# BIOLOGY

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

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

## General comments

The paper differentiated well.

## Comments on specific questions

### Question 1

Nearly all candidates realised that statement 3 was correct. Only the stronger candidates correctly chose option **D**. The most common incorrect response was to select option **B**.

### Questions 2 and 3

The majority of candidates answered these questions correctly.

**Question 4**

This question proved to be straightforward for all abilities, with the vast majority of all candidates answering correctly.

**Question 5**

Most candidates who performed well overall answered correctly. Of the weaker candidates, many incorrectly selected options that identified centrioles as spherical rather than cylindrical.

**Questions 6**, **7** and **9**

Almost all the stronger performing candidates and many of the weaker candidates answered these questions correctly.

**Question 8**

Almost half of candidates answered correctly. The most common incorrect response was to select option **A**. Since the student was recording the time taken for the first appearance of a colour change, the 'the time the solutions are heated' is a variable that cannot be standardised.

**Question 10**

Almost all the stronger performing candidates were able to identify the molecules as glycerol and fatty acids, to conclude that the bonds were ester bonds (option **A**). Many of the weaker candidates also answered correctly. The most common incorrect response was to select option **B**.

**Question 11**

This question proved to be straightforward for all abilities, with most candidates answering correctly.

**Question 12**

Those candidates who performed well overall were able to answer correctly. The most common incorrect response was to select option **B**. The amino acids in a β-pleated sheet are not coiled and the quaternary structure does not always contain two types of polypeptide.

**Questions 13**, **15** and **16**

Most candidates found these questions straightforward. Almost all the stronger performing candidates and many of the weaker candidates answered correctly.

**Question 14**

Almost half of candidates answered correctly. The most common incorrect response was to select option **A**. Since induced fit can occur at an active site, the site does not have a fixed shape.

**Question 17**

Almost half of all candidates were able to process the information provided and then select the correct explanation. All other options were selected by at least some of the candidates.

**Question 18**

Most candidates realised that the space Y would be taken up by solution X and correctly selected option **C**.

**Question 19**, **20**, **26** and **36**

These questions were straightforward for all abilities and most candidates answered correctly.

**Question 21**

Most of the stronger performing candidates realised that only statement 2 is a feature of nuclear division and so answered correctly. The weaker candidates selected across all options, with option **A** as the most common incorrect response.

**Questions 22**, **24**, **29**, **31** and **37**

Most candidates found these questions straightforward. Almost all the stronger performing candidates and many of the weaker candidates answered correctly.

**Questions 23**, **25**, **27**, **32, 34** and **35**

Almost all the stronger performing candidates and many of the weaker candidates answered these questions correctly.

**Question 28**

Almost all the stronger performing candidates correctly worked out the fifth event in the cardiac cycle and so answered correctly. The weaker candidates selected across all options, with some answering correctly.

**Question 30**

Some candidates found this question challenging, although most of the stronger performing candidates answered correctly. The weaker candidates selected across all options, with the most common incorrect response being option **B**.

**Questions 38** and **39**

At least half of those who performed well overall answered correctly. Others found these questions more challenging and selected across all options.

**Question 40**

Almost all the stronger performing candidates and many of the weaker candidates answered these questions correctly.

# BIOLOGY

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

## Key messages

- Candidates should check the scaling used for axes carefully before extracting data from graphs. **Question 2** included a bar chart comparing the content of three components in cigarette smoke. The *y*-axis value was 0.4 mg for each 2 mm square and the *y*-axis printed values were every 2 mg from 0 to 20. Some candidates incorrectly used one 2 mm square to equate to 0.2 mg. Using a ruler to check across from the *y*-axis would also have helped some candidates.
- For **Question 3(b)**, a number of candidates knew that mature red blood cells lack organelles to allow room for haemoglobin molecules but did not realise that these cells have cytoplasm. Candidates should be aware that the cytoplasm contains haemoglobin molecules and that these molecules require an aqueous environment to function in the carriage of oxygen and carbon dioxide.
- Candidates were generally more familiar with the concept of viral and bacterial diseases. Many did not appreciate in **Question 5** that malaria is a disease caused by a protoctist, and that protoctists are eukaryotic organisms.

## General comments

Many candidates demonstrated that they were knowledgeable of the syllabus learning outcomes. Generally, responses contained separate clear sentences, each containing a correct idea pertinent to the question. Each response to each part-question contained enough different main points to cover the marks allocated to the question, and where there were extended responses, these appeared to be planned and laid out in a logical sequence to show the correct train of thought.

In questions such as **Question 1(a)**, where candidates were asked to identify with a label line a structure or region, a ruler should be used for the label line, and the end of the label line should clearly end at the structure or within the region.

In **Question 2(c)**, there was generally good understanding of the difference between the role of haemoglobin and red blood cells. However, for a number of weak responses, it was clear that the candidates thought that red blood cells and haemoglobin were the same, or that a red blood cell carried only one haemoglobin molecule. There were responses that described the binding of oxygen to a red blood cell, or stated that if carbon monoxide bound to a haemoglobin molecule, this meant that a red blood cell could not carry any oxygen.

**Question 3(d)** and **(e)** were based on a condition of red blood cells that was associated with the disease spherocytosis type 2. Even though this was clearly stated, a proportion of candidates focused their ideas and their written responses on sickle cell anaemia. Candidates should be prepared to come across unfamiliar material in questions.

In completing **Table 4.1** in **Question 4(a)**, there was a gap in knowledge for many candidates in relation to the name of the bond between the DNA nucleotide monomers. A higher proportion gave hydrogen bond as their answer rather than correctly stating phosphodiester bond.

**Question 5(e)** was about problems with developing a vaccine. A proportion answered this as problems with current vaccines and gave general ideas such as malnutrition giving a poor response, or inability to reach people to carry out a vaccination programme.

In **Question 6**, **Fig. 6.1** was a graph of substrate concentration against rate of reaction for an enzyme-catalysed reaction. Candidates were asked to explain the differences between the rates of reaction at a low substrate concentration compared to a high substrate concentration. Only some were aware that this meant

that biological explanations were required and many gave only a description of the results at the two values stated.

There were some part-questions where candidates were required to make comparisons. Some were very accomplished in this, but others did not use comparative terms or make it clear to which side they were referring; this was particularly apparent in **Question 3(e)**, where it was not always clear if candidates were referring to normal red blood cells or spherocytosis type 2 red blood cells.

