CONTENTS

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

General comments

The mean score was 28.5 (71.25%) and there was a very good spread of scores, the standard deviation being 6.4. Fifteen questions were answered correctly by 80% or more of candidates – **Questions 1**, **2**, **3**, **4**, **7**, **9**, **10**, **15**, **16**, **17**, **20**, **23**, **27**, **33** and **34**. Candidates found only three questions difficult; 40% or fewer candidates answered **Questions 5**, **14** and **35** correctly.

Comments on specific questions

Question 4

Weaker candidates do not appreciate that smooth endoplasmic reticulum synthesises steroids, whilst rough endoplasmic reticulum is the site of protein synthesis and transports proteins.

Question 5

Many candidates failed to realise that the mitochondria were kept in a 0.25 mol dm^{-3} sucrose solution in order to maintain the organelles osmotic integrity. The respiratory substrate used by mitochondria is glucose, not sucrose.

Question 6

The relative difficulty of this item reveals a poor understanding of the function of mitochondria. It was not surprising that option **A** was popular as this option mentioned energy. Option **C** attracted a high proportion of weaker candidates, indicating their confusion between respiration and gas exchange.

Question 8

Whilst the majority of candidates selected those options which included a 1, 4 glycosidic link, many weaker candidates chose option **C** with the incorrect 2, 6 glycosidic link.

Question 14

Only the more able candidates were able to determine the correct response. Options **C** and **D** are both incorrect. At R, the enzyme is working at the optimum, so its structure would not be starting to break and at S, the enzyme, not the substrate would be completely denatured. Option **B** was the most popular response, but kinetic energy increases as temperature increases and therefore at point Q on the graph, kinetic energy was not at its highest.

Question 18

The high discrimination shows that the more able candidates understand the concept of active transport, as movement from a low concentration to a high concentration.

Question 21

The number of incorrect responses amongst weaker candidates shows poor understanding of the behaviour of chromatids during mitosis and the relationship with haploid number.

Question 24

The high discrimination value shows that the more able candidates realised that the codon is found on mRNA and the anticodon on tRNA.

Question 25

Weaker candidates do not seem to appreciate that ‘all blood vessels’, includes capillaries, whose wall only consists of endothelial cells.

Question 26

Many candidates were unable to interpret the diagram correctly. They should know that a closed system has blood flowing only in vessels and that a double system passes through the heart twice. Therefore, they should have been able to see that the diagram shows a single closed system.

Question 28

Less able candidates did not appreciate the fact that skeletal muscles in the legs are responsible for blood movement.

Question 34

Predictably, this was a very easy question.

Question 35

Fewer than expected of the more able candidates knew the answer, resulting in a low discrimination value.

Paper 9700/02

Paper 2

General comments

There were many very good, some excellent, answers to all questions on the paper. There was no indication that any candidate was rushed to finish the paper. Very few candidates left sections not completed. There were many well-prepared candidates.

Questions 3 (c) and **5 (b)** and **(c)** proved to be the most difficult for most, even the better, candidates. **Question 5** was the lowest scoring. All sections of the questions, except perhaps **6 (c)**, were accessible to the majority of candidates. There were several areas of the syllabus where many candidates showed weakness or where common errors were made. These include in particular the use of water potential terminology (**Question 2 (c)**) and knowledge of the nitrogen cycle (**Question 5 (c)**). In answering questions on some parts of the syllabus, many candidates were extremely vague (**Question 5 (b)**). It was also clear that many candidates did not appreciate what was required in answer to a question asking them to *explain* (**Questions 2 (b)** and **3 (c)**). These are discussed in the body of the report.

Comments on specific questions

Question 1

(a) Although the majority of candidates named **W**, **X** and **Y** correctly, common errors were to name **W** as a nitrogenous base, rather than cytosine and **X** as a ribose or a pentose sugar, rather than deoxyribose. Some candidates named **Y** as phosphate or ATP, rather than a nucleotide.

(b) Many candidates stated what was meant by semi-conservative replication or the process of replication rather than explain, as asked, how the structure of DNA enables it to replicate semi-conservatively. There were quite a few who were confused by the question and described transcription. Very few candidates made it clear that when the DNA double helix unwinds, both strands act as templates, even although they summarised that two strands were produced. Many candidates stated categorically that only one did. Even fewer clearly stated that the bases of activated nucleotides pair up with their complementary base on each of the old strands. It was clear that many candidates had learnt that complementary bases pair to form a new strand and that they were not aware what this really meant.

(c) Most candidates gave very vague answers to this part. They made such statements as, 'so that all the nuclei/cells are the same', without reference to the significance of the exact copy being genetically identical or that the copy contained the same genetic information. However, some candidates did appreciate that if the copies were not genetically identical, mutations could arise and gave good examples of the consequences of such mutations. Others either linked their answer to the idea of maintaining genetic stability or to the outcome, if otherwise, of mutations, but not to both of these ideas. There were many very imprecise answers making reference, for example, to 'keeping the same genes', 'keeping the chromosomes/diploid number the same', 'to producing the wrong protein' and 'producing harmful consequences'. Some candidates did not appreciate that if two nuclei contain the same genes they may not be identical genetically, as they may have different alleles of the same gene.

