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FOREWORD

This booklet contains reports written by Examiners on the work of candidates in certain papers. **Its contents are primarily for the information of the subject teachers concerned**.

BIOLOGY

GCE Advanced Level and GCE Advanced Subsidiary Level

Paper 9700/01
Multiple Choice

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

General comments

The mean score for this Paper was 27.3 (68.3%) and there was a very good spread of scores, the standard deviation being 5.8. Eleven items were answered correctly by 80% or more of candidates, **Questions 2**, **5**, **8**, **12**, **17**, **24**, **26**, **27**, **31**, **35** and **37**. Four questions were difficult; fewer than 40% of candidates answered **Questions 6**, **22**, **30** and **36** correctly.

Comments on specific questions

Question 6

Both the better candidates and the less able seemed to be baffled by this question. It requires application of the knowledge of how plant cells behave when immersed in a solution with a water potential near to zero (syllabus section A(k)).

Question 8

Candidates had no difficulty recognising a glycosidic bond and its formation by condensation.

Question 14

A majority understood that there would be no reaction above 50°C but weaker candidates, in particular, did not pay sufficient attention to the label on the y axis.

Question 1

The terms chromatid and centromere were very well known.

Question 18

Option **B** was a popular incorrect answer. A separate tRNA molecule is not required for each of the ten amino acids because each of the tRNA molecules, specific to one of the four kinds of amino acid, can be reused.

Question 22

Most candidates knew that pulmonary arteries carry deoxygenated blood. However, there is a common misconception that this blood is devoid of oxygen.

Question 28

The popularity of option **D** reveals that many candidates, including the more able, are uncertain whether alveoli contain smooth muscle.

Question 30

Only the most able knew that the amount of oxygen delivered to the muscles is limited by the volume of blood flowing to them. The more popular answer was that the limitation is due to the speed of dissociation of oxyhaemoglobin. Evidently it is not generally appreciated how quickly dissociation occurs.

Question 33

The long-term consequences of alcohol consumption on the liver (syllabus section J(e)) were not well known.

Question 36

More chose option **C** than chose the correct option, **B**. The graph shows that after the first exposure to the antigen there was a five-day delay before the rise in antibody concentration. After a second exposure, a rise would occur after an interval of less than five days due to the ability of memory cells to respond immediately.

Questions 39 and 40

Neither of these two questions was difficult. Their low discrimination values are due to weaker candidates having a relatively good knowledge of ecology.

Paper 9700/02

Paper 2

General comments

There were many extremely encouraging answers to all 6 questions especially **Questions 2** and **3** from the well prepared candidates, though disappointingly there were some low scores, and even the more able candidates had some difficulty with **Questions 1 (d)**, **4 (b)**, **4 (d)**, **5 (b)**, **5 (d)(ii)**, **5 (e)** and **6 (b)**.

As in previous sessions, candidates often lost marks by not using their biological knowledge to answer the question set. For example, in **Question 1 (c)**, where candidates were asked to describe in outline what happens to DNA in the nucleus during stage **A** of the mitotic cycle shown in Fig. 1.1, many described all the changes that take place in this interphase cell including condensing of chromatin threads, synthesis of ATP and the formation of new cytoplasmic organelles. Many candidates only gave a brief description, if any, of DNA replication.

Again, in answer to **Question 4 (d)**, many candidates spent far too much time describing in detail the apoplast, symplast and vacuolar pathways in describing how water passes from the stem to the air surrounding a leaf. Reference to transpiration pull in the xylem, evaporation of water from the walls of the spongy mesophyll cells into the air spaces and diffusion of water vapour through stomata to the atmosphere would have been more appropriate.

Other candidates were far too imprecise in their answers. For example, in **Question 6 (b)**, statements such as 'drug tolerance is where a person gets adapted to a drug and needs more to feel normal and in control' were far too common. A more precise explanation of drug tolerance in terms of decreased sensitivity of receptors and more drug being required to achieve the same sensation/euphoria would have gained credit.

There were sufficient marking points to allow candidates to demonstrate their knowledge and understanding and most candidates appeared to have had sufficient time.

Comments on specific questions

Question 1

(a) Overall, a slightly disappointing level of response.

(b) The vast majority of candidates listed the letters **A-E** in the correct order in which the stages of a mitotic cell cycle shown in Fig. 1.1 occurred. Letters **D** and **E** and letters **D** and **B** were occasionally transposed.

(c) Most candidates clearly explained what was happening in stage **D** (anaphase) in terms of centromeres dividing and the moving apart of chromatids/chromosomes as they were pulled to opposite poles by the contracting spindle fibres. Weaker candidates referred to 'ends' or 'sides' rather than poles. Several confused mitosis with meiosis and referred to the separation of homologous chromosomes, whilst others confused anaphase with metaphase.

(d) The best candidates, in describing what happens to the DNA in the nucleus during stage **A** (interphase), referred to the replication of DNA with the assembly of nucleotides on each template strand involving base pairing and the doubling of the amount of DNA. As mentioned earlier, a considerable number described all the changes that occur in the interphase cell. Even those who confined their answer to what happens to DNA in the phase often had one strand acting as a template, referred to mRNA and were obviously thinking in terms of transcription not replication.

(e) Very poorly answered, even by those who had gained full marks up to this point. Many did not appreciate the significance of mitosis in the growth of a multicellular organism in terms of the production of genetically identical cells and the maintenance of genetic stability. Most responses referred to the production of new cells, so increasing cell number and replacing old cells. Several made reference to identical cells but with no qualification in terms of genetic uniformity. Disappointingly, a number of candidates made reference to maintaining genetic stability in **(c)** rather than in **(d)**.

Question 2

The standard of response was generally good with many candidates correctly completing the table to show which of the five statements given about disease applied to emphysema, tuberculosis, obesity, rickets and smallpox.

A significant number did not however realise that rickets was a form of malnutrition or that tuberculosis has not completely been eliminated by vaccination. Despite being instructed to use a tick (√) to show that the statement applies or a cross (**x**) if it does not, several candidates failed to follow this instruction, giving ticks but no crosses.

Question 3

There were many excellent answers to this question.

By far the majority of candidates correctly used the label lines and letters given in Fig. 3.1 – a drawing made from an electron micrograph of a plasma cell – to identify where various cellular processes take place. Mistakes were rare and most candidates achieved the maximum mark. Where errors were made **B** (polypeptide synthesis) and **E** (active uptake of amino acids) were most often confused.

In stating the function of plasma cells during an immune response, almost all without exception referred to the secretion of antibodies, rarely giving immunoglobulins. Occasionally candidates mentioned incorrectly the production of antibiotics, even antigens, made reference to memory cells but without appropriate qualification, or stated that the function of plasma cells was to carry out phagocytosis.

