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Paper 9700/12
Multiple Choice

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

General comments

Candidates found questions **6**, **8**, **10**, **15**, **18** and **26** most straightforward. Questions **2**, **13**, **17**, **23**, **24** and **34** were the most challenging.

Comments on specific questions

Question 1

About half of the candidates were able to combine the data from the eyepiece graticule and stage micrometer to derive the actual length of the cell. Option **B** was the most common incorrect response. Candidates selecting this option may have omitted to convert the number of divisions of a stage micrometer scale to a length in micrometres.

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Question 2

Many candidates selected option **D**, suggesting that they had not considered the formation of vesicles by the cell surface membrane during endocytosis.

Question 4

The majority of candidates knew that the nucleus and ribosomes contain RNA. Fewer realised that RNA would also be present in mitochondria, with about one third of candidates selecting option **D**. The key knowledge these candidates had not considered was that mitochondria contain ribosomes.

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Question 7

About half of the candidates selected incorrect options, all of which included procedure 2. Since procedure 2 lacks any step to hydrolyse the polymer, it can only test whether the polymer itself is a reducing sugar.

Question 11

The majority of candidates selected options that included bond 2. Bond 2 is a peptide bond and is therefore essential in the formation of the primary structure of proteins.

Question 13

Over two fifths of all candidates incorrectly selected option **A**. This describes the actual experiment, not the controls.

Question 14

Only the stronger candidates were familiar with the effect of the presence of a competitive inhibitor on the K_m and V_{max} of an enzyme.

Question 17

Few candidates were able to select the correct option. Candidates needed to consider the shortest distance over which diffusion would need to occur for the dye to reach the centre of each agar block. The 5 mm $\times$ 10 mm $\times$ 15 mm block has a minimum thickness of 5 mm so the diffusion distance to the centre is 2.5 mm. This is the same as the 5 mm $\times$ 5 mm $\times$ 5 mm block.

Question 23

The majority of candidates were unsure of the distinction between a DNA strand and a DNA molecule. A DNA molecule consists of two strands of DNA.

Question 24

Over half of all candidates incorrectly selected option **A**. This option would have been correct if the table had showed mRNA codons instead of tRNA codons.

Question 28

Candidates were able to identify the neutrophil with little difficulty. Distinguishing the monocyte and the lymphocyte proved challenging and many candidates incorrectly selected option **C**.

Question 31

Option **C** was the most common incorrect option. Candidates selecting this option had not considered that infection with a virus would trigger an immune response leading to an increase in the number of white blood cells.

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Question 34

Weaker candidates frequently selected options **A** and **B**. Derivation of the correct answer depended on realising that to pass through a cell, oxygen must cross two cell surface membranes – one on the way in and one on the way out. Furthermore, to reach a molecule of haemoglobin, oxygen must pass through the cell surface membrane of a red blood cell.

Question 36

The question was limited to identification of a factor leading to an increase in the distribution of *Anopheles* mosquitoes. Option **B** was the most commonly selected incorrect response. Development of drug resistance in *Plasmodium* would increase the prevalence of malaria but would not affect the distribution of the mosquito.

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Paper 9700/22
AS Level Structured Questions

Key messages

- Several questions required candidates to consider data presented in the form of a graph or a bar chart. Candidates should carefully note the distinction between 'describe' and 'explain' in questions of this type. Descriptions are expected to describe overall trends and patterns, including relevant details such as peaks. Sometimes, a precise description will require data points to be identified, in which case it is often necessary to quote the corresponding values for both the *x*-axis and *y*-axis.

  Explanations should explain any trends or patterns shown by the data, making use of candidates' knowledge and understanding together with any other information provided. Different explanations may apply to different parts of the data range and, in these cases, explanations should be clearly linked to the relevant data ranges.

General comments

Many candidates were well prepared and demonstrated a good knowledge and understanding of the syllabus content.

Candidates did not always note the requirements of questions with sufficient care. For example, in **Question 1(b)** some candidates attempted to explain mass flow in terms of sucrose loading at the source, although the question was in the context of sucrose unloading. Similarly, in **Question 3(b)** candidates often outlined ventricular diastole only in the left or the right side of the heart, although the question was not limited to any particular side.

Comments on specific questions

Question 1

(a) Most candidates displayed good knowledge of how the structure of a phloem sieve tube element is adapted to its function.