Question 2

(a)(i) A large number of candidates were familiar with transverse sections of leaves and correctly labelled all four cell types. Common mistakes were to label the xylem vessels as sieve tubes and the converse or to label the companion cells sieve tubes. However, it was encouraging to see that the majority of candidates knew the location of phloem in relation to the xylem in the leaf and could distinguish companion cells from sieve tube elements. More than a few candidates labelled the upper epidermis as the lower epidermis. Others did not know where the palisade mesophyll was.

(ii) In calculating the magnification of Fig. 2.1, the majority of candidates took the simplest and expected direct approach and measured the length of the scale bar in mm and divided it by 0.5 to obtain a magnification of 240. Others made rather more work for themselves and measured the width of the figure itself and by proportion with the scale bar arrived at the same correct, but sometimes incorrect, answer. Others merely measured the width of the figure in mm and divided that by 0.5 and obtained the incorrect answer.

(b) The majority of candidates named sucrose, an assimilate given in the syllabus. Far fewer candidates gave amino acids as the second assimilate. The lists of other named assimilates was almost infinite but common ones were glucose, starch, proteins, water, ATP, carbon dioxide, oxygen and mineral ions.

(c) There were many exceptionally good answers to this part. The better candidates were well aware that the water potential of the spongy mesophyll of the leaf was lower/more negative than that of the water potential in the vascular tissue and gave accurate accounts of how water evaporated from the cell walls of the spongy mesophyll cells into the airspaces between them and diffused, as water vapour, out through the stomata into the atmosphere.

Many candidates are still confused when using water potential terms. They still do not appreciate that if water moves between two places, it always moves from a higher/less negative water potential to a lower/more negative water potential. They still refer to water potential in one place being more/greater or less/smaller than in another place. Numerous candidates referred in length to water moving via the apoplastic, symplastic or vacuolar pathways, but to many these were just terms which they had heard of and most were unclear as to what these pathways were. Surprisingly, too many candidates still believe that water, rather than water vapour, moves out through the stomata and that it evaporates on the surface of the leaf, rather than from the surface of the cell walls of the spongy mesophyll cells around the airspaces in the leaves. Others think that water vapour passes to the atmosphere from the guard cells.

Question 3

There were many excellent and accurate answers to **(a)** and **(b)** but much fewer to **(c)**.

(a) Some common errors were to state that haemoglobin consists of four protein chains, or to refer to haem and iron as if they were the same, rather than that the haem group contains an iron/Fe^{2+} ion, and that oxygen binds to or is carried by haem. Others referred to the presence iron atoms, iron molecules or Fe^{3+} ions. Many of the weaker candidates often equated haemoglobin with the red blood cell and described its biconcave shape, large surface area and the lack of a nucleus. It was encouraging that the better candidates saw the significance of the outer hydrophilic R groups in maintaining solubility and also of cooperative bonding.

(b) By far the majority of candidates completed the table correctly.

(c) The majority of candidates, even the better ones, did not explain how carbon dioxide stimulates the release of oxygen from the blood but described the Bohr shift. The Examiners expected the candidates to explain that carbon dioxide reacts with water to form carbonic acid and that this dissociates. The hydrogen ions so formed then combine with the haemoglobin forming haemoglobinic acid so releasing oxygen. Rather than do this, many candidates described how the amount of oxygen carried by the blood and in the alveoli is affected by the partial pressure of carbon dioxide. Others gave detailed accounts of muscle tissue and myoglobin, the role of chemoreceptors and of the partial pressures of carbon dioxide in leading to the release of oxygen at the tissue level. Some were even less specific and referred in length to diffusion gradients and saturation curves. Candidates should be made aware of the glossary of terms used in examinations provided in the syllabus and that what is required in answers beginning with 'Explain' and 'Describe'.

Question 4

Many candidates found the three parts of **(a)** to be the easiest part of the paper. There were many correct answers to all three parts. There were some common mistakes.

(a)(i) **A** and **B**: 'Transcription' and 'translation' were often given the incorrect way round. **B** was sometimes described as protein synthesis rather than named as 'translation' and **C** named as pinocytosis or endocytosis, rather than exocytosis.

(ii) **D** was sometimes named as a lysosome, tRNA or Golgi vesicle.

(iii) **F** was often named as rRNA or RNA, rather than mRNA.

(b) Whereas the majority of candidates were aware of the significance of the active site in the reaction, many thought that it had a specific shape to accommodate the peptide bond between the two amino acids and such statements as 'only the peptide bond between glycine and isoleucine fits the active site' were far too common. Many candidates stated that the active site was specific, but not that it had a specific shape. Some candidates still think that the substrate has to have the same shape as the active site.

(c) Very few candidates scored all three marks allocated to this part.

Most did not indicate which bond was broken. Some ringed the O H C ---- N part of the molecule. Others indicated that the wrong bond was broken e.g. one of the two C----- C bonds. Many merely added to the diagram + H_2 O and did not indicate how the OH and H group of water were involved in the hydrolysis. Some that did added an OH group to the N of the peptide bond. Others confused hydrolysis with condensation.