The majority of candidates made appropriate reference to the presence of the nucleus/nuclear membrane, mitochondria or other named organelle and occasionally the lack of a cell wall in stating two *visible* features from Fig. 3.1 in which the plasma cell differs from a typical prokaryotic cell. Others correctly referred to the plasma cell being larger or having ribosomes fixed to the endoplasmic reticulum. Occasionally candidates made imprecise reference to plasma cells having more or many organelles, the incorrect inference being that prokaryotic cells do have a few, or failed to notice the word *visible* and made biologically sound statements that could not be credited.

Question 4

There were many good quality answers to the question though **(b)** and **(d)** provided difficulty for several candidates.

(a)(i)(ii) This part of the question was answered well with the majority of candidates correctly shading in the transverse sections of the root and stem shown in Fig. 4.1 to indicate those areas specialised for the transport of water in the root (xylem) and sucrose in the stem (phloem). A significant number of candidates shaded in the root hairs and the central hollow of the root and stem transverse sections respectively. Some candidates incorrectly shaded in the inner xlem area of the vascular bundles in the transverse section of the stem instead of the outer phloem groupings, to indicate where sucrose transport takes place.

A few candidates ignored instructions and shaded in both the xylem and phloem areas of both root and stem and had to give a 'key' in order to answer the question.

(b) Very poorly answered. Many candidates suggested that the reason why vascular bundles were situated towards the outside of the stem was to improve transport of water, salts and organic solutes into and out of leaves, or made reference to the cambium being able to more effectively carry out secondary growth/thickening. Few made appropriate reference to bending, support or strength in their responses.

(c) Little difficulty here with almost all (in what was often an inappropriately extended answer) making at least reference to osmosis down a water potential gradient, in describing the process by which water passes from the soil into the root hairs. Many candidates still refer to 'less', 'more' or 'greater' water potential whilst others referred incorrectly to concentration gradients and to semi-permeable cell membranes rather than to water potential gradients and partially permeable membranes. The terminology described in the Institute of Biology publication "Biological Nomenclature" should be followed. For example, in terms of osmosis the use of "partially permeable membrane" is acceptable – semi-permeable or differentially permeable should no longer be in use. Several candidates read 'root hairs' as 'root' and discussed details of water movement across the root – apoplast, symplast, vacuolar pathways and even referred to the casparian strip. A number of candidates believe osmosis to be an active process.

(d) In explaining how water passes from the stem to the air surrounding a leaf, many candidates did not address the movement of water in the stem in terms of transpiration pull/mass flow in the xylem, before moving into the spongy mesophyll, evaporating from the damp walls into air spaces and moving out into the atmosphere via stomata, as water vapour by diffusion. Many candidates who made no mention of the damp walls or indeed water vapour, had water passing through the stomata or even guard cells with evaporation occurring from the lower surface of the leaf. Many gave detailed descriptions of the pathways – vacuolar, symplast, apoplast – through which water might flow. Few candidates achieved maximum marks.

Question 5

There were some clear and precise answers to this question though a considerable number had difficulty in explaining themselves in **(b)** and **(d)(ii)**.

(a)(i) Able candidates named **X** in the diagram of a haemoglobin molecule shown in Fig. 5.1 as haem. The mis-spelling of haem was a problem for a number of candidates who referred to heam. Many inappropriately referred to **X** as iron, a few incorrectly as a red blood cell.

(ii) In explaining why haemoglobin is described as a globular protein with a quaternary structure, a significant number of candidates did not correctly address the latter part of the description, *with reference to Fig. 5.1*, failing to refer to the 4 polypeptide chains, and restricting their answer to an explanation of a globular protein as having a compact/coiled/folded shape or with a suitable reference to solubility or even more occasionally as being metabolically active.

(b) Weaker responses here were characterised by a reference to iron being needed for haemoglobin or even red blood cell formation rather than iron being needed for the production of haem. In further explaining why a deficiency of iron in the diet leads to a lack of energy/tiredness, many did not appreciate that less haemoglobin meant less oxygen transported and this resulted in less respiration. There were few clear explanations amongst candidates' responses with many writing at length about less energy and/or anaerobic respiration. For many a "deficiency of iron in the diet" was incorrectly read as "absence of iron" with candidates inappropriately referring to no haemoglobin with no oxygen transport, leading to anaerobic respiration and lactic acid production. There were many references to anaemia.

(c) Most candidates appreciated that myoglobin is found in muscle tissue. Several candidates stated 'muscles' though strictly speaking these are organs not a tissue. Answers such as foetus, lungs and bone marrow were not uncommon.

(d)(i) The majority of candidates, in referring to Fig. 5.1, correctly stated the percentage saturation of myoglobin and haemoglobin at the partial pressure of oxygen given of 2kPa, as 90% and 24% respectively.

(ii) In explaining the significance of the difference in the percentage saturation given in **(d)(i)**, not all appreciated that, whilst haemoglobin would readily release oxygen in the tissues, myoglobin has a higher affinity, holding onto oxygen, acting as a store and only releasing oxygen, at a low partial pressure of oxygen/under strenuous exercise.

(e) Candidates were asked to draw on Fig. 5.2 a dissociation curve for haemoglobin when the partial pressure of carbon dioxide in the blood increases. Whilst many understood that the dissociation curve would be down and to the right of H, the curve for haemoglobin, not all indicated that it would start at 0, plateau at between 90-98% saturation, have an oxygen saturation of 50% plus, at pp 6kPa and indeed would be a sigmoid curve. Several candidates had the curve to the left of the haemoglobin curve H.

Question 6

Many excellent answers to all parts.

(a) The most knowledgeable candidates correctly completed the table on the effect of drugs on the body by indicating which two of the statements listed in the question matched most closely alcohol, coffee, nicotine and heroin. There was plenty of choice from which correct responses could be made and most candidates scored well. Weaker candidates were only able to correctly complete the table for alcohol and caffeine.

(b) Many candidates correctly explained the term drug tolerance in terms of decreased response, more having to be taken to achieve the same effect and only occasionally mentioning increased rate of metabolism of the drug or decreased sensitivity of receptors in their answers. Inappropriate and imprecise language as mentioned earlier was a problem for many, and several candidates confused drug tolerance with physical dependence by referring to addiction.

(c) Candidates were asked to explain how a non-competitive inhibitor acts on an enzyme to prevent it catalysing a reaction. Many able candidates made suitable reference to the inhibitor fitting into a site other than the active site of the enzyme, altering the tertiary structure and therefore the shape of the active site so that the substrate no longer fits.

Others also appreciated that some non-competitive inhibitors do actually bind permanently to the active site causing irreversible inhibition and increasing the substrate concentration makes no difference to enzyme function (e.g. penicillin actually binds irreversibly to the active site of bacterial enzymes).

Both responses were credited.