(b) Effective responses were clear and focused, and used appropriate terms such as concentration gradient, water potential gradient and hydrostatic pressure in the correct contexts. Weaker responses were sometimes confused and often used terms incorrectly.

Some candidates described how the process of loading sucrose into phloem sieve tube elements helps mass flow. These candidates had not noted that the question was in the context of sucrose unloading.

Question 2

(a) Many candidates recognised that the enzyme was a PAP2 enzyme. Most of these candidates were able to select information from Fig. 2.2 to explain their choice. Some candidates attempted to explain the slight rise then fall in the graph's shape. This was not necessary to address the question.

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(b) The majority of responses correctly stated that the activity of the PAP enzyme increases with increasing concentration of phosphatidate. Fewer provided more detail by describing the change in gradient of the line with increasing phosphatidate concentration.

Candidates often supported their answers by quoting two values from the graph to show the changing activity of the enzyme at different concentrations of phosphatidate. Some candidates only quoted a single value from the graph, which was insufficient to exemplify a change in PAP activity with phosphatidate concentration.

Many candidates were able to explain the effect of increasing phosphatidate concentration in terms of the formation of enzyme–substrate complexes. Some also noted that the concentration of phosphatidate was the limiting factor.

(c) (i) Stronger explanations were based on consideration of energy density, which is the amount of energy stored per unit volume. These explanations typically focused on the compact nature of the packing of triglyceride molecules and the presence of many carbon–hydrogen bonds in the hydrocarbon chains of the fatty acids. Although details of oxidative phosphorylation were not required, a few candidates were able to explain that when carbon–hydrogen bonds are broken, large numbers of hydrogen ions or protons are released to power the process.

The responses of some candidates were too vague to provide effective explanations.

(ii) Most candidates showed a good understanding of bilayer formation in cell membranes, with responses based on the knowledge that phospholipids have a hydrophilic head and hydrophobic tail. Fewer candidates developed this further by discussing the specific orientation of the phospholipid molecules with respect to interactions with water molecules.

Question 3

(a) Most candidates correctly referred to the venae cavae (vena cava was also acceptable) with many able to give the precise name of the two blood vessels.

Some candidates did not name the blood vessels, instead only stating that the blood vessels were veins.

A number of candidates incorrectly included the pulmonary vein in their answers and there were some responses that referred to arteries.

(b) Many candidates provided well organised accounts that described and explained the events of ventricular diastole in detail.

Some responses were confused, mixing up the names of the different valves and when they open or close. Some candidates only referred to events in one half of the heart and a few answered the question in terms of ventricular systole.

(c) (i) Strong candidates were able to use the information provided in Fig. 3.1 to deduce the base sequences for **P**, **Q**, and **R**. However, weaker responses were extremely varied, reflecting uncertainty about complementary base pairing, the differences between RNA and DNA and the distinction between the template strand (strand that is transcribed) and non-template strand of DNA.

(ii) Many candidates did not know the type of polypeptide in a haemoglobin molecule that is affected by the mutation causing sickle cell anaemia. Examples of incorrect responses included polypeptide, β-polypeptide, α-polypeptide, α-globin, primary structure, globular protein and valine.

(d) Many candidates were able to explain that a shift to the right in the oxygen dissociation curve indicates that the haemoglobin has a lower affinity for oxygen and that, as a result, the uptake of oxygen in the lungs will decrease and the release of oxygen in respiring tissues will increase.

Some candidates tried to explain the shape of the oxygen dissociation curve. This did not address the requirements of the question.

One common error was for candidates to explain the uptake and release of oxygen in terms of the shape and decreased surface area of the sickle cell red blood cells, rather than from consideration of the oxygen dissociation curve.

Question 4

(a) The most effective responses gave clear comparative sentences for each of the three structural differences required. Weaker answers were more confused. Some referred to relevant differences without linking these specifically to one or other of the two structures being compared.

(b) Many candidates correctly named the three phases and were able to state a process occurring during each. Phases were not always listed in the correct order.

A number of candidates did not note that the three phases all occurred during interphase and, instead, described stages of mitosis.

Question 5

(a) This was well known with most candidates correctly stating that myasthenia gravis is an autoimmune condition and explaining what this means. Some candidates gave additional relevant details. The most common error was for candidates to suggest that in myasthenia gravis antibodies bind to the neurotransmitter instead of the receptors.

(b) The majority of candidates were able to state the full name of the pathogen known as HIV. A small number of candidates thought that the H stands for High.