## Comments on specific questions

### Question 1

**(a)** Candidates were required to add a label line to **Fig. 1.1** to identify one area with phloem sieve tubes. Most chose an area within a vascular bundle, and many chose one of the larger bundles so that they could clearly label the area concerned. A good number added their line to the outer darker area of sclerenchyma, and some chose the inner xylem. Some ended their label line at the junction between the phloem sieve tubes and sclerenchyma and did not gain credit.

**(b)** There were many good answers here. Stronger responses used the term photosynthates or assimilates or gave correct examples of assimilates, in particular sucrose and amino acids, rather than stating 'food', which did not earn credit. Stating that transport occurred from a source to a sink was commonly seen, with some also giving correct examples of sources and sinks. It is more accurate to state that transport is from the source to a sink, rather than to state that the assimilates are transported to a source to be taken to a sink. Weaker responses were too vague in describing the transport of assimilates to gain credit.

**(c) (i)** This was well known by many. Some did not follow the instruction to name the tissue and stated epidermal cell. Common errors were to state cuticle, endodermis or epithelial tissue.

**(ii)** To work out the correct proportions of tissues when viewing specimens using a microscope, it is only necessary to use an eyepiece graticule, which many candidates knew.

**(d)** Many candidates demonstrated very good drawing skills and there were some excellent diagrams drawn. The instruction was to label only those structures that are found only in plant cells and quite a few answers gained only partial credit as they also labelled those found in animal cells. In some diagrams, the large permanent vacuole was too small or missing and in others a double membrane was drawn for the tonoplast. Some did not draw in a cell wall. Very weak responses included structures within the cell that should not be there, such as drawing in a vascular bundle. A few drew sections through a leaf.

### Question 2

**(a)** A very high proportion interpreted **Fig. 2.1** correctly and gave the two WHO regions required. There were some who only gave one region, SEARO, and some mistakenly gave AMRO instead of EMRO as the second region.

**(b)** Candidates needed to use their knowledge of the effects of each of the three components of cigarette smoke listed. Those who knew that nicotine increased the stickiness of platelets, and so increased the risk of blood clots, were able to compare the data for the AFRO and EURO regions to see that AFRO had the higher nicotine content. This was also supported with the correct comparative data taken from the graph. The reference in the key to (x10) by nicotine indicated that the value plotted was ten times larger than actual, but for the correct extraction of data, 9.2 compared to 7.7–7.9 mg per cigarette was acceptable. Many just stated tar, while some gave tar and nicotine as the two bars that were higher than those for EURO. Some weak responses included carbon monoxide, despite this being a higher value for EURO than AFRO.

**(c)** The quality of responses varied widely. There were two approaches that were acceptable for this question: carbon monoxide in cigarette smoke entering the blood stream leading to a decrease in available oxygen, and less oxygen entering the blood stream during gas exchange. The majority who gained credit concentrated on the effect of carbon monoxide. Some of the in-depth responses focusing only on carbon monoxide gave enough detail to gain full credit. It was important to explain

in some way that the affinity of haemoglobin for carbon monoxide was (far) greater than for oxygen and to show understanding that, overall, the percentage saturation of haemoglobin would decrease, as there would be less haemoglobin available to bind oxygen. Many remembered the term carboxyhaemoglobin and quite a number noted that binding was more permanent or more stable than when oxygen binds to haemoglobin. Some candidates gave good accounts but lost a little credit by accidentally stating 'carbon dioxide' within their response. Some weak responses used 'red blood cell' instead of haemoglobin, a few of whom suggested oxygen was complementary to the biconcave shape of the red blood cell. Weaker responses that focused only on cigarette smoke in the airways tended not to note the introduction to the question about short-term effects and wrote about emphysema, or gave vague ideas suggesting that tar would block the airways. More thoughtful accounts that focused on cigarette smoke affecting the airways noted the accumulation of mucus and the decreased quantity of air containing oxygen that could reach the gas exchange surfaces.

**Question 3**

**(a)** The strongest responses gave comparative sentences to clearly show the advantages of the electron microscope over the light microscope. Some did not do this, stating only that electron microscopes have a high resolution. Quite a number repeated the information given to them about a higher magnification and this did not earn credit. The ability to see more detail needed to be supported by a correct example, such as being able to see ribosomes or details of the internal structure of mitochondria. It was not enough to say 'can see more detail in the cell'. Some confused values of wavelength with resolution or gave the incorrect units for the resolutions achieved, for example stating that the electron microscope, compared to the light microscope, could see structures smaller than 200 μm instead of 200 nm. Some gained credit for knowing that the electron microscope had a higher resolution but went on to contradict themselves by getting the values the wrong way around.

**(b)** Candidates were expected to use their knowledge of red blood cell structure to be able to make comparisons, using information about erythroblasts that could be taken from the text and from the image shown in **Fig. 3.1**. Many correctly noted the presence of the nucleus in an erythroblast cell and the difference in shape of the two cell types. A common error was to state that the red blood cell had a concave, rather than a biconcave shape. Some referred only to surface area without mentioning specific shapes. A number of candidates stated that the red blood cells had no cytoplasm, while others stated that the cells were hollow. Credit was awarded for a comparison with regard to haemoglobin: those who only stated that red blood cells have haemoglobin were not credited as this did not identify whether or not erythroblasts had haemoglobin. As candidates were not expected to know about the stages of development of red blood cells, stating that erythroblasts did not have any haemoglobin (whereas red blood cells do) was awarded credit. However, there were also some good answers explaining that the organelles were still present within the erythroblast for the synthesis of haemoglobin, so that there would be some, but less, haemoglobin than red blood cells. To achieve further credit, some candidates needed to give three differences to match the level of credit available for this question. Weaker candidates just repeated the information given, explaining that erythroblasts were in the bone marrow and red blood cells were in the circulation.

**(c) (i)** Many achieved full credit for completing **Table 3.1**. Some logically placed the organelles in sequence of the process of synthesis: nucleus, ribosome or rough endoplasmic reticulum and Golgi body. Those who suggested Golgi body but then incorrectly qualified with reference to packaging into Golgi vesicles or secreting proteins were not credited as the question asked only about protein synthesis and these stages occur after protein synthesis. Mitochondria providing ATP for synthesis needed to be qualified with more detail, such as the activation of amino acids to form aminoacyl tRNA. Some candidates did not give organelles so this column sometimes contained DNA, mRNA, rRNA or tRNA. Cytoplasm was a relatively common, incorrect, inclusion and a number confused the nucleus with the nucleolus.

**(ii)** Many candidates answered correctly. Most candidates recognised that they should name an enzyme but some gave terms related to the carriage of gases by haemoglobin, such as carbaminohaemoglobin. Others gave carbon anhydrase or just anhydrase and this did not gain credit. Carboxylase was also seen.

