from the aerial parts of a plant. It is acceptable to describe the aerial parts as the leaves. Candidates must be precise and state that water vapour is lost, rather than water. The loss should not be described as evaporation through or from the stomata or evaporation from the leaf. Evaporation occurs from the surface of the mesophyll cells within the leaf.

General comments

There were some excellent performances from many candidates. Answers from these candidates showed that they had stayed focused on the theme presented and were making use of any stimulus material provided to help them produce a full answer. Attention had been paid to the level of credit allocated to each part-question and responses had enough points and ideas within them to achieve maximum credit.

A proportion of candidates did not use the information accompanying the question to help them construct their response. Examples of this include **Question 1(b)(i)** where the stage of prophase of mitosis was drawn rather than a chromosome at prophase; **Question 2(a)** where many missed the fact that phospholipases break down phospholipids and wrote about the breakdown of haemoglobin; **Question 2(c)** where some described the synthesis of triglycerides instead of describing the structure that synthesises triglycerides; **Question 4(b)** where some described movement of glucose and sodium ions across the cell rather than outlined the transport mechanisms that resulted in this movement.

Some candidates found it helpful to add information to graphs and figures. For example, in **Question 3(b)**, many who gained credit had used a ruler and had marked on **Fig. 3.1** to help them obtain an accurate answer. For **Question 4(b)** some had written on **Fig. 4.2**, detailing transport mechanisms by the relevant transport proteins to help them organise their response and many found it helpful to write the treatments by each curve in **Fig. 4.3**. In **Question 6**, candidates added labels to **Fig. 6.1** before attempting to answer the questions.

Comments on specific questions

Question 1

This question assessed knowledge of chromosome structure and mitosis from **Topic 5**.

(a) The correct answer, region **C**, was identified by many candidates at all ability levels, but region **D** was also given very frequently as the answer. The very end of the root contains protective cells that compose the root cap, so only a very small proportion of these are meristematic cells.

(b) (i) Most of the candidates were able to gain full credit with a simple diagram that was well labelled. Others drew an adequate diagram but labelled only the centromere. Although kinetochore was accepted as a label, this structure describes the complex that allows attachment to the spindle and is not solely part of the chromosome. The candidates who drew the late prophase stage of mitosis were not penalised: however the majority of these tended to have no or few labels specifically for the chromosome and instead labelled structures such as the spindle and centrioles. A common error was to label the centromere as centrosome. Some weaker responses drew other stages of mitosis or only drew one chromatid.

(ii) A complete response required information about the disassembly and assembly of the nuclear envelope and the stages of mitosis in which these occur. The strongest responses used descriptive terminology such as 'disassembles' or 'breaks down' to describe the behaviour of the nuclear envelope during prophase, rather than 'disappears', which should be avoided. Some candidates had additional knowledge of vesicle formation following the dissolution of the nuclear envelope. Those gaining partial credit did not state the correct stages or wrote only about disassembly or reassembly. Some wrote about both disassembly and reassembly but were less sure about the stages: it was quite common to see metaphase named instead of prophase and also common to see cytokinesis instead of telophase.

Question 2

Candidates were not expected to be familiar with **Fig. 2.1**, which showed the structure of a phosphatidylcholine. Knowledge of phospholipids and reference to **Fig. 2.1** allowed comparisons to be made with triglycerides. This allowed assessment of learning outcomes from **Topic 2** of the syllabus to be assessed. The final part of **Question 2** made links to **Topic 1**, where candidates had to name and describe the cell structure that synthesised triglycerides.

(a) This was well answered by some, who realised that an outline suggestion was required to gain full credit. The best responses explained that phospholipids were part of the cell surface membrane and their breakdown would lead to damage to the cell surface membrane. A complete response continued to explain that the red blood cell would burst or to describe how cell contents would leak out of the cell. Some candidates concentrated on the destruction of phospholipids and gave accounts of enzyme mechanism of action. Weak responses did not take account of the information that phospholipases break down phospholipids and gave accounts of haemoglobin breakdown. A number indicated that haemoglobin contained phosphate groups.

(b) Generally, candidates used the italicised prompts to give similarities first and then the differences. There was a wide variation of quality of response. Some candidates gave very clear and concise answers with many more correct comparisons than required for full credit. The differences tended to be better known than the similarities. Common errors were to think that both triglycerides and phospholipids contain phosphate and that choline in the phospholipid was replaced by glycerol in the triglyceride.

(c) Many knew that the smooth endoplasmic reticulum was the organelle in which triglycerides are synthesised; fewer went on to give a good description of the organelle. The full name of the organelle was given in most cases, which is always preferable and a complete abbreviation to SER was not credited. A common error was to describe them as flattened sacs rather than tubular. When the organelle was incorrectly named as the Golgi body or rough endoplasmic reticulum, candidates were allowed to gain some credit for a correct description of the organelle. Some candidates had not read the question carefully enough and described the formation of triglycerides.

Question 3

In addition to the **Topic 3** theme of enzymes, links were also made with **Topics 1**, **2** and **6**, with **Question 3(e)** requiring candidates to think carefully about applying knowledge and understanding to unfamiliar material in an extended response.

(a) A proportion of candidates were able to recall the term intracellular enzyme to gain credit. There were quite a number who stated intercellular or intrinsic. 'Interacellular' was not credited. Weaker responses stated 'biological catalyst' and 'endocytosis' was seen on a number of occasions.

(b) (i) Many candidates knew how to derive the K_m value required using **Fig. 3.1** and most of these remembered to give the correct units for the substrate concentration. Some mistakenly gave this value as a rate of reaction rather than a substrate concentration and stopped when they had determined ½ V_{max}, so gaining only partial credit. Values within a range were acceptable, but there were some who knew what to do but then were imprecise when determining the substrate concentration at 0.5 au. A derived value of 9 mmol dm^{-3} was the most common incorrect value seen. Some candidates left this part blank.

(ii) Most of those gaining full credit gave an answer in terms of affinity of an enzyme for its substrate. Incorrect answers tended to state that enzyme **G** had a higher rate of reaction than enzyme **H** or just wrote out a sentence stating the K_m values of both. Some thought that the differences were due to the presence of inhibitors. There were some who left this question blank.

(c) The majority knew that lysosomes are vesicles that contain hydrolytic enzymes. The most common cell structure named, other than lysosomes, was Golgi vesicles. As not all Golgi vesicles are destined to become lysosomes this could not be credited. Lysozymes could not be considered correct as this is the name of an enzyme.

(d) To gain credit, candidates should have suggested a feature indicative of impaired structure or functioning of the mitochondrion. The most common correct answer was to suggest that less ATP was produced, although answers referring to other features, such as fewer mitochondrial enzymes or to damaged cristae were also seen. Those not gaining credit simply stated a feature of a fully functioning mitochondrion or suggested that mitochondria release the chemicals that act as signals, neither of which answered the question.

(e) There were some outstanding extended responses seen, with some candidates giving a clear step-by-step and comprehensive account. These correctly defined a mutation and identified the mutation as a base substitution. The main steps of relevance in transcription and translation were provided, rather than including unnecessary detail of the process, and accurate descriptions were given of how a different tertiary structure could result. The very best of these made logical suggestions as to how the more severe form of Gaucher's disease could be as a result of a very altered shape of active site of glucocerebrosidase. It was not necessary to state or describe all the different types of mutation that could occur as candidates were provided with a specific example. Reference was sometimes made to an anticodon with a different amino acid rather than a tRNA with a different amino acid. Descriptions of how the changed amino acids with different R groups could change the tertiary structure of the enzyme were very varied in quality. There were only a few who gave a clear statement that the mRNA codon specifies a particular amino acid. Common confused phrases included: gene coding for the amino acid; change in the gene sequence; code changed (rather than the codon); change in the bases of the amino acids; change in the amino acid sequence of the gene; change in the sequence of nucleotides in the enzyme. Quite a few candidates began their response only with the polypeptide and did not explain how a mutation could lead to a single amino acid change. Weaker responses suggested that there were two amino acid changes in the same polypeptide and that a mutation was caused not by a change in the DNA but directly within the polypeptide chain.

Question 4

This question was based on the theme of the infectious disease cholera.

(a) This was generally well answered and many gained full credit. Candidates were expected to answer in terms of water potential, but there were some that described the movement of ions as

changing the concentration or diffusion gradient. In these cases, it was sometimes possible to gain partial credit if water was described as leaving the cell by osmosis or through the partially permeable membrane.

(b) Many gained some credit in this question by showing an understanding that the presence of glucose and sodium ions in the intestinal epithelial cell would lower the water potential and this would mean that water would also enter the cell. The strongest responses began with describing the active transport of sodium ions out of the cell to show that this created a concentration gradient to power the inward flow of the ions from the intestinal lumen. It was important for candidates to make it clear whether they were writing about the entrance of sodium ions and glucose into the cell or the exit. The movement in of sodium ions was correctly described as facilitated diffusion but it was far less common to see the movement in with glucose described as cotransport or a description that showed an understanding that the diffusion in of the ions was driving the cotransport of glucose into the cell. Many included in their answer an explanation as to why these substances could not cross the phospholipid bilayer, which was not required. Glucose was frequently correctly described as exiting the cell by facilitated diffusion, although some incorrectly described this as active transport. In a similar way, some described the use of ATP to move sodium ions out of the cell but called this mechanism facilitated diffusion. Some weak responses described movement of substances within cells rather than across the cell surface membrane.

(c) Most correct responses showed an understanding that arteries carry higher pressure blood; there were fewer that noted that arteries were deeper and less accessible or that there would be greater risks associated. Answers that were not credited suggested that blood in veins would reach the heart and hence the rest of the body sooner than blood in arteries or that slower blood flow would give more time for the contents of the drip to reach cells.

(d) Many candidates showed an understanding that the presence of tetracycline at the ribosome would hinder translation and so prevent or impair polypeptide synthesis.

(e) (i) There were many who gained full credit, giving responses of a high standard that noted trends shared between the treatments and also differences between treatments and correctly used the axes labels when describing these trends. Some candidates were more careful than others in following each curve through from 16 h to 128 h after treatment and correctly noted that Group **B** switched with Group **C** after 48 h in having the higher volumes until 128 h. Unclear or ambiguous statements were sometimes credited when the candidate also gave correct supporting data. Some attempted to explain the results, which was not required, while others extracted data for each collection time without attempting to make statements about trends.

(ii) Most decided that the results supported treating very severe cases of cholera with tetracycline and the strongest answers made it clear that there was an advantage over taking no antibiotics, using information extracted from **Fig. 4.3** to support their decision.

(f) Candidates generally answered this question about antibiotic resistance by beginning with susceptible bacteria and some showed an understanding of the difficulty faced in ensuring that people with cholera follow a treatment of multiple doses. They suggested that a single dose that could kill all bacteria would avoid any risk of mutation and antibiotic resistance. There was a wide variation in the quality of response seen, with the best using terminology accurately and showing an understanding of the development of antibiotic resistance by bacteria. Others assumed that unless a single dose was given, the bacteria would definitely mutate to gain antibiotic resistance, despite seeing on **Fig. 4.3** that the mean volume of diarrhoea of patients with cholera on a multiple dose treatment regime did decrease to 0 dm^3, implying the presence of only susceptible bacteria in the patients.

(g) Some candidates demonstrated good knowledge of the structure of an antibody molecule and understood the concept of forming an antigen-antibody complex. To gain full credit, reference also needed to be made to the fact that the non-self antigens were different or to the fact that the specific antibody could be synthesised as a result of activation of specific B-lymphocytes. Some could have improved their response by explaining that the different targets were different antigens and by giving more detail of antibody structure, such as explaining that differences between antibodies could be seen by the antigen binding sites or variable regions.

(h) Many stated the type of immunity of newborn babies as natural passive immunity. However, quite a few stated passive immunity or natural immunity and these could not be credited as they were not sufficiently precise.

Question 5

Aspects of movement of water within plants, from **Topic 7**, were assessed in this question.

(a) A large number of candidates gained full credit. A higher proportion had more difficulty with the spelling of Casparian strip than with plasmodesmata. Description **B** was least well known of the three, and it was common to see lignin as an incorrect response. Some confused plasmodesmata and parenchyma in **C**.

(b) Many realised that the symplastic pathway involved cytoplasm and living cells. Some candidates focused too much on this and did not state why this pathway could not occur in xylem vessel elements. For those gaining partial credit, more described the fact that xylem vessel elements had no contents or were hollow than stated that the cells were non-living (and hence had no cytoplasm for a symplastic pathway). Some incorrectly concentrated on describing lignin and how its impermeable nature prevented the passage of water.

(c) Most gained credit with an acceptable reference to transpiration. Very few explained that only cuticular transpiration would occur at night. Some good responses stated that stomata would be closed at night and explained why. Others wrote about some stomata closing or that fewer stomata were open at night and these were acceptable, but ambiguous statements such as stomata are partly closed at night were not. Not all made the link between stomatal closure and lack of photosynthesis at night and only a few linked the change in rate of transpiration with a change in water potential gradient between the roots and the leaves. Some only explained the situation during the day and did not answer the question. Some weaker responses described transpiration as the evaporation of water from the leaf and references to less evaporation were credited only when it was clear that this was within the leaf (from the surface of the mesophyll cells).

Question 6

This question assessed learning outcomes in **Topic 8**.

(a) (i) The great majority correctly gave **S** as the valve described. Only the weakest responses stated **V** (the semi-lunar valve between the right ventricle and pulmonary artery).

(ii) Most gained full credit here. A common incorrect answer was to name the vessel as the pulmonary artery and to give letter **W**.

(b) This proved to be a challenging question. Many knew that the correct wider area for the location of the sinoatrial node was the right atrium: some were precise enough to qualify this as in the wall of the right atrium.

(c) Many candidates gained full credit, with some of the stronger responses giving most of the correct ideas expected. Many others gained at least partial credit, either for referring to the delay in impulse conduction or stating that the impulse passed down the septum via the Purkyne fibres. Some confused the atrioventricular node with the sinoatrial node or thought that the delay was the time taken for the wave of excitation to pass across the atrial walls. Others stated that the role was to cause the contraction of the ventricles, which was too vague. Some misread atrioventricular node as atrioventricular valve.

BIOLOGY

Paper 9700/23
AS Level Structured Questions

Key messages

In **Question 1(b)(i)**, candidates needed to know that the mitochondrion is the organelle that carries out aerobic respiration and so is important in the synthesis (production) of ATP. ATP is a molecule and not a form of energy, so it is not correct to describe a molecule of ATP as energy in the form of ATP, ATP energy or ATP (energy). Hydrolysis of ATP provides energy for cell activities and because of this it can be described as the energy currency of a cell.

Question 4 was based on the infectious disease malaria. Candidates should understand the difference between the name of an infectious disease and the causative organism (pathogen) involved. For example, 'malaria enters red blood cells' would not be credited for '*Plasmodium* enters red blood cells'. It is also important to understand the difference between the name and the type of causative organism. The spellings of the names must be correct. The first letter of the genus name is upper case and the first letter of the species name is lower case.