(c) Candidates were able to provide full and detailed responses that focused on the consequences of a reduced number of T_h cells on the effectiveness of the immune system and susceptibility to infectious diseases. Most responses considered the role of T_h cells in stimulating antibody production, but a wide range of other effects were noted. The effect of falling numbers of T_h cells on cytokine production was not always included in explanations.

(d) (i) Some candidates were able to develop detailed and accurate descriptions of the trends shown in Fig. 5.1. Other accounts were confused with candidates mixing up the two sets of data presented.

Some candidates exemplified the trends described with appropriate and accurately referenced data quotes from Fig. 5.1.

(ii) The majority of responses included one or two relevant reasons. Some candidates did not note the requirements of the question with significant care. Instead of considering why it is difficult to provide ART to everyone living with HIV, some attempted to explain why treatment might not be successful or the problems with developing a vaccine.

Question 6

(a) Most candidates made reference to turgor pressure. Fewer explained that this was as a result of water entering the vacuole by osmosis through the tonoplast.

Some responses incorrectly stated that parenchyma cells have particularly thick cell walls or lignified cell walls.

(b) (i) Most candidates were able to clearly explain the term *magnification*. Some responses were too vague, for example ‘zooming in to see more detail’. Others incorrectly implied that magnification is an increase in size of the actual object.

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(ii) Most candidates measured the length of the line correctly and carried out the appropriate calculation to derive the magnification. Some candidates incorrectly attributed a unit to the calculated magnification.

(c) (i) Many candidates correctly deduced the transport mechanism and were able to explain their answer. Examples of incorrect answers included diffusion, facilitated diffusion and osmosis. Some candidates referred to the pathway, rather than the transport mechanism, with both symplastic pathway and apoplastic pathway suggested.

A number of responses gave relevant explanations that fitted the data but were matched to an incorrect mechanism.

(ii) Some responses recognised that the charged nature of hydrogen ions means that they cannot pass across the hydrophobic core of the tonoplast membrane. As a result, transport of hydrogen ions across the tonoplast requires specialised membrane proteins. Strong responses were able to account for transport of hydrogen ions in just one direction.

(iii) Many candidates knew the role of hydrolase enzymes. Fewer were able to address this question in detail by considering the consequences of hydrolase enzymes leaking out from the vacuole. Candidates needed to relate the optimum pH of the enzymes to the pH in the cytosol.

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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 necessary skills to engage with this examination.

Candidates should carefully note the precise requirements of each question, including the command word. For example, the command word 'explain' typically requires some reasoning, often with reference to underlying theory.

General comments

In general, candidates demonstrated a good understanding of the skills required and the majority of candidates showed that they were familiar with the use of the microscope.

Comments on specific questions

Question 1

(a) (i) Most candidates were able to state the risk of using hydrogen peroxide solution and gave a valid reason for their decision.

(ii) The majority of candidates followed the instructions and suggested a suitable number of temperatures spread evenly across the expected range.

(iii) Most candidates correctly stated the two measurements that would need to be made.

(iv) The majority of candidates organised their results clearly by presenting a ruled table with appropriate column headings. Not all candidates included units in the column headings when applicable.

Nearly all candidates recorded results for each of the temperatures that they had stated in **(a)(ii)**. Many of these sets of results were in agreement with the expected trend.

(v) Many candidates correctly stated at least four more concentrations of hydrogen peroxide solution across a suitable range. Most were able to outline how these solutions could be prepared using the 5.0% hydrogen peroxide solution.

(vi) Many candidates correctly stated one other variable that would need to be standardised and described how this variable could be standardised.

(b) (i) Most candidates used the headings given in the table to label the *x*-axis (pH) and the *y*-axis (enzyme activity / arbitrary units). Some candidates labelled the axes incorrectly or gave incomplete headings. The majority of candidates used an appropriate scale for both axes, plotted the five points accurately and joined the points appropriately with a thin line.

The most common errors were using incorrect scales and drawing lines that were too thick.

(ii) Most candidates showed on their graph how they estimated the enzyme activity when the pH was 4.0 and correctly stated this value.

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(iii) Many candidates correctly described the trend in the results.

(iv) Some candidates were able to provide detailed explanations. Some did not clearly link explanations to particular pH ranges. Not all explanations made good use of syllabus knowledge, for example by referring to enzyme-substrate complexes and the shape of the active site. Stronger candidates considered the effect of pH on ionic bonding

Question 2

(a) (i) Many candidates made use of a sharp pencil to produce accurate drawings that made good use of the available space. Most followed the instruction to draw four starch grains and used a single line to show the outline shape of each grain. Some included additional relevant detail by showing surface features of the grains.