**(d)** The two most popular ideas that gained candidates full credit were correct reference to the difference in surface area to volume ratios and the decreased ability for a spherical red blood cell to pass through capillaries. Many were able to gain some of the credit available. Very few responses noted that the shape of a biconcave cell rather than a spherical cell would be more advantageous in terms of distance for oxygen to travel to reach haemoglobin molecules and time taken to reach high levels of saturation of haemoglobin with oxygen.

**(e)** Stronger responses compared both cell types, worked sequentially through the scenario presented and used the correct terminology in their response to gain full credit. These responses made it clear as to whether they were referring to the normal red blood cell or the red blood cell with spherocytosis type 2. Others could have improved their response by explaining that osmosis occurred with water entering both cells (down the water potential gradient) and then comparing the effects of this in both cells rather than only writing about one cell type. Weak responses suggested that the mutation gave spherocytosis type 2 cells a stronger membrane, while quite a few attempted to explain how differences would affect the ability of the cells to take up oxygen.

**Question 4**

**(a)** Almost all candidates were able to gain some credit completing **Table 4.1**. The most well-known bonds were the glycosidic bonds between glucose monomers and the least well-known were the phosphodiester bonds between nucleotides. An error seen in a number of responses was to state protein as the monomer for collagen – some stated amino acids (protein) or protein (amino acids), but this did not gain credit.

**(b)** Most candidates gained some credit for their explanations of the different structures. Many knew that amylose has $\alpha$-glucose monomers and cellulose has $\beta$-glucose monomers; details of the bonds were less well known. Stronger responses stated $\alpha$-1,4 for amylose and $\beta$-1,4 for cellulose, but others only stated 1,4. It was quite common for candidates to suggest that cellulose has both $\alpha$-1,4 and $\beta$-1,4 bonds. The descriptions varied greatly when candidates were explaining that only cellulose molecules had adjacent glucose monomers rotated through 180°.

**(c)** The description of semi-conservative replication of DNA was generally very well answered and many candidates gained full credit. A common error was to write about strands of DNA when referring to DNA molecules or the DNA double helix. Some candidates used the term ‘unzipping’ to mean unwinding, which was not credited. The idea of unzipping is related to the breaking of the hydrogen bonds between complementary bases on the two polynucleotide strands, and although this term is helpful in the explanation, it should always be qualified with reference to the breaking of hydrogen bonds. Some candidates could have made it clearer that the process is a sequential addition of activated nucleotides, that is, there is elongation of a growing polynucleotide chain. Some incorrectly stated that DNA ligase was the main enzyme for polymerisation. Fewer wrote about the idea of leading and lagging strands and the requirement of ligase to seal together (Okazaki) fragments.

**Question 5**

**(a)** Most candidates knew that the end result of the action of penicillin on bacterial cells was cell lysis. Quite a few understood that penicillin acted as an inhibitor of the transpeptidase enzyme and gave good accounts of how this would prevent cross-links forming between peptidoglycan chains. However, there was considerable confusion seen in many other accounts: some thought that penicillin was able to produce autolysin to make holes in the cell wall, or that penicillin made holes. Others believed that it prevented the formation of peptidoglycan molecules. The weakest responses suggested that it was involved in the immune response, with some describing penicillin as engulfing bacteria.

**(b)** The name of a species of *Plasmodium* was generally well known. Many, however, wrote the genus of the mosquito, Anopheles.

**(c)** A range of ideas were seen, and many candidates were able to give a reasonable suggestion to gain credit. Some knew that protein was used by females for some aspect of reproduction but did not mention egg development. There were vague accounts such as ‘only females reproduce’ or quite incorrect use of terminology ‘for females when they are pregnant’. Many incorrectly suggested females needed blood to feed to their larvae.

**(d)** Suggesting explanations for the results in **Fig. 5.1** was a challenge for a number of candidates. However, there were quite a few who worked steadily through the information provided to understand well what the research showed. These candidates explained themselves accurately and could go on to make a valid comment as to the importance of the results for doctors.

Those who believed *Plasmodium* was a bacterium got very confused with the pathogen and the bacteria that live in the gut of *Anopheles*. Some thought the bacteria lived in the gut of humans rather than in the mosquito. Many answered in terms of antibiotic resistance, which was not applicable to this unfamiliar context. It was a difficult concept for some candidates to understand that: a blood meal containing antibiotics taken by *Anophleles* would only kill bacteria and not the protoctist *Plasmodium*; presence of bacteria in the gut of *Anopheles* would mean competition for *Plasmodium* and that this would decrease the chance of the pathogen establishing itself; that a reduced number of *Plasmodium* gave a greater chance of the immune system of the mosquito eliminating the pathogen.

**(e)** Many gave answers related to the problems experienced generally with vaccines that are being used, rather than about the difficulties researchers faced in developing a malaria vaccine. Knowledge that vaccines contain antigens to provoke an immune response was evident in a minority of answers. Of these, some could have improved their response by stating that different species have different antigens, rather than using the term 'strains' to mean species. Also, some wrote as if each species only had one antigen, rather than showing an understanding that, as eukaryotes, they would have many antigens. The term antigenic variation was not always used in context of the ability to change antigens in different stages of the life cycle, and here some thought that this was mutation (rather than differences in which antigens are expressed). Where credit was given, this was frequently for understanding that the pathogens spent stages of their life cycle within host cells so were not exposed to the immune system responses, or some valid reference to cost was stated.

**Question 6**

**(a)** Candidates who gained credit usually did so for showing understanding that telomeres prevent the loss of genes or genetic information. It was not sufficient to say that they prevent the loss of DNA or loss of genetic material as telomeres are lengths of DNA and are genetic material, and telomeres do shorten during replication of DNA. Fewer stated that telomeres allow continued replication of DNA.

**(b)** Candidates were asked about stem cells and cancer cells and so responses needed to indicate that they were referring to both types of cells. It was well understood that these cells carried out mitosis; stronger responses qualified this with knowledge that there was continuous replication or a higher rate of replication. Some made the mistake of stating that stem cells have uncontrolled mitosis but this is only true of cancer cells.

**(c)** The induced fit theory was well known. A few wrote 'induced fit lock and key' or gave one of the two in brackets, so could not be awarded credit.