In **Question 5(a)**, there were some responses that confused evaporation and transpiration. Transpiration can be defined as the loss of water vapour from the aerial parts of a plant. It is acceptable to describe the aerial parts as the leaves. Candidates must be precise and state that water vapour is lost, rather than water. The loss should not be described as evaporation through or from the stomata or evaporation from the leaf. Evaporation occurs from the surface of the mesophyll cells within the leaf.

General comments

There were many well-written answers that were often supported by impressive factual knowledge. Candidates were particularly strong on cell biology (**Question 1**) and the cardiac cycle (**Question 2(c)**).

In **Question 5**, several candidates had difficulty reading the graph correctly and accurately, mistaking the descending figures on the *y*-axis of **Fig. 5.1 B**. Candidates were expected to make accurate data quotes: in **Question 5(b)** many stated the lowest water potential as 1.35 without including the units or the time. Many candidates gave detailed descriptions of the changes in the rate of transpiration and did not go on to discuss water potential in enough detail, which was the subject of the question. Only the best answers made links between the changes in water potential and photosynthesis. Many answers to **Question 2(c)** started with atrial systole and described the whole cardiac cycle instead of concentrating on the events that occurred between stages **H** and **J** as shown in **Fig. 2.1**. This question, and **Question 5(b)**, required a planned response before starting to write so that ideas were expressed in a logical sequence.

Some candidates used symbols in their answers to represent increase and decrease (upward and downward pointing arrows). Some also used the hash symbol (#) to indicate number. These and other symbols or shortened forms of words should not be used. Candidates should also avoid using abbreviations when asked to name structures, organisms or processes. RER, for example, was not accepted for **Question 1(b)(ii)**. In **Question 3(c)** there was confusion between antigen and pathogen. In **Question 6(a)** there was confusion between receptors, antibodies and antigens.

Candidates should read the questions very carefully. In **Question 1(a)** some gave their answer to two decimal places instead of one decimal place as indicated clearly in the question.

Comments on specific questions

Question 1

This short question, which included a calculation, assessed knowledge and understanding of subject matter from **Topic 1** of the syllabus.

(a) Candidates were required to write the formula for calculating the actual width of the mitochondrion in **Fig. 1.1**. Many candidates did this, but a very large number gave the formula for calculating magnification. Almost all of these candidates rearranged the formula to calculate the actual width as 2.5 µm. As a result, any of the three versions of the formula were credited. The most common error in the calculation was to measure the width in the image in centimetres and multiply by 1000 instead of by 10 000. Some candidates divided the magnification (16 000) by the width.

(b) (i) Almost all candidates identified the organelle in **Fig. 1.1** as a mitochondrion and gave a correct role. Answers that did not gain credit were 'produce ATP for respiration' and 'produce energy'.

(ii) Fewer candidates identified structure **B** as the rough endoplasmic reticulum. Common misidentifications were smooth endoplasmic reticulum and Golgi body. No credit was given for the reasons for identifying these structures as they were not supported by the electron micrograph. Many candidates gave a function for rough endoplasmic reticulum, assuming that the question was asking for the same response as **Question 1(b)(i)**. These candidates referred to protein synthesis rather than to the presence of ribosomes on the surface of the endoplasmic reticulum. Some stated that ribosomes were *in* the rough endoplasmic reticulum.

Question 2

This question was based on **Topic 8**. The strongest responses in **Question 2(c)** focused only on the events occurring between stages **H** and **J** and wrote concise sequential accounts.

(a) Answers that made clear comparisons between the ventricles tended to gain credit. Many referred correctly to the difference in the maximum pressures within the two ventricles, the distance travelled by blood in the pulmonary and systemic circuits and the greater resistance to flow in the systemic circuit. However, many candidates stated that the left ventricle has a thicker wall because it has to withstand a higher pressure than the right ventricle. This point did not gain credit. Although there was no requirement to name the type of muscle tissue, some responses referred to smooth muscle, rather than to cardiac muscle, in the walls of the heart. Some candidates wrote about the difference between the thickness of the ventricles and the atria and not the difference in thickness between the two ventricles, so could not gain credit.

(b) (i) Most candidates identified the two blood vessels as the vena cava and the pulmonary artery. Common errors were to give them the other way around or to state that **G** was the pulmonary vein. Some named **G** as the aorta.

(ii) Many candidates identified stage **K** of the cardiac cycle in **Fig. 2.1** as systole rather than diastole. Several referred to 'the atrioventricular diastole' or to 'the distole'.

(c) There were many excellent answers to this question. The best answers explained that the atrioventricular valves close when the blood pressure in the ventricles is greater than the pressure in the atria and that semilunar valves open when the pressure in the ventricles is greater than the pressure in the pulmonary artery and in the aorta. Many candidates started their answer by describing what happens during the filling of the ventricles, which was unnecessary. Many also omitted all reference to the control of ventricular contraction by the atrioventricular node and Purkyne fibres. Some candidates wrote 'atria' when the context of their answer showed that they meant 'aorta'; several used the term 'constrict' instead of 'contract'. Some candidates described all the events of the cardiac cycle with no specific reference to the events occurring between stages **H** and **J** in **Fig. 2.1**. Some candidates referred to smooth muscle in the heart and, instead of referring to contraction of the specific chambers of the heart, simply stated that the heart contracts.

Question 3

This question was based mainly on subject matter from **Topics 9** and **11** and required candidates to apply knowledge and understanding to unfamiliar material. In **Question 3(b)**, candidates used knowledge of phospholipid structure (**Topic 2**) and the reason for the bilayer arrangement in membranes (**Topic 4**) to explain how a monolayer forms.

(a) Many candidates explained that alveolar type 1 cells are thin so that there is a short diffusion distance for gas exchange. Reasons for not gaining full credit included stating that these cells form a barrier that is one cell thick and omitting to refer to diffusion. Many stated that it is 'easy' or 'easier' for gases to diffuse without referring to the short distance, and some omitted to explain that gases diffuse across these cells. Some stated that the cells have thin membranes even though all cells have cell surface membranes of the same thickness. It is not correct to describe an epithelium as a membrane. Several stated that these cells are structured to bring about efficient diffusion. There were references implying that the cell had a wall: these were not credited.

(b) Few candidates were successful in explaining how phospholipids interact with water to form a monolayer on the surface of the fluid that lines the alveoli. Many wrote an answer about the structure of a bilayer and some wrote about micelles. Many omitted to give a relevant description of a phospholipid referring to heads and tails without using the terms hydrophilic and hydrophobic. Candidates often did not state clearly the orientation of the 'tails' or that the polar heads form hydrogen bonds with water. Instead, they often stated that they interact with water which was restating the question. Some did not gain credit because they stated that some phospholipids contain glycoproteins and glycolipids that can form hydrogen bonds with water.

(c) Most candidates stated that macrophages engulf pathogens in the lungs by phagocytosis and then gave details of the fate of the pathogens within these cells. Stronger answers gave more information about the role of macrophages in reducing the chances of infections and their role in antigen presentation. Many candidates made no reference to macrophages moving around or patrolling the airways. Some candidates used the term 'scavenge' to describe this activity, but as this term can be applied to a range of situations, credit was not given unless the response was further qualified. Many gave details of the process of phagocytosis rather than focusing on the role of the cells.

(d) (i) There were many good answers explaining that elastase breaks down elastin so that neutrophils can enter alveoli. Some stated instead that neutrophils enter alveolar cells rather than pass between them onto the surface of these cells. Many knew that elastase breaks down elastin, but could not suggest why. Weaker responses stated that elastase breaks down pathogens. Some suggested that elastase was the enzyme for synthesising elastin and stated that the enzyme helps to maintain the alveoli.

(ii) Most answers pointed out that elastase will continue to break down elastin when the inhibitor is not present. Some stated correctly that elastase breaks down *more* elastin than when the inhibitor is present and stronger answers explained how the loss of elastin leads to the bursting of alveoli. Some candidates answered as if this was a question on the mechanisms of enzyme inhibition and stated that the inhibitor no longer entered the active site or the allosteric site of elastase. These answers gained no credit. Some candidates wrote about what happens when the inhibitor is present. Some candidates simply stated that in emphysema alveoli burst and outlined some of the consequences. Many incorrectly stated that lack of elastin prevents the expansion of alveoli.

Question 4

Malaria, which is covered in **Topics 10** and **11**, was the theme of this question. Part of the question required candidates to handle data in tabular form and describe the trends shown. The best answers gave trends that covered all the information presented, rather than just concentrated on only part of the table.

(a) (i) Many candidates gave the full correct scientific name for one of the four species of *Plasmodium* that most commonly infect humans. Only correct spellings were accepted. A common misspelling of the specific epithet *falciparum* was *flaciparum*. Many gave *P.* vivax or *P.* malariae. Some answers were underlined. Many did not use a capital letter *P* for *Plasmodium* and/or used a capital *F* for *falciparum*.

(ii) Most candidates identified the vector as *Anopheles*. Many gave more information than required and correctly stated that the vectors are female *Anopheles* mosquitoes.

(b) Most candidates identified the trend in cases of malaria and deaths from malaria in all countries or in the WHO African region. Fewer were able to identify trends in the figures for the percentages of cases and deaths that occurred in the African region. Most gave descriptions, but some offered explanations that did not gain any credit. Some candidates simply restated the figures from the table without identifying any trends.

(c) Some candidates started their answers by describing the trends, which was unnecessary. The most likely reasons for the reduction in number of cases and numbers of deaths from malaria are effective control of the vector and the use of drug treatments, notably artemisinin combination therapy. Candidates also mentioned the importance of education in methods to reduce transmission. Many referred to education, but without any further elaboration. Most candidates described control methods that are more appropriate to water-borne and airborne diseases, such as cholera and tuberculosis. Common answers that did not gain credit were improved sanitation and better hygiene. Statements such as 'better treatment' needed further qualification before credit could be given. Many candidates stated that vaccination programmes are used for malaria, but this is not yet the case.

(d) This question prompted many answers that explained the difficulty with using a vaccine to give protection against malaria. These answers only gained credit if they explained that features such as antigen concealment and antigen diversity have made it difficult to develop vaccines for malaria. Stronger candidates included the resistance of *Plasmodium* to drugs and the resistance of mosquitoes to insecticides. Some candidates began their answers by stating that '*Plasmodium* has many life cycles' rather than stating that it has different stages in its life cycle. *Plasmodium* was also described as a bacterium and as a virus. Migration of people was frequently stated without explaining that, as a result, malaria has been transferred to countries that were free of the disease. Many used the term immune instead of resistance when making reference to drugs and/or insecticides and so were not credited for this point.

Question 5

A tree species unfamiliar to the syllabus, *Caryocar brasiliense*, was used as a theme to assess the ability of candidates to apply knowledge of **Topic 7**.

(a) There were many good definitions of transpiration, although some candidates omitted to say that it is water *vapour* that diffuses from the aerial parts of plants. Others wrote that osmosis is responsible for water loss. Some candidates wrote lengthy descriptions of transpiration pull and/or the transpiration stream. Many quoted the statement from the syllabus that transpiration is the inevitable consequence of gas exchange in the leaf, but then gave no further detail that could gain credit.

(b) Most candidates described the changes in the mean water potential of the leaf cells of *Caryocar brasiliense* and included a suitable data quote. Many also described the changes in the transpiration rate, which did not gain any credit. Most of the explanations centred on transpiration, but few considered the link with photosynthesis to explain that stomatal opening and closing could be responsible for the changes in water potential. Very few considered the change in solute concentrations in the leaf cells as a result of loss of water or the increased rate of photosynthesis. Few also explained the decrease in water potential linked with the idea of the loss of water or with water being used and not being replaced by uptake from the roots.

(c) Most candidates identified three xeromorphic features that reduce the gradient for water vapour between air spaces inside the leaves and the surrounding air. Sunken stomata, trichomes and rolled leaves were given on many scripts. Other xeromorphic features, such as small leaves, needle-like leaves, low stomatal density and thick cuticle, did not gain credit as the explanation for these features is not linked to a reduced gradient for water vapour.

Question 6

Subject matter from **Topics 4**, **5 and 6** were assessed in this question.

(a) The complementary structure of epidermal growth factor (EGF) and the receptor on cell **A** shown in **Fig. 6.1** was described by many candidates. Some thought the receptor was an antibody and others that EGF was an antigen. Others described the binding site on the receptors on cell **A** and cell **B** as active sites. Some just referred to 'cell **A** binding to ECF' as it was complementary and did not specifically include receptors in their answers.

(b) Candidates were asked to explain why more mRNA is produced in the G_1 phase of the cell cycle than during mitosis. This could be answered by stating that more proteins are required in this phase, or that proteins are required for growth, for making organelles, for synthesising DNA and for any cell activity that requires enzymes. Stating that DNA is highly condensed during mitosis so is not available for transcription was another way to answer this question, but rarely seen. Often candidates stated the role of mRNA in synthesis of protein, but did not link this to the idea that in the G_1 phase it is required to produce considerably more protein.

(c) Candidates were asked to state the substances used to synthesise DNA and many gained full credit for giving concise, correct statements. A proportion of candidates gave an outline of DNA replication and in their account included at least two or three of the substances used to synthesise DNA during the S phase of the cell cycle. Nucleotides, DNA polymerase, helicase and ligase were common responses. RNA polymerase and Okazaki fragments were two responses that were not credited. Other incorrect responses included amino acids, mRNA and tRNA.

(d) (i) Nearly all candidates identified structure **X** in **Fig. 6.2** as the centromere. Incorrect answers included the centrosome and the centriole. Almost all stated a correct function, although some were confused between chromosomes and chromatids.

(ii) The drawings of the chromosome were very varied. Common errors included omitting the centromere and drawing the separating chromatids with arms that were about the same length, and not like the chromosome in **Fig. 6.2**. Some candidates used the poles in the outline drawing of the cell as the centromeres.

BIOLOGY

Paper 9700/31
Advanced Practical Skills 1

Key messages

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

Candidates should be able to use simple dilution to obtain the required concentrations of a solution by adding a unit volume of a solution of a known concentration, in this case 1 mol dm^{-3} sucrose solution, to water. To make a standard volume of a specific concentration the formula $V_1C_1 = V_2C_2$ can be used.

When carrying out practical work candidates should be encouraged to consider how they could improve their investigations to increase the confidence in their results, e.g. by repeating the procedure. For example, candidates could have repeated releasing a small volume of the blue solution into each of the different sucrose solutions.

When the question states 'explain how the enzyme was affected by change in temperature' the candidate needs to say why something happens, such as referring to the binding of substrates to the active sites of enzymes and the formation of enzyme-substrate complexes.

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 completed the sentence using the words 'lose' and 'less'.

