BIOLOGY

Paper 9700/12
Multiple Choice

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

General comments

The paper differentiated well.

Comments on specific questions

Questions 1, 2 and 3

The majority of weaker candidates found these questions difficult. Candidates need to understand how to use microscopy to draw with correct proportions and how to calculate magnifications.

Question 6

Nearly all of the stronger candidates answered correctly. Few of the less able candidates were able to identify the processes requiring ATP.

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Question 11

Few of the weaker candidates were aware that enzymes and haemoglobin are all examples of globular proteins.

Question 12

The majority of stronger candidates selected the correct response. Weaker candidates did not know which molecules contain carboxyl groups.

Question 14

Many candidates overlooked the evidence provided in the diagram and concluded that the shape of the active site and the shape of the substrate were complementary. The diagram clearly shows an induced fit, as described in option **A**.

Question 15

The majority of weaker candidates incorrectly thought that the Michaelis-Menten constant could be used to calculate the rate of an enzyme-catalysed reaction.

Question 24

Many candidates incorrectly thought that the pentose sugar in ATP is deoxyribose. The majority of weaker candidates misidentified structure P as adenosine, rather than the purine, adenine.

Question 25

Weaker candidates frequently selected options containing uracil. It was clear from the question that DNA nucleotides were required.

Questions 30 and 31

Weaker candidates found these questions challenging. Many were unable to recall the detailed knowledge of the circulatory system required.

Question 32

The majority of candidates found this difficult. Both oxygen and carbon monoxide can bind to the haem group.

Question 37

The majority of stronger candidates answered correctly. Many of the weaker candidates incorrectly thought that the antibiotic causes bacterial DNA to mutate.

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Paper 9700/22
AS Level Structured Questions

Key messages

Diagrams that are drawn to help support an answer should be labelled or annotated appropriately. Label lines should clearly and unambiguously identify the particular structures or regions intended; use of a ruler is frequently helpful for this purpose. Where candidates respond with both a labelled diagram and written text, it is not necessary to repeat the information.

Candidates should be reminded that learning outcomes that involve practical work, including microscope work, can be assessed in Paper 2 as well as Paper 3. **Questions 1(a)** and **(b)**, **Question 3(c)** and **Question 6(b)** are examples of this.

It is good practice for candidates, once they have completed their response, to check that their response matches the actual question, including the level of detail required. Consideration of the mark allocation can be helpful in this regard.

General comments

Many candidates were clearly very well prepared for this examination and had a good knowledge and understanding of the syllabus learning outcomes. As a result, these candidates were able to gain very good marks.

There was evidence that some candidates had not read the questions with sufficient care. For example, in **Question 3(b)(ii)**, many candidates considered general benefits of using immobilised enzymes rather than specifically addressing product inhibition. Similarly, **Question 5(b)(ii)** was about the lining of the blood vessels but answers were often about the walls of the blood vessels instead.

Comments on specific questions

Question 1

(a) Many candidates were able to gain the mark by stating a feature shown in Fig. 1.1 that would be apparent in transmission, but not scanning, electron micrographs, such as presence of organelles. Other candidates considered features that would be apparent in scanning, but not transmission electron micrographs, and were absent from Fig. 1.1, such as surface contours.

(b) Candidates were able to identify a number of features that identify **G** as the Golgi body and not the rough endoplasmic reticulum. Some responses were too vague for credit. For example, some candidates noted that the membrane of **G** was not connected to, or continuous with, the nucleus, rather than referring more specifically to the nuclear envelope.

(c) The majority of candidates gained a mark for displaying a correct formula and many went on to complete the calculation correctly using acceptable measured values for the diameter **X–Y**.

Some candidates derived a correct value from the formula but gave the answer to one decimal place of a nanometre. The question stated that the answer should be given to the nearest whole nanometre.

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(d) (i) Candidates were told that space was available for a diagram to illustrate their answer. Most candidates decided to use the space provided for this purpose. Well-drawn and annotated diagrams provided sufficient details to access all of the marks with no further elaboration. Candidates providing accurate descriptions with no supporting diagram were also able to access all of the marks.