Question 5

The majority of answers to parts **(b)** and **(c)** this question, even those from the better candidates, were very poor and often very vague.

(a) There were many correct calculations, with the working clearly shown. Common mistakes were to do the calculation without the contribution from the dead plants and animals from other ecosystems, to express the answer to the nearest whole number as 10.7 rather than 11 and to give the answer as 11 $kJm^{-2}yr^{-1}$.

(b) By far the majority of candidates referred to energy being *used* in metabolic reactions, such as respiration, but failed to appreciate that energy was *lost* in respiration. Although many candidates noted that not all parts of producers are eaten or are digestible, few appreciated that there are large energy losses to the decomposers. Many candidates mentioned that energy was lost as heat but did not qualify how or by which processes it was lost. This part of the question produced some extraordinary vague answers. Answers such as 'Energy is lost in the vital processes of life' were far too common.

(c) Only a very small minority of candidates answered the question by outlining how bacteria convert the nitrogen in the form of protein from dead plants into a form that may be taken up by living plants. The Examiners expected reference to the proteins being hydrolysed to amino acids, the amino acids being converted to ammonia or deaminated and the ammonia being oxidised to nitrates. The candidates wrote about the nitrogen cycle in the most general and the vaguest of terms. Many candidates stated that the proteins were denitrified to nitrogen and then fixed back to nitrate by *Rhizobium* or that they were converted directly to nitrites then to nitrates by nitrifying bacteria. Surprisingly few candidates appeared to be aware that such proteins are hydrolysed to amino acids and then deaminated to ammonia. The Examiners concluded that many candidates did not read the question sufficiently carefully and gave the answer to what they thought was the question 'Outline how bacteria convert nitrogen to a form that can be taken up by plants'. Even so many candidates started with nitrogen from the air and built it up into proteins.

Question 6

(a) Many candidates had problems in completing the table. The majority knew that haemoglobin is only found in the cytoplasm of the red blood cells, although some also thought that it was found in the plasma. Similarly the majority knew that all components contained water, although some thought that it was absent in the red blood cell. Many did not appreciate that only the red blood cells did not contain antibodies and that only the tissue fluid was in direct contact with the muscle cells.

(b) Only a few candidates had difficulty stating two effects of nicotine on the cardiovascular system. Most stated increased heart rate and blood pressure. Others referred to constriction of blood vessels, rather than arteries and arterioles and to stickiness of blood cells, rather than platelets. Some candidates, especially the weaker ones, gave the effects of tar and other irritants in smoke on the respiratory system, rather than the cardiovascular system.

(c) Some candidates were put off by the data, but many successfully used the data to give support to their explanation. For example, to support the fact that men are more at risk of dying from lung cancer, the better candidates selected the data from New Zealand where roughly the same percentage of men and women smoke but the deaths from lung cancer in men is much higher or they noted that in all six countries given in the table, the death rate for men is higher than for women. Some candidates gave the data but did not state whether this was to support the statement or not. Problems arose for the candidates when they started to work out averages from the data. Most did this incorrectly and added percentage and death rates for men and women. For France, for example, candidates stated that 54% of the population smoked and this resulted in 87.7 deaths per 100 000 of the population. This often became misinterpreted further and quoted as in France, for example, 54% of the population smoke and 87.7% of the population die from lung cancer. Some candidates failed to realise that one set of figures were percentages and the other deaths per 100 000. More than a few candidates thought that to obtain the actual number of deaths one had to multiply 100 000 by 100 000. Quite a few took the deaths from lung cancer to be deaths per 100 000 of the smokers, not the population as a whole. Apart from the use of figures from the table, many candidates found it difficult to express comparative facts, such the percentage of males who smoke in Malaysia and China are both relatively high, but the deaths from lung cancer per 100 000 are much lower in Malaysia.

(d) This part proved very difficult for most candidates. A large number of candidates referred further to the data from the table. Whereas the Examiner expected any reasonable suggestion as to what other information should be taken into consideration. These include the age at which men started to smoke, how many cigarettes they smoke a day and the risk factors that are linked with lung cancer, such as their working environment and whether or not this was polluted with other carcinogens. Some candidates wrote about diet/exercise and various other topics which were not relevant. Many thought that a healthy lifestyle, with plenty of exercise and a good diet, could counteract lung cancer.

Paper 9700/03

Practical 1

General comments

The paper was accessible to the majority of candidates, who demonstrated good knowledge and understanding of those practical skills that were tested. The paper also discriminated well between weaker and more able candidates whilst at the same time allowing all candidates to demonstrate their ability in answering questions. It was pleasing to see that far fewer 'text book diagrams' were drawn by candidates, most of whom made a genuine attempt to draw what they saw and interpreted well what they saw through the microscope. This is to be applauded. There was no evidence that candidates ran out of time and almost every candidate completed every question.

Comments on specific questions

Question 1

Candidates were able to make a good attempt at this question. The photographs were interpreted correctly by most candidates who then went on to give some good clear answers to the question.