The most common error was for candidates to draw lines that were too thick or that did not meet up precisely.

(ii) Many candidates correctly identified the starch grains in Fig. 2.1 that matched most closely to the starch grains drawn in **(a)(i)**.

(iii) Most candidates were able to take accurate measurements and use these to calculate the mean image length. The most common mistake was for candidates to measure the length of the complete lines and not the lengths of the grains.

(iv) Some candidates were able to use the information provided to calibrate a scale for the drawing and then work out the mean actual length of the three starch grains.

(b) Many candidates understood the expectations of a plan diagram and did not include any cells in their drawings. Most made good use of the space available and represented the distribution of different tissues accurately. Many candidates showed the stele in the correct proportion to the diameter of the root. Most candidates followed the instructions by using a label line and the letter **G** to correctly identify the tissue that contained most of the starch grains.

(c) Many candidates organised the table in such a way that comparisons were clear. Most were able to list at least three observable differences between Fig. 2.4 and Fig. 2.5.

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Paper 9700/42
A Level Structured Questions

Key messages

1 In calculations, working must be clearly shown when the instruction to show working is included in the question, e.g. **Questions 1(b)** and **4(a)**. In these cases, full marks will not be available for an answer without working.

2 If a question asks for an explanation then a description is not sufficient. Explanations must consider the underlying rationale or mechanism. Several candidates only provided descriptions when answering **Questions 8(a)** and **8(b)**.

3 When deriving offspring genotypes and phenotypes from genetic crosses, it is important that genotypes and phenotypes are clearly linked.

General comments

Candidates demonstrated a good knowledge and understanding across most topic areas and, in most cases, recognised, and tried to address, the requirements of the questions. Command words and mark allocations should always be noted carefully so that appropriate responses can be provided. **Questions 2**, **3(a)** and **8** proved to be the most difficult.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates were able to name features **A** and **B** correctly. The most common error was to describe the function of the feature rather than to name it.

(ii) Many label lines were imprecise and stopped short of the correct part of the cell. Some candidates misunderstood the process of selective reabsorption and put the labels the wrong way round.

(b) Most candidates calculated the correct answer and showed relevant working. Some candidates did not show their working, which was a requirement of the question.

(c) Some candidates had clearly learned the functioning of dip sticks for testing for the presence of glucose and were able to provide full responses. Many candidates only had a vague knowledge of the enzymes involved and were not able to describe the reactions correctly.

Question 2

(a) (i) The role of primers in PCR was generally not well described. Many answers concentrated on the role of *Taq* polymerase, which was not the focus of the question. Effective responses were related to the context of detecting TRECs and made reference to the role of primers in the specificity of the DNA amplification process.

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(ii) Many responses mistakenly considered techniques such as electrophoresis or microarrays instead of describing how the results of PCR contribute to the diagnosis of SCID. Responses that did address the question often omitted explanations and were limited to stating that the detection of TRECs by PCR indicates that the child does not have SCID (or *vice versa*).

(b) (i) This question was well done by the majority of candidates. Most identified the overall trends for each of the three approaches and many supported their answers with relevant data quotes. More detailed answers referred to the continuing role of testing children with multiple infections or stated the year in which the screening programme became dominant in identifying children with SCID.

(ii) Most responses recognised the role of screening soon after birth for providing early diagnosis or early access to treatment. Few candidates developed this further to consider that children with SCID would be less likely to suffer from repeated infections if they received early treatment or that negative results provide comfort, particularly in families with a known history of SCID inheritance.

(c) This was a challenging question. Many candidates understood that an allele encoding ADA would need to be inserted into the virus, but few could suggest how to obtain and isolate the ADA allele. Most candidates suggested using the recombinant virus to infect children with SCID, rather than considering that gene therapy for SCID should be targeted at the immune system. Some candidates mentioned inhalation as a possible delivery method. This would be suitable for respiratory disorders, such as cystic fibrosis, but not for SCID.

(d) Candidates were aware of a range of challenges in using viruses for gene therapy. Many considered the potential for side effects, with some referring to leukaemia. Fewer candidates were able to relate these risks to the effects of random integration of viral DNA sequences into the host cell's DNA. Some candidates recognised the difficulty of targeting the relevant cell types and a number considered the role of the patients' immune systems in destroying the viruses and making the gene therapy ineffective.