(ii) Many candidates were able to complete **Fig. 1.3** correctly by drawing an arrow on each test-tube to show the blue solution moving up in the left hand test-tube, remaining at the same level in the middle test-tube and moving down in the right hand test-tube.

(b) (i) Many candidates were able to show how to prepare the dilutions, giving at least four correct concentrations of sucrose, stating the appropriate volume of sucrose for the selected concentrations and the correct volume of water to make 40 cm^3 for each concentration.

(ii) Most candidates correctly stated that the length of the pieces of potato to be used should be just below 4.5 cm.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for concentration of sucrose solution / mol dm^{-3} and the heading for the direction of movement. The majority of candidates gained credit for recording the speed of movement in an appropriate way and deciding to record the results for repeated drops. Credit was given to those candidates who recorded results for at least four concentrations of sucrose and included the correct sequence of directions.

(iv) Many candidates were able to estimate the correct concentration of sucrose solution using their results in **Question 1(b)(iii)**.

(v) The stronger candidates identified a significant source of error, e.g. the difficulty of measuring and cutting pieces of potato to the correct dimensions.

(vi) Many candidates correctly stated that to produce a more accurate estimate more concentrations of sucrose solutions should be used. The higher-achieving candidates stated that these concentrations should be between two stated concentrations and the result could be read from a graph.

(vii) Some candidates correctly stated that there was no net movement of water when the concentration of the sucrose solution surrounding the potato had a water potential equal to the water potential in the potato tissue.

(viii) Many candidates showed on the graph how they estimated the water potential, by indicating where $0.3\,\text{mol}\,\text{dm}^{-3}$ was located. Stronger candidates correctly stated the water potential as $-8\,\text{kPa} \times 10^{2}$.

Question 2

(a) (i) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. Many candidates were able to draw at least six starch grains (three from **F** and three from **G**) with no grains overlapping. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates were credited for showing starch grains from **F** as oval shapes and starch grains from **G** as angular shapes.

Many candidates used a label line and the label **X**, to correctly identify the surface markings on a starch grain.

(ii) Many candidates correctly annotated their drawings to describe three observable differences between the starch grains from **F** and **G.**

(b) (i) Most candidates used the headings given in the table to correctly label the *x*-axis (time / minutes) and the *y*-axis (reducing sugar concentration / μM). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates used scales of 10.0 to 2 cm, labelled at least each 2 cm, for the *x*-axis and 2.0 to 2 cm, labelled at least each 2 cm, for the *y*-axis. Many candidates plotted the points exactly with a small cross or dot in a circle, and some drew a sharp, clear, ruled line, accurately connecting the points. The most common error was drawing lines which were too thick or not ruled to the centre of the point.

(ii) Many candidates stated the correct reducing sugar concentrations at 35 minutes and at 15 minutes and calculated the difference between them. The stronger candidates then showed division of the difference by the value at 15 minutes, multiplied by 100.

(c) Credit was awarded to candidates whose drawings did not include any shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions. Many candidates gained credit for drawing only three vascular bundles and the epidermis as two lines drawn close together. Credit was given to those candidates who drew the vascular bundles divided into at least three sections and used a label line to correctly identify the phloem.

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.

When the question states 'explain the effect of temperature on the enzyme activity in the plant extract solution', the answer needs to say why something happens, such as referring to kinetic energy, the binding of the substrates to the active sites of enzymes and the formation of enzyme-substrate complexes.

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 showed that they were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly stated the times to measure the height of the foam. The stronger candidates decided on at least five times, spaced at regular intervals.

(ii) The majority of candidates were able to draw a double-headed arrow on **Fig. 1.1B** showing where the layer of foam was to be measured.

(b) (i) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for pH and the heading for height with units (mm). The majority of candidates gained credit for recording heights for at least five pH values. The stronger candidates recorded heights in whole millimetres.

(ii) Many candidates correctly stated the highest height of foam for pH 5 and the first time when this height was reached. The stronger candidates used these measurements to calculate the rate of production of oxygen by dividing the height of foam in millimetres by the time in seconds and stating the answer to the appropriate degree of accuracy.

(iii) Many candidates were able to measure the difference between the temperature of the room at the start of the investigation and the temperature after all the measurements had been recorded. Most candidates correctly stated whether temperature was a significant source of error based on the change of temperature during the course of the investigation.

(iv) Most candidates recorded the maximum height of foam using **U**.

(v) Many candidates correctly estimated the pH of **U** by stating a pH recorded in **Question 1 (b)(i)** or stating that the pH of **U** was between two pH values.

(vi) Many candidates described how they could modify the procedure to investigate the effect of substrate concentration by using at least five concentrations of hydrogen peroxide prepared by proportional dilution or serial dilution. The stronger candidates described how the dependent

variable could be measured more accurately either by counting the number of bubbles or by measuring the volume of oxygen by using the displacement of water.

(c) (i) Most candidates used the headings given in the table to correctly label the *x*-axis (temperature / °C) and the *y*-axis (rate of enzyme activity / arbitrary units). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most candidates used scales of 10.0 to 2 cm for the *x*-axis and 10.0 to 2 cm for the *y*-axis. Many candidates plotted the points exactly with a small cross or dot in a circle, and some drew a sharp, clear, ruled line, accurately connecting the points. The most common error was drawing lines which were too thick or not ruled to the centre of the point.

(ii) Many candidates correctly stated that the effect of temperature on the enzyme activity in the plant extract solution was that as temperature increased more enzyme-substrate complexes formed until the optimum temperature was reached at 16 °C and then at higher temperatures the enzyme became denatured.

Question 2

(a) (i) Credit was awarded to candidates whose drawings had no shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing only the area indicated in **Fig. 2.1**. Many candidates gained credit for correctly drawing the details of the tissues at the top of **R**, the tissues in the part of the vascular ring below **R** and the tissues beneath the epidermis. Most candidates used a label line to correctly identify the epidermis.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. Many candidates were able to draw four cells from the centre of the stem with double lines representing the cell walls and each cell of the group touching at least two of the other cells. 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 drawn with at least five sides. Most candidates used a label line, and the label **C**, to correctly identify the cell wall as a structure made of cellulose.

(b) (i) Many candidates correctly measured the length of an air space, using the line **X**, and showed the units for this measurement. The stronger candidates divided the measurement for **X** by 16 and multiplied by 1000 to calculate the actual length of the air space in µm. The most common error was to omit the units, mm or cm.

(ii) Many candidates listed only observable differences between **J1** and **Fig. 2.2** and included at least three differences, such as on **J1** the vascular tissue is positioned in the shape of a ring while the vascular bundles in **Fig. 2.2** are distributed throughout the stem.

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.

In this paper, candidates were required to draw a bar chart. The bars should be plotted accurately. All lines, both vertical and horizontal, should be clear, sharp and unbroken (0.5 mm thick or less).

When asked to draw cells, candidates should follow instructions carefully to draw the required number of whole cells, using a suitable pencil to draw clear, sharp lines. Only the structures specified should be labelled. When drawing the observable features of cells in a specimen the drawings must have the correct proportions. Plant cell walls should be drawn with two sharp lines and the relative thickness of the cell walls should be in the correct proportion to the size of the cells.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required for this paper. The majority of candidates showed that they were familiar with the use of the microscope. Stronger candidates showed familiarity with the materials and apparatus used in the practical work.

Comments on specific questions

Question 1

(a) (i) The majority of candidates suggested suitable times at which the samples should be taken, with appropriate units.

(ii) Many candidates stated an appropriate volume for **W**.

(iii) The majority of candidates organised their results clearly by presenting them in a ruled table. The stronger candidates included columns with the heading for time along with the correct units and the heading for colour. Many candidates gained credit for recording appropriate colours for all times stated. Credit was given to those candidates who recorded results for the first ten minutes and the second ten minutes.

(iv) Some candidates correctly described and compared the results for the first and second ten minutes. A common error was to not include reference to specific times and colours for the two data sets.

(b) (i) Many candidates correctly stated that you could use a simple, proportional or serial dilution to prepare a range of concentrations of the reducing sugar. The stronger answers stated that at least five concentrations should be prepared.

(ii) Some candidates gained credit for describing the comparison of the unknown concentration time to first colour change with the times obtained for the known concentrations or for plotting a graph of the known concentration times (standard concentration graph) and reading the value for the concentration of the unknown from the graph. The most common error was to have no reference to the time taken to the first colour change.

(c) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (type of sugar) and the *y*-axis (rate of metabolic reactions / arbitrary units (au)). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates ensured that all five bars were the same width and used a scale of 0.1 au to 2.0 cm for the *y*-axis, and labelled at least each 2 cm. Many candidates plotted the horizontal line at the top of each bar exactly with a thin ruled line.

(ii) Many candidates were able to describe a difference in the rate of reactions between sucrose and glucose. The stronger responses included explanations for this difference, such as glucose being a monosaccharide and sucrose a disaccharide that is broken down into glucose and fructose.

Question 2

(a) (i) Credit was awarded to candidates whose drawings had no shading and used most of the space provided. The stronger candidates gained credit for carefully following instructions and drawing only the area indicated in **Fig. 2.1**. Many candidates gained credit for drawing at least three layers. Credit was also given to candidates who drew the correct shape and proportions of the vascular bundle. Most candidates used a label line and label to correctly identify the pith.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to draw clear, thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw a group of four cells with double lines representing the cell walls and each cell touching at least two other cells. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates gained credit for showing inclusions in the cells or for drawing the correct shape of the cells. Most candidates used a label line and label to correctly identify the cell wall.

(b) (i) Many candidates correctly measured the length of the diameter of the root and the diameter of the vascular bundles using the line **P**–**Q** and showed appropriate units for these measurements. The majority of candidates displayed a ratio of a larger number to a smaller number using whole numbers to the lowest common denominator. The most common error was to give a single number as the answer rather than a ratio.

(ii) Many candidates listed only observable differences between the stem **L1** and the root in **Fig. 2.2** and included at least two differences.

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.

In this paper, candidates were asked to suggest improvements to find a more accurate estimate of the concentration of glucose in mock urine. To do this, the candidates needed to suggest a method of obtaining at least five different known concentrations of glucose. Candidates should be able to plot a graph of results of known concentrations of glucose (standard concentration graph) in order to determine the concentration of the unknown glucose in the mock urine.

When asked to draw cells, candidates should follow instructions carefully to draw the required number of whole cells, using a suitable pencil, to draw clear, sharp lines. Only the structure specified should be labelled. When drawing the observable features of cells in a specimen the drawings must have the correct proportions. Plant cell walls should be drawn with two sharp lines and the relative thickness of the cell walls should be in the correct proportion to the size of the cells.

General comments

In general, many candidates demonstrated that they had a good understanding of the skills required for this paper. The majority of candidates showed that they were familiar with the use of the microscope. Stronger candidates showed familiarity with the materials and apparatus used in the practical work.

Comments on specific questions

Question 1

(a) (i) The majority of candidates organised their results clearly by presenting them in a ruled table. Many gained credit for the correct heading for the dependent variable column (time to first colour change / s). Credit was given to those candidates who collected both colours and times for **U1**, **U2** and **U3**. The most common error was to incorrectly label or not label the column for the independent variable. Some candidates incorrectly recorded a time of more than 90 seconds instead of recording it as 'more than 90'.

(ii) Most candidates correctly identified the sample which did not contain glucose. In this question, candidates were required to use their results from **Question 1(a)(i)**. Some had recorded more than one sample with a blue colour but only referred to one sample in their response to this question, so did not gain credit.

(iii) The majority of candidates correctly stated that the mock urine with the highest concentration would be the sample with the shortest time to the first colour change.

(iv) Most candidates correctly stated that the mock urine sample with the highest concentration was the sample in their results table with the shortest time.

(v) The majority of candidates correctly completed **Table 1.1** to describe how **G** could be diluted.

(vi) The majority of candidates gained credit for this question by referring to an appropriate variable.

(vii) Many candidates repeated the Benedict's test with the 0.5% glucose solution and recorded the result in an appropriate table. The stronger candidates also recorded the repeat Benedict's test of the sample stated in **Question 1(a)(iv)**.

(viii) Many candidates correctly estimated the concentration of glucose in the sample required. A common error was to incorrectly estimate the concentration as being above 0.5% if the time for the sample was longer than that for the 0.5% glucose solution. The shorter the time the more concentrated the glucose solution, therefore if the time was longer than the time for 0.5% glucose solution then the glucose concentration was less than 0.5%.

(ix) Many candidates correctly stated that, to produce a more accurate estimate of the glucose concentration of the mock urine sample, more known concentrations of glucose should be used. Stronger answers stated that these concentrations should be between two stated concentrations and the results should then be plotted on a graph and the unknown concentration read off from the graph.

(b) Credit was awarded to candidates whose drawings had no shading and used most of the space provided. The stronger candidates carefully followed instructions and drew only the area indicated in **Fig. 1.2**. Many gained credit for drawing at least four layers and the correct shape and proportions of the inner layer and central lumen. A common error was to draw more than half of the central lumen.

Question 2

(a) Credit was awarded to candidates whose drawings were made using a sharp pencil to draw clear, thin lines which joined up precisely and used most of the space provided. Many candidates were able to draw a group of four cells from the upper epidermis with double lines representing the cell walls and each cell touching at least one other cell. The most common error was to draw lines that did not meet up precisely or were too thick. Many candidates gained credit for showing inclusions in the cells. Most candidates used a label line and the label **C** to correctly identify the cell wall as the structure made of cellulose.

(b) (i) Most candidates correctly used the headings given in the table to label the *x*-axis (time of day) and the *y*-axis (mean rate of transpiration / au). Some candidates, however, labelled the incorrect axis or gave incomplete headings. Most responses used the correct scales. Many candidates plotted the points exactly with a small cross or dot in a circle, and some drew a sharp, clear ruled line, accurately connecting the points. The most common error was drawing lines which were too thick or not drawn through the centre of the point.

(ii) The majority of candidates stated the correct mean rate of transpiration required and showed how they then calculated the difference between them. The stronger answers clearly displayed all workings and gave a correct answer with appropriate units.

(iii) Many candidates were able to suggest that a difference in temperature and light intensity would provide an explanation for the difference in the mean rates of transpiration. Stronger responses also included an explanation of how these increase the rate of transpiration by increasing the evaporation of water. The most common error was to not include the times 08.30 and 11.30.

(c) (i) Many candidates correctly measured the length of the vascular bundles using the lines **P**, **Q**, **R** and **S** and showed appropriate units for these measurements. The majority of candidates gained credit for showing division by the magnification. The most common error was not to display the original measurements with appropriate units (mm or cm) in the workings.

(ii) The majority of candidates displayed how they obtained the mean actual length and calculated the correct answer.

(d) Many candidates listed only observable differences between the leaf **K1** and the leaf in **Fig. 2.1** and included at least two differences.