**(d)** Many responses gave descriptions of the rates of reaction at the two different substrate concentrations. While these descriptions were correct, they did not answer the question, which required explanations of the differences between the two. Where explanations were given, there were generally correct references to the states of the active sites, enzyme-substrate complex formation and limiting factors. One common misunderstanding amongst some candidates was that at the lower substrate concentrations, because there was still an increase in rate of reaction as substrate concentration increased, there must be more enzyme-substrate complexes forming than at the higher substrate concentration. A number of weaker responses, instead of comparing the two points, attempted to describe the trend between the two.

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# BIOLOGY

**Paper 9700/33**
**Advanced Practical Skills 1**

## Key messages

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

Candidates should consider the command word of the question before responding. For example, in **Question 1(b)(iii)**, candidates are asked to explain the shape of the graph, so the answer should include reasons for the shape, such as referring to increased kinetic energy and the formation of enzyme-substrate complexes between 5.5 °C and 36.0 °C, and the shape of the active site changing between 36 °C and 49.5 °C leading to the substrate being unable to bind and fewer enzyme-substrate complexes being formed.

## General comments

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

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

The majority of centres provided all the materials required and the majority of the candidates experienced no problems with materials or apparatus when completing the question paper.

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

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

## Comments on specific questions

### Question 1

**(a) (i)** Many candidates correctly assessed the risk for **E** as medium or high, for **S** as low and for **C** as medium or high.

**(ii)** Many candidates answered correctly and completed **Fig. 1.1** with sufficient detail.

**(iii)** The majority of candidates organised their results clearly by presenting a ruled table. Stronger responses included the heading for percentage concentration of copper sulfate solution and the heading for time with units (seconds). Most candidates gained credit for recording the times for at least five concentrations of copper sulfate. Many candidates correctly recorded results which showed that the higher the percentage concentration of copper sulfate the longer the time the iodine remained yellow. The stronger candidates also recorded the times in whole seconds.

**(iv)** The majority of candidates correctly recorded the time for **U** in seconds.

**(v)** The majority of candidates correctly estimated the concentration of copper sulfate in **U**.

**(vi)** Many candidates correctly stated that a significant source of error was judging the exact time of the colour change. Some candidates also correctly stated that using a glass rod caused drop sizes to be unequal.

**(vii)** The best answers suggested using concentrations of copper sulfate close to the concentration of copper sulfate in **U**.

**(viii)** Many candidates suggested suitable improvements, with stronger responses suggesting the use of a colorimeter or colour standards.

**(b) (i)** The majority of candidates drew the graph correctly, with appropriate scales on the axes and accurately plotted the points. The most common errors were not including the correct label for each axis, omitting the units for the axes and not labelling the scale at least every 2 cm.

**(ii)** Most candidates answered correctly, using their graph to find the rate of reaction when the temperature was 37.5 °C.

**(iii)** Some candidates suggested suitable explanations for the shape of the graph at the stated temperatures. A common error was to describe the graph rather than explaining why it was that shape.

**Question 2**

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

**(ii)** Credit was awarded to candidates whose drawings were made using a sharp pencil to produce thin continuous lines which joined up precisely and used most of the space provided. Many candidates were able to draw four adjacent epidermal cells with each cell touching one of the other cells and double lines representing the walls. The most common error was to draw lines that did not meet up precisely enough. Most candidates used a label line to show the cell wall of one cell.

**(b) (i)** Some candidates correctly measured the thickness of the leaf shown by line **X**-**Y** and then showed the correct calculation of the actual thickness of the leaf and used appropriate units. The most common error was the omission of units.

**(ii)** Many candidates showed the addition of the lengths of the five cells and division by five.

**(iii)** The best answers were organised into a table with three columns headed features, **K1** and **Fig. 2.1**. Many candidates listed at least three observable differences between **K1** and **Fig. 2.1**.

# BIOLOGY

**Paper 9700/34**
**Advanced Practical Skills 2**

## Key messages

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

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

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

## General comments

In general, candidates demonstrated a very good understanding of the skills required. Most candidates showed they were familiar with the microscope and demonstrated good drawing skills.

## Comments on specific questions

### Question 1

**(a) (i)** The majority of candidates recorded measurements within the correct range and gained credit for this. A common error was to include units in the body of the table.

**(ii)** Most candidates stated that all the potato cylinders should be cut to the same length and were credited. The stronger candidates stated the apparatus they would use to ensure the cylinders were all the same length.

**(iii)** The majority of candidates gained credit for stating a volume of buffer within a suitable range.

**(iv)** The majority of candidates organised their results clearly by presenting a ruled table. Stronger responses included the heading for pH and the heading for colour intensity. The majority of candidates gained credit for recording the results for at least five different pH values. Most gained credit for their results showing the correct trend and also for using the scale provided to record their results.

**(v)** The majority of candidates gained credit for recording the results for **PU** using the key provided in **Fig. 1.2**.

**(vi)** Most candidates correctly estimated the pH of **PU** from their results.

**(vii)** Many candidates gained credit for identifying that a colorimeter could be used to make a more accurate estimate of the pH of **PU**.

**(viii)** Most candidates were able to describe a suitable modification to the procedure. The majority of candidates gained credit for stating five different temperatures and, in order to achieve these temperatures, that they would use a thermostatically controlled water-bath.

**(b) (i)** Most candidates drew the graph correctly, with appropriate scales and labels on the axes and plotting the points accurately. Some candidates labelled the axes incorrectly or gave incomplete headings. The strongest responses plotted the points precisely using a small cross or dot in a circle and accurately connected the points with a ruled line. The most common error was drawing lines which were not ruled to the centre of each plot.

**(ii)** The majority of candidates described the correct trend and illustrated this trend with correct data from their graph.

**(iii)** Many candidates identified that a low pH may cause the proteins in the cell surface membrane to denature and gained credit for this. Some candidates suggested that this would reduce the absorption of minerals by active transport. Descriptions of the denaturing of enzymes were not required here.

**Question 2**

**(a) (i)** Credit was awarded to candidates whose drawings did not include any cells or shading and used most of the space provided. The higher achieving candidates gained credit for carefully following the instructions and drawing the correct part of the leaf section. Many candidates gained credit for drawing at least three layers of tissue and for drawing the correct proportion of the vascular tissue in relation to the other tissues. Most candidates used a label line to correctly identify the lower epidermis.

**(ii)** Credit was awarded to candidates whose drawings were made using lines which joined up precisely and used most of the space provided. Most candidates followed the instructions and drew four cells, each cell touching at least one other cell. The most common error was to draw lines that did not meet up precisely enough. Many candidates were credited for drawing the correct shape of the cells. Most candidates used a label line to identify the cell wall of one cell.