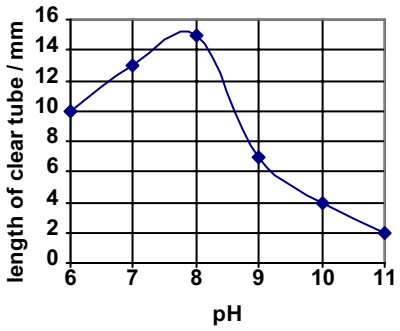
(a)(i) Good answers included reference to concentration or dilution. Many candidates gave the answer of 'making sure it was the same volume'. This showed a lack of understanding appropriate to AS Level about what variable was being controlled.

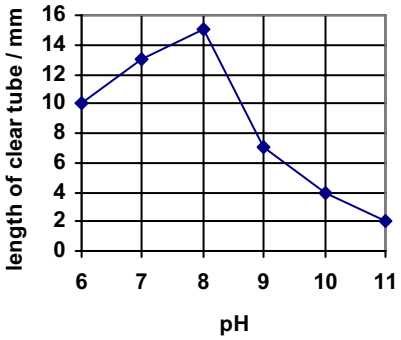
(ii) This part was answered well by the vast majority of candidates who clearly and correctly drew the varying lengths of egg white in the capillary tubes. Provided the lengths were all drawn at their correct relative length to each other, the candidates scored two marks.

(iii) This part was well answered with many candidates scoring full marks. Credit was given for realising that in S1 the enzyme was denatured and then for giving a good explanation as to how temperature and pH affected the reaction in the other tubes. Good answers included reference to kinetic energy and how pH affects the active site of the enzyme molecule.

(b)(i) Surprisingly many candidates failed to score well on this part. Some candidates produced excellent graphs, but many candidates only scored one or two of the marks. Errors included failing to include units, drawing the axes the wrong way round, errors in plotting, and even connecting the plots together in the wrong order. Candidates would be well advised to practice their graph skills in order to gain an extra two or three marks on the paper. It was pleasing to see however that very few candidates made the error of plotting the length of the egg white remaining, against the length of clear tube, since this gives a graph the shape of which is the inverse of the rate changes.

The Institute of Biology recommend that "A smooth curve should only be drawn if there is good reason to believe that intermediate values fall on the curve. Otherwise, straight lines joining the points should be drawn, thus indicating uncertainty about the intermediate values". (Biological Nomenclature, 3rd Ed., 2000, pub. IOB). The figures below show the data used in this question, plotted with a smooth curve and plotted with straight lines between the points.





As can be seen, for the part of the graph between pH 9 and pH 11, it is very clear that intermediate values fall on the curve, whereas for the part of the graph between pH 7 and pH 9 there is very great uncertainty where intermediate values might lie. This is typical of many biological graphs. In this case, the uncertainty might lead to a preference for straight, ruled lines between the points, but an appropriate and plausible smooth curve is equally acceptable.

(ii) This part was well answered. Most candidates clearly understood the importance of optimum pH and then went on to explain the causes and effects of changes to the active site of the enzyme.

(c) This part was not so well answered. Examiners had five marking points for this three mark question, but very few candidates scored full marks. Many answers were not specific to the question and candidates would be well advised to read questions carefully before answering them. Vague references to other experiments and plotting graphs did not score. Good answers included how serial dilution could be used to produce a range of at least five different enzyme concentrations. Explanation of how to control and eliminate variables was all credit worthy. Very few candidates referred to how they would ensure reliability or validity in their answer, for example, by replicating readings.

Question 2

Candidates performed very well on this question and many were able to obtain full marks. It was pleasing to see the continuing improvement and quality of drawings in the interpretation of microscope slides.

(a)(i) Most candidates scored full marks on this part and answered the question correctly by drawing a plan diagram. Very few went on to include cellular detail in their drawings and this was credited. Most were drawn with clear, sharp, well defined lines and there was very little evidence of 'text book' diagrams. Labelling was generally clear and accurate. More able candidates also correctly identified parenchyma, sclerenchyma and collenchyma tissues within the specimen.

(ii) This was also well done with most candidates correctly identifying the specimen as a stem and then going on to give a good reason for their decision such as the presence of vascular bundles, phloem outside the xylem, or the presence of pith or trichomes.

(iii) Again, this was generally well done. Most candidates carried out the instruction and only drew four cells and this was credited. Credit was also given for drawing thin walled cells, of equal shape and size, with air spaces between them.

Paper 9700/04

Paper 4

General comments

The paper showed a good range of marks but there were fewer high scoring candidates than in previous examinations. ***Section A*** provided a chance for all candidates to score well, however this chance was frequently not taken. ***Section B*** was misunderstood by many and very few candidates scored full marks.

Comments on specific questions

Section A

Question 1

(a) A large number of candidates coped well and knew the technical terms, however some referred to phosphate molecules rather than groups, some to ribulose instead of ribose and others to amines instead of adenine. There was some confusion over the terms adenine/adenosine and nucleoside/nucleotide. Several described the functions of ATP and then failed to mention this in part **(b)**.