BIOLOGY

Paper 9700/36
Advanced Practical Skills 2

Key messages

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

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

Candidates should become familiar with carrying out investigations, including the setting up of a control. The control removes the effect of the independent variable, including replacing a solution with water or denaturing an enzyme by boiling.

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 explained that the test-tubes were left in the water-bath for at least 3 minutes in order to allow the contents of the test-tubes to reach the required temperature.

(ii) The majority of candidates were able to measure the difference between the temperature of the water-bath in step 6 and the temperature of the water-bath in step 16. Most candidates correctly stated whether temperature was a significant source of error based on the change of temperature.

(iii) The majority of candidates organised their results clearly by presenting a ruled table. The stronger candidates included the heading for trial or test-tube. The majority of candidates gained credit for recording three times.

(iv) The stronger candidates suggested that the advantage of carrying out a trial test was to learn to identify when the end-point was reached.

(v) Most candidates were able to identify the dependent variable.

(vi) Many candidates were able to complete **Fig. 1.4** correctly, showing the correct concentration below each beaker (50%, 25% and 12.5%), transferring 20 cm^3 of the previous concentration to the next beaker and adding 20 cm^3 of distilled water to each beaker.

(vii) The majority of candidates organised their results clearly using a ruled table. The stronger candidates included the heading for percentage concentration of milk and the heading for time to reach the end-point / seconds. The majority of candidates gained credit for recording the times for at least three substrate concentrations. Credit was given for those candidates who recorded the

fastest time for the highest concentration of milk. The stronger responses recorded time in whole seconds.

(viii) Many candidates correctly stated that the control for this investigation was either to replace the milk with water or to use boiled and cooled enzyme.

(ix) Many candidates correctly stated that the substrate concentration could be standardised by using one concentration of milk and described how they could modify the procedure to investigate the effect of temperature by using at least five temperatures and using a thermostatically controlled water-bath.

(b) (i) Most candidates used the headings given in the table to correctly label the *x*-axis (source of milk) and the *y*-axis (percentage mass of protein in milk). Some candidates, however, labelled the incorrect axis or gave incomplete headings. The stronger candidates ensured that all five bars were the same width and used a scale of 2.00 to 2 cm for the *y*-axis, labelled at least each 2 cm. Many candidates plotted the horizontal line at the top of each bar precisely and with a thin line.

(ii) Many candidates suggested an explanation in terms of the seal having the highest percentage mass of protein in its milk and that more enzyme-substrate complexes were formed.

Question 2

(a) (i) Credit was awarded to candidates whose drawings had no shading and used most of the space provided. The stronger candidates gained credit for carefully following the instructions and drawing only the area indicated in **Fig. 2.1**. Many candidates gained credit for drawing at least three layers making up the outer stele or the edge of the root. Credit was given to those candidates who drew air spaces in the cortex and used a label line to correctly identify the endodermis.

(ii) Credit was awarded to candidates whose drawings were made using a sharp pencil to produce clear, thin lines which joined up neatly and used most of the space provided. Many candidates were able to draw one large xylem vessel and three adjoining smaller xylem vessels 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 the lumen of the largest xylem vessel being at least twice the size of the smallest xylem vessel lumen.

(iii) Most candidates correctly annotated their drawing to describe one observable feature of the xylem vessel that adapted it for its function, e.g. large lumen allows unrestricted flow or the thickness of the wall prevents collapse of the xylem vessel.

(b) Many candidates correctly measured the diameter of the root using the line **X**–**Y** and measured the length of the scale bar, showing the units for both measurements. The stronger candidates calculated the magnification by converting the length of the scale bar into micrometres and dividing the measurement of the scale bar by 2499. The measurement for the line **X**–**Y**, in millimetres, was then divided by the value for the magnification and multiplied by 1000 to convert to micrometres. Alternative ways to calculate the actual diameter of the root were accepted. The most common error was to omit units, mm or cm.

(c) Many candidates listed only observable differences between **M1** and **Fig. 2.2** and included at least three differences, such as on **M1** air spaces were present while in **Fig. 2.2** the air spaces were absent.

BIOLOGY

Paper 9700/41
A Level Structured Questions

Key messages

Candidates need to read the question carefully and answer the question that is asked. For example, **Question 10(b)** asked about the effects of sickle cell anaemia, so details of the mutation that causes sickle cell anaemia are not needed.

Candidates should use precise words for their descriptions. For example, for **Question 5(b)**, calcium ions (not calcium) enter the cytoplasm of the presynaptic knob (not the presynaptic membrane). Subject-specific vocabulary needs to be fully understood in order to be used appropriately.

Candidates need to have a thorough understanding of the basic concepts of molecular biology. For example, genes consist of sequences of nucleotides while polypeptides consist of sequences of amino acids. Misunderstanding or confusion of these fundamental ideas potentially caused problems in **Questions 3(b)**, **7(a)(ii)** and **10(a)**.

Candidates should be aware of the need to include units at least once in responses such as **Questions 2(c)(ii)** and **4(b)(i)**, where data is quoted.

Microarrays were mentioned in answers to **Questions 3(b)** and **7(c)** concerning DNA analysis. Microarrays compare the transcriptional activation of genes from two different types of cells by comparing what mRNA molecules are produced. Microarray analysis does not indicate the evolutionary relationship of two samples but the differences in which genes are switched on in a paired comparison, e.g. normal cells and cancer cells.

General comments

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

Recall of facts was good on **Questions 5** (nervous coordination), and **6** (respiration). Candidates found integration of different areas of biology with question source material difficult in **Question 1** (biodiversity and conservation) and **Question 3** (evolution). **Question 2** (photosynthesis) made demands on data analysis skills and the ability to visualise a practical procedure. Candidates found the experimental details and data in **Question 4** accessible. Classical and molecular genetics were examined in **Question 7** but some candidates found this combined approach harder than a standard Mendelian genetics question. Misuse of technical terms as well as incorrect recall led to poor performance for some candidates on **Question 8** (homeostasis).

Candidates showed better knowledge of C4 photosynthesis for **Question 9(b)** than the adaptations of rice plants in **9(a)**. Some fundamental mistakes were made about the chemical composition of DNA in **Question 10(a)**, while description of the sickle cell anaemia phenotype for **10(b)** was often poor, due to confusing haemoglobin molecules with red blood cells.

Comments on specific questions

Question 1

(a) Most candidates could list two levels of biodiversity, usually species diversity and either habitat diversity or genetic variation within a species.

(b) (i) Many candidates and gave two examples of phenotypic variation (such as colour and dorsal fin shape), rather than two sources of phenotypic variation (genes and environment).

(ii) Most candidates realised the mobility of whales and the large area of sea they inhabit makes estimating population size difficult.

(c) Generally candidates achieved some credit on this question. Many used the information provided selectively to cite pollution due to industrial activity or shipping, or to consider how a busy shipping lane might impact on whales through accidents with boats or fishing gear, or noise disturbance.

(d) Knowledge of bioaccumulation of toxins up the food chain was variable. Some candidates described the incremental doses of toxins from food very well. Some answers did not specify toxins or PCBs or DDT at all, but vaguely described unnamed pollutants in the water being absorbed through the whale's skin. A serious, but not infrequent, misunderstanding was that the toxins helped with the thermal insulation of the whale.

(e) (i) Many applied their knowledge well in context and could explain why the action potential did not occur and give a valid reason for the death of the whales. Muscle paralysis was in the stem of the question so did not score unless amplified as a reason for death of whales.

(ii) Correct answers picked up on the information given in the question that the algae were unicellular. Erroneous suggestions included stating that these algae had no chlorophyll or cellulose in their walls.

Question 2

(a) (i) Many candidates correctly linked the role of NADPH to the reduction of GP to TP, gaining full credit. Some realised that the end product would be TP from GP but were unable to describe the role of NADPH in providing the hydrogen needed for the reaction.

(ii) Many candidates applied their understanding of the Calvin cycle to work out that the concentration of RuBP would decrease because it was used up (to form GP) but not regenerated. A few realised that it would decrease but did not fully answer the question by giving a reason, while some incorrectly suggested that the concentration of RuBP would increase or stay the same.

(b) Weaker answers about the colour standard tube **A** did not get beyond the idea of a control of a fair test. The idea of using tube **A** to compare with tube **B** went further and scored credit, but only the best answers fully explained the use of **A** to judge the end-point of the colour change in tube **B**.

Candidates usually explained that the foil would prevent light entering the beaker and some developed a logical series of ideas as to how this would prevent the light dependent reaction and the decolourisation of DCPIP. A few candidates showed confusion between oxidation and reduction.

The reason for covering the beaker was to prevent light entering and light dependent photosynthesis happening, but some candidates reversed their answer to hypothetical positive statements 'if light gets in the light dependent reaction will occur and it will change the colour of the DCPIP'. Candidates need to be able to give either positive or negative reasons depending on the way the question is phrased. Here negatives were needed, since the foil stopped a list of occurrences (no light enters, no reduction of DCPIP, etc.).

(c) (i) The majority of candidates were able to use the formula provided to calculate the rate and insert the correct answer into **Table 2.1**.

(ii) Candidates commonly gained credit for stating that the highest rate of photosynthesis occurred in purple light and the lowest rate occurred in green light. Candidates who only restated the figures

without providing any ranking or analysis of them did not score. Some candidates went on to link the difference in rates to the ability of the photosynthetic pigments to absorb the different wavelengths. The role of accessory pigments was mentioned by a significant number of candidates, while a few also referred to the light exciting electrons. It was rare to see any reference to non-cyclic photophosphorylation or that the data represented an action spectrum. Candidates who seemed unfamiliar with the bimodal peak of an absorption or action spectrum attempted to describe a general linear relationship trend of the type 'as wavelength increases...' which was not an appropriate way of describing this data pattern.

Question 3

(a) Most candidates clearly linked the shared niche with the concept of competition. However, most candidates just reiterated that the virus in grey squirrels killed red squirrels, without utilising their knowledge of the transmission of infectious disease to explain that the virus passed from the greys to the reds.

(b) Many candidates understood that molecular analysis involved comparing DNA in some way and some gave clear reasons why mitochondrial DNA is ideal for this purpose. However, few candidates focused on comparing base sequence data, but wrote about other techniques such as gel electrophoresis, PCR and microarrays which would not in themselves allow a comparison of molecular similarity between the two squirrel species. Credit was not awarded for discussing morphological characteristic comparisons or for suggesting interbreeding the two species of squirrel to see if fertile offspring would be produced, since the question asked for molecular level comparisons.

(c) Although most candidates realised that the pine marten was the selection pressure, they did not appreciate how the red squirrels had adapted over many years due to their long coexistence with the predator. Many answers suggested reasons such as being faster or more camouflaged for the red squirrels' current success but small size alone did not score. In general, candidates did not realise that the two species of squirrel had evolved allopatrically in response to different selection pressures in two parts of the world in the past.

Some candidates mistakenly tried to apply a standard description of natural selection to this scenario, describing the directional selection of a single population of squirrels towards smaller size or redder coats. These answers showed a misunderstanding of the question in not realising that two separate species were involved, but as a result of the introduction of the greys to the habitat of the reds, were now subject to the same selection pressure.

Question 4

(a) (i) Most candidates understood the significance of the target specificity achieved by Cry1Ac. Few were able to take this idea further and to suggest that beneficial insects such as pollinators would not be harmed, or to state genes coding for other Cry-proteins might not be effective in killing pests of cotton. Some candidates did not give an answer that suggested why one gene is to be preferred to another but instead described the benefits of inserting any Bt gene.

(ii) Candidates showed a good awareness of the role of promoters in initiating expression or transcription of a gene. Many also identified RNA polymerase as binding to the promoter sequence and some referred to selection of the correct template strand. Few candidates appreciated that promoters can control where and how much the gene is expressed. Errors included writing DNA polymerase instead of RNA polymerase and implying that the promoter binds to the DNA rather than itself being a section of the DNA.

(iii) Candidates were required to apply their knowledge of marker genes in a novel context. They had difficulty in clearly expressing the idea that on exposure to herbicide the surviving plants would be shown to possess ('marked' or identified as possessing) the Bt gene, since it was acquired alongside the herbicide resistance gene.

(b) (i) Most candidates correctly stated that although the Bt cotton seeds cost more, the cost of insecticide for growing Bt cotton was less. Many also correctly calculated the overall cost and stated that the total sum was greater for Bt cotton. A significant number discussed income and yield rather than, or in addition to, the comparative costs of growing the two types of cotton.

(ii) Most candidates correctly stated that farmers chose the non-GM crops because the seeds, or overall growth costs, were cheaper. Some candidates did not state which type of cotton they were referring to, so could not gain credit. Some candidates made contradictory statements, stating that farmers grew non-GM because 'its seeds are more expensive'. This could did not gain credit as it did not specify that it is Bt seeds that are more expensive.

(c) Many candidates knew that a variety of Bt cotton better adapted to drought conditions could be achieved by selective breeding (or artificial selection), and described in varying levels of detail the general principles of the process applied to this specific example.

Question 5

(a) Many candidates scored full credit on this question and showed a good understanding of the role of the myelin sheath. Weaker candidates sometimes stated that action potentials occur faster, rather than that the transmission of action potentials is faster. Few answers mentioned local circuits, and very few stated that the circuits were longer where a myelin sheath exists.

(b) The events at a synapse were well understood and candidates who used subject-specific terms with precision scored all of the credit available. The commonest errors were to omit the word 'ions' and refer to 'calcium channels', to write the calcium ion in symbols incorrectly (e.g. with a single positive charge instead of two positive charges) and to state that ions moved into the membrane instead of into the axoplasm of the pre-synaptic knob. Many candidates omitted to state that the calcium ions enter the knob by diffusion.

Question 6

(a) This question assessed understanding of the requirements for oxidative phosphorylation. Most candidates realised the need for oxygen but fewer appreciated a need for a hydrogen ion supply for the concentration gradient.

(b) Most candidates correctly stated that water would enter the mitochondrion by osmosis, possibly causing bursting of the organelle. A few candidates referred to the mitochondrion as a cell, so could not gain credit. Some did not realise that the question was about osmosis and focused on the movement of ions and other solutes.

(c) Most candidates correctly described oxygen as the final electron acceptor.

(d) Most candidates correctly named ATP synthase (or ATP synthetase) but some made the error of writing ATPase instead.

(e) This was a straightforward question requiring recall of oxidative phosphorylation. The commonest misconception was stating that protons are pumped to the inner membrane rather than to the inter-membrane space. Some candidates thought that the pumping used ATP, rather than energy from the movement of electrons along the electron carrier chain. Similarly not all answers stated that protons move back in the reverse direction to the matrix by passive diffusion (due to the proton gradient). Good answers identified that the protons passed through the ATP synthase channel, allowing ADP and P_i to join to make ATP.

Question 7

(a) (i) Most candidates correctly stated that a person with galactosaemia would need to restrict their dietary intake of dairy or lactose-containing products. A few candidates confused galactose with glucose and mistakenly thought that an insulin injection would help.