Question 2

(a) (i) Some candidates incorrectly stated that macrophages have their origin in the thymus glands or lymph nodes, instead of the bone marrow.

(ii) Many candidates provided comprehensive responses with sequential accounts that included the correct scientific terminology. Good answers referred to the ability of macrophages to detect or recognise foreign antigens, following which the macrophages engulf the pathogen by phagocytosis or endocytosis. Some candidates did not use these terms but were still able to gain credit by describing the formation of pseudopodia. Further marks were available for descriptions of the formation of a vacuole or phagosome around the pathogen, fusion with a lysosome and destruction of the pathogen by hydrolytic or digestive enzymes. Some candidates also made correct reference to antigen presentation.

A number of answers became confused when candidates tried to explain the mode of action on the basis of the production of antibodies.

(iii) The most common correct answers included the suggestion that the pathogen might produce enzyme inhibitors or form a resistant spore. The suggestion that the cell wall protected the pathogen was also credited but only if this was qualified with the idea of a resistance to digestive enzymes. 'Antigen concealment' was a common incorrect suggestion by some candidates. These candidates had not realised that, in order for the pathogen to be engulfed, the macrophage must have already recognised foreign antigens on the pathogen.

(b) Generally, this question was well answered. Common errors included describing the role of nasal hairs, referring to the trapping of dust particles (without any mention of bacteria or other pathogens) and describing the role of the cilia in moving bacteria away from the lung tissue (without any reference to the mucus in which the bacteria are trapped). Some candidates incorrectly suggested that the cilia push the mucus down the oesophagus.

(c) Sensible suggestions included spreading *M. tuberculosis* from the lungs to other organs through the blood or lymph systems. A common incorrect answer was that the bacteria would be moved around the body inside red blood cells.

(d) Many candidates did know that *M. bovis* can be transmitted by consuming undercooked meat or unpasteurised milk from infected cattle.

(e) The best answers considered that initially treating people with TB with four antibiotics would overcome the problem of some bacteria being resistant to one or more of the antibiotics and therefore increase the probability of killing all of the bacteria. Less precise responses stated that all the bacteria would be killed without any further qualification.

A number of candidates correctly stated that the treatment would reduce the chances of mutations arising and so decrease the risk of the bacteria gaining resistance.

(f) Many candidates incorrectly stated that the numbers of cases of TB and MDR-TB shown in Table 2.1 increased every year. Although the trend is an increase, there were decreases in the number of cases of TB and MDR-TB in some years.

(g) Marks were available for discussing any factors that would affect the number of cases of TB and MDR-TB, whether these would lead to increases or decreases.

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Question 3

(a) Many candidates had a very good knowledge and understanding of the subject matter and were able to provide full responses.

(b) (i) Valid responses explained why product inhibition of an intracellular enzyme is useful in controlling the rate of formation of product, but that this becomes a disadvantage when using the enzyme free in solution to maximise yield. This is because productivity will decrease as the product accumulates.

(ii) Relevant answers focused on how the use of immobilised enzymes could reduce the problem of product inhibition, rather than giving the general advantages of using immobilised enzymes.

(c) Candidates who appeared to have carried out a practical to investigate the progress of an enzyme-catalysed reaction were able to give a clear outline of the main points. Many responses included vague statements about the amount of enzyme, substrate or product, and did not make specific reference to controlling variables or give information about how the progress of the reactions could be measured. It was expected that candidates would outline the need to control variables such as pH and temperature, measure substrate or product concentration at timed intervals and plot a graph of substrate or product concentration against time. This allows determination of the rate of disappearance of substrate or the rate of appearance of product.

Question 4

(a) Many candidates were able to provide full responses that included reference to the apoplast and symplast pathways, as well as describing additional details such as the plasmodesmata and osmosis.

(b) Many candidates stated incorrectly that the additional mitochondria in the cytoplasm of cell **X** are required for the uptake of water.

Question 5

(a) Most candidates were able to recall the relevant details needed to answer the question.

(b) (i) Most candidates were able to identify the types of blood vessels in Fig. 5.1. Some incorrectly named specific vessels, such as the vena cava and aorta.