(b) The most commonly used correct answers stated that if the phosphate group was removed then energy would be released. Surprisingly few candidates went on to talk about ATP being a link molecule or that it is soluble and diffuses readily.

(c) Many candidates wrote well beyond the lines provided for this question. Some mistakenly talked about glycolysis, failing to realise that the question was asking about the mitochondria. It was interesting to note that the descriptions of the electron transport chain and how it functions were generally lacking in detail, many referred to hydrogen passing along the chain. Despite these problems many scored well and were able to describe the main features of chemiosmosis.

Question 2

(a) Most candidates identified the stage as either prophase I or metaphase I.

(b)(c) Candidates often miss the cue words 'Describe' and 'Explain' and thus put parts of their answer in the incorrect section. It is important to train candidates, using the glossary in the syllabus as a guide, practising with past examination questions to ensure that candidates develop this skill appropriately. Most recognised that chiasma formation had occurred but only a few stated that synapsis had taken place. Many were able to say that there was an exchange of genetic material but rarely stated that it was between non-sister chromatids. A common answer simply referred to exchange with another chromosome. Very few mentioned the fact that linkage groups were broken or that new linkage groups would be made. This question highlighted a common problem regarding the inability of many candidates to distinguish between gene and allele.

(d) Many candidates ignored 'other sources' and expanded ideas already covered or wrote about gene mutation, which is not a result of meiosis. Independent assortment was often correctly applied as a consequence of random orientation of homologous chromosomes on the equator. Many still use the term 'random assortment' which did not gain credit. Random fusion of gametes was frequently given but few went on to describe that gametes need to fuse because they are haploid as a result of meiosis.

Question 3

(a) Some candidates seemed to assume that an action potential was produced as soon as the receptor was stimulated. Better candidates were able to indicate that sodium ions would rush in and depolarise the receptor. They were also able to go on to show that the receptor potential had to be greater than a certain threshold for an action potential to be produced in the sensory neurone. Weaker candidates wrote about saltatory conduction and gave general information about the nature of the action potential.

(b) This should have been a fairly easy question but a surprising number of candidates gave superficial answers. Whilst some realised that the motor neurone originated in the CNS they failed to mention the synapse with the relay neurone even though it was clearly shown in the diagram. Most candidates achieved 1 mark for mentioning the response of the muscle.

(c) This question was generally well answered with most achieving two marks. References to the synapse were often made along with the idea that the refractory period will stop the impulse going backwards. A significant number of candidates indicated that acetylcholine vesicles were only found in the presynaptic knob though some incorrectly said they were found in the presynaptic membrane. Most knew that receptors were only found in the postsynaptic membrane.

Question 4

(a) Candidates were usually able to identify the guard cells but quite a number mistakenly referred to cell **A** as a palisade or mesophyll cell.

(b) Despite the fact that only the role of the stoma was required in the answer many candidates gave a detailed description of the mechanisms involved in stomata opening and closing. Most were able to state that carbon dioxide moved into the leaf and oxygen moved out and that diffusion was the method but very few were able to give extra detail. Better candidates discussed the link between water control and photosynthesis and referred to transpiration.

(c) This part question proved to be quite easy for many. Cell shape was commonly given as well as the variable thickness of the cell wall. It was surprising that few mentioned the vacuole or chloroplasts or that the cells were joined only at the ends.

Question 5

(a) It was rare to find a candidate who was unable to give a correct answer to this question, namely that the Calvin cycle occurs in the stroma of the chloroplast.

(b) It was pleasing to note that the majority of the candidates knew the main stages of the light independent stage of photosynthesis. It was well understood that RuBP fixes carbon dioxide and that it produces an unstable six-carbon compound and the reaction is enzyme controlled.

(c) Following on from part **(b)** candidates usually correctly stated ATP and reduced NADP as the products of the light dependent stage and were able to go on and relate how they were used in the Calvin cycle. Many candidates achieved the maximum 3 marks.

(d) Common answers explained that the concentration of RuBP would go up and that of GP would go down but many failed to get a third mark because they assumed there would be no fixation of carbon dioxide if its concentration was lowered. Despite this fact many scored full marks for this question.

Section B

In previous exams candidates have performed well in this section with many scoring maximum marks. This has not been the case with this exam, particularly with those who chose **Question 7**, and there were limited numbers of candidates getting full marks.

Question 6

(a) Candidates were asked to describe the role of auxins in apical dominance and yet many failed to state what was meant by the phrase 'apical dominance'. Although auxin was mentioned as being 'present' in the apical bud many failed to mention that it was produced there and travelled down the stem. Only the better candidates were able to describe movement via the phloem or cell to cell by active transport. However, even the weaker candidates were able to state that if the apical bud were removed then the lateral buds would grow.

(b) Due to the sequential nature of this question many candidates were able to score well. They had learned that the trigger was the entry of water and then were able to describe accurately the roles played by gibberellins and enzymes in germination. It was pleasing to note that most candidates had a good working knowledge of this topic and of the structure of the seed.