Many weaker candidates gave vague and imprecise answers often referring to the enzyme being altered, with no reference to the tertiary or 3D shape being changed or stated that the enzyme rather than the active site did not bind with the substrate. Where diagrams were used to answer the question, labels were given rather than annotations as suggested, e.g. active site – rather than active site changes shape. There is still confusion in a significant number of candidates as to whether the substrate fits into the active site or vice versa.

Paper 9700/03

Practical

General comments

In general, the Paper was well answered by most candidates. The Paper proved to be accessible, allowing candidates to demonstrate knowledge, while at the same time discriminating between weaker and more able candidates. There was no evidence that any candidate was penalised due to a lack of time to complete the Paper. Although mentioned in previous Reports, it was evident that candidates are still drawing the cellular tissue that they see under the microscope as if it were taken straight from a text book. It is most important that candidates draw what they see, if they wish to score marks.

Comments on specific questions

Question 1

This was well answered by most candidates. In part **(a)(i)**, **(ii)** and **(iii)**, the table was completed and numerical calculations accurately done. However it was evident that in some Centres, due to extreme temperatures, the enzyme was denatured. For this reason, the error was carried forward into the rest of the question (part **(b)** and **(c)**) in order that candidates could score marks for correct reference to denaturisation of the enzyme and not be unduly penalised.

In part **(b)** good answers referred to the yeast being allowed to reach the correct temperature and to allow the gases to vent out of the apparatus due to expansion due to heat. In Centres where the air temperature was excessively high, any candidate that referred to 'suck back' due to the cooling and contraction of the liquid was also credited. This was to ensure that candidates were given every opportunity to score marks in adverse experimental conditions.

In part **(c)** credit was given to those candidates who correctly referred back to their results in their answer. Too many candidates failed to read the question and went straight into an explanation without referring to their results. Credit was also given for a correct explanation of increase in kinetic energy and collision of the molecules.

Part **(d)** was not well answered by many candidates. Simple reference to a control failed to score. The question asked for an explanation and required the idea that the yeast or enzymes in the yeast were responsible and this could be demonstrated by not having them in one of the test tubes. More able candidates also referred to being able to find the true rate of reaction by taking the results of T2 from T1.

Part **(e)** was worth three marks, but very few candidates noticed this fact. Instead they gave only one or two ways to improve the experiment and thus limited the number of marks they could score. Candidates would be well advised to look and see how many marks the question is worth before attempting to answer it. Good answers included reference to maintaining a constant temperature, taking more readings, controlling the pH or measuring the volume of gas produced.

Question 2

The quality of response was very Centre specific. All too often candidates simply drew what they knew to exist in text books. This failed to score marks, particularly when they drew things that they could not possibly see from the specimen. Some candidates drew excellent drawings that were well labelled.

Part **(a)** gained credit when drawings were of high quality with clear single lines. Candidates were instructed to draw region Y but all to often drew some other region. Credit was given to candidates who followed instruction and had 'three arms' to their drawing. Credit was also given for drawings with correct scale and clear accurate labelling.

In part **(b)** some candidates described what they should have done and did not carry out the task to determine a ratio. This limited their total to three of the four marks. Able candidates gave clear descriptions of how to use the graticule to measure both the alveolus and the alveolar wall, repeat the readings and calculate a mean. If the candidate then gave a correct ratio, they scored all four marks.

Paper 9700/04

Paper 4

General comments

The Paper showed a large range of marks; there were a large number of high scoring candidates but there were also a number of relatively low scoring candidates. However, the majority of the candidates found the Paper very accessible. It seemed that the timing was about right as the majority of questions were fully answered.

Comments on specific questions

Question 1

(a) Most candidates picked up 1 or 2 marks making reference to 'packed cells' and 'just below the epidermis'. Descriptions such as "below the cuticle" lost marks. Weaker candidates could not describe their orientation in the leaf or gave vague answers such as 'arranged in a regular pattern'.

(b) The Examiners were looking for reference to a large number of chloroplasts, a large vacuole, the chloroplasts being close to the cell wall/cell membrane. Also reference to the elongated arrangement to intercept maximum light. References to the thin cell wall and the movement of chloroplasts were also credited.

(c) The candidates were asked to describe the role of the thylakoid membrane in photosynthesis. This was well answered as most candidates knew the role of the membrane. This area of the syllabus appeared to be well known to the majority of candidates. In particular the Examiners were looking for reference to the photosystems, the sites of photophosphorylation, the site of the ETC, the production of ATP and reduced NADP.

(d) The method by which carbon dioxide is fixed in the stroma appeared to be well known. The majority of candidates scored full marks, reference being made to carbon dioxide reacting with RuBP to form PGA using Rubisco. Credit was also given for the role of ATP and reduced NADP in the formation of PGA.

Question 2

(a) This was generally well answered. Even weaker candidates knew the function of ATP, but lost marks by giving too vague examples of uses such as 'photosynthesis or respiration.' The common correct answers were active transport and muscle contraction.

(b) Very few candidates referred to substrate level phosphorylation taking place in both the cytoplasm and the matrix of the mitochondria. The fact that oxidative phosphorylation took place on the inner membrane of the mitochondria was commonly known.

(c) The majority of candidates were not able to compare the relative amounts of ATP produced by substrate level phosphorylation and oxidative phosphorylation. Most candidates scored a mark for knowing that oxidative phosphorylation produced the most. Many candidates attempted to compare aerobic and anaerobic respiration.

(d) In an attempt to explain why oxidative phosphorylation is not possible in the absence of oxygen, many of the candidates rewrote the question and described what happens when oxygen is present. Some described the effect on Krebs cycle and the production of lactate. Many missed the important aspects of the ETC and the need for the proton gradient was rarely mentioned.

Question 3

(a) This section was well answered by most candidates. However, many merely referred to **A** as a 'vesicle'. The Examiners were looking for reference to synaptic vesicle, vesicle containing transmitter or vesicle containing acetylcholine. Also there was some confusion over structure **E**. Incorrect answers commonly made reference to 'channel protein', 'carrier protein' or 'receptor cell'.

(b) The majority of candidates drew the arrow pointing in the correct direction.

(c) There were some very good answers to this section, showing that the candidates had a good knowledge and understanding of the events that take place at a synapse. A number of candidates not only described the role of calcium ions but also went on to describe the events which took place at the postsynaptic membrane. They were not given credit for this extra information. Few candidates referred to an action potential or depolarisation causing the calcium channels to open. Some answers lacked precision describing the synaptic knob as the presynaptic membrane and stating that the calcium ions went into the membrane rather than through the membrane.

Question 4

(a) Unfortunately candidates found Fig. 4.1 rather confusing. Therefore credit was given for answers ranging from Telophase I to Metaphase II.

(b) There were some good answers with reference being made to centromeres dividing, chromatids being pulled apart to opposite poles, the reformation of the nuclear membrane and cytokinesis. The biggest weakness in some answers related to chromosomes separating rather than chromatids and stating that the centromere breaks or splits.