**(b)** The majority of candidates identified a correct observable feature that identified the cells as being xylem, for example thick cell walls. A common error was to describe the colours of the staining of the cell walls or to describe features which were not observable.

**(c) (i)** The majority of candidates correctly measured the length of line **L** and used appropriate units (cm or mm). Many candidates recorded the number of eyepiece graticule units within the correct range. Most responses were credited for showing all of their workings and calculating the correct answer using appropriate units.

**(ii)** The majority of candidates demonstrated the correct calculation using their answer to **Question 2(c)(i)**.

**(iii)** Many candidates answered correctly and annotated **Fig. 2.3** with three observable differences between **Fig. 2.3** and **M1**.

# BIOLOGY

**Paper 9700/42**
**A Level Structured Questions**

## Key messages

- Candidates should check the command words given in questions carefully, particularly with reference to 'describe' or 'explain'. Candidates should avoid giving detailed descriptions for questions that require an explanation.
- Candidates should take great care with the spelling of biological terms to maximise the credit available.

## General comments

Many candidates found questions on gene technology and speciation more challenging, particularly **Questions 3(b)(ii)**, **Question 3(d)** and **Question 6**.

The question paper discriminated well and candidates obtained a range of scores, including many with high levels of credit.

## Comments on specific questions

***Section A***

**Question 1**

**(a) (i)** Many candidates stated that a decrease in the water potential of the blood would lead to the release of ADH. Other correct changes in the internal environment that would also stimulate ADH release included an increase in blood glucose or ion concentration or a lower blood volume, although the latter was rarely seen. References to dehydration or low water potential were not credited as they did not constitute a change.

**(ii)** The majority of responses correctly identified the posterior pituitary gland as the body part that releases ADH into the blood. Several candidates missed out on the credit as they stated pituitary gland or incorrectly stated the anterior pituitary gland. Other responses included hypothalamus, kidney, liver and endocrine system.

**(b)** The membrane protein **A** and structure **B** were, in general, correctly named with a large proportion of candidates gaining full credit. **A** was identified as a receptor, ADH receptor, receptor protein and G-protein coupled receptor. Incorrect answers referred to **A** as a channel protein or in some cases glycogen phosphorylase or glycoprotein portion. For **B** the most common response was vesicle with aquaporins or simply vesicle. There were many responses stating aquaporin alone which were not credited. Some obscure responses were also seen including glucose and mitochondria.

**(c)** There was a good spread of credit here with some excellent accounts outlining the response of structure **B** to stimulation by phosphorylase enzyme and the consequences of this. Most responses started out with the movement of vesicles towards, or fusion with, the cell surface membrane. The consequences were also well understood by stronger candidates who commented that the increase in aquaporins in the cell surface membrane would increase its permeability, increasing the reabsorption of water by osmosis from the collecting duct into the cell and thence the tissue fluid and blood. Many continued to add that the water potential in the blood would

increase to the norm and that a smaller volume of more concentrated urine would be excreted. However, while weaker candidates understood that water would return to the blood, they needed to mention that it would leave the collecting duct and explain the effect on the urine concentration or volume.

**Question 2**

**(a)** Many candidates understood that discontinuous variation, demonstrated by the stickleback fish phenotypes in the scenario provided, had discrete categories, with various forms of wording to that effect. Further explanation was often omitted, with fewer candidates explaining that there were no intermediates or that the environment had no effect or that there was only a single gene involved. There were a significant number of incorrect references to the environment affecting the phenotype in the different water conditions seen, or the phenotype being affected by genes (plural, rather than singular).

**(b)** Many incorrect responses referred to protection from humans (rather than predators) or suggested that these fish had evolved from saltwater rather than recently migrated. However, all three potential options were given in responses by stronger candidates.

**(c)** This question on natural selection was generally well interpreted in the scenario. At a basic level, responses linked the complete armour phenotype to a selective disadvantage, and therefore stickleback fish with this phenotype have reduced survival and reproduction. More extended answers then described that the low armour allele was preferentially passed on and therefore increased in allelic frequency. Good answers further explained that this is an example of directional selection or provided valid suggestions as to why the complete armour phenotype could be at a selective disadvantage. Partial credit was often due to a lack of clarity, for example not being clear which phenotype was at a selective advantage, which allele was being passed on, or allele frequencies changing without stating a direction. Some candidates discussed genes rather than alleles.

**Question 3**

**(a)** The advantages of producing human therapeutic proteins by recombinant DNA technology were well understood. Many candidates appreciated that the therapeutic protein would be identical to human insulin, so therefore would not stimulate an immune response or allergic reaction and would elicit a faster response than animal insulin. Most recognised that large scale production would be possible, at lower cost. There was also frequent mention of no risk of transmission of infection as well as no religious or ethical objections. However, few remarked that there would be no development of tolerance. References to less immune response or less risk of disease transmission were not credited as there would be none using recombinant DNA technology. Some candidates described the method of extracting and inserting the human insulin gene into plasmids, which was not required.

**(b) (i)** Most candidates provided a correct calculation of the percentage sequence similarity of human and salmon calcitonin. An incorrect calculation was usually due to miscounting of the number of identical amino acids in the two sequences.

**(ii)** There was some confusion about the use of bioinformatics, with some candidates referring to the use of electrophoresis or microarrays to identify sequence similarity rather than to accessing existing databases containing base/amino acid sequences and then using the available software to carry out comparisons or computer modelling of protein structure. Of those candidates who did identify this as being an electronic source of sequence data, several omitted to state the type of sequence. Despite this a good number of candidates scored credit here.

**(c) (i)** The majority of candidates knew that the enzymes that cut plasmid DNA are restriction endonucleases and some could name specific enzymes. Almost all candidates also knew that ligase enzymes are used in forming recombinant plasmids to join the DNA. Incorrect answers included recombinant enzyme or reverse transcriptase instead of restriction enzyme and DNA polymerase instead of DNA ligase. Very occasionally the answers would be the wrong way around.

**(ii)** The identification of the properties of plasmids that allow them to be used as vectors in gene cloning was straightforward for most candidates but explaining them proved to be more problematic. The most common response was a statement that plasmids are small, or have a low molecular mass, so can easily be taken up by cells or bacteria. There were frequent references to plasmids having restriction sites which could be cut by restriction enzymes in order to insert a gene, although mention of polylinkers to allow cutting by different restriction enzymes was rare. Many commented that plasmids have circular DNA, but this was seldom linked to stability. Some understood that plasmids would have marker genes or gave examples, such as the gene for antibiotic resistance, but stated that this would be to recognise the plasmid rather than the transformed cell. While some appreciated that plasmids can replicate independently as they have an origin of replication, this was only occasionally qualified by stating that many plasmids could be produced. Very few candidates suggested features without explanations.