Question 7

(a) Many candidates saw the phrase 'natural selection' and spent some time interpreting the question solely in terms of Darwinism rather than concentrating on variation. Consequently this had a negative effect on the marks obtained. Most were able to mention that organisms with favourable characteristics are able to survive and pass them on to their offspring. A lot of candidates wasted time giving too much detail on the peppered moth.

(b) Candidates who understood what was meant by an 'isolating mechanism' usually scored well. Both allopatric and sympatric speciation were referred to and many details were given, particularly for allopatric speciation. Some, however, thought that humans were doing the isolating and went on to describe artificial selection methods. On the whole this question was not well answered.

Paper 9700/05

Practical 2

General comments

The paper proved to be accessible to the vast majority of candidates who demonstrated good understanding, knowledge and practical skills. The paper discriminated well between weaker and more able candidates and the overall quality of responses was very high. There was no evidence that candidates ran out of time and almost every candidate completed every question.

Comments on specific questions

Question 1

It was most pleasing to see that most candidates were able to carry out this investigation and produce some very useful data from which they were able to go on and answer the rest of the question. The quality of responses was high overall but some candidates found parts **(d)**, **(e)** and **(f)** more difficult. This indicates that there is still an issue with experimental design and this is an area that candidates would be well advised to concentrate on.

(a) This part was impressively done with most candidates scoring at least 3 of the marks. Candidates do not always find it easy to design a table to display results. However, most were able to hold data for tubes 2 and 3 and include time and units in the header. Most also went on to clearly show than tube 2 had taken longer than tube 3 to change colour and scored the fourth mark.

(b) Although this tended to be Centre specific, there were some very good answers to this part. Clear reference to light causing chlorophyll to donate an electron, which then reduced the DCPIP instead of NAD, scored high marks.

(c) This part was not quite so well done, but more able candidates clearly identified that it would slow down enzyme controlled reactions that would spoil the experiment if allowed to happen prematurely. Credit was also given for reference to the release of autolytic enzymes in the leaf extract.

(d) This should have been an easy 1 mark answer, but many failed to realise the role of buffers in maintaining a constant pH.

(e) This part was poorly done. Many candidates thought that the sucrose was acting as an energy source rather than maintaining an osmotic equilibrium to maintain the integrity of the cell membranes. Good answers included reference to isotonic solutions.

(f) Most candidates managed to score at least 1 mark here, but as Examiners had 6 marking points, scores should have been higher. As previously stated, experimental design is the Achilles heal of many candidates. Good answers referred to filtering or centrifuging, using a colorimeter, better light control, having a constant temperature and repeating and averaging results.

Question 2

This question was very well done with the majority of candidates scoring over 12 marks.

(a) Most candidates scored both marks on this question but a worrying number were unable to calculate an acceptable ratio. Credit was given for 4.5:1 or 9:2 but a reverse ratio was only given 1 of the marks available.

(b)(i) Most candidates scored 1 of the 2 marks on this section for correct reference to the large number of red blood cells visible on the slide. More able candidates then went on to qualify this statement by saying that a graticule or haemocytometer was need to make an accurate count of the cells. Credit was also given for saying that many of the cells were clumped or overlapping and that this made counting difficult.

(ii) Most candidates correctly realised that the ratio of red to white cells was much greater but this was not always the case and what should have been an easy mark proved to be too difficult for some candidates.

(c)(i)-(iii) This part was well done by most candidates and even though there were no spare marks with only 8 marking points, a large number of candidates scored full marks. Diagrams were mainly clearly drawn with well defined lines. Credit was given for correct scale with the phagocyte being the largest. There were 2 labelling marks and most candidates scored both of these.

(iv) Most candidates scored both of these marks for correctly calculating the scale and using the correct units. Candidates who incorrectly drew a phagocyte for a lymphocyte in **(iii)** had their error carried forward so that they were not penalised again for the same error.

Paper 9700/06
Options

General comments

Of the four options available, a majority of Centres answered ***Option 1 (Mammalian Physiology)*** and ***Option 3 (Growth, Development and Reproduction)***. A number of Centres attempted ***Option 4 (Applications of Genetics)***, with a very few answering ***Option 2 (Microbiology and Biotechnology)***.

Although candidates appeared to find some questions more straightforward than others, there did not appear to be any particular problems with any of the options.

Comments on specific questions

Option 1 – Mammalian physiology

Question 1

(a)(i) It was clear that many candidates did not appreciate that '*digestion*' and '*absorption*' are different processes. Many who answered this question explained the role of the ileum in digestion as having microvilli, which gives it a large surface area for absorption. Clearly, this is one of the possible answers to part **(ii)**.

In order to gain credit in this part, it was expected that answers would include reference to the production of enzymes, such as maltase, lactase and sucrase, which are held in the cell membranes. Good candidates also knew that pancreatic enzymes, such as amylase are held in the glycocalyx. A further mark was available for a correct reference to enterokinase.

(ii) Both available marks were frequently awarded here. This was either for explaining that the presence of microvilli provide a large surface area for more rapid/efficient absorption or for pointing out the presence of numerous mitochondria, which provide energy/ATP for active uptake.