Question 3

(a) (i) Most candidates correctly defined alleles as alternative forms of a gene. Fewer elaborated this further by stating that different alleles code for different proteins or have different DNA nucleotide sequences.

(ii) Many responses correctly suggested that allele **R** may code for an enzyme controlling pigment production or for a transcription factor regulating gene expression of the pigment. Few provided more specific details of gene interactions.

Some responses were limited to repetition of the information already provided in the question.

(b) The genetic diagram explaining a dihybrid cross between two heterozygous plants was generally well constructed. Nearly all candidates correctly noted the parental genotypes. Some presented the genotypes in such a way that alleles of the same gene were not next to each other, e.g. **RTrt** rather than **RrTt**. This is not good practice and increases the risk of making later errors.

Some candidates identified the genotype of one parent as **Rr** and the genotype of the other parent as **Tt**, forgetting that all individuals will have both genes.

The most frequent errors involved omitting to link phenotypes either to genotypes or to ratios. For example, many candidates derived the correct ratio of 9 : 4 : 3 but did not state the flower colour for each.

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Question 4

(a) Many candidates were able to apply the formulae of the Hardy-Weinberg principle to calculate the expected number of brown fish that were homozygous. The most frequent errors involved relating the number of blue-silver fish (1437) to q rather than q^2 and the number of brown fish (14990 to p, rather than $p^2 + 2pq$.

Some candidates correctly calculated the expected frequency in the population of brown fish that were homozygous but did not complete the final step to convert this to the actual number in the population.

(b) Nearly all candidates knew at least two conditions that would need to be present in order for the Hardy-Weinberg principle to apply to populations.

(c) Most candidates recognised the need to cross blue-silver fish together for the most rapid results and many went on to describe the selective removal of brown fish over several generations in order to achieve this.

Several responses described selective breeding in generic terms only, referring to 'desirable characteristics' rather than the phenotypes relevant to the context of this question.

(d) The majority of responses recognised phenotypic consequences of genetic modification that would increase food production. Fewer described the relevance of inserting genes in order to achieve this outcome. Several candidates considered selective breeding in their responses instead of genetic modification.

Question 5

(a) Many candidates were able to define recombinant DNA correctly. Some simply described the example of the plasmid given rather than identifying the defining features of recombinant DNA in general.

(b) Many candidates understood that the purpose of including the gene for GFP was to act as a marker. Fewer were able to describe what the marker indicates.

A number of candidates incorrectly stated that the presence of the gene for GFP allows the plasmid to be seen.

(c) The majority of responses correctly described the type of DNA end produced by *Sma*I digestion.

(d) (i) Most candidates correctly identified the two restriction endonucleases.

(ii) Candidates found this question challenging. Most candidates showed blunt ends on the DNA sequence to be removed, although both restriction endonucleases produced 'sticky ends'.

(iii) Few responses included suggestions that provided a valid rationale for using different restriction sites at the two ends of the gene. Candidates recognising that genes are unlikely to have a nearby restriction site for the same enzyme at both ends provided the most convincing suggestions for this example.

(iv) Nearly all candidates knew the name of the enzyme responsible for joining double-stranded DNA sequences together.

Question 6

(a) The majority of candidates were able to add the correct taxonomic groups to the table.

(b) Many candidates made relevant comments relating to low genetic variation, inbreeding depression and increased homozygosity.

(c) Candidates were able to make a wide range of different suggestions that were valid as long as they could be logically explained.

(d) Most candidates correctly recognised that underwater respiration would occur under anaerobic conditions, leading to a build-up of lactate. On returning to the surface, this lactate would then need to be removed. Almost all candidates referred to an oxygen debt and the need for extra oxygen to convert lactate to pyruvate or glycogen. Some candidates also considered that extra oxygen would be needed to reoxygenate haemoglobin or replenish ATP.

A few candidates incorrectly stated that lactate was converted to glucose.

(e) Many candidates did not note the requirement of the question to focus on the proteins and simply described the sliding filament model of muscle contraction.

Question 7

(a) Most candidates correctly named the two parts of a chloroplast. Some candidates stated the answers the wrong way round. A common error was for the stroma to be named as the cytoplasm.