(c) In describing two ways in which meiosis leads to variation most candidates were familiar with the terms 'crossing over' and 'independent assortment'. However, weaker candidates could not describe what happens during these events. Common errors were to state that genes were exchanged during crossing over and that an exchange took place between sister chromatids.

Question 5

(a) Good candidates gained full marks here. Generally phenotype was better described than genotype. The Examiners were looking for the idea that the phenotype is the feature or characteristic resulting from the interaction of the genotype and the environment and that the genotype represents the genetic characteristics which are inherited and is not affected by the environment.

(b) There appeared to be no problem in describing artificial selection, as most candidates knew that it is carried out by humans who choose organisms with characteristics that are of benefit to them. However, some candidates made reference to 'genetic engineering'. Natural selection did not appear to be so well understood. A number of candidates described natural selection as a result of the action of 'nature' rather than of the environment.

(c) A large number of candidates were not able to correctly define the terms 'gene' and 'allele'. Candidates often did not appreciate what is meant by 'define'. Instead they gave examples which did not answer the question. Answers were often very vague and therefore did not gain any credit.

(i) The Examiners were looking for reference to a gene being a length of DNA, or a sequence of bases coding for a characteristic, a protein, or a polypeptide.

(ii) The definition of an allele was expected to refer to an alternative form of a gene occupying the same gene locus on homologous chromosomes.

Paper 9700/05

Practical 2

General comments

In general, the Paper was well answered by most candidates. The Paper proved to be accessible, allowing candidates to demonstrate knowledge, while at the same time discriminating between weaker and more able candidates. There was no evidence that any candidate was penalised due to a lack of time to complete the Paper. Although mentioned in previous Reports, it was evident that candidates are still drawing the cellular tissue that they see under the microscope as if it were taken straight from a text book. It is most important that candidates draw what they see, if they wish to score marks.

Comments on specific questions

Question 1

(a)(i) Most candidates scored at least one mark on this section, with a considerable number scoring full marks. Very few candidates failed to realise that the answer to F1 was infinity.

(ii) Very few candidates failed to score in this part and credit was given for a wide range of answers that indicated the correct colour change.

(iii) Credit was given for giving the correct order of solutions, and error was carried forward, so that any candidates who failed to get the correct answer in **(i)** due to high temperatures denaturing the enzyme, were not penalised. More able candidates realised that a high urea content in urine produced the most rapid result and that very little urea would be present in the renal vein due to filtration by the kidney.

(c) This produced a wide range of responses and credit was given for naming a more precise way to measure pH, repeating the experiment, or starting them at the same time.

Question 2

The quality of response was very Centre specific. All too often candidates simply drew what they knew to exist in text books. This failed to score marks, particularly when they drew things that they could not possibly see from the specimen. Some candidates drew excellent drawings that were well labelled.

(a) This required two cells only. Candidates that drew only two cells were awarded a mark for following instructions. Marks were also awarded for the shape, correct size of nucleus and suitable labelling.

(b) Good candidates drew what they saw and scored full marks. Marks were not awarded for knowing about cartilage cells, but for correct interpretation of the specimen.

(c) Candidates all too often gave textbook answers, yet again describing things that they could not see. More able candidates referred to the scattering of cells in the cartilage and the comparison of shape. Candidates should be warned that questions of this kind require a comparison and not just a description of one of the cells. Stating that ‘cells that line the lumen are packed together’ does not score unless a comparison is made by saying that ‘cells in the cartilage are scattered’.

Question 3

More able candidates read the question and answered what was asked of them. The question was highly structured to enable candidates to score high marks. However, weaker candidates just wrote about the experiment without referring to the individual sections and lost marks.

(a) Candidates were asked about setting up the apparatus, not carrying out the experiment. Reference to supporting the apparatus, assembling under water, correct use of the clip to fill the capillary tube and acclimatisation, all scored marks.

(b) Most candidates scored full marks with correct reference to light, temperature or humidity.

(c) This was generally well answered with reference to correct procedure scoring marks. Good answers included reference to time, readings from the scale, replication, and resetting fan speed or distance.

(d) This discriminated well. More able candidates referred to $\pi r^2 h$ and scored 2 marks. Candidates who referred to cross sectional area multiplied by the distance that bubble moved also scored full marks.

Paper 9700/06

Options

General comments

Of the four available options, far more candidates attempted ***Option 3*** (*Growth, development and reproduction*) than any of the others. A significant number did attempt ***Option 4*** (*Applications of genetics*), whilst very few attempted ***Option 1*** (*Biodiversity*) and an extremely small number ***Option 2*** (*Biotechnology*).

The standard of answers was variable, though there were some candidates who scored highly on both ***Option 3*** and ***4***. Those who attempted ***Options 1*** and ***2*** tended to score less well.

Comments on specific questions

Option 1

Biodiversity

This option was considerably less popular than ***Options 3*** or ***4***. Hence, the following comments are made on the basis of a relatively small number of scripts.

Question 1

(a) Answers here all too often described biodiversity as the existence of a large number of 'different types of organisms'. This did not gain any credit. The mark scheme for this section required reference to a large number of different *species* and, therefore, a wide range of different genes or alleles.

(b) Here, also, answers tended to be rather vague and candidates did not always seem to appreciate that the word *ecological* was in bold. Whilst candidates did pick up marks here, it was rare for all three marks to be awarded.

Commonly, candidates did appreciate that tropical rainforest does have a particularly high biodiversity (which is currently in rapid decline). Some gained a further mark for a correct reference to the role of rainforests in a reduction of global warming – though few described them as 'carbon sinks'. The high level of transpiration and their affect on rainfall patterns was considered to be a further valid point, as was the role of the forests in reducing levels of flooding and soil erosion.

(c)(i) Here, again, answers tended to be vague, with little more than references to 'more trees in A' or 'decreasing numbers of trees from A to D'. The mark scheme required something more specific, i.e. there is a reduced *variety* of trees between A and D, which means there is less variety of habitat and less variety of food available for birds. Some candidates did point out that there are many more layers of canopy in A than any of the other systems and, also, the increased use of pesticides between A and D would contribute to the reduced number of bird species.

(ii) Some candidates did pick up both available marks in this section. One was usually for the fact that there is no competition at all with other trees and the other point often credited was the fact that, in system D, there is a much better availability of light for the coffee trees. Few suggested that it could be because there is a greater density of coffee trees, i.e. more per unit area, or that the increased use of pesticides and fertilisers will contribute towards a greater yield. A further mark was available for suggesting that, in D, there are fewer habitats for pests.

(iii) The only point worthy of credit that was usually made in this section was the fact that there are fewer bird species to eat the pests – hence, the need for a greater use of pesticides. Other marking points were that, in system D, the coffee plants are the ONLY source of food for the pests, so that pest populations on the coffee trees are likely to become very high indeed.