(ii) Many candidates listed structural features of the wall, rather than structural features of the endothelial tissue.

Question 6

(a) Most candidates demonstrated an excellent knowledge of DNA replication and were able to provide many of the correct terms. In **1**, most candidates were able to recall and correctly spell the four bases. In **2**, it was essential for candidates to identify the enzyme specifically as DNA polymerase, rather than simply stating that it was a polymerase.

(b) (i) Some candidates were clearly well practised and competent in identifying stages of mitosis from slides or photomicrographs. Others were less confident and gained only partial credit. In cell **K**, a mark was given for stating prophase or early prophase, but as chromosomes would be visible in late prophase, this answer was rejected.

(ii) Only a few candidates realised that the labelled cell must be in late interphase because it is clearly the same size as the cells undergoing mitosis and therefore must have grown and approximately doubled in size since cytokinesis.

(iii) Many candidates were able to describe the arrangement of the chromosomes at the equator of the cell; some correctly used the term, metaphase plate.

Additional marks were available for describing other relevant details, such as noting that the spindle is fully formed, the spindle is attached to each chromosome at the centromere, the nucleolus has disappeared and the nuclear envelope has broken down.

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Paper 9700/33
Advanced Practical Skills

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 are assessed in this examination.

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 lines and the relative thickness of the cell walls should be in the correct proportion to the size of the cells.

Candidates must learn the methods for the tests for biological molecules, as specified in the syllabus. When testing for reducing sugar, the volume of Benedict's solution must be the same as, or more than, the volume of the sample being tested and the water-bath must be maintained at a temperature of at least 80°C (up to 100°C).

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

Candidates should be encouraged to read the whole of each question before attempting it. This allows candidates to plan the use of time more effectively and, by increasing understanding of how the different steps fit together, helps candidates to make appropriate decisions when necessary.

General comments

Many candidates demonstrated that they had a good understanding of the skills required and the majority of candidates were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly stated a suitable temperature at which to carry out the Benedict's test.

(ii) Many candidates were able to show how to carry out a serial dilution within the requirements of the question.

(iii) More able candidates recognised that the test conditions for **S1**, **S2** and **S3** should be the same as those for the known concentrations of reducing sugar. These candidates were also aware of appropriate volumes of Benedict's solution to use in the test.

(iv) The majority of candidates organised their results clearly by presenting a ruled table, with headings for percentage concentration of reducing sugar and time with units (seconds). The results of most candidates showed the expected trend and were recorded correctly (time in whole seconds) for a sufficient number of different concentrations of reducing solution.

(v) Many candidates recorded results that showed the expected trend.

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(vi) Most candidates correctly labelled the positions on Fig. 1.3 of the percentage concentrations of reducing sugar solutions. Many added labels for **S1**, **S2** and **S3** in the positions that correctly corresponded to their results.

(vii) Many candidates suggested an appropriate explanation for the results that they had recorded.

(viii) Most candidates appreciated that if all sucrose had been hydrolysed within 30 minutes, then no more reducing sugar could be released for times that were longer than 30 minutes.

(b) (i) The majority of candidates knew the name of the test for protein.

(ii) The question required candidates to describe a control for this experiment that would provide evidence that hydrolysis of sucrose was the result of the activity of an enzyme. Some candidates did not take account of this requirement and described other types of control.

(c) Most candidates correctly used the headings given in Table 1.2 to label the *x*-axis and the *y*-axis. More able candidates ensured that all five bars were the same width, used an appropriate scale for the *y*-axis and precisely plotted the horizontal line at the top of each bar with a thin line.

The most common errors were not including a full axis label for each axis, omitting the units for the *y*-axis, not labelling the scale every 2 cm and drawing lines which were too thick.

Question 2

(a) (i) Most candidates used the eyepiece graticule correctly to make measurements and stated appropriate values in eyepiece graticule units.

(ii) The drawings of many candidates were of an appropriate size and did not include any cells. More able candidates drew the vascular bundle in the correct proportion to the depth of the mid-rib and showed that it was subdivided into at least two layers. Many candidates used one label line and label to identify the vascular bundle.