(b) Responses to this question were very variable. Many candidates reversed the positions of carbon dioxide and oxygen. One frequent error was to refer to reduced NAD rather than reduced NADP.

(c) Candidates recognised a number of functions of organic compounds made from triose phosphate but there were few full and detailed responses. Some descriptions were too vague. For example, stating that starch is a storage compound does not make the nature of what is being stored clear.

Question 8

(a) Many candidates correctly described competitive or non-competitive inhibition and addressed the question effectively.

(b) Most candidates recognised that inhibition of acetylcholinesterase would leave acetylcholine bound to receptors in the postsynaptic membrane. Some correctly described the consequences of this. Many candidates incorrectly considered that this would prevent the generation of impulses by the postsynaptic membrane.

(c) Candidates were able to suggest a variety of valid approaches. Some suggested using a chemical to break down the inhibitor while others proposed increasing the concentration of acetylcholinesterase.

Section B

Question 9

(a) Most candidates gave detailed accounts of how meiosis can result in genetic variation, covering crossing over and independent assortment in metaphase 1. Reference was not always made to homologous chromosomes and few considered independent assortment of chromosomes in metaphase 2.

Most candidates described the role of random fertilisation. Fewer considered the effects of random mating.

(b) This question was well answered, especially for albinism, where candidates demonstrated detailed knowledge of the link between genotype and phenotype.

Most candidates recognised that haemophilia is a sex-linked disease and included details of its effects in their responses. Some candidates confused haemophilia with sickle cell anaemia.

Question 10

(a) Most candidates described quadrats with appropriate details including the use of random number generators to determine quadrat placement and how to record the plants within each quadrat. Some candidates considered how to process the data collected.

A small number of candidates had not noted that the question was in the context of plants and described mark-release-recapture.

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(b) This was an open-ended question and candidates were able to respond very widely. Most candidates discussed habitat loss, often linking this to deforestation due to agriculture or industrialisation. Climate change leading to global warming was frequently considered, as was overexploitation of resources due to overfishing or hunting.

Few candidates referred to habitat fragmentation or the introduction of alien species.

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BIOLOGY

Paper 9700/52
Planning, Analysis and Evaluation

Key messages

The use of scientific language is important in this paper. General descriptive terms like amount should be avoided if a more appropriate scientific term is available, such as volume or mass.

Similarly, when describing statistical analyses, relevant terminology should be used precisely. There was a tendency for statistical terms to be included in responses without consideration of whether they are being applied meaningfully or in appropriate contexts.

General comments

Candidates were able to demonstrate a good knowledge and understanding of the syllabus content. The requirements of individual questions were not always addressed with sufficient care, suggesting that some candidates would benefit from more careful consideration of the intent of each question.

Comments on specific questions

Question 1

(a) Identification of the independent variable proved difficult for a significant number of candidates. Some suggested that the independent variable was the colour or type of seaweed. These candidates had not noted that the question related only to green seaweed and the colour or type of seaweed was therefore not a variable.

Many candidates correctly recognised that wavelength of light was the independent variable. Less precise descriptions were acceptable, such as colour of light or colour of the filter.

The majority of candidates correctly gave the dependent variable as the time for methylene blue to change colour. Some responses were too vague, referring only to time or colour change without further qualification.

A very few candidates confused the dependent variable and the independent variable.

(b) (i) Most candidates described crushing or blending seaweed samples in an appropriate piece of apparatus before filtering through fine mesh cloth. Fewer considered steps to standardise this process for the different types of seaweed, e.g. using the same mass of each type of seaweed or crushing or blending each sample in a standard volume of cold buffer.

Many candidates realised that the suspension of chloroplasts obtained needed to be kept cool, but few explained clearly how this could be achieved. Some suggested adding ice directly to the suspension, which is not appropriate. A number of candidates incorrectly suggested that cooling the chloroplasts is necessary to denature the enzymes.

Most candidates described addition of methylene blue to the chloroplast suspensions. Not all stated how this would be standardised for all of the chloroplast suspensions, e.g. by stating how the same volume of suspension was added to each tube or describing a standard method to add the methylene blue indicator.

Some candidates recognised that timing must start immediately at the point that the suspension is mixed with methylene blue and illuminated. A number of valid methods to achieve this were suggested, e.g. covering the tubes with aluminium foil until the moment of starting the timer or setting up the apparatus in a dark room and then switching on the light source and timer at the same moment.