(d) Many answers to this question did indicate that the candidates knew that the *Rhizobium* in the root nodules of the *Inga* tree (described as leguminous) are nitrogen fixing, so that they contribute to the fertility of the soil by adding nitrate or ammonium ions.

(e) Very few marks were gained in this section. This was largely because candidates did not even attempt to describe *international* measures to conserve biodiversity – they simply described *methods* to conserve biodiversity.

In order to gain credit here it was necessary to suggest that a premium could be paid for coffee produced under system A or provide grants or subsidies for farmers who produce coffee under system A. Equally, consumers should be educated, informed and encouraged only to buy coffee grown under system A. Uses could also be found for the non-coffee trees grown under system A.

Question 2

(a) Structure A is the operculum (a number of candidates answering this question simply thought it was a 'gill') and structure B is a gill bar (gill arch was acceptable).

(b) The only point worthy of credit that was often made here was that the structure increases the surface area. However, few explained that this is a result of the presence of *many* gill filaments, each having *many* gill lamellae.

Often there were vague answers about the gill filaments being thin, though it was expected that this would be explained in terms of the small diffusion distance between the water and the blood.

(c) Many candidates did know that this is the 'counter-current' or 'counter-flow' system and were given a mark for such a description. However, very few were then able to explain precisely how this increases the efficiency of gaseous exchange.

In order to gain further credit, it was necessary to explain that this system ensures that there is always a diffusion gradient between the water and the blood. This increases the length of blood vessel along which exchange can occur, so that the water progressively loses its oxygen as it passes through the gills. Overall, this means that more oxygen is taken out of the water than would be the case if the blood and the water were flowing in the same direction.

(d)(i) There was a tendency in this section, either for candidates to gain all of the four available marks, or none at all, i.e. if candidates had a good knowledge and understanding of the way in which fish ventilate their gills, they were able to write very thorough answers.

The main points required were that, when the operculum is closed, the volume of the buccal cavity (or mouth) is increased by lowering of the jaw or floor of the mouth. This brings about a reduction in pressure, so the water flows in. The floor of the mouth is then raised, which increases the pressure, so that, with the operculum now open, the water is pushed out through the gills.

(ii) This question asked for an *explanation* of the curve shown in Fig. 2.3. As is all too often the case, many candidates simply gave a description. There were some marks for this, though a description was not sufficient to gain all three of the marks available.

Many answers did point out that, initially, as the speed of swimming increases, so does the rate of pumping. Few, however, went on to explain that this is because there is an increased level of respiration (aerobic) in the muscles and, hence an increased demand for oxygen.

However, the rate of pumping decreases slightly (or remains more or less level) between swimming speeds of 0.4 and 0.6 ms^{-1} then stops completely (i.e. mouth remains open) at a speed of 0.7 ms^{-1}. At such speeds, ram ventilation is used i.e. sufficient water flows over the gills as a result of the speed of swimming.

Question 3

Of the candidates who answered this option, it was evident that **(a)** (viruses and bacteria) was more popular than **(b)** (chordates and arthropods).

(a)(i) On occasions, answers here were somewhat confused. Candidates were asked to describe the structure of a *named* virus and indicate its approximate size. Not uncommonly, answers named HIV, then went on to describe a bacteriophage. In such cases, the mark was not given for the correct name, though correct structural features of the virus that was being described were given appropriate credit. A majority of candidates who attempted this question illustrated their answer with a diagram.

As far as indicating an approximate size was concerned, anything between 10 and 300 nm was considered to be acceptable.

(ii) Here, also, a majority of answers included useful diagrams, generally showing the reproduction of a bacteriophage. Descriptions of the process were often thorough and it was not uncommon for at least five of the available seven marks to be gained. A common error was to suggest that the 'phage attaches to the bacterial cell wall', when, of course, it must attach to the bacterial cell membrane, as a result of an interaction between the viral protein and components of the host cell membrane.

The few candidates who attempted to describe the replication of HIV usually managed to correctly explain the role of the viral reverse transcriptase enzyme, which is injected into the host cell, along with the viral RNA.

(iii) In this section, the Examiners were looking for candidates to discuss the *differences* between viruses and E.coli. As such, answers did not always make the comparison and all too often would only include a point about one or the other. In some cases, if it was suggested that some structure is present in the bacterium, it was assumed that the implication was that it was absent in viruses – and credited if it was correct. This was true in the case of bacteria having a cellular structure, cell membranes, cell walls and ribosomes. Other points worthy of credit were that viruses are much smaller than bacteria (precise sizes did not need to be quoted), viruses can only reproduce inside host cells and viruses do not feed, grow, respire, excrete or, indeed, have any form of metabolism.

Points about genetic material were often included, though, equally often, they were somewhat confused. The correct points would have been that viruses have EITHER DNA or RNA, whereas bacteria have both. Also that viral nucleic acid is single-stranded and linear, whereas bacterial DNA is double-stranded and circular.

(b)(i) Very few candidates actually attempted this question though those who did generally knew about chordates and arthropods. Again, if it was suggested that one group possesses a particular structure, it was assumed that the implication was that such a structure is absent in the other. This was the case with chordates having a notochord (at some stage) as well as gill or pharyngeal slits and a postanal tail.

Other valid points of distinction include chordates having a hollow, dorsal nerve cord, arthropods a solid, ventral nerve cord, chordates having a closed blood system and arthropods an open system (or haemocoel) and chordates having an endoskeleton, as opposed to the exoskeleton of arthropods.

(ii) Those who answered this question did tend to know that the term *triploblastic coelomate* refers to the presence of three body layers (one mark) which are called the ectoderm (outside) the mesoderm and endoderm (inside). There were a further two marks for explaining that the coelom itself is a cavity, which is fluid-filled.

Few actually explained that the coelom is within the mesoderm and that the mesoderm itself is divided into the somatic mesoderm (outside) and the splanchnic mesoderm (inside). Further marks were given if candidates stated that the coelom is actually lined by the peritoneum and that the two layers of mesoderm are connected by mesentery.

(iii) On the whole, this section was not answered particularly well. The main marking points were as follows:

It isolates muscles of the gut from those of the body wall, which is an advantage in terms of separating muscle contractions associated with digestion from those associated with locomotion.

It allows the development of specialised cavities (pleural, pericardial and abdominal), within which organs can develop (a mark was awarded for a suitable example), as well as the regulation of fluid composition.

The fluid within the coelom can act as a hydrostatic skeleton, by providing an incompressible fluid against which the muscles can act – this is of particular importance in the locomotion of organisms such as annelids.

The fluid can also be used as a transport system, as well as a medium for excretion.

Option 2

Biotechnology

There were very few candidates who attempted Biotechnology. On the whole, those who did gained relatively few marks and it is not possible to make any constructive comments about the performance on this option.

Option 3

Growth, development and reproduction

As already stated above, this was by far the most commonly answered option.