(ii) Most candidates attempted to explain how a mutation in a gene could result in a change in an enzyme, but few scored all of the credit available for this question.

There were many confused descriptions of the relationship between bases or nucleotides in DNA, codons on mRNA and amino acids in proteins, such as, 'the mutation causes a change in the base sequence of an amino acid', 'the mutation results in a different amino acid in the base sequence' and 'the mutation changes one gene on the DNA giving a different amino acid'.

Many candidates did not refer precisely enough to changes in the amino acid sequence or primary structure of the polypeptide and to the tertiary structure or three-dimensional shape of the resulting protein or enzyme.

From the information in the question, it was apparent that the GALT enzyme did not 'digest' or 'break down' galactose yet many candidates used these terms.

(b) This task involved working out the ratios of offspring of simple monohybrid crosses and was accessible to most candidates. The few incorrect responses stated that the offspring would have the same phenotypes as the parents, e.g. carrier × carrier giving 100% carriers.

(c) Most candidates scored some credit for this question, either for the term genetic screening or for reference to or an adequate description of amniocentesis. A few incorrectly described gene screening of an IVF embryo. Other candidates did not understand the idea that the amniotic fluid contained foetal cells and that the DNA of the foetal cells was being screened, not the fluid itself. A few candidates mistakenly thought that it would be possible to screen for the presence of galactose from the foetus within the mother's urine.

Question 8

(a) This question required candidates to describe the basic principles of a negative feedback mechanism. Most candidates instead focused on a detailed description of the control of a single named factor, which did not always highlight the general features of negative feedback such as change in a factor away from the norm, detection by a receptor, nerve impulses or hormones reaching an effector and a corrective action taking place to restore the factor to its normal set-point. Terms that a significant minority of candidates used incorrectly were 'stimulus' (as in statements about the stimulus being sent to the effector) and effector (as in the effector being the source of the hormones).

(b) This question gave candidates an unfamiliar diagram revealing the recently discovered role of the hypothalamus in controlling blood glucose concentration, which contrasts with the account where cells in the islets of Langerhans carry out the monitoring of blood glucose concentration. Virtually no candidates noticed this challenge to their existing framework of knowledge and commented that the two systems would both operate together or that this hypothalamic control would supplement the detection by the pancreas. Weaker candidates wrote an answer based on pancreatic detection that made no use of the new diagram at all and did not answer the question about the role of the nervous system.

Those candidates who did attempt to interpret the diagram and explain it often made mistakes such as substituting the vague term 'level' for concentration, referring to blood glucose concentrations being statically high or low rather than increasing or decreasing as a stimulus to trigger negative feedback, and writing that hormones were produced rather than released or secreted in response to nervous stimulation of the endocrine tissue. A particular weakness was the large number of candidates who referred to signals or messages travelling from the hypothalamus to the pancreas and adrenal glands, rather than impulses travelling along neurones. A more subtle mistake was to say that these nerve impulses travelled along sensory neurones. The hypothalamus as a central nervous system receptor would be linked to the endocrine glands by motor neurones.

(c) Describing and explaining aspects of thermoregulation was one of the weakest areas of the paper for many candidates. There was a lack of familiarity with concepts of energy conversion and heat transfer to surroundings, and errors in understanding such as the belief that blood capillaries can move closer to or further away from the surface of the skin.

In describing vasoconstriction, the majority could not name the arterioles of the skin as the blood vessels whose diameter constricts, or the capillaries as the vessels with reduced blood flow. Many candidates described shivering just as muscle movement rather than as muscle contraction. Many candidates did not respond to the comparative term *increasing* secretion of adrenaline as *increasing* the rate of respiration or metabolism, resulting in *more* heat being released.

Question 9

(a) Although this question earned credit for many candidates, many answers lacked precision, making general statements such as 'the rice plant grows tall so the leaves can exchange gases'. Credit

was most often given for references to aerenchyma, high tolerance of cells to ethanol and the presence of ethanol dehydrogenase in cells of the root.

Candidates who described air trapped on leaves often did not stipulate that this applies only to submerged leaves. Similarly, some said anaerobic respiration occurs, but did not specify that this happens only in the parts of the plant that are underwater.

Few candidates described the presence of aerenchyma in both the stem and roots and the fact that this enables oxygen to diffuse to the roots.

(b) Candidates were usually able to provide a good explanation of how the leaves of maize or sorghum are able to maximise carbon dioxide fixation at high temperatures. The role of the bundle sheath cells in keeping air away from RuBP or rubisco, and therefore preventing photorespiration, was frequently mentioned. Many candidates were able to describe the events in the mesophyll cells where carbon dioxide combines with PEP in the presence of PEP carboxylase to form oxaloacetate and its subsequent conversion to malate. Some candidates were not clear that the malate then passes to the bundle sheath cells where the carbon dioxide is only then released in order to react with RuBP. Many references to the enzymes having high optimum temperatures were provided. Where candidates understood the significance of the anatomy of the leaves some excellent descriptions of the roles played by the bundle sheath and mesophyll cells were seen.

Question 10

(a) Most candidates were able to correctly describe addition, substitution and deletion gene mutations. However, many candidates confused base sequence and amino acid sequence, and some referred to addition and substitution without attempting to name what was added or substituted. Stronger answers named frameshift as a consequence of addition or deletion, but few explained that this resulted in alteration of the sequence of triplets of nucleotides following the mutation. Few candidates were able to explain that a shortened polypeptide could be the result of a premature stop codon or that a stop codon did not code for an amino acid. Most thought a shortened polypeptide would be the result of a base deletion. Very few used the term nonsense mutation.

(b) This question was generally poorly answered. Many candidates gave a lengthy description of the mutant sickle cell allele, with details of the base change involved and the resulting amino acid change, but did not address the question about the phenotypic effects of the allele.

Detailed knowledge of how sickle cell haemoglobin and red blood cells differ from the norm was rarely shown. Few candidates specified that the β polypeptide chain is altered, or that it forms fibres in low oxygen concentrations due to its lower solubility. Most candidates described the formation of sickle-shaped red blood cells, but a large number of candidates confused haemoglobin molecules and red blood cells, making no distinction between them. For example, some used haemoglobin dissociation terminology inappropriately in saying that sickle-shaped red blood cells have lower affinity for oxygen.

There was confusion about what happens in a sickle cell crisis where the sickle-shaped cells get stuck in capillaries, blocking blood flow, with many candidates wrongly describing this as blood clotting. Symptoms of sickle cell anaemia were poorly described, with most answers being vague references to tiredness and paleness and few candidates mentioning pain due to sickle cell crisis. Some candidates were able to describe the protection against malaria.

BIOLOGY

Paper 9700/42
A Level Structured Questions

Key messages

Candidates should ensure they are precise when using biological terms such as ethanol dehydrogenase rather than alcohol dehydrogenase.

If a question requires a comparison then the candidate's answer should be phrased to achieve this by using words such as higher and faster rather than high and fast.

General comments

Some candidates had difficulty when faced with questions in which the command word was 'suggest' where they were expected to draw upon their general biological knowledge. This was evident in **Questions 1(a)**, **1(d)**, **4(b)** and **6(b)**.

Questions 5, **8**, and **10** proved to be more challenging than the other questions. **Questions 1**, **4**, **7** and **9** were more accessible to candidates.

Comments on specific questions

Question 1

(a) (i) The consequences to the ecosystem of a decrease in snow leopard numbers were well understood by most candidates. Almost all appreciated that there would be an increase in the numbers of herbivores, often continuing to state that overgrazing would reduce the number of plant species. Many commented that this would lead to a decrease in biodiversity and degradation of the habitat, often expressed in terms of soil erosion. Fewer candidates mentioned that there would be increased competition for grazing or that a lack of food would result in a decline in the herbivore populations. References to a disturbance in the food web (rather than simply the food chain) were relatively rare.

(ii) There were many correct suggestions as to why the actual number of snow leopards in 2003 may have been higher than the estimated number, most notably that leopards are difficult to see due to their camouflage. Some candidates also stated that leopards are solitary or live in inaccessible locations. No comments on the difficulty in obtaining government permission to access certain areas were seen.

(b) Many candidates provided good descriptions as to how actions taken by participating governments could help to conserve endangered species, often including the banning of hunting and trading of snow leopard products and the instigation of education and awareness campaigns. While some mentioned that the leopards' habitat should be declared a national park or nature reserve, there were fewer comments on enforcement methods, such as fines or imprisonment, or how illegal trading or hunting might be detected. A significant number of candidates referred to zoos and captivity breeding programmes, which were not credited.

(c) Many candidates appreciated that a decrease in the number of snow leopards would result in a loss of genetic diversity or a reduction in the gene pool. However, there were fewer references to inbreeding depression, loss of hybrid vigour or the expression of harmful recessive alleles. While some mentioned that a drop in the population could jeopardise the leopards' likelihood of survival, hardly any commented on their possible inability to adapt to changing environmental conditions.

(d) Suggestions as to the type of evidence used to classify the snow leopards in 1775 most commonly centred on their morphology or other suitable alternatives. Some candidates referred to the use of behavioural characteristics although mention of reproductive isolation was rare. A number of candidates incorrectly commented on the use of molecular techniques for classification.

Question 2

(a) (i) Most candidates correctly gave NADP, some spelling it out in full. A few gave NAD, NADH, and NADPH.

(ii) Most candidates referred to photolysis, or splitting, of water as the source of hydrogen, and a few to photosystem II and the role of an enzyme. Although many referred to hydrogen ions and electrons and gave the photolysis equation, few went on to say the hydrogen was made available by the ions and electrons combining.

(b) (i) Only a few candidates knew that the temperature should be kept low to reduce or stop enzyme activity. Many wrongly thought it was to prevent denaturation. There were few mentions of preventing damage to chloroplasts.

(ii) This question was well answered with most knowing the purpose of a buffer.

(iii) Many candidates understood that having the same water potential would avoid osmosis. Fewer gained full credit as many stated that the chloroplast would become turgid or flaccid which was not credited.

(c) (i) The majority gave the correct answer, although a few totalled the column instead of giving the mean.

(ii) Most candidates were able to make the correct calculation of the mean rate. There were some errors due to incorrect rounding of figures.

(iii) Most candidates understood the relationship between increasing light intensity and time for decolourisation. However, even some stronger candidates who clearly understood the process, did not gain full credit as they were not specific enough in their responses. Some referred to light or energy absorbed, but not light energy. The most common explanation was reference to photolysis. A few good responses summed up the process as reduction.

Question 3

(a) A good number of candidates achieved full credit on this question. They had used the information given as directed and identified two causes of extinction. However, many candidates achieved no credit as they simply copied out two parts of the information given, without identifying the way it was a cause of extinction. For example, some wrote that large areas of waste land were drained for agriculture but did not link this as a cause of extinction by loss of habitat.

(b) Many candidates wrote about morphological differences or sampling techniques to catch the deer to compare them, rather than about the molecular similarity, and so gained no credit. The strongest candidates achieved full credit here for describing how DNA sequencing and amino acid sequencing can be carried out and compared for both populations. The most common answer was that of using a microarray, but then many candidates went on to describe how a microarray would be carried out, so often gained no further credit. A minority of candidates mentioned mitochondrial DNA.

(c) Most candidates found this question challenging because they deduced incorrectly that allopatric speciation had taken place and that the populations had become reproductively isolated and a new species emerged. The most common correct answer was to identify that the populations had been geographically isolated but few candidates went on to say that this had been in place for 12 000 years. A good number of candidates wrote about mutations occurring but many did not make it clear that, as mutations are random, the mutations occurring in the different populations would be different. Most candidates recognised that the selection pressures or environmental conditions would be different between the populations. A small number of candidates referred to genetic drift taking place. It was rare to see the answer that population **A** had had a large decrease in genetic diversity or had a population bottleneck.

Question 4

(a) The majority of candidates were incorrect in their explanations of how vasodilation helps to return the body temperature to its set point. One frequent error was to write that the capillaries were the blood vessels that became wider and not the arterioles. Other incorrect answers were that arteries became wider or that the blood vessels moved nearer to the skin surface. Consequently, many candidates did not go on to to explain how more blood could flow to the capillaries. Most candidates did explain that heat was lost after vasodilation occurred.

Candidates were more successful at explaining how sweating reduced body temperature as the water evaporated, although a significant number of candidates wrote that this evaporation used heat rather than heat energy. Many candidates showed good use of the term latent heat of vaporisation in the correct context. Many did not point out that when the body had an increased temperature, this would stimulate more sweating to occur.

(b) Most candidates found this a very challenging question as it drew on a number of different areas of the syllabus, namely hormones and their actions, homeostasis and the kidney. A large number of candidates used the term 'level' instead of 'concentration' of blood glucose and some candidates wrote about glucose concentration in the body rather than in the blood. Only a minority of candidates went on to explain that a high concentration of blood glucose would lower blood water potential, which would be detected by osmoreceptors in the hypothalamus and cause feelings of thirst. Some candidates then confused the loss of water with loss of body mass. A good number of candidates did recognise that less glucose would be taken up by cells and converted to glycogen and therefore lost in the urine. A few stated that this would cause fats or proteins to be respired.

(c) (i) A majority of candidates knew that the biosensor contained immobilised glucose oxidase and that it reacted with glucose in the blood. There were many incorrect answers given about the reaction that occurred as it was confused with the dipstick reaction. Only a few candidates identified that oxygen was detected and that this caused an electric current to be generated, which was detected by an electrode. Quite a few candidates highlighted that the value given was numerical or quantitative.

(ii) Most candidates were successful here. A few incorrectly stated that it would be faster, when in fact, both tests are very fast.

Question 5

(a) (i) Explanations as to why the amino acid sequences are not changed by the presence of CAG repeats were often confused and inaccurate. Some candidates mentioned the degeneracy of the genetic code while others commented on the effect the CAG repeats would have on protein structure. Few appreciated that the insertion of the CAG triplet would not affect the triplet codes on either side as there would be no frameshift.

(ii) Many candidates were unable to explain why Huntington's disease cannot be treated by gene therapy. Nevertheless, many gained credit for understanding that the disease is caused by a dominant allele. Stronger candidates went on to state that gene therapy could only be used to treat recessive disorders and that the introduction of the normal recessive allele would have no effect on the expression of the Huntington allele. Some appreciated that it would be impossible to remove or replace the allele but few mentioned that tissues in many parts of the body, not only the brain, would be affected. Weaker responses simply repeated the information that they had been given in the stem of the question or suggested that it would be very difficult to remove the CAG repeats from the allele.

(b) (i) The majority of candidates correctly stated the probability required.

(ii) There were many correct suggestions for the advantages and disadvantages of screening for Huntington's disease before any symptoms occur. While the most common advantage was that it would allow a person who tested positive to decide whether or not to have children, many candidates also stated that preparations could be made before the onset of the disease although references to early treatment were not credited. Only rarely did candidates comment that a negative result would remove anxiety.