Most candidates described the use of coloured filters to vary the wavelength of light. A few candidates confused wavelength with intensity and moved the light source to different distances from the chloroplast suspensions, rather than keeping a constant distance. Others incorrectly suggested that a different filter should be selected for each of the suspensions to match the colour of the seaweed.

Descriptions of how to use the filters were often unclear. Not all candidates described where the filters should be placed or considered how it could be ensured that the only light reaching the chloroplast suspensions had passed through the filters.

Most responses included consideration of how to determine the end-point of the reaction. This is when the methylene blue becomes colourless. However, descriptions of this step were often vague. Strong responses recognised that at the end-point the suspensions themselves would not be colourless but would be the same colour as they were before methylene blue was added. The strongest responses suggested comparing the colour of the experimental samples with colour standards containing only chloroplast suspensions without methylene blue. Some candidates suggested using a white tile or white card as a background against which to view the sample. This was a valid approach.

Most candidates stated that the investigation should be repeated using the same range of light wavelengths for all three chloroplast suspensions. Not all went on to refer to the calculation of mean values for each set of repeats.

Many candidates considered the hazards presented by this investigation and correctly evaluated that this was either a low risk procedure or provided justification as to why the risk could be classified as medium together with suggested precautions.

Many accounts were well presented and demonstrated effective planning skills. A few responses misunderstood the principles of the experiment and simply suggested adding methylene blue drop by drop until it was decolourised.

(ii) Most candidates understood that an action spectrum is a graph in which the rate of photosynthesis is plotted against the wavelength of light. Some candidates were able to provide clear and full descriptions of how an action spectrum could be produced for each seaweed. Many, however, did not convert the recorded times to rates of photosynthesis by multiplying by 1/t.

A minority of candidates incorrectly suggested that the action spectrum was the single wavelength of light that decolourised the methylene blue fastest.

(c) (i) This question was generally well answered with candidates providing a comparison of the pigments found in the different seaweeds, rather than simply listing the pigments in each seaweed. A few candidates incorrectly suggested that results could be interpreted quantitatively by comparing the density of colour between different bands.

(ii) Candidates generally found this question difficult. Very often candidates described the wavelength of light as a property of the pigments, e.g. by describing pigments as having particular wavelengths. Few candidates recognised the significance of absorption.

Strong responses discussed evidence both for and against the suggestion that brown seaweed and red seaweed can photosynthesise in deeper water than green seaweed. This required making links between the wavelengths of light that the different seaweeds could absorb due to their specific pigments with the wavelengths of light that would be available at different depths.

Question 2

(a) (i) Most candidates were able to draw valid conclusions that were consistent with the data in Fig. 2.1. Some candidates incorrectly concluded that Parkinson's disease is a sex-linked condition.

(ii) Many responses stated that the two sets of data to compare were ordinal and could be ranked. Others recognised that there was an increasing relationship between age and the occurrence of Parkinson's disease or that there were sufficient pairwise comparisons available for the calculation to be valid. A number of responses were too vague or described features that, while true, are not relevant in determining whether calculation of a Spearman's rank correlation is a valid exercise.

(iii) The majority of responses stated an appropriate null hypothesis. Some candidates proposed the null hypothesis that there was no difference between age and the occurrence of Parkinson's disease. These candidates had not considered the context of the statistical test.

(b) (i) Many candidates were able to identify two variables that had been standardised. A few candidates listed variables for which there was no indication to show that they had been standardised. Some candidates described relevant variables in terms of amount. The term 'amount' is too vague if more appropriate terms such as volume or mass are actually intended.

(ii) Most candidates were able to make suitable suggestions. Some responses were too vague, e.g. references to food without further qualification such as mass or type.

(c) Many candidates were able to describe advantages of calculating standard deviations. Some confused standard deviations with standard errors. Standard deviations on their own do not show how close the calculated mean is likely to be to the true mean.

Common misconceptions included the idea that using standard deviations makes results more 'reliable' or more 'accurate'.

(d) Candidates did not always recognise that the key comparison in Table 2.1 was between group 3 and group 4, since differences between these two groups reveals the effect of the Chinese herbal drug. Responses simply stating that Chinese herbal medicine increases dopamine levels were too vague to provide evidence of support for the conclusion.

Most candidates were able to describe evidence from the study that suggested the conclusion may not be valid. Not all of this evidence came from Table 2.1. For example, references to shortcomings of the experimental procedure were relevant, such as the short time span of the study or limiting the study to males only.