Question 1

(a)(i) The structures labelled on the diagram of the human spermatozoan were generally well known and it was common for candidates to gain both marks in this section. A common error was to think that label A was the head, when it is clear that it was pointing specifically to the plasma membrane. A majority knew that B was the acrosome, C the nucleus and D a mitochondrion.

In this section, half marks were 'rounded up', which meant that, even when A was named as the 'head', candidates could still gain the two marks.

(ii) As far as the functions of the membrane and the acrosome are concerned, answers were too often rather vague and confused. That said, many did know that the function of the acrosome is to attach to receptors in the zona pellucida, which leads to fusion with the membrane of the oocyte.

Functions of the acrosome were somewhat confused, but it was expected that candidates would explain that it releases *enzymes* (such as hyaluronidase) that *digest* a path between the follicle cells and through the zona pellucida.

(b)(i) Here, candidates were asked to *compare* the penetrating ability of the two types of sperm, as illustrated in Fig. 1.2. As ever, when data of this sort is involved, candidates are expected to use data quotes to illustrate their answers and they are credited for doing so. In this case, any valid figures comparing the two types of sperm would gain one mark – the most common correct figures used were that the initial percentage of oocytes penetrated is 56% in the case of the frozen and thawed sperm, as opposed to only 18% in the fresh (not frozen) sperm. Also that the maximum figure for the frozen sperm is 56%, though that of the fresh sperm is 80%.

In addition, a sensible comparison would be that the percentage of oocytes penetrated by the fresh sperm gradually increases from the start, reaching a maximum after 24 hours, after which the percentage declines, whereas the percentage penetrated by the frozen sperm decreases throughout the course of the investigation.

(ii) In this section, candidates were asked to *explain* the differences in behaviour of the fresh sperm at different times after ejaculation. As is all too often the case, many answers turned out to be further detailed descriptions, with no attempt being made to make an explanation.

A correct explanation would be that, during the first 24 hours, the sperm are undergoing the process of capacitation (occasionally decapitation!), which involves the removal of plasma or glycoprotein. This would then account for the fact that the percentage of oocytes penetrated increases during this time.

As far as the decrease after 24 hours is concerned, many answers were somewhat vague and confused, with unclear references to sperm dying and losing their motility or the membranes of the oocytes hardening to prevent any further penetration. The correct explanation would be that the availability of nutrients or energy sources would have diminished after this period of time.

(iii) A majority of candidates in this section attempted to explain why the percentage penetration by the frozen and thawed sperm decreased during this investigation. The point is that the percentage penetration immediately after thawing was high – and the question was looking for an explanation for this. One mark was given for pointing out that capacitation could already have occurred i.e. during the process of freezing or thawing. Equally acceptable as an explanation was the fact that some damage (non-lethal) during the freezing or thawing process may well have altered the membrane in some way – or even removed the glycoprotein.

(c) Some candidates did not find it easy to interpret the information provided in the lead in to this question and in Table 1.1. Answers were all too often very confused, with references to nitric acid (there was no mention, whatsoever, of nitric acid in the information given) and a total misunderstanding of the purpose of the oxyhaemoglobin in the investigation.

The only acceptable sequence of events was that there is an increased synthesis of the enzyme nitric oxide synthetase when the sperm is in contact with the zona pellucida. This enzyme then increases the production of nitric oxide in the fertilised oocyte. These increased levels of nitric oxide then lead to an increased uptake of calcium ions by the fertilised oocyte. The evidence for this final stage is the fact that, when oxyhaemoglobin is added, it absorbs the nitric oxide as a result of which there is then no increase in the level of calcium ions.

Question 2

(a) This section was very well answered and it was not uncommon for candidates to gain all three marks in this section. Correct points frequently included the presence of feathery stigmas, which protrude beyond the petals, as well as versatile anthers, which also protrude beyond the petals. The petals themselves are typically small, dull coloured and inconspicuous. The pollen grains are always small and light and produced in very large quantities.

Suggesting the *absence* of nectaries did not gain any credit.

(b) This was not well answered. The question was clearly asking about changes in the *ovary* that result in development of the *fruit*. Answers frequently described the whole process of fertilisation, including references to the development of the ovules into embryo and endosperm and the integuments into the seed coat or testa. Clearly, none of these points is relevant here and did not gain any credit.

As far as changes to the ovary are concerned, marks were awarded for describing the fact that the ovary swells or grows and becomes fleshy. Although this point was often made, few also pointed out that there is an accompanying increase in the sugar content, as well as a change in colour during the ripening process – these last two being adaptations to assist in the dispersal of the fruits and seeds.

(c) It was quite common for candidates to think that growing plants from cuttings is the same as grafting. Much of their answer to this section was therefore devoted to a description of the process of grafting – this did not gain any credit.

Marks were given for explaining that our knowledge of growth and development means that we would select meristematic tissue, as well as using plant growth substances, such as auxins or cytokinins, to stimulate the growth of new (adventitious) roots.

(d) Many candidates gained credit here for pointing out that, if bananas are grown from cuttings, they are, in fact, being propagated in an asexual way and they are, therefore all clones (i.e. they are genetically identical). What was often not made clear is that they will all be susceptible to the Black Sigatoka only if the plants from which they were originally derived were susceptible – they are not all going to susceptible simply because they are all genetically identical. Some were also awarded a further mark if they pointed out that any variation which might give some plants resistance could only arise through mutation.

Some candidates seemed to be suggesting that, if the parents were infected with the fungus, then so would the cuttings – not appreciating that the question was about the *susceptibility* of the cuttings to the disease.

(e) Here, again, answers were often not very clear and it was rare for all three marks to be gained. The correct explanation is that triploid plants *cannot* carry out meiosis. Homologous pairs of chromosomes cannot be formed during prophase one and any crossing over will result in a tangle of chromosomes. All of this means that it is impossible to produce viable gametes. Hence, these triploid plants will be sterile.

A surprising number of candidates saw the reference to the triploid state and thought that this question had something to do with the endosperm!

Question 3

(a) This question was not quite as popular as alternative **(b)**. **(i)** was, generally, not well answered, though it was not uncommon for full marks to be gained in **(ii)** and there were good answers to **(iii)**.

(i) Many candidates were confusing the term absolute growth *rate* with absolute *growth*. In order to gain credit, it was necessary to explain that it is a measure of how the *rate* of growth varies with time, i.e. a graph of absolute growth rate must show the increase in a given parameter (i.e. mass) per unit time (e.g. per year) against time. There was further credit for knowing that this is also known as the *actual growth rate* and that it is useful for showing when growth is most rapid.