(iii) Most candidates followed the instructions by drawing the required cells and using a label line and label to identify a cell wall. Many candidates drew cells in the correct proportions and used a double line to show the thickness of the cell wall. More able candidates used a sharp pencil to draw clear, thin lines that were continuous.

The most common error was to draw lines that did not meet up precisely.

(b) (i) Many candidates measured **L1**, **L2** and **L3** accurately and included appropriate units for the measurements. Most correctly determined the required ratio and, where possible, simplified this by dividing each side by the highest common factor. The most common errors were including units in the final answer and showing the inverse of the expected ratio.

(ii) Many candidates identified a relevant feature and described how this feature reduced water loss.

(iii) More able candidates were able to list at least three observable differences between **P1** and Fig. 2.3.

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Paper 9700/42
A Level Structured Questions

Key messages

- Candidates should be aware that appropriate scientific terminology is expected where relevant to the question. For example, in **Question 2** reference should be made to nerve impulses, rather than nerve signals or messages.

- When describing the relationship between a dependent variable and an independent variable, it should be clear that it is the independent variable that affects the dependent variable. In many expressions this means that the independent variable will be listed first. For example, in **Question 6(b)** the relationship evident in the table can be stated: 'as the concentration of starfish extract increases, the percentage tyrosinase activity decreases'. This correctly implies that the starfish extract affects the tyrosinase activity, as indicated by the second sentence of the question. Stating that 'as the percentage tyrosinase activity decreases, the concentration of starfish extract increases' would incorrectly imply that tyrosinase activity affects the concentration of the starfish extract.

General comments

Many candidates were well prepared and demonstrated sound subject knowledge and understanding. They carefully noted the requirements of the questions and addressed these requirements with clear and well-structured responses.

Weaker responses lacked detail, included inaccuracies and often included irrelevant material that did not address the actual questions.

Comments on specific questions

Section A

Question 1

(a) (i) A large number of candidates were unable to name the domain to which the aye-aye belongs. Common errors were eukaryotes or Animalia.

(ii) Most candidates were able to state that habitat destruction or hunting were reasons why the aye-aye has become endangered.

(iii) Captive breeding was frequently given as one way in which zoos could help protect the aye-aye from extinction. Some candidates only focused on this aspect and explained this in detail. They had not noted that the question required candidates to 'suggest ways in which zoos may help to protect this species from extinction' and that further explanation was not needed.

Good responses addressed the question by including additional aspects, such as raising awareness, conducting research and providing good veterinary healthcare.

(b) (i) This question asked for reasons as to why there is a large genetic difference between the two populations of aye-ayes. Many candidates noted that geographical barriers, rivers and mountains separated the populations. Different environmental conditions can then lead to selection for different alleles. A complete description of forms of speciation was not required here.

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(ii) Most candidates correctly named the type of speciation that may be occurring.

(iii) Candidates were asked to suggest and explain a pre-zygotic mechanism that could prevent the two populations from reproducing. Many stated that physical differences or courtship behavioural differences would prevent successful mating.

Question 2

(a) (i) The majority of candidates correctly identified the structures on the diagram of the motor neurone. The most frequent incorrect answer was referring to the cell body as a dendron.

(ii) Understanding of the reflex arc varied amongst candidates. There were a number of weak responses that made poor use of terminology, such as referring to transfer of messages or signals, rather than transfer of action potentials or impulses. Other weak responses were too vague or included errors, such as stating that a reflex arc involves processing by the brain.

(b) (i) The majority of answers demonstrated some understanding of how a myelinated neurone can increase the speed of transmission of action potentials, but there was much variation in the depth of knowledge that was displayed.

(ii) This question required candidates to apply knowledge of the fast transmission of nerve impulses to the particular example of the blue whale. Candidates taking into account the large distances over which nerve impulses need to be transmitted were able to successfully engage with the question. Several answers only repeated the information provided in the question or did not consider the unique features of the blue whale that were relevant.

Question 3

(a) (i) Nearly all candidates recalled that the polymerase chain reaction is used to amplify DNA.