**(d)** Most candidates found this question difficult and were unable to provide good explanations as to the differences in control of gene expression in prokaryotes and eukaryotes or why expression vector plasmids must contain a prokaryotic promotor. Very few referred to the differences in eukaryotic and prokaryotic promoter sequences or RNA polymerases. A few understood that prokaryotic RNA polymerase could not recognise a eukaryotic promoter so would only bind to a prokaryotic one. However, many candidates gained credit for appreciating that, in the absence of binding, no transcription or gene expression would occur, or vice versa. Very occasionally, candidates noted that the transcription factors required to bind eukaryotic promoters would be absent in prokaryotic cells.

**Question 4**

**(a) (i)** The majority of candidates found it difficult to complete **Table 4.1** correctly, although most achieved at least two correct rows. Several answers selected where a process did happen but left other boxes blank. Candidates should follow the clear instructions in the question, which required a definitive positive or negative response in each box of the table.

**(ii)** The comparison of meiosis in gametogenesis in production of sperm in humans and production of pollen grains in flowering plants was challenging for many candidates. It was clear that, whilst most candidates had some knowledge of the processes in each, responses frequently did not make direct comparisons between the two processes, as was required by the question. In particular, candidates often described features of one process, then described features of the second process, but omitted to directly compare where they were similar or different. Aspects of spermatogenesis were generally better described than pollen grain formation. Very few candidates made reference to genetic variation, which is one of the key aspects of gamete formation.

**(b) (i)** This question was generally answered well. The first two genotypes posed little difficulty. Responses for the third genotype often did not allow for the absence of the allele for pigment production in petals. The fourth genotype occasionally yielded answers where petal colour was omitted rather than given as white.

**(ii)** Stronger responses described that the mutation would cause a change in primary and tertiary structures, and some extended to the potential type of mutation involved and its effects on the gene. However, some answers simply described the role of dominant and recessive alleles, rather than how the mutation itself would cause the lack of pigment production. Few described the outcome of the mutation in the gene product in the biosynthetic pathway itself. Some weaker candidates omitted the word ‘base’ from substitution, addition or deletion.

**(iii)** Despite being given the information in the question stem that one known mutation does not occur in the protein-coding region of DNA, several responses described features of genes that encode proteins, such as transcription factors or start codons. Of the correct options, named features were more generally seen such as promoters or stop codons. Occasionally promoters were only described, but this could still be credited where they were described as regulatory regions or binding sites for proteins that regulate transcription.

**Question 5**

**(a) (i)** Most candidates knew where light absorption in chloroplasts takes place. Answers included in the thylakoid, thylakoid membranes, grana, granum with a few referring to the lamella. Other answers

included in the photosystems, accessory pigments and the chlorophyll in the thylakoid membrane, although references to photosystems or pigments alone were not credited. Some candidates stated that this happens within the stroma.

**(ii)** The majority of candidates gained credit here. Reduced NADP, oxygen and ATP were stated with similar frequency. Incorrect answers included water, NADP, reduced NAD and hydrogen ions with some also indicating that rubisco or carbon dioxide is a product.

**(iii)** There were some excellent descriptions of the reactions in the stroma that lead to the production of polysaccharides, such as alginate. Many candidates began by stating that rubisco would catalyse the fixation of carbon dioxide to RuBP leading to the production of an unstable six carbon compound which would then split to yield two molecules of glycerate-3-phosphate (GP). While most appreciated that GP would be metabolised to triose phosphate (TP), they did not add that this would be a reduction reaction: however, many understood that both ATP and reduced NADP from the light dependent reaction would be necessary for this step. The synthesis of glucose from TP was poorly explained, with weaker candidates commenting that TP would be converted to glucose or omitting glucose altogether and simply stating that it would form polysaccharides. Few mentioned that condensation reactions, or the formation of glycosidic bonds, would be involved. Weaker candidates did not identify the six-carbon compound as unstable or suggested that rubisco catalysed the formation of glycerate-3-phosphate. Although some recognised that GP would be reduced to TP, only the use of reduced NADP was mentioned.

**(b) (i)** Many candidates described rather than explained the difference in the rate of photosynthesis at low and high carbon dioxide concentrations. Nevertheless, some candidates went on to state that more carbon dioxide would be fixed at the higher concentration, resulting in an increase in the Calvin cycle or the enhanced production of glycerate-3-phosphate or triose phosphate.

**(ii)** Candidates found describing and explaining the effect of increasing daylength on the rate of photosynthesis at high concentration of carbon dioxide more straightforward. Most were able to state the relationship and quote appropriate figures from the table to support their answer. Stronger candidates recognised that the increase in daylength would allow more light to be absorbed by chlorophyll, or other suitable alternatives, and the consequential increase in the light dependant reaction and its products. Some candidates incorrectly suggested that higher light intensity would cause the stomata to open more widely, allowing greater uptake of carbon dioxide for the light independent reaction.

**(c) (i)** The effect of increasing pH from 8.1 to 8.4 on the rate of photosynthesis was described rather than explained in most responses, although some candidates appreciated that pH 8.4 would be closer to, or at, the optimum for the enzymes involved in the light dependent or independent reactions. Few candidates mentioned the effect of fewer protons on enzyme activity.

**(ii)** Few candidates were able to suggest why the data in **Fig. 5.2** did not fully support the idea that seaweeds could help to reduce ocean acidification. Many described the difference in the rate of photosynthesis between pH 8.1 and 7.8, while stronger candidates made the connection between a lower rate at lower pH and a reduction in the rate of carbon dioxide absorption or fixation, often adding that this would lead to a greater concentration of the acidic gas remaining in the ocean.

**Question 6**

**(a) (i)** Candidates found this question challenging and few responses gave any reasoning to their answer and were limited to the prediction only. Only a minority of answers referred to the involvement of homologous chromosomes pairing up or the formation of bivalents during a successful meiosis. Some gave numerical answers, which had no justification here without any prior knowledge.

**(ii)** Where credit was awarded for this question, it was predominantly for a statement of reproductive isolation and a statement of sympatric speciation. Some answers attempted to describe the lack of gene flow with the original parent species, but this was often limited to a repetition of part of the question (lack of mating) and so did not gain credit. Despite the evidence being for a behavioural effect, some answers incorrectly described incompatibility with parents, or migration of the hybrids and allopatric speciation. Mutations were often mentioned in answers but they were not specified as different mutations. Maintenance of the gene pool and a pre-zygotic isolating mechanism were rarely included in responses.