(b)(i) There were 2 marks here for making a valid *comparison*. Answers were all too often somewhat vague and did not include suitable figures from Fig. 1.2. In order to gain credit, it was expected that valid points of comparison would be made between the two curves, backed up by quoting levels of glucose uptake (in arbitrary units) at different times during the investigation, with and without the presence of phlorrhizin.

(ii) Here there was the usual problem, that candidates were asked to provide an *explanation* for the description given in the previous part. All too often they simply amplified the description. Many also repeated the information that had been given in the question – '…phlorrhizin, which inhibits active transport of glucose'.

Only the better answers pointed out that, in the presence of the phlorrhizin, the glucose could only be taken up by diffusion, which would depend on the presence of a concentration gradient.

Very few answers included an attempt to explain *how* the active transport might be inhibited i.e. by the pholorrhizin binding to the carrier proteins or distorting their shape.

(c) The role of calcium ions in muscle contraction was clearly well understood by many candidates and it was not unusual for 3 or 4 marks to be gained in this part.

Some attempted to explain the role of calcium at the neuromuscular junction, while others explained the role within the muscle itself – some got the two confused and produced some rather muddled answers.

As regards the role at the neuromuscular junction, credit was given for explaining that, on the arrival of an action potential, calcium ions flood through the presynaptic membrane and cause the release of acetylcholine into the synaptic cleft, allowing the action potential to be passed into the muscle.

Within the sarcomere, calcium is stored in the sarcoplasmic reticulum and released on the arrival of the action potential. t then binds with the troponin, which cause the tropomyosin to move and allows the myosin to bind with the actin, bringing about contraction of the muscle.

(d)(i) This calculation required candidates to take 1.2 from 3.15, to give 1.95.

If this is correctly calculated as a percentage of 3.15, it gives an answer of 61.9%. If candidates rounded this up to 62%, they were still given the credit.

(ii) Few seemed to be able to suggest how the peppermint oil would disrupt the uptake of glucose – most suggested that it must 'block' or interfere with the protein carriers. Given that it is a lipid, it will not be as simple as this and it was expected that candidates would realise that the oil must dissolve in the phospholipids bilayer, thereby disrupting membrane structure and distorting, or changing the shape of the protein carriers.

Question 2

(a) Labelling of the diagram of the ear was relatively straightforward, each label gaining a half mark, which were then rounded up i.e. one or two correct labels gained 1 mark and three or four gained 2 marks. Correct answers were: **A** – cochlea, **B** – Eustachian tube, **C** – incus or anvil, **D** – eardrum or tympanic membrane.

(b) 1 mark here for stating that the role of the Eustachion tube is to equalise pressure on each side of the tympanic membrane.

(c) There was some confusion here between the role of the ear as an organ of balance and hearing sounds. Good answers pointed out that the semicircular canals contain a fluid, as well as hair cells a cupula in the ampulla. Credit was then given for describing that, when the head moves, the inertia of the fluid causes the cupula to move, as a result of which the hair cells act as receptors and initiate an impulse to the brain (more specifically the cerebellum). A further mark was available if candidates pointed out that there are three semicircular canals, each lying in a different plane.

(d) Many answers gained both of the available marks in this part. Most knew that the middle ear is normally air filled, so the presence of the viscous substance will prevent movement of the ossicles, which means that the vibrations will not be passed on to the oval window and cochlea.

Question 3

(a) A majority of the candidates answering this option knew that **A** represents the *peripheral* nervous system and **B** the *autonomic* system.

(b)(i) A majority of answers gained 1 mark here for describing the fact that the heart beat increased when the frequency of stimulation of the sympathetic nerve is increased. Few, however, quoted figures from Fig. 3.2 or pointed out that the extent of increase levels off at higher frequencies.

Some candidates thought that the figures on the vertical axis represented the actual heart rate, rather than the *change*.

(ii) Here also, figures were rarely quoted and, again, some candidates thought that the vertical axis represented the actuial rate of the heart beat.

As in **(i)** 1 mark was often gained for describing the fall in heart rate as a result of stimulation of the parasympathetic nerve. Few attempted to compare the curve at 4Hz, with the one at 8Hz.

(iii) This was well understood – most knew that the different effects are the result of different transmitter substances – noradrenaline (sympathetic) and acetylcholine (parasympathetic), each having a different effect on the post-synaptic membrane.

Question 4

(a)(i)(ii) Some confusion here. Candidates ought to have been able to work out that the part labelled 'central vein' must be the vessel which carries blood away from the liver i.e. the hepatic vein – and should therefore be labelled **Q**. The correct label for **P** (hepatic portal vein) was the large vessel on the left of the diagram.

(iii) Most candidates did know that the substance secreted into channel **R** is *bile*.

(b)(i) Generally, this part was well answered. Many answers included reference to the fact that the plasma protein molecules are too large to leave the capillaries, as a result of which they remain in the blood and decrease the water potential (some slightly confused answers referred to their presence *increasing* the solute potential of the blood). As a result of this, *water* will return to the blood from the tissue fluid, as a result of osmosis down the water potential gradient.