The most frequent disadvantages were that the sufferer would experience stress and worry as no treatment would be possible. Some also appreciated that the symptoms of the disease might never appear, even if the result were positive. Few mentioned financial or social discrimination, such as the refusal of life insurance.

(c) (i) Only a minority of candidates understood what is meant by the term embryo biopsy.

(ii) Most candidates appreciated that PCR would be used to amplify a small sample of DNA.

(iii) The social and ethical implications of screening embryos elicited a variety of responses, often quite emotive. While many recognised that embryos with the Huntington allele were likely to be discarded, some erroneously referred to termination of pregnancy or abortion, often linked to the gender of the embryo. Some commented that the child would be rejected or discriminated against by society because it was conceived unnaturally or might have a disability. Many stated that it would be immoral or against religious beliefs to destroy embryos or for parents to choose one embryo over another. Few candidates mentioned that embryo screening could reduce the frequency of the Huntington allele in the population, as people with the allele would now be able to have children without it.

Question 6

(a) (i) The majority of candidates scored full credit for correctly stating the relationship and for giving two correct data quotes.

(ii) Almost all candidates gave the correct percentage decrease.

(b) Overall, this question was not well answered. Inexact responses meant that many candidates did not gain full credit, although many did have a general idea of how eugenol might reduce pain. Reduced movement of sodium ions into neurones was often given in answers, but not *sensory* neurones, which was required for credit to be awarded. Similarly, depolarisation was often stated, rather than depolarisation of the sensory neurone *membrane*, and 'the threshold was not reached' rather than 'the threshold *potential* was not reached'. Most candidates gained credit for understanding that there would be no or fewer action potentials. A minority were aware that eugenol prevented the opening of sodium ion channels and that impulses did not reach the brain. The involvement of the sodium-potassium pumps and the fact that the resting potential was not restored were rarely given.

Question 7

(a) Many candidates correctly identified the addition of inorganic phosphate to ADP. Those who did not gain the credit simply referred to 'phosphate', omitting 'inorganic'. Fewer candidates knew the details of the substrate-linked reactions in glycolysis or Krebs, and so were unable to name a phosphorylated compound.

(b) (i) Many correctly identified the ester bond, but a good number instead stated phosphodiester, hydrogen or glycosidic bonds.

(ii) Some candidates correctly gave the role of acetyl coenzyme A, but many suggested that it combined with oxaloacetate or entered the Krebs cycle, rather than transporting the acetyl group to the Krebs cycle.

(iii) Most candidates referred to a larger number of C–H bonds or more hydrogen. Some mentioned double bonds or H^+ ions. Very few went on to link the increased hydrogen to producing more reduced NAD or more oxidative phosphorylation.

(c) (i) The majority of candidates correctly calculated the missing value in the equation.

(ii) Most candidates were able to calculate and state the correct answer to two decimal places.

Question 8

(a) Only the strongest candidates performed well on this question. Of the few candidates who gained credit, most knew that autosomal linkage referred to two genes on the same chromosome, and that

these would be inherited together. Fewer referred to the fact that autosomes are non-sex chromosomes. Credit was often lost by referring to alleles rather than genes. The most common errors demonstrated a lack of clear thinking about the basics of genetics: the nature of genes, alleles and chromosomes.

(b) Very few candidates gained credit here. Most did not recognise the two groups of phenotypes as parental and non-parental, but tried to interpret them in terms of homozygosity and heterozygosity of the two genes involved, with many genetic diagrams but little interpretation attempted. For the few candidates who recognised that crossing over was involved, there was often very little clear logical explanation. They were seldom specific that crossing over occurred between the two gene loci. While some mentioned that 12% of the plants were of particular phenotypes and were the result of crossing over, few mentioned this as a cross-over value. Some went into detail of crossing over, but few mentioned that this resulted in new combinations of alleles or recombinants, or that the minority phenotypes were recombinants.

(c) Most candidates gained some credit here. Many candidates wrote in great detail about transcription, translation, amino acids, polypeptides and tertiary structure, which were not required. Most candidates referred to a change in base or nucleotide sequence, without specifying that it occurred in DNA. Similarly, many stated that it occurred by substitution, deletion or insertion without reference to bases. Very few mentioned valid mutagenic agents and most quoted radiation without further qualification.

Question 9

(a) In general, candidates provided clear summaries of how the structure of a mitochondrion is related to its function. Many candidates started by providing a labelled diagram which helped to illustrate the structures they were referring to. For most candidates the majority of the credit was awarded for describing the processes that occur on the inner mitochondrial membrane, linking that the cristae provide a larger surface area in order to accommodate large numbers of embedded proteins such as the electron carriers or ATP synthase. Many candidates mixed up ATP synthase with the opposing action of ATPase. To earn full credit, candidates needed to give details of an additional structure, which was generally focused on the mitochondrial matrix, and its role as the site of enzymes involved in the link reaction and Krebs cycle. The most comprehensive answers also described the intermembrane space, though in general this aspect was less well described. While there was often reference to protons or H^+ ions, it was often unclear where these protons were being shuttled from and to, or that there is a high concentration in this location. Candidates who described the mitochondrial DNA and ribosomes usually successfully linked this feature to their role in coding for or translating proteins and enzymes essential for mitochondrial function. A key omission in many answers was that the mitochondria are the main site for ATP synthesis, as candidates did not extend their explanations from the location of ATP synthase, Krebs cycle or the ETC. Some candidates wrongly described the mitochondria as stand-alone cells, claiming that they have a nucleus (because they contain mitochondrial DNA) and cytoplasm (in the matrix).

(b) Respiration in anaerobic conditions in both mammals and yeast was neatly compared across most answers, and there were few confused responses between the two types of organism. For full credit to be awarded, candidates needed to ensure that diagrams used to illustrate answers were accompanied by written answers that demonstrated full understanding of the process. Most candidates focused on the biochemical detail, such as the molecules that undergo reduction, the enzymes involved, and the final products. Precise use of terms was required to gain credit, such as saying ethanol, rather than generic alcohol. Relatively few candidates gave details of why respiration occurs anaerobically, such as to continue generating small amounts of ATP by allowing glycolysis to occur in the absence of further stages of respiration. In order to obtain maximum credit, candidates had to make some reference to differences in yeast cells, as required in the question.

Question 10

(a) There were some excellent answers which gained maximum credit for an accurate detailed account of the process. Many other candidates achieved partial credit, largely for appreciating that crossing over took place in prophase 1, with chiasmata formation, and that there was exchange of genetic material and a new combination of alleles was formed. The breaking of linkage groups was not often included. Although many correctly identified metaphase 1 as the first stage where separation took place, many did not correctly identify that there was random assortment of

homologous pairs (or bivalents) rather than simply stating 'chromosomes' without further qualification. Generally, candidates did not identify that this gave rise to a very large number of combinations. Independent assortment, which takes place at metaphase 2, was largely not included in answers and reference to mutation was rarely seen.

(b) This question yielded the least credit of all of the extended responses. Many answers were limited to stating that the production of melanin is required for pigmentation of hair and skin, and did not mention tyrosinase, suggesting that melanin is encoded by a gene. More developed answers were able to describe the role of tyrosinase in the production of melanin from tyrosine and that this process does not occur when only inactive tyrosinase is produced. Few answers mentioned that this reaction occurs in melanocytes. In addition, few answers made reference to genetics and discussed mutant alleles, as required by the question. Only more able candidates demonstrated knowledge of the mutant allele being recessive, that the gene for tyrosinase is affected by the mutation, and that the phenotype is only observed in homozygous recessive individuals. A number of candidates only described how gene mutations occurred, but did not follow the context of the question or answer with the required detail.

BIOLOGY

Paper 9700/43
A Level Structured Questions

Key messages

Candidates need to read the question carefully and answer the question that is asked. For example, **Question 10(b)** asked about the effects of sickle cell anaemia, so details of the mutation that causes sickle cell anaemia are not needed.

Candidates should use precise words for their descriptions. For example, for **Question 5(b)**, calcium ions (not calcium) enter the cytoplasm of the presynaptic knob (not the presynaptic membrane). Subject-specific vocabulary needs to be fully understood in order to be used appropriately.

Candidates need to have a thorough understanding of the basic concepts of molecular biology. For example, genes consist of sequences of nucleotides while polypeptides consist of sequences of amino acids. Misunderstanding or confusion of these fundamental ideas potentially caused problems in **Questions 3(b)**, **7(a)(ii)** and **10(a)**.

Candidates should be aware of the need to include units at least once in responses such as **Questions 2(c)(ii)** and **4(b)(i)**, where data is quoted.

Microarrays were mentioned in answers to **Questions 3(b)** and **7(c)** concerning DNA analysis. Microarrays compare the transcriptional activation of genes from two different types of cells by comparing what mRNA molecules are produced. Microarray analysis does not indicate the evolutionary relationship of two samples but the differences in which genes are switched on in a paired comparison, e.g. normal cells and cancer cells.

General comments

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

Recall of facts was good on **Questions 5** (nervous coordination), and **6** (respiration). Candidates found integration of different areas of biology with question source material difficult in **Question 1** (biodiversity and conservation) and **Question 3** (evolution). **Question 2** (photosynthesis) made demands on data analysis skills and the ability to visualise a practical procedure. Candidates found the experimental details and data in **Question 4** accessible. Classical and molecular genetics were examined in **Question 7** but some candidates found this combined approach harder than a standard Mendelian genetics question. Misuse of technical terms as well as incorrect recall led to poor performance for some candidates on **Question 8** (homeostasis).

Candidates showed better knowledge of C4 photosynthesis for **Question 9(b)** than the adaptations of rice plants in **9(a)**. Some fundamental mistakes were made about the chemical composition of DNA in **Question 10(a)**, while description of the sickle cell anaemia phenotype for **10(b)** was often poor, due to confusing haemoglobin molecules with red blood cells.

Comments on specific questions

Question 1

(a) Most candidates could list two levels of biodiversity, usually species diversity and either habitat diversity or genetic variation within a species.

(b) (i) Many candidates and gave two examples of phenotypic variation (such as colour and dorsal fin shape), rather than two sources of phenotypic variation (genes and environment).

(ii) Most candidates realised the mobility of whales and the large area of sea they inhabit makes estimating population size difficult.

(c) Generally candidates achieved some credit on this question. Many used the information provided selectively to cite pollution due to industrial activity or shipping, or to consider how a busy shipping lane might impact on whales through accidents with boats or fishing gear, or noise disturbance.

(d) Knowledge of bioaccumulation of toxins up the food chain was variable. Some candidates described the incremental doses of toxins from food very well. Some answers did not specify toxins or PCBs or DDT at all, but vaguely described unnamed pollutants in the water being absorbed through the whale's skin. A serious, but not infrequent, misunderstanding was that the toxins helped with the thermal insulation of the whale.

(e) (i) Many applied their knowledge well in context and could explain why the action potential did not occur and give a valid reason for the death of the whales. Muscle paralysis was in the stem of the question so did not score unless amplified as a reason for death of whales.

(ii) Correct answers picked up on the information given in the question that the algae were unicellular. Erroneous suggestions included stating that these algae had no chlorophyll or cellulose in their walls.

Question 2

(a) (i) Many candidates correctly linked the role of NADPH to the reduction of GP to TP, gaining full credit. Some realised that the end product would be TP from GP but were unable to describe the role of NADPH in providing the hydrogen needed for the reaction.

(ii) Many candidates applied their understanding of the Calvin cycle to work out that the concentration of RuBP would decrease because it was used up (to form GP) but not regenerated. A few realised that it would decrease but did not fully answer the question by giving a reason, while some incorrectly suggested that the concentration of RuBP would increase or stay the same.

(b) Weaker answers about the colour standard tube **A** did not get beyond the idea of a control of a fair test. The idea of using tube **A** to compare with tube **B** went further and scored credit, but only the best answers fully explained the use of **A** to judge the end-point of the colour change in tube **B**.

Candidates usually explained that the foil would prevent light entering the beaker and some developed a logical series of ideas as to how this would prevent the light dependent reaction and the decolourisation of DCPIP. A few candidates showed confusion between oxidation and reduction.

The reason for covering the beaker was to prevent light entering and light dependent photosynthesis happening, but some candidates reversed their answer to hypothetical positive statements 'if light gets in the light dependent reaction will occur and it will change the colour of the DCPIP'. Candidates need to be able to give either positive or negative reasons depending on the way the question is phrased. Here negatives were needed, since the foil stopped a list of occurrences (no light enters, no reduction of DCPIP, etc.).

(c) (i) The majority of candidates were able to use the formula provided to calculate the rate and insert the correct answer into **Table 2.1**.

(ii) Candidates commonly gained credit for stating that the highest rate of photosynthesis occurred in purple light and the lowest rate occurred in green light. Candidates who only restated the figures

without providing any ranking or analysis of them did not score. Some candidates went on to link the difference in rates to the ability of the photosynthetic pigments to absorb the different wavelengths. The role of accessory pigments was mentioned by a significant number of candidates, while a few also referred to the light exciting electrons. It was rare to see any reference to non-cyclic photophosphorylation or that the data represented an action spectrum. Candidates who seemed unfamiliar with the bimodal peak of an absorption or action spectrum attempted to describe a general linear relationship trend of the type 'as wavelength increases...' which was not an appropriate way of describing this data pattern.

Question 3

(a) Most candidates clearly linked the shared niche with the concept of competition. However, most candidates just reiterated that the virus in grey squirrels killed red squirrels, without utilising their knowledge of the transmission of infectious disease to explain that the virus passed from the greys to the reds.

(b) Many candidates understood that molecular analysis involved comparing DNA in some way and some gave clear reasons why mitochondrial DNA is ideal for this purpose. However, few candidates focused on comparing base sequence data, but wrote about other techniques such as gel electrophoresis, PCR and microarrays which would not in themselves allow a comparison of molecular similarity between the two squirrel species. Credit was not awarded for discussing morphological characteristic comparisons or for suggesting interbreeding the two species of squirrel to see if fertile offspring would be produced, since the question asked for molecular level comparisons.

(c) Although most candidates realised that the pine marten was the selection pressure, they did not appreciate how the red squirrels had adapted over many years due to their long coexistence with the predator. Many answers suggested reasons such as being faster or more camouflaged for the red squirrels' current success but small size alone did not score. In general, candidates did not realise that the two species of squirrel had evolved allopatrically in response to different selection pressures in two parts of the world in the past.

Some candidates mistakenly tried to apply a standard description of natural selection to this scenario, describing the directional selection of a single population of squirrels towards smaller size or redder coats. These answers showed a misunderstanding of the question in not realising that two separate species were involved, but as a result of the introduction of the greys to the habitat of the reds, were now subject to the same selection pressure.