As far as relative growth rate is concerned, this is the rate of growth, taking into account the size (i.e. mass) at the start of the measurement. Many candidates stated that it is the rate, taking into account the growth rate at the start. Another way of putting this is that it is the absolute growth rate, divided by the mass at the start, i.e. change in mass in one year, divided by the mass at the start of the year. It is also known as the *specific growth rate* (few candidates seemed to know this) and it is useful for comparing the growth rate in different sized organisms. Many candidates did know that it also measures the *efficiency* of growth.

(ii) One mark was available in this section for naming the organism chosen to measure growth by means of dry mass. Some candidates did not get this mark – usually because of their choice. It was felt that vertebrates were inappropriate, some having chosen frogs, mice, rats or even rabbits. The best and most appropriate examples were plants being grown from seeds, such as peas or beans. Some candidates were even able to provide Latin names for the species, e.g. Pisum sativum or Phaseolus vulgaris. Examples of arthropods or worms were regarded as just about acceptable.

Marks were then awarded if they suggested that it would be necessary to take a large number of seeds (probably a minimum of 50) and allow them all to germinate under identical conditions – marks were available for outlining what particular parameters would need to be controlled (i.e. amount of water, nutrients, temperature). At specified intervals, samples would need to be removed and dried in an oven at a suitable temperature (up to 110^{o}C is acceptable). This should be done until a constant mass is achieved, after which the samples should be placed in a dessicator to cool. An average mass can then be calculated.

(iii) Problems associated with using dry mass were not always particularly well explained. Many did appreciate that, when using wet or fresh mass the problem is that the amount of water will fluctuate. Few explained what will cause it to do so and there was credit for suggesting that, in plants, environmental conditions will determine this, by influencing the level of transpiration. As far as animals are concerned, it will be affected by sweating and ingestion or egestion of different amounts of water.

Problems associated with measuring growth by using single dimensions, such as height, were often included and there were marks for pointing out that growth in one dimension might not be representative of growth in all dimensions – this is particularly so when some parts of organisms (such as leaves) are long and narrow, whereas others are short, but wide. Problems of allometric growth were sometimes correctly included here.

Finally, difficulties associated with the growth of some arthropods, with a series of instars were sometimes explained – and credited appropriately.

(b) This question was, on balance, answered more often than **(a)** – there were many excellent, thorough answers. The only problem, on occasion, was that candidates did not distinguish between the different parts of the question (i.e. **(i)**, **(ii)** and **(iii)**), which made the marking very difficult.

(i) On occasion, answers were a little confused and candidates did not always appreciate that the hypothalamus brings about any control via the pituitary gland. Good answers pointed out that the hypothalamus is connected to the anterior pituitary (it is the anterior lobe that is involved in the control of growth and development) via a portal system of capillaries and that it secretes releasing factors, which stimulate the pituitary to secrete a range of hormones. Further marks were then given for including appropriate examples, i.e. GnRH from the hypothalamus, stimulating secretion of FSH and LH or TRH stimulating secretion of TSH.

Finally, there were two marks available for explaining that the hypothalamus itself is controlled on the basis of negative feedback – and giving an appropriate example of how this works.

(ii) An initial mark in this section was for explaining that it is the *anterior* lobe of the pituitary gland which is responsible for secreting a whole range of hormones which are associated with the control of growth and development. There was then further credit for correctly naming such hormones, as well as outlining their precise roles.

Hormones which were commonly included were FSH (plus roles in the development of primary follicles and oestrogen production in females, as well as stimulating spermatogenesis in males), LH (roles in ovulation, development of the corpus luteum and secretion of progesterone in females, secretion of testosterone in males), TSH (stimulation of thyroxine secretion by the thyroid gland) and Growth Hormone (which stimulates, particularly, growth of the limb bones, as well as increasing the rate of protein synthesis).

In addition, there was credit for explaining that the FSH and LH are responsible for the control of the menstrual cycle and that oestrogen and testosterone stimulate the development of secondary sexual characteristics in females and males, respectively.

On occasion, candidates did not always make it clear which hormone was associated with which function – in such cases, it was not usually possible to give the marks.

Many answers included references to hormones, such as prolactin and oxytocin, which were irrelevant as far as growth and development is concerned.

(iii) Again, this section was, generally, well answered. Many answers pointed out that the thyroid gland secretes two hormones – thyroxine (T_4) and triiodothyronine (T_3).

Further credit was then available for outlining the roles of these hormones i.e. control of *basal* metabolic rate, increase in the rate of cellular respiration as well as stimulation of the processes of transcription and protein synthesis.

Many candidates also cited the stimulation of growth (especially of the skeleton) and of brain development. However, few pointed out the role of the thyroid in the regulation of body temperature.

Option 4

Applications of genetics

Question 1

(a) Many who did this option did realise that the main effect of inbreeding on genetic diversity is that it is reduced. Good answers went on to say that it results in the loss of some alleles (*not* genes), increases the level of homozygosity (or, alternatively, decreases heterozygosity) and can lead to an accumulation of deleterious recessive alleles.

A number of candidates talked about 'inbreeding depression' – this was not relevant to this question and did not, therefore, gain any credit.

(b) In this section, it appeared as though many candidates struggled somewhat to understand thoroughly the information given in the lead in and the data in Table 1.1.

(i) The answer to this section was 1430 – 1500. Some candidates gained this mark, though an appreciable number thought it was 1145 – 1330. It is reasonably clear in Table 1.1 that it is only between 1430 and 1500 that phenotype B releases pollen and, equally, it is only between these times that the stigma of phenotype A is receptive.

(ii) It was not often that candidates gained more than 1 mark in this section. This was usually for pointing out that, when pollen is released by either phenotype, its own stigma is always in an inappropriate position. In addition, as correctly explained by some candidates, when pollen is released by a particular phenotype, it is always at a time when its own stigma is not receptive. Given that the behaviour of the two phenotypes in this regard is clearly synchronised, neither of them will self-pollinate, with A pollinating B in the morning and B pollinating A in the afternoon, i.e. inbreeding is avoided/outbreeding is promoted.

(c) This section was not always well answered and it was not unusual to find it left blank.

(i) A majority of candidates who answered this question did know that the number of degrees of freedom was, in this case, one.

(ii) Equally, those who understood the chi-squared test appreciated that a value of 0.39 is less than any value in Table 1.2, so that the probability must be > 0.1.

(iii) Given that biologists always work at a probability level of 0.05, the relevant chi-squared figure from the Table is 3.84. In the test, the calculated chi-squared figure was much less than this, so that the conclusion drawn must be that there is no significant difference between the observed and the expected results. This means that the observed ratio of phenotypes is, effectively 1 : 1 and any difference can only be due to chance.

(iv) It was very rare indeed for candidates to gain any credit here – suggesting that they really did not understand the question.

The only way that *both* phenotypes can be maintained in the population for many generations is if there are two alleles, with one phenotype being heterozygous and the other homozygous recessive. In fact, this would also be true in a case of co-dominance (one homozygous, one heterozygous).