**(b)** Most responses correctly identified from the information provided that the hybrid butterflies would be at a selective disadvantage due to their lack of distinctive coloration and would therefore be predated. Further explanation was rarely provided, whilst some responses suggested that future hybrid offspring would be sterile, despite being informed in the question stem that the hybrids are fertile. Other creditworthy points in terms of the hybrid pool decreasing, the parents being better adapted or that there was disruptive selection were rarely seen.

**Question 7**

**(a)** Comments regarding the low mineral content of the soil in the wetlands were rare, although some recognised that the soil would not be able to provide sufficient minerals to satisfy the needs of the Venus fly trap. While candidates frequently went on to state that the digestion of trapped insects would supplement the mineral demand of the plant, this was not always linked to growth. Weaker responses simply referred to nutrients.

**(b) (i)** The majority of candidates stated that the hairs would detect the stimulus, although there were other suggestions, like stomata, spikes or even cilia.

**(ii)** Explanations as to how the plant does not waste energy by closing unnecessarily were sometimes vague but stronger candidates understood that either one hair would need to be stimulated twice in close succession or, alternatively, two or more hairs had to be stimulated simultaneously or within 35 seconds.

**(c)** Descriptions of the differences between the action potential of a Venus fly trap and a human were often inaccurate, particularly when quoting figures, with candidates concentrating on changes in electrical potential rather than the duration of the phases. Many gained credit for stating that the resting potential of the Venus fly trap was 0 mV whereas that of a human was 70 mV. Stronger candidates noted that the duration of the refractory period and hyperpolarisation were longer in the plant whereas the duration of the action potential, depolarisation and repolarisation were shorter. Few commented that there was a smaller change in membrane potential in the Venus fly trap.

**(d)** There were some very detailed accounts of the mechanism of leaf closure following the production of an action potential. Stronger candidates began by stating that the action potential would spread to the lobes, triggering the hinge or midrib cells to pump hydrogen ions into the cell walls. The breaking of cross linkages resulting in the loosening of the cell walls was less frequently mentioned although some referred to the release of elastic tension. Many commented that calcium pectate in the middle lamella would dissolve and calcium ions would enter the hinge cells, lowering the water potential so that water would follow by osmosis, making them turgid. Many also appreciated that the lobes would become concave as a result, thereby trapping the insect although there was occasionally confusion between concave and convex. Weaker candidates offered descriptions of neurochemical transmission, how enzymes would be secreted to digest the insect or how the insect would be prevented from escaping. Some stated that the calcium pectate would act as a glue necessary to stick the insect to the leaf.

**Question 8**

The stages involved in oxidative phosphorylation were largely well known, with the majority of candidates obtaining high levels of credit for this question. Mistakes were generally due to imprecise answers rather than lack of knowledge.

***Section B***

**Question 9**

**(a)** Most candidates gained some credit for accounts of the similarities and differences between members of the two kingdoms. Many presented their responses in the form of a table. The features of kingdom Fungi were, on the whole, better described than those of kingdom Animalia. Most candidates appreciated that many fungi are unicellular, often giving yeast as an example,

although some, for example mushrooms, can be multicellular. Many stated that fungi consist of hyphae, have a cell wall composed of chitin and reproduce by means of spores. For kingdom Animalia, many candidates commented on the multicellular nature of these organisms and that most would be motile. References to specialised cells differentiated into tissues were less frequent, as was the mention of the presence of cilia or flagella on some cells. The most common shared characteristics included linear DNA associated with histones, membrane bound organelles, which were often listed, and 80s ribosomes. Although many recognised that both kingdoms belong to the domain Eukarya, few mentioned that they are composed of eukaryotic cells. Some candidates stated that both have heterotrophic nutrition although others believed that fungi are autotrophic. No references to glycogen were seen. Weaker candidates confused fungi with bacteria so achieved no credit for either the common features of the two kingdoms or those of fungi alone.

**(b)** There were many comprehensive discussions of the methods used in breeding programmes for endangered mammal species. Most candidates understood the importance of sperm banks, or frozen zoos, and assisted reproduction in increasing the captive population. Many named both *in vitro* fertilisation and artificial insemination, often giving considerable detail of each procedure. The use of surrogate mothers was frequently mentioned although few stated that the health of the mother and development of the foetus could be monitored. Comments on the provision of an environment resembling their natural habitat as far as possible were rare, as were the keeping of genetic records or stud books. However, some candidates briefly mentioned international cooperation between zoos, mostly in the context of exchanging animals in breeding programmes to prevent inbreeding depression. The difficulties associated with captive breeding, such as the stress experienced by the animals leading to the rejection of a potential mate, were recognised by a number of candidates although comments on the disruption of the reproductive cycle were less common. Many also appreciated that problems might arise once the captively bred animals were released back into the wild, most notably their inability to find food, escape predators, or greater susceptibility to disease. However, some also mentioned their failure to integrate into social groups or their lack of fear of humans. Some candidates did not address the question and instead described the role of zoos in caring for and protecting the animals, educating the public, and how research programmes could be established to study their dietary requirements or behaviour.

**Question 10**

**(a)** Candidates generally made good attempts at describing the features of the ATP molecule that make it suitable for its role. Nearly all candidates described the molecule as small, although references to its solubility were more vague, and there were many descriptions of ATP being passed from cell to cell rather than between organelles and structures within the cell. References to ATP as an energy source generally described the breakdown of ATP to ADP and inorganic phosphate releasing energy with more developed answers referencing the specific amount of energy released per phosphate, and the reversibility of ATP breakdown. Only good answers approaching full credit referred to ATP being an intermediate between energy yielding and energy requiring reactions, and the high turnover rate of ATP. Weaker responses frequently described the production of ATP during respiration, or reactions/processes in which ATP plays a role, rather than describing the molecular features of ATP itself.

**(b)** Candidates predominantly achieved credit on generic aspects of experimental investigations, such as using a water-bath to control temperature, assessing over a suitable temperature range, performing repeats and calculating means. However, the specifics of this investigation were frequently lacking in candidate responses. Whilst some candidates understood that methylene blue (or DCPIP) turns colourless during the investigations, and more specifically when reduced, few responses effectively described the assay setup, such as providing glucose as a respiratory substrate, the yeast needing to be in suspension, or how anaerobic conditions would be achieved. In some cases, candidates who suggested temperatures to test often did not give a minimum range of five reasonable temperatures. Weaker responses used the term average rather than mean, and a large number did not show how to calculate rate of respiration. Some candidates also incorrectly referred to the methylene blue changing colour rather than turning colourless. A number of responses confused this investigation with that of aerobic respiration and/or photosynthesis (e.g. use of an absorbent to remove carbon dioxide or measuring volume of gas produced). Some answers also merely described the molecular steps in anaerobic respiration, rather than the experimental investigation.