(ii) Relatively few candidates realised that only tiny quantities of DNA would be available for testing from embryos and that without amplification this would be insufficient for analysis. Incomplete answers often referred to the need to perform repeats, without stating why this would not be possible with the original sample.

(b) This question required candidates to identify the DNA sequence differences between the **Hb^A** and **Hb^S** alleles and recognise how these differences would affect the fragments resulting from *Mst*II digestion. Few answers explicitly stated that the mutation in the **Hb^S** allele meant that the *Mst*II restriction site was destroyed and would no longer be cut by *Mst*II.

Some candidates did not appear to understand what was meant by RFLP analysis and developed answers dependent on DNA sequencing.

A number of responses included generic descriptions of how restriction enzymes function, including recognition of specific palindromic sequences and whether cut ends were sticky or blunt. Such details were not relevant to the question.

(c) Descriptions of the principles of separating DNA fragments by gel electrophoresis were generally clear and many candidates were able to include specific details, such as the negative charge of DNA molecules. Some responses were vague, referring only to DNA molecules being charged and providing no explanation to account for the separation of DNA fragments cut with restriction endonucleases.

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(d) (i) The majority of candidates recognised that the known homozygous samples could be used as reference samples to compare with the DNA samples from embryos.

(ii) Nearly all candidates correctly interpreted Fig. 3.4 to identify the genotypes of the DNA samples.

(e) Discussions of ethical and social considerations were mainly negative, focusing on reasons against employing the genetic testing of embryos. These reasons included religious and moral objections, and the potential for improper use in selecting embryos for desirable characteristics.

A large number of candidates mistakenly referred to termination of pregnancies or risk of fetal damage through *in utero* sampling methods. These were not relevant since the introductory information made clear that genetic testing was occurring prior to implantation.

Few candidates considered positive aspects of genetic testing of embryos, although these were also relevant to the question. Positive aspects include preventing the inheritance of genetic disorders and allowing people with genetic risk factors to have children, who might otherwise choose not to do so.

Very few candidates were able to give sufficient detail to fully address the question.

Question 4

(a) Most candidates were able to mention at least four bonds that hold a molecule of rubisco in shape.

(b) Most candidates were able to suggest that the sugar phosphate would be broken down by rubisco activase or that the enzyme would remove the sugar phosphate from the active site of rubisco in some other way.

(c) (i) Candidates generally had a reasonable understanding of C4 anatomy. Good accounts noted that RuBP and rubisco are located in the bundle sheath cells. Some accounts only mentioned one of the two chemicals.

A number of candidates described biochemical adaptations of C4 plants, which were not relevant to the question.

(ii) Many candidates recognised that there would be more oxygen production as a result of an increase in the rate of the light-dependent reactions. In turn, this would increase the rate of reaction between oxygen and rubisco. A common mistake was to say that stomata would close at high light intensities and so carbon dioxide could not enter the leaf.

(iii) Few candidates were able to provide a full explanation.

Question 5

(a) (i) Many candidates did not know the sequence of events in the sliding filament model of muscle contraction. Whilst some candidates recalled that the release of ADP and inorganic phosphate from the myosin head causes the sarcomere to shorten, many believed the opposite.

(ii) Describing the function of ATP in the sliding filament model proved difficult for most candidates. Although the question required an explanation of the precise function, many answers only referred to the provision by ATP of energy for muscle contraction, without providing any specific details of biochemical events.

Few answers described the binding of ATP to the myosin head or how the myosin head acts as the ATPase that hydrolyses ATP.

(b) (i) The majority of candidates correctly addressed this question. Some candidates incorrectly believed that high blood pressure in the glomerulus is due only to the narrow diameter of the capillaries.

(ii) Many candidates were unable to name the main filtration barrier to ultrafiltration. Frequent incorrect answers included basal membranes, podocytes and even larger structures such as the glomerulus.

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(c) (i) The inverse relationship between GFR and creatinine concentration was noted by most candidates but many did not qualify this further to provide a precise description or did not extract supporting data from Fig. 5.2. Some answers suggested incorrectly that the creatinine concentration controlled the GFR, in contradiction to the introductory sentence of **(c)**.