Question 2

(a)(i) It was not uncommon for candidates who attempted this option to gain all three marks here. Many pointed out that sufferers of CF have a build up of thick, dehydrated mucus in their lungs and gut (two marks). This results in breathing difficulties, a high level of lung infection and the presence of scar tissue in the lungs. A further mark was available if they also cited digestion problems because the mucus blocks the secretion of digestive enzymes from the pancreas.

(ii) Equally, this section was well answered. Many knew that it is inherited via a recessive *allele*, which is carried on chromosome 7 (i.e. it is autosomal). This means that sufferers are homozygous recessive and heterozygotes are carriers. Many candidates also correctly explained that, if both parents are carriers, there is a 1 in 4 chance that a child will have the disease (in fact, one mark was given for any such correct statement about inheritance of the disease).

(iii) Generally, this was not well known. Some did point out that it is caused by a large number of different mutations, each of which has a different DNA code or base sequence. This means that each mutation will require a specific probe in order to reveal the presence of the disease, i.e. if the wrong probe is being used, it will not reveal its presence.

(b) The majority of candidates did not find this section to be straightforward. Many answers suggested that candidates had not fully understood the lead in to this question or the data presented in Table 2.1.

(i) The main point here was that this investigation was into transport across the cell membrane. If, therefore, the CFTR protein is not correctly inserted, no transport will take place at all, in which case the study could not be carried out.

(ii) Good candidates appreciated that the evidence in Table 2.1 indicates that inadequate functioning of the pancreas is a result of a much reduced ability to transport HCO_3^- which results in a significant change in the transport ratio between HCO_3^- and Cl ions, i.e. < 0.1: 1. Clearly, this will lead to a reduction in pH, which must have an effect on the production of mucus.

(iii) Although one mark was frequently gained here, it was rare for candidates to be awarded both of the marks that were available.

Many suggested that it results in poor digestion – though few went into any further detail, i.e. that there will be reduced levels of digestion of protein, lipids and starch. On occasions, candidates gained a mark for suggesting that this will lead to malnutrition.

Some thought that diabetes could result – whilst this is not the case (and was not, therefore, credited) it is true that there will be a reduced secretion of insulin and glucagon and a mark was given for such a suggestion.

Question 3

(a)(i) This question was about *why* selective breeding is carried out. Credit was given for explaining that it is carried out to alter the phenotype of domesticated animals or plants (this point was rarely made), so that they have desirable characteristics, which are of some use or value to humans.

Further marks were then awarded if candidates explained more precisely why this might be done. For example, it might be to improve *quantitative* traits in plants or animals – common examples of these were milk yield in cattle and yield, such as fruit numbers or size, in plants. Equally, there may be *qualitative* traits, such as disease resistance or appearance.

Other reasons worthy of credit in this question would be ornamental i.e. flower colour or a particular look in show animals, or for some entirely different reason, such as speed in racehorses or greyhounds.

It was not uncommon for candidates to gain most of the six marks available in this section.

(ii) The candidates who attempted this question, did not answer this section particularly well. Many suggested that it would be necessary to select plants showing resistance to the particular disease, then simply self-fertilise them for many generations. Clearly, this would be an example of inbreeding and would lead to problems, as outlined in the very first question of this option.

In order to gain credit here, it was expected that candidates would explain that, having selected the disease-resistant plants, they would be crossed with plants without the resistance. It would then be necessary to sow the seeds of the offspring and expose them to the disease. Those showing resistance could then be interbred – and the process repeated for many generations.

Some better answers also suggested that it would then be necessary to backcross the resistant offspring with the original parents to ensure the inclusion of 'background genes' for traits other than disease-resistance. Again, it would be necessary to carry this out for a large number of generations.

The inclusion of sensible practical details were also given credit, i.e. use of male sterility genes, the removal of anthers, the careful transfer of pollen from anther to stigma and the enclosing of pollinated flowers in muslin bags.

(iii) This was very well known and understood by a majority of candidates. Many knew that it is only 'orthodox' seeds that can be stored effectively in seed banks and that they are usually dehydrated and stored at a temperature of –20°C. Few pointed out that the storage life can be doubled by a 5°C reduction in temperature, as well as 2% reduction in humidity.

However, many did know that, every five years, it is usual to carry out germination tests on the seeds and that, if there is less than 85% germination, seeds will normally be grown and fresh seeds collected.

A mark was also awarded for knowing that seeds that cannot be stored in this way are known as 'recalcitrant' seeds.

Finally, as far as the use of seed banks is concerned, credit was given if candidates pointed out that they act as a gene bank, maintaining genetic diversity, and that seeds within them can be used to introduce traits into domesticated plants, such as crop species, as well re-establishing species of plant which have become endangered, or even extinct, in the wild.

(b) Generally, candidates who attempted this question produced competent answers, the main problem being an inappropriate use of terms, such as gene, allele, chromosome and chromatid.

(i) Some candidates knew little more than that linkage means the occurrence of two or more genes on the same chromosome. Some did know that this means that they do not assort independently in meiosis, though few pointed out that this means that they are, therefore, inherited together or that the number of linkage groups is equal to the number of pairs of homologous chromosomes (or the haploid number of chromosomes).

As far as crossing over is concerned, better answers explained that it takes place during prophase 1 of meiosis, though it was rarely explained that this is during synapsis. Many thought that it takes place between homologous chromosomes, when, in fact, it involves exchange between paternal and maternal *chromatids* – with chromatids breaking and rejoining with the non-sister chromatid. It was all too often stated that this results in the exchange of *genes*, when it was necessary to use the term *allele* in order to gain this mark.

Many answers included diagrams, which were not always suitably annotated, though, more often than not, the chiasma was labelled and credited.

Very few candidates pointed out that, the closer together genes are on a chromosome, the less likely the alleles are to be separated by crossing-over.

(ii) Here, candidates generally knew that HLA system involves six (or four) loci, which are designated as A, B, C, DP,D and DR. Also that they are a very tightly linked and, therefore, inherited as a unit, known as a haplotype. Some candidates knew that they are to be found on chromosome 6.

Credit was also given if it was pointed out that the system involves a large number of alleles and, therefore, many possible combinations. Also that children receive one haplotype from each parent, which means that the probability of two siblings sharing one haplotype is 0.5, whilst the probability of two siblings having identical haplotypes is 0.25.

(iii) This was not usually answered particularly well. Few candidates who answered this question seemed to appreciate that the HLA loci code for proteins, which are present in the plasma membrane. These act as antigens, so that cells can be recognised as 'self' or 'non-self'.

In the case of transplants, if the cells are recognised as non-self, the transplant will be rejected as a result of an immune reaction, involving T cells and the production of antibodies.

The ABO blood grouping system was often cited as an example of this – and was credited appropriately. A mark was also awarded if candidates explained that, in such cases of incompatibility, the chances of rejection can be reduced through the use of immunosupressant drugs.