# BIOLOGY

**Paper 9700/52**
**Planning, Analysis and Evaluation**

## Key messages

- When planning an investigation, it is important to set out the work in a logical way and for it to be detailed enough for another person to follow.
- When planning such investigations, it is not necessary to copy out all the information given in the question paper. The information provided should serve as the basis for developing the method asked for in the question.

## General comments

The responses covered the full range of credit and there was no evidence that candidates were short of time on this paper.

## Comments on specific questions

### Question 1

**(a) (i)** Many candidates were able to correctly state a hypothesis, linking an increase in temperature to an increase in carbon dioxide. Less successful attempts made reference to a change in carbon dioxide, rather than an increase. A few candidates gave a null hypothesis rather than a hypothesis.

**(ii)** Many candidates correctly identified the independent variable as temperature. Candidates need to be clear that the dependent variable is something that is measured, in this case the colour or pH of the solution, rather than the concentration of carbon dioxide. Credit was given for time taken for the solution to change to yellow/orange. A few candidates gave the same answer for both the independent and dependent variable and therefore could not gain credit for either.

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

Many candidates chose to test at least five different temperatures and provided a method for doing this. Some candidates added details such as volumes of hydrogencarbonate indicator solution and *Chlorella* suspension rather than just stating they would standardise these. Many candidates correctly mentioned mixing the *Chlorella* and indicator together. In order to gain credit for this they needed to then identify when the end-point would be reached, either by recording the colour or pH after a set time or by recording the time taken for the solution to turn a stated colour or pH. Therefore, just stating they would record the time for a colour change did not gain credit.

Many excellent responses contained details about how to ensure the indicator solution was at the same starting pH by using the oxygen pump. Other candidates needed to include more detail, as it was unclear which pump was being added to which solution.

Many responses mentioned replicating the test a suitable number of times, but this was sometimes linked to calculating an average. It is important to use the term mean in scientific work. In this particular experiment, if the candidate had chosen to record either the time taken to reach a specific colour or had recorded a pH, credit was awarded for reference to calculating a mean.

However, if the candidate had chosen to record the colour of the solution after a set time, calculating a mean was not appropriate, as you cannot calculate the mean of a colour.

Safety issues should be specific to the investigation or an assessment made of the risk. This investigation was low risk. Credit was given to responses which correctly identified that some people could be allergic to *Chlorella* and should therefore wear gloves or that hydrogencarbonate could be an irritant and gloves should be worn.

**(b) (i)** The correct answer was 1 divided by the time taken for a stated colour or pH to be reached. Since the question asked how to calculate rate, candidates needed to make reference to the time taken for the dependent variable, in this case the colour or pH of the solution, to appear.

**(ii)** Many candidates were able to correctly place temperature on the *x*-axis. Fewer were able to correctly label the *y*-axis. Candidates should use the information provided in the question when labelling axes. The label on the *y*-axis should have been rate of respiration which was stated in the question. Some candidates missed out units and therefore could not gain full credit. The majority of candidates were able to sketch a graph to show the expected result of the effect of temperature on the rate of respiration.

**(c) (i)** The majority of candidates gave the correct answer.

**(ii)** Some candidates showed a good understanding of the null hypothesis. These candidates realised that as the statistical test being used in the question was a Pearson's linear correlation, they therefore needed to refer to a correlation in their null hypothesis. A common error was to include the term 'difference', which was not relevant to this statistical test. A few answers included a description of the results rather than a null hypothesis. A common error was to state there is a 'correlation' or a 'relationship' – in other words to state the alternative hypothesis. Many other answers did not specify both variables.

**(iii)** Most candidates were able to state that a Pearson's linear correlation coefficient value of 0.85 indicated a positive correlation. Fewer were able to state that this suggested the correlation was strong. Credit was given to candidates who made reference to the fact that 0.85 was close to 1.0.

**(iv)** Careful study of **Table 1.1** was required for candidates to do well in this question. Candidates needed to consider the whole range of data and information provided in the question when asked to explain why the conclusion may not be valid. Successful responses referred to no replicates. Many candidates discussed that more intermediate cell densities should have been tested; to improve answers, candidates needed to make reference to the fact that it was the range of cell densities tested which needed expanding. Credit was also given for reference to the fact that there were fewer than the number of paired observations recommended for a Pearson's linear correlation test.

**Question 2**

**(a)** Candidates were asked to suggest a tissue in which the fungal pathogen could be found and to suggest a reason for their answer. Since the pathogen caused the leaf cells to lose turgor, the tissue selected should have been involved in water transport in some way. The most common correct answer was xylem as it transports water. Less successful attempts made reference to organelles, cells or organs, which were not credited due to the question specifically asking for a tissue.

**(b)** The majority of candidates successfully identified the reason why the results for the F2 generation were considered to be anomalous was that a ratio of 3:1 was expected. More successful candidates were able to suggest that the reason was due to interactions between genes. It was common to see references to mutations or miscounting which were not creditworthy.

**(c) (i)** There were some good responses here which showed a thorough understanding of the use of microarrays. The very best answers included details such as known sequences of single-stranded DNA being attached to the wells on the plates, mRNA from both the resistant and non-resistant plants being converted into cDNA and these cDNA molecules being labelled with different coloured fluorescent dyes which allows the presence of genes to be identified. Less successful attempts confused mRNA, DNA and cDNA and many did not highlight the need to use a different coloured dye for genetic material taken from the resistant and non-resistant plants.

**(ii)** The vast majority of candidates were able to select the correct numbers from the table, although fewer expressed these numbers to their simplest form and therefore were unable to gain credit. Many candidates gave their answer to whole numbers as directed in the question.

**(iii)** Many candidates were able to calculate the percentage change correctly, with many rounding their answer correctly, i.e. to no more than one decimal place more than the raw data they were manipulating.

**(iv)** Candidates who ensured that they applied their answers to the specific data provided and used the column headings in tables to help guide their response were most likely to gain full credit. Successful responses compared the number of genes expressed in the resistant variety at 24 hours after infection with the fungal pathogen with number of genes expressed at 48 hours. Candidates who also compared the number of genes expressed by the resistant variety with the non-resistant variety at one particular time also went on to gain full credit.