(ii) Most candidates used the normal GFR value provided to identify the creatinine concentration of the blood at this point. Many only quoted the value and did not provide the appropriate units.

(iii) Many candidates explained the decrease in GFR as a consequence of an increase in the creatinine concentration. These candidates had not appreciated the significance of the information provided that the concentration of creatinine in the blood largely depends on the GFR.

Most candidates who suggested a correct cause of a decrease in the GFR included either low blood pressure or suitably described kidney damage. Few were able to suggest two valid reasons for a decrease in GFR.

Question 6

(a) (i) Many candidates were able to outline how gene mutations may occur and described some of the different types. Not all responses were sufficiently precise, with a number of candidates omitting to mention DNA and others referring to radiation, rather than ionising radiation (or a specific example), as a cause of mutation.

(ii) Most candidates gave a correct definition of the term recessive allele.

(iii) Many candidates did not explain the symbols that they were using for the alleles. This information needed to be set out clearly. Not all identified the child with albinism. Although the question stated that albinism is an autosomal condition, some candidates provided genetic diagrams based on sex-linked inheritance.

(b) Most candidates were able to address this question effectively.

Question 7

(a) (i) Many candidates incorrectly divided by 360 000, rather than 135 000, when calculating the percentage increase in red deer.

(ii) Most candidates suggested three environmental factors that would prevent an increase in the deer population, such as predation, lack of food and disease.

(b) For both parts **(i)** and **(ii)**, many candidates were unable to sketch a suitable curve on the axes provided or identify the type of force of natural selection that was acting.

Question 8

All candidates demonstrated some knowledge of respiration. No statement was consistently matched to an incorrect structure or compound.

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Section B

Question 9

(a) Many candidates recognised that only photosystem I is involved in cyclic photophosphorylation and that ATP production follows absorption of light energy as the result of electrons being excited, emitted and passed along a chain of carriers. Good descriptions were often given of the structure of a photosystem. Some candidates mistakenly thought that chlorophyll b was a primary pigment.

(b) Some candidates were confused about which electron would combine with a proton to reduce NADP. Many candidates mentioned that reduced NADP would convert GP, rather than reduce it.

Question 10

(a) Some candidates were able to provide full explanations that referred to a wide range of relevant details. Other candidates did not always address the requirements of the question, resulting in many responses that were generic in nature. These often referred to auxin acting at the tips of shoots and roots to prevent lateral growth, without considering events at the cellular level.

(b) The question required candidates to give examples of environmental effects on the phenotype of individual organisms. Most responses did not address this aspect of the question and instead discussed long-term effects over many generations as a result of selection pressures that act on whole populations. These effects cause changes in allele frequencies over several generations and, over time, will cause phenotype frequencies in populations to change. They do not change the phenotype of individual organisms. Candidates need to be clear about the distinction between environmental effects on individual phenotypes and the effect of selection on whole populations.

Where candidates did describe interactions between genes and the environment, they most frequently considered examples related to continuous variation and nutrition. Some candidates considered more specific examples, such as the effect of temperature on the colour of animal fur.

Very few candidates related the modification of gene expression to phenotypic changes.

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Paper 9700/52
Planning, Analysis and Evaluation

Key messages

- Data should be analysed to find patterns and trends that are relevant to the question. If data quotes are used, they should be accurate and pertinent.
- In planning questions, candidates need to take note of the instruction that the method described should be detailed enough for another person to follow. Relevant details include the apparatus and reagents required, the quantities that will be used, how the independent variable will be changed, how the dependent variable will be measured and how other variables should be standardised. Listing different variables without further qualification is not appropriate.
- Candidates need to be familiar with the statistical terms used in the syllabus and be able to explain how they are used.

General comments

Many candidates were able to demonstrate a good understanding of the principles relevant to this assessment with well-presented and clear responses.

Comments on specific questions

Question 1

(a) Most candidates correctly calculated the minimum concentration of lipase in washing liquid **B**. The only common error was incorrect rounding of the final answer to 0.29.