Question 4

(a) (i) Most candidates understood the significance of the target specificity achieved by Cry1Ac. Few were able to take this idea further and to suggest that beneficial insects such as pollinators would not be harmed, or to state genes coding for other Cry-proteins might not be effective in killing pests of cotton. Some candidates did not give an answer that suggested why one gene is to be preferred to another but instead described the benefits of inserting any Bt gene.

(ii) Candidates showed a good awareness of the role of promoters in initiating expression or transcription of a gene. Many also identified RNA polymerase as binding to the promoter sequence and some referred to selection of the correct template strand. Few candidates appreciated that promoters can control where and how much the gene is expressed. Errors included writing DNA polymerase instead of RNA polymerase and implying that the promoter binds to the DNA rather than itself being a section of the DNA.

(iii) Candidates were required to apply their knowledge of marker genes in a novel context. They had difficulty in clearly expressing the idea that on exposure to herbicide the surviving plants would be shown to possess ('marked' or identified as possessing) the Bt gene, since it was acquired alongside the herbicide resistance gene.

(b) (i) Most candidates correctly stated that although the Bt cotton seeds cost more, the cost of insecticide for growing Bt cotton was less. Many also correctly calculated the overall cost and stated that the total sum was greater for Bt cotton. A significant number discussed income and yield rather than, or in addition to, the comparative costs of growing the two types of cotton.

(ii) Most candidates correctly stated that farmers chose the non-GM crops because the seeds, or overall growth costs, were cheaper. Some candidates did not state which type of cotton they were referring to, so could not gain credit. Some candidates made contradictory statements, stating that farmers grew non-GM because 'its seeds are more expensive'. This could did not gain credit as it did not specify that it is Bt seeds that are more expensive.

(c) Many candidates knew that a variety of Bt cotton better adapted to drought conditions could be achieved by selective breeding (or artificial selection), and described in varying levels of detail the general principles of the process applied to this specific example.

Question 5

(a) Many candidates scored full credit on this question and showed a good understanding of the role of the myelin sheath. Weaker candidates sometimes stated that action potentials occur faster, rather than that the transmission of action potentials is faster. Few answers mentioned local circuits, and very few stated that the circuits were longer where a myelin sheath exists.

(b) The events at a synapse were well understood and candidates who used subject-specific terms with precision scored all of the credit available. The commonest errors were to omit the word 'ions' and refer to 'calcium channels', to write the calcium ion in symbols incorrectly (e.g. with a single positive charge instead of two positive charges) and to state that ions moved into the membrane instead of into the axoplasm of the pre-synaptic knob. Many candidates omitted to state that the calcium ions enter the knob by diffusion.

Question 6

(a) This question assessed understanding of the requirements for oxidative phosphorylation. Most candidates realised the need for oxygen but fewer appreciated a need for a hydrogen ion supply for the concentration gradient.

(b) Most candidates correctly stated that water would enter the mitochondrion by osmosis, possibly causing bursting of the organelle. A few candidates referred to the mitochondrion as a cell, so could not gain credit. Some did not realise that the question was about osmosis and focused on the movement of ions and other solutes.

(c) Most candidates correctly described oxygen as the final electron acceptor.

(d) Most candidates correctly named ATP synthase (or ATP synthetase) but some made the error of writing ATPase instead.

(e) This was a straightforward question requiring recall of oxidative phosphorylation. The commonest misconception was stating that protons are pumped to the inner membrane rather than to the inter-membrane space. Some candidates thought that the pumping used ATP, rather than energy from the movement of electrons along the electron carrier chain. Similarly not all answers stated that protons move back in the reverse direction to the matrix by passive diffusion (due to the proton gradient). Good answers identified that the protons passed through the ATP synthase channel, allowing ADP and P_i to join to make ATP.

Question 7

(a) (i) Most candidates correctly stated that a person with galactosaemia would need to restrict their dietary intake of dairy or lactose-containing products. A few candidates confused galactose with glucose and mistakenly thought that an insulin injection would help.

(ii) Most candidates attempted to explain how a mutation in a gene could result in a change in an enzyme, but few scored all of the credit available for this question.

There were many confused descriptions of the relationship between bases or nucleotides in DNA, codons on mRNA and amino acids in proteins, such as, 'the mutation causes a change in the base sequence of an amino acid', 'the mutation results in a different amino acid in the base sequence' and 'the mutation changes one gene on the DNA giving a different amino acid'.

Many candidates did not refer precisely enough to changes in the amino acid sequence or primary structure of the polypeptide and to the tertiary structure or three-dimensional shape of the resulting protein or enzyme.

From the information in the question, it was apparent that the GALT enzyme did not 'digest' or 'break down' galactose yet many candidates used these terms.

(b) This task involved working out the ratios of offspring of simple monohybrid crosses and was accessible to most candidates. The few incorrect responses stated that the offspring would have the same phenotypes as the parents, e.g. carrier × carrier giving 100% carriers.

(c) Most candidates scored some credit for this question, either for the term genetic screening or for reference to or an adequate description of amniocentesis. A few incorrectly described gene screening of an IVF embryo. Other candidates did not understand the idea that the amniotic fluid contained foetal cells and that the DNA of the foetal cells was being screened, not the fluid itself. A few candidates mistakenly thought that it would be possible to screen for the presence of galactose from the foetus within the mother's urine.

Question 8

(a) This question required candidates to describe the basic principles of a negative feedback mechanism. Most candidates instead focused on a detailed description of the control of a single named factor, which did not always highlight the general features of negative feedback such as change in a factor away from the norm, detection by a receptor, nerve impulses or hormones reaching an effector and a corrective action taking place to restore the factor to its normal set-point. Terms that a significant minority of candidates used incorrectly were 'stimulus' (as in statements about the stimulus being sent to the effector) and effector (as in the effector being the source of the hormones).

(b) This question gave candidates an unfamiliar diagram revealing the recently discovered role of the hypothalamus in controlling blood glucose concentration, which contrasts with the account where cells in the islets of Langerhans carry out the monitoring of blood glucose concentration. Virtually no candidates noticed this challenge to their existing framework of knowledge and commented that the two systems would both operate together or that this hypothalamic control would supplement the detection by the pancreas. Weaker candidates wrote an answer based on pancreatic detection that made no use of the new diagram at all and did not answer the question about the role of the nervous system.

Those candidates who did attempt to interpret the diagram and explain it often made mistakes such as substituting the vague term 'level' for concentration, referring to blood glucose concentrations being statically high or low rather than increasing or decreasing as a stimulus to trigger negative feedback, and writing that hormones were produced rather than released or secreted in response to nervous stimulation of the endocrine tissue. A particular weakness was the large number of candidates who referred to signals or messages travelling from the hypothalamus to the pancreas and adrenal glands, rather than impulses travelling along neurones. A more subtle mistake was to say that these nerve impulses travelled along sensory neurones. The hypothalamus as a central nervous system receptor would be linked to the endocrine glands by motor neurones.

(c) Describing and explaining aspects of thermoregulation was one of the weakest areas of the paper for many candidates. There was a lack of familiarity with concepts of energy conversion and heat transfer to surroundings, and errors in understanding such as the belief that blood capillaries can move closer to or further away from the surface of the skin.

In describing vasoconstriction, the majority could not name the arterioles of the skin as the blood vessels whose diameter constricts, or the capillaries as the vessels with reduced blood flow. Many candidates described shivering just as muscle movement rather than as muscle contraction. Many candidates did not respond to the comparative term *increasing* secretion of adrenaline as *increasing* the rate of respiration or metabolism, resulting in *more* heat being released.

Question 9

(a) Although this question earned credit for many candidates, many answers lacked precision, making general statements such as 'the rice plant grows tall so the leaves can exchange gases'. Credit

was most often given for references to aerenchyma, high tolerance of cells to ethanol and the presence of ethanol dehydrogenase in cells of the root.

Candidates who described air trapped on leaves often did not stipulate that this applies only to submerged leaves. Similarly, some said anaerobic respiration occurs, but did not specify that this happens only in the parts of the plant that are underwater.

Few candidates described the presence of aerenchyma in both the stem and roots and the fact that this enables oxygen to diffuse to the roots.

(b) Candidates were usually able to provide a good explanation of how the leaves of maize or sorghum are able to maximise carbon dioxide fixation at high temperatures. The role of the bundle sheath cells in keeping air away from RuBP or rubisco, and therefore preventing photorespiration, was frequently mentioned. Many candidates were able to describe the events in the mesophyll cells where carbon dioxide combines with PEP in the presence of PEP carboxylase to form oxaloacetate and its subsequent conversion to malate. Some candidates were not clear that the malate then passes to the bundle sheath cells where the carbon dioxide is only then released in order to react with RuBP. Many references to the enzymes having high optimum temperatures were provided. Where candidates understood the significance of the anatomy of the leaves some excellent descriptions of the roles played by the bundle sheath and mesophyll cells were seen.

Question 10

(a) Most candidates were able to correctly describe addition, substitution and deletion gene mutations. However, many candidates confused base sequence and amino acid sequence, and some referred to addition and substitution without attempting to name what was added or substituted. Stronger answers named frameshift as a consequence of addition or deletion, but few explained that this resulted in alteration of the sequence of triplets of nucleotides following the mutation. Few candidates were able to explain that a shortened polypeptide could be the result of a premature stop codon or that a stop codon did not code for an amino acid. Most thought a shortened polypeptide would be the result of a base deletion. Very few used the term nonsense mutation.

(b) This question was generally poorly answered. Many candidates gave a lengthy description of the mutant sickle cell allele, with details of the base change involved and the resulting amino acid change, but did not address the question about the phenotypic effects of the allele.

Detailed knowledge of how sickle cell haemoglobin and red blood cells differ from the norm was rarely shown. Few candidates specified that the β polypeptide chain is altered, or that it forms fibres in low oxygen concentrations due to its lower solubility. Most candidates described the formation of sickle-shaped red blood cells, but a large number of candidates confused haemoglobin molecules and red blood cells, making no distinction between them. For example, some used haemoglobin dissociation terminology inappropriately in saying that sickle-shaped red blood cells have lower affinity for oxygen.

There was confusion about what happens in a sickle cell crisis where the sickle-shaped cells get stuck in capillaries, blocking blood flow, with many candidates wrongly describing this as blood clotting. Symptoms of sickle cell anaemia were poorly described, with most answers being vague references to tiredness and paleness and few candidates mentioning pain due to sickle cell crisis. Some candidates were able to describe the protection against malaria.

BIOLOGY

Paper 9700/51
Planning, Analysis and Evaluation

Key messages

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In the experimental design question it is important that the response is written as a logical sequence of steps that the candidate would actually do, not as a series of suggestions that they should do.

General comments

There was a good range of responses and the majority of candidates seemed to be at ease with the material on which the questions were based. There was no indication of a lack of time to complete the paper. There were a number of occasions where candidates wrote additional information at the bottom of pages without indicating they had done this. It is important that this is indicated in the main part of the answer.

Comments on specific questions

Question 1

This question required candidates to appreciate how to make up a stated stock solution of urea, dilute it appropriately and then plan an investigation to find K_m values at different temperatures.

(a) (i) This required a practical approach to weighing out the correct mass of urea to dissolve in 500 cm^3 of water and many responses gained full credit for taking 6.01 g of urea and dissolving it in 500 cm^3 of water. Full credit was also gained by those who took a mass to make a stock solution which was then appropriately diluted to give the required volume and molarity. This was commonly adding 60.1 g to 1 dm^3 then diluting × 5 (100 cm^3 urea solution and 400 cm^3 water). The mass used needed to relate correctly to the required final molarity and volume. It was important to use units in the correct way, so masses needed to be stated in grams and not 'a mole' or '0.2 of a mole' and 500 cm^3 of water used and not 500 cm^{-3}, as was sometimes given. Some candidates began with a stated molarity and so gained no credit for the weighing point, but were able to gain credit for a correct dilution. A small number of candidates incorrectly suggested either making urea from ammonium and carbonate ions, or suggested collecting urine of the correct molarity.

(ii) Many students showed a good knowledge of serial dilution and gave clear accounts, often supported by a small diagram. The most common error was to describe only one step from the starting concentration in detail and then simply say 'repeat' without making it clear that the dilution just achieved was the starting point for the next step rather than the original stock solution. Some candidates confused serial dilution with proportional dilution.

(b) (i) There was some confusion over both the variables. The introduction to the question stated that a student carried out an investigation to find the K_m of the enzyme urease at different temperatures. Thus, the independent variable is temperature (not urea concentration). The dependent variable is the parameter measured directly in the investigation, in this case it is conductivity (not rate of reaction).

(ii) Many candidates gained credit by describing one of two ways of approaching this. The final reaction mixture needed to either lack the substrate (urea) or to lack the active enzyme (urease)

which could be achieved by boiling or removal of the urease. Some weaker responses stated just 'use water' with no reference to the lack of urea or urease. There were quite a few responses which showed a misunderstanding of what a control was and described a factor that should be controlled like pH, rather than getting across the idea of a controlled experiment.

(iii) Although there were a good number of very reasonable answers they were not always set out in the most appropriate way. Many candidates unnecessarily described the methods for preparing the urea solutions, which was not required. Likewise, there was no need to list the dependent and independent variables or give a generic list of all the factors that might be controlled in any investigation. Candidates should produce a sequential description of the key steps in the investigation, set out so that it could be followed by others.

The experiments described needed to be set up at a suitable range and number of temperatures. Five values controlled by a water-bath or equivalent were needed, with values above 70 °C or below 10 °C discounted as enzyme activity would be low or non-existent. The question referred to using the apparatus shown in **Fig. 1.2** but given that the aim was to be able to work out the initial rate of reaction, the conductivity should be recorded immediately after the enzyme and substrate were put together. The initial rate will be very soon after enzyme and substrate are mixed which not all candidates showed awareness of. **Fig. 1.2** shows the apparatus during the course of the reaction when enzyme and substrate were already mixed. To produce the results aimed for, suitable volumes of the urease solution and the urea solution needed to be heated to temperature before mixing. The solutions needed to be buffered as changing pH would be a variable that would alter the results. Once the two solutions are together the probe should be read immediately. Omission of this critical step denied access to maximum credit. Thus a good answer would show the probe already in the tube containing one of the solutions and then the other would be added and a reading taken immediately. Standardising the volume in the tube was often mentioned but it was the enzyme and substrate volumes separately that needed to be standardised, not just the combined volume. The combined volume should not exceed the volume of the tube allowing for the probe. The units for the volume of urease were not well understood by some: 1 g per 10 cm^3 is not a volume. A number of candidates seemed to be adding a stated mass of urease which was a misunderstanding of the information in the question. The method described needed to make it clear that each urease concentration would be tested at each temperature and that at least three sets of results would be obtained for each set of conditions to allow a mean to be calculated. The term 'average' should not be used. This is a low risk investigation but urease is a potential allergen or irritant.