(b) Many candidates suggested proportional (or simple) dilution as a suitable method for diluting 1000 μg cm^{-3} lipase stock solution. More complete answers identified the need to make up a minimum of three stated concentrations of lipase between 700 μg cm^{-3} and 200 μg cm^{-3} and matched the suggested concentrations to the method of dilution described (proportional or serial). Weaker candidates suggested serial dilution as a suitable method, either based on 1 in 10 or 50 / 50 dilutions. Neither of these are appropriate for generating a suitable range of concentrations to test in this context.

(c) Most candidates correctly identified the independent variable, but fewer were able to provide a sufficiently precise description of the dependent variable. Weaker answers referred to concentration of fatty acids or rate of change of pH.

(d) Most candidates were able to describe a basic plan, but many simply listed variables without describing a procedure. This question requires candidates to produce a workable method that another person could use to obtain valid results; few responses achieved this standard. Good practice for candidates would be to write a method that is then given to another student to use and evaluate.

When considering standardisation of variables, it should be clear that the conditions decided upon apply to all of the test solutions. Describing conditions for a single example without indicating that this extends to all is insufficient.

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Most candidates standardised the volume of the different concentrations of lipase, but not all volumes suggested were suitable for the size of the test-tubes or boiling tubes proposed. Many candidates standardised the size of the piece of fat-stained fabric for all of the concentrations of lipase.

Temperature was standardised by most candidates at 30 °C but methods to maintain the required temperature were not always described and some methods were unsuitable, e.g. references to air conditioning.

The majority of candidates planned to start a timer as soon as the fabric and pH meter were submerged in the liquid and stop it as soon as the pH reached 6.5. Very few candidates realised that using a buffer to attain the initial pH of 7.9 was inappropriate.

The majority of candidates referred to replicating or repeating the experiments. When describing repeats or replicates, further details should be included, e.g. repeating at least twice to give three results and calculating the mean.

In terms of safety, almost all candidates recognised that this was a low risk investigation.

(e) (i) Few candidates recognised that the reciprocal of the time taken for the pH to fall from 7.9 to 6.5 is a measure of rate (i.e. 1/t). Some candidates referred to measuring the gradient of a line on a graph, which is not appropriate for this example. Others recognised that dividing by time is relevant for calculating rates but were unsure of what to divide.

(ii) Most candidates were able to draw an appropriate line on the graph. A few candidates reversed the axes. The dependent variable should always be plotted on the *y*-axis.

Errors often occurred as a result of candidates not noting the requirements of the question. The most frequent error was to omit units from one or both axes. Some candidates plotted a graph of time, instead of rate, against lipase concentration. Others sketched standard graphs showing rate of reaction against substrate concentration and included labels for V_{max} and K_m.

(iii) Candidates found this question challenging. Many did not appear to understand that the curve in **(e)(ii)** is a calibration curve that could be used to find an unknown concentration of lipase in washing liquids.

A common error was to assume that the working concentration of enzyme corresponded to a plateau on the graph.

(f) Very few candidates were able to give a suitable suggestion. Many focused on the different methods of dilution for washing liquid **A** and washing liquid **B**. Since the question was about washing liquids that had already been diluted, this was not relevant.

Another common misconception was that the investigation was not carried out at the optimum temperature.

Candidates who considered that the two washing liquids may contain components other than lipase that affect the hydrolysis of fats or that the lipase enzymes in the two washing liquids may have different activities were able to suggest relevant reasons.

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Question 2

(a) Many candidates selected from the information provided to correctly identify two key variables that were controlled in this investigation. Some candidates speculated on variables that may have been controlled but for which no information was provided, e.g. the type of microscope used or the light intensity.

(b) Few candidates understood the purpose of calculating standard deviations. Some candidates referred to 'a range of values' without any reference to the mean. Others considered that using standard deviations allows for errors in the women's reactions.

(c) Most candidates noted at least one correct feature about the CFFT, with many identifying two or more. The descriptions of features provided by some candidates were too vague. Other candidates quoted individual values from Fig. 2.1 rather than identifying features that were evident from patterns in the data.

(d) Most candidates were able to suggest two acceptable reasons, often related to the small sample size and the limited age range.

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