(c) (i) The curve reaching a plateau was correctly drawn by the great majority of candidates. A large number correctly indicated V_{max} and $½V_{max}$ and were able to draw across and down to place K_m on the *x*-axis. Responses that did not gain credit included placing K_m on the *y*-axis or just writing $K_m = ½V_{max}$ or $½K_m = V_{max}$ somewhere on the plot. A few tried calculating the slope to give the initial rate, which was not required.

(ii) The majority of candidates gained credit here for identifying that **D** was the temperature as it had the lowest K_m. A few just copied out the information in the question by saying 'the lower the K_m the greater the affinity' without pointing out that **D** was the lowest K_m. The most common incorrect response was **A**.

Question 2

This question looked at a laboratory investigation into the effect of saline conditions on germination and then related it to the possible significance in agriculture.

(a) (i) This was well answered. The commonest responses were temperature, soaking times or number of grains. The candidates tended to answer the question in two ways. Thus for 'time' they would either say 'time grains were soaked' or 'the grains were soaked for 12 hours'. Either of these was acceptable and often both were given.

(ii) This was less well answered with many responses giving another variable that had been standardised. Mass of grains was ignored as it was unclear if this referred to individual grains or all of the grains. Size was too imprecise to be creditworthy. Age of grain, pH, light exposure, spacing of grains were all seen and credited. Volume of salt solution was commonly mentioned, but only

credited in relation to the soaking of the filter paper in the petri dish as the volume for the pre-soaking of the grain is not critical, as long as the grain was covered.

(b) (i) Most candidates identified the two results that were most likely to be anomalous.

(ii) The question asked for the statistical test which could be used to investigate a possible correlation. This indicates either Pearson's linear correlation or Spearman's rank correlation as these are the two tests in the syllabus that relate to correlation. However, a large number of the responses incorrectly gave the *t*-test or the chi-squared test. For those who identified it must be a correlation test a large majority correctly identified Pearson's linear correlation with a valid reason, although a few suggested a 'Pearson's rank' test, which is a contradiction. Some candidates, having chosen Pearson's linear correlation, simply stated what the test is used for rather than saying why it is the correct test to use.

(c) There were some misconceptions here, where candidates gave comparative conclusions rather than those valid for both varieties **X** and **Y**. The overall trends that could be concluded were required, not just raw, unqualified data quotes. Looking vertically down the data it is clear that as the salinity increases the cumulative percentage germination decreases. Looking horizontally across the data shows the trend of increasing cumulative percentage germination from day 1 to day 5. Many candidates gave these two ideas expressed in various ways. A few gained only partial credit by not mentioning germination and only giving increasing or decreasing figures. Far fewer were able to develop the ideas further and see that in both nearly all/90% plus, germination occurs in the first day, or that over the 5 day period in both some do not germinate.

(d) (i) This question was well answered and a large majority of candidates produced a comparative answer, stating that germination was higher in variety **X** than variety **Y**. Some made a general statement regarding all salt concentrations but many chose a specific concentration such as $60\,\text{mmol}\,\text{dm}^{-3}$ as representing a 'salty soil'. Both were acceptable provided the statement was comparative. Those who just chose to quote data needed to make it comparative by a link word such as 'only' to imply one is greater than the other. Again, some responses did not mention germination.

(ii) Many candidates did not appreciate what was required here. This question needed to be answered in a field context. All the data which suggested that variety **X** was better suited to salty conditions was based on laboratory experiments with seeds being germinated on filter paper in petri dishes. To answer this question, candidates needed to suggest a further investigation where barley of both varieties was grown in salty soils and then some aspect of the germination, growth or yield of each variety was recorded. This would allow the researchers to suggest which variety was most suitable for farmers to plant in salty soils.

BIOLOGY

Paper 9700/52
Planning, Analysis and Evaluation

Key messages

In this paper, candidates will be presented with unfamiliar procedures and contexts. Therefore, they need to read the questions carefully in order to understand the basis of the question.

Candidates should understand the meaning of units and use them in the correct context.

In describing an experimental method candidates should write a logical sequence of steps that would actually be carried out, not a series of suggestions that they should do.

General comments

Candidates did seem to have been short of time, although in many cases they showed difficulty in expressing their answers clearly. This was evident in **Questions 2(c)** and **(d)**. In some questions it was clear that candidates had not made use of the information given, for example in **Question 1**, the volume of the boiling tube and the function of a biosensor. In some other questions, candidates gave a response that did not answer the question, for example, **Question 1(a)(ii)** and **2(a)(i)**.

Comments on specific questions

Question 1

(a) (i) Many candidates gave a correct answer, but there were also a high proportion who did not know how to calculate the correct mass of lactose to make 0.15 mol dm^{-3} lactose. A common error was to add 0.15 g of lactose to 1 dm^3 of water. There were also candidates who confused mass, volume and concentration units and so weighed 51.35 g mol^{-1} of lactose or added 1 dm^{-3} of water to lactose. Credit was allowed if a 1 mol dm^{-3} lactose solution was made correctly and then diluted to give a 0.15 mol dm^{-3} solution.

(ii) Very few candidates were able to describe proportional dilution correctly. The great majority described serial dilution. It is essential that candidates know the difference between these two methods of dilution. Candidates who used the formula $C_1V_1 = C_2V_2$ rarely gained credit as they only explained how to make one further solution. The statement 'repeat to make the other solutions' was not acceptable.

(b) (i) Candidates had difficulty identifying which was the dependent variable and which was the independent variable. A great many candidates gave two answers for both of these variables. Careful reading of the information in the question should have established that the independent variable was pH and that, as K_m was being measured, there needed to be a range of concentrations of the enzyme substrate. The dependent variable in this case was the glucose concentration, measured using a biosensor. However, many candidates quoted what their calculated data would tell them, rather than the raw data they would collect.

(ii) The most common correct suggestion for a control was to use boiled or denatured enzyme. Other candidates referred to leaving out either the enzyme or substrate, but did not gain credit unless they replaced the missing component by water or other suitable liquid to maintain the volume. There were a lot of candidates who were uncertain about the difference between a control and a controlled or standardised variable and so gave answers about maintaining the temperature.

(iii) Although there were some good responses presented in a logical way, the majority were not in a form that could be used by another person. The question specified that candidates did not need to describe the methods for preparing the lactose solutions but many did so. A great many candidates also listed the dependent variable, the independent variable and all of the factors that might be controlled in any investigation, but did not actually describe any procedure. These responses gained very little or no credit. Candidates need to produce an answer which is like a practical schedule that identifies the apparatus, and has instructions on what to do in order to test the independent variable, standardise important variables and measure the dependent variable.

A suitable range and number of pH values needed to be stated for this investigation. Many candidates referred to using five different pHs, but did not state any values. Most candidates mentioned that a buffer should be used to maintain pH, although in some cases appeared to think that the buffer was a different solution to pH solution. A large minority referred to mixing concentrated acids and alkalis to make a specific pH and then adding buffer to keep the pH constant. Candidates should be aware that buffers are solutions with a specific pH that does not change during a chemical reaction and are not hazardous. A common error in weaker answers was that changing the concentration of lactose changes its pH.

Candidates were told to use the apparatus shown in **Fig.1.2**, which features a partly filled 40 cm^3 boiling tube, but many candidates added volumes of lactose or lactase that exceeded this total volume. Some weaker answers referred to a known volume of lactose and lactase being added to the boiling tube without making it clear that the individual volumes of lactose and lactase needed to be the same for each measurement. Although most candidates referred to keeping the temperature constant, many of these did not say how this was to be achieved. Only the strongest answers showed the understanding that the lactose and lactase should be equilibrated separately before being mixed. Some candidates also appeared be confused by the lactase unit of concentration as they referred to adding 10 g of lactase.

The question told candidates that the initial rate of reaction should be measured, but very few realised that this measurement should made as soon as possible after the enzyme and substrate are mixed. Ideally the biosensor should already be in place or added immediately so that a measurement can be taken straight away. This is a critical step and an understanding of this idea was required to gain maximum credit. A great many candidates stated that the mixture should be left for period of time, often 5 or 10 minutes before taking a measurement, by which time at low substrate concentration and optimum pH any reaction would be complete. Additionally, candidates seemed to be unsure of what should be measured, even though the question informed them that a glucose biosensor measures glucose concentration. The majority measured either rate of reaction or K_m, both of which are calculated values. Stronger answers explained that all of the different concentrations of lactose needed to be measured at each of the pH values tested and that at least three sets of results would be obtained for each set of conditions to allow a mean to be calculated. The term 'average' should be avoided. Poorer answers often made measurements without adding the enzyme. Some candidates also spent time unnecessarily writing extensively about how to process the results to obtain a K_M value. Most candidates realised this was a low risk experiment, although credit was allowed for lactase allergy and a suitable precaution. Lactose intolerance was a common, but inappropriate, suggestion.

(c) (i) Most candidates were able to draw a correct curve and the strongest responses also labelled the curve correctly. Poorer answers showed some uncertainty about where to place the labels, in particular K_m, which was often placed on both axes. Others just wrote that K_m = ½ V_{max} somewhere on the plot, next to ½ V_{max}, or on the *y*-axis. A few candidates drew an exponential line or a bell shaped curve.

(ii) The majority of candidates gained maximum credit for this question. A few weaker answers did not identify the value as the lowest, but just stated the phrase 'the lower the K_m the greater the affinity', and so did not gain the credit.

Question 2

(a) (i) Relatively few candidates identified a correct variable that could be standardised. The most common was the volume of saline used for irrigation, although some candidates did not gain credit if they referred to 'amount' of saline. Many candidates described how the planting had been standardised instead of what could be standardised after planting. Others gave responses that did

not take into account the fact that this was a field investigation, so abiotic factors such as temperature and soil pH cannot be standardised.

(ii) Most candidates identified a correct variable, commonly light intensity and temperature. Common errors were to give answers such as 'the maturity of the crop' or 'the growth of the crop'.

(b) Very few candidates were able to explain why dry mass was used. Many knew that water has a mass, but fewer went on to make the link that the different plants may have contained different volumes of water. Some candidates understood that the biomass was being measured but did not always relate this to the increase in organic matter, so statements like 'dry mass tells you what the yield is without water' and 'it shows the actual growth' were common. Candidates often did not word their answers to make it clear that different crops could then be compared.

(c) Many candidates gave a correct answer, commonly finding the dry mass of the control, halving it and then finding the concentration of saline solution that gave a crop with this dry mass. Relatively few candidates plotted a graph of the yields of crops at different salt concentrations and found the intercept at 50% yield. Weaker answers did not seem to understand that the comparisons of yield needed to be made to the control plots. These answers tended to either measure the dry mass at planting, then grow the plants and measure the dry mass at the end, or find the lowest and highest dry mass and calculate the 50% value of these values. Some of the weakest answers suggested that the crop plants contained salt that was absorbed and reduced the growth.

(d) Stronger answers gained maximum credit as candidates recognised that monocotyledons are generally more tolerant to salt solutions than dicotyledons and identified the most tolerant and the most susceptible crop. Less effective answers tended to make the same point, that monocotyledons are more tolerant, several times. A great many compared crops grown for human and animal consumption which both show the same pattern. Very few candidates observed that even the most tolerant crops show some sensitivity to saline solutions. Candidates who wrote extensively often ended up contradicting themselves. Some candidates did not show understanding of the *y*-axis label and so interpreted the data in reverse. A few candidates thought this was a question about natural selection and so answered in terms of resistance and adaptation.

(e) Most candidates gave at least one correct reason, commonly an abiotic or climatic factor. The majority however did not consider any other factors, such as farming techniques, seed germination in saline soil, or the effects of irrigation on soil.

BIOLOGY

Paper 9700/51
Planning, Analysis and Evaluation

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General comments

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which could be achieved by boiling or removal of the urease. Some weaker responses stated just 'use water' with no reference to the lack of urea or urease. There were quite a few responses which showed a misunderstanding of what a control was and described a factor that should be controlled like pH, rather than getting across the idea of a controlled experiment.

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(c) (i) The curve reaching a plateau was correctly drawn by the great majority of candidates. A large number correctly indicated V_{max} and $½V_{max}$ and were able to draw across and down to place K_m on the *x*-axis. Responses that did not gain credit included placing K_m on the *y*-axis or just writing $K_m = ½V_{max}$ or $½K_m = V_{max}$ somewhere on the plot. A few tried calculating the slope to give the initial rate, which was not required.

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Question 2

This question looked at a laboratory investigation into the effect of saline conditions on germination and then related it to the possible significance in agriculture.

(a) (i) This was well answered. The commonest responses were temperature, soaking times or number of grains. The candidates tended to answer the question in two ways. Thus for 'time' they would either say 'time grains were soaked' or 'the grains were soaked for 12 hours'. Either of these was acceptable and often both were given.

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credited in relation to the soaking of the filter paper in the petri dish as the volume for the pre-soaking of the grain is not critical, as long as the grain was covered.

(b) (i) Most candidates identified the two results that were most likely to be anomalous.

(ii) The question asked for the statistical test which could be used to investigate a possible correlation. This indicates either Pearson's linear correlation or Spearman's rank correlation as these are the two tests in the syllabus that relate to correlation. However, a large number of the responses incorrectly gave the *t*-test or the chi-squared test. For those who identified it must be a correlation test a large majority correctly identified Pearson's linear correlation with a valid reason, although a few suggested a 'Pearson's rank' test, which is a contradiction. Some candidates, having chosen Pearson's linear correlation, simply stated what the test is used for rather than saying why it is the correct test to use.

(c) There were some misconceptions here, where candidates gave comparative conclusions rather than those valid for both varieties **X** and **Y**. The overall trends that could be concluded were required, not just raw, unqualified data quotes. Looking vertically down the data it is clear that as the salinity increases the cumulative percentage germination decreases. Looking horizontally across the data shows the trend of increasing cumulative percentage germination from day 1 to day 5. Many candidates gave these two ideas expressed in various ways. A few gained only partial credit by not mentioning germination and only giving increasing or decreasing figures. Far fewer were able to develop the ideas further and see that in both nearly all/90% plus, germination occurs in the first day, or that over the 5 day period in both some do not germinate.

(d) (i) This question was well answered and a large majority of candidates produced a comparative answer, stating that germination was higher in variety **X** than variety **Y**. Some made a general statement regarding all salt concentrations but many chose a specific concentration such as $60\,\text{mmol}\,\text{dm}^{-3}$ as representing a 'salty soil'. Both were acceptable provided the statement was comparative. Those who just chose to quote data needed to make it comparative by a link word such as 'only' to imply one is greater than the other. Again, some responses did not mention germination.

(ii) Many candidates did not appreciate what was required here. This question needed to be answered in a field context. All the data which suggested that variety **X** was better suited to salty conditions was based on laboratory experiments with seeds being germinated on filter paper in petri dishes. To answer this question, candidates needed to suggest a further investigation where barley of both varieties was grown in salty soils and then some aspect of the germination, growth or yield of each variety was recorded. This would allow the researchers to suggest which variety was most suitable for farmers to plant in salty soils.