(ii) This part was also well answered and it was reasonably common for all 3 marks to be gained. These were usually for describing the conversion of fibrinogen to fibrin by thrombin – and going on to point out that clotting then results because fibrin is insoluble and forms a mesh, in which are trapped red cells and platelets.

Option 2 – Microbiology and biotechnology

Very few candidates attempted this option – the following comments are based on a relatively small number of scripts.

Question 1

(a)(i) Generally well answered – most who attempted this option knew that bacterial genetic material consists of a circular (single) molecule of DNA, which is not surrounded by a nuclear envelope or membrane, as it is in eukaryotic cells.

Further credit was given for reference to the presence of plasmids in the cells of bacteria.

(ii) Again, this tended to be well answered. Marks were given for correct reference to the use of agar plates, the need for sterile equipment and the maintenance of a suitable, constant temperature. Also, the technique of streaking, the use of metal loops and the isolation of individual colonies after incubation.

(b)(i) Given that the conditions will need to simulate those present in the stomachs of baleen whales, credit was available for stating that they would need to be anaerobic, acidic and at 37°C. There would also need to be a suitable nutrient, such as krill protein.

(ii) The answer here was expected to include an explanation of how these bacteria would evolve via natural selection i.e. the bacteria are the natural inhabitants of the gut of the whales and when the whales ingest oil, spontaneous mutations occur, some of which allow the bacteria to break down the naphthalene and anthracene. Such bacteria are then favoured by natural selection, surviving to reproduce and pass the mutated genes on to future generations.

(c) This part was not as well answered as the earlier parts of this question. However, some candidates did appreciate that the oil spills often form a thick layer of oil, which tends to create anaerobic conditions. Such conditions will suit newly isolated bacteria better than previous species, allowing them to operate deeper in the slick, making use of different enzymes and chemical pathways to breakdown specific hydrocarbons.

Question 2

(a) Candidates doing this option were not always sure of the term *lysogenic*. Marking points for which credit would have been awarded were that it means the phage DNA integrates into the host chromosome, where it replicates, though no phage particles are produced and the bacterial cell is not lysed or destroyed.

(b)(i) Here, it was rarely made clear that such a dilution must be done in the vicinity of a Bunsen burner (to avoid contamination) and that the dilutions should be made with sterile water. Some answers made a correct reference to the process of serial dilution and went on to explain what that means.

Others explained that, in order to dilute by a factor of 10, it would be necessary to takes 1 cm^3 of the NFLX solution and add 9 cm^3 of water – however, they did not always going on to say that this would need to keep on being repeated until a sufficient number of dilutions had been created.

(ii) In this type of question, there is invariably credit given if figures are correctly quoted from the graph in order to back up the explanation. In this case, the cloudiness measure in the lower dilutions is a result of the ineffectiveness of the NFLX, so that the bacterial population continues to increase and produce larger numbers of cells. It is also clear from Fig. 2.1 that the minimum inhibitory concentration is somewhere between 100 and 1000 μg cm^{-3}.

Credit was given if candidates also explained that there is still some cloudiness at the higher concentrations of NFLX because, although the bacteria will have been killed there will still be bacterial debris present in the tubes.

Question 3

(a) Labels of the parts of the photomicrograph of *Penicillium* were often incorrect, suggesting that it was not, necessarily a structure with which the candidates were particularly familiar.

Correct answers were: **A** – conidiospore, **B** – coinidiophore, **C** – metula (or rami), **D** – phialides or sterigma.

(b)(i) Points that were expected to be made in an explanation of the term *batch culture* were that it is a fermentation with a constant volume of medium, with all necessary nutrients added at the start and product harvested at the end. The organisms involved will show a normal growth curve and the process is generally halted when sufficient product has formed.

(ii) Temperature and pH were often correctly listed here, though a valid third factor was rare. This could have been aeration, sugar concentration, levels of a suitable source of nitrogen and the degree of foaming.

(c) Candidates who did this usually drew adequate growth curves for the Penicillium, though they were somewhat unsure as to the shape of the curve to represent the concentration of penicillin. It was expected that this would start to rise around the end of the log phase.

Question 4

(a)(i) Most realised that the general relationship was that the greater the initial sugar content, the greater the final alcohol content. Few pointed out that the main exception to this was **B**. Figures were rarely quoted to substantiate this.

Some suggested that the percentage of alcohol is approximately half the percentage of the initial sugar – with the exceptions of **B** and **E**, this is broadly correct and was allowed a mark.

(ii) Candidates did not always seem to be aware that, at high levels, alcohol is toxic to yeast and inhibits respiration or fermentation. Candidates could have gained marks had they explained that it can influence membrane permeability and denature proteins/enzymes at high concentrations.

(b) Calculations here were generally good – though candidates did not always remember that the beer had been diluted 1000 times.

To gain all 3 marks it was necessary to calculate the volume of the grid in view:

($0.2 \times 0.2 \times 0.1 = 0.004\ mm^3$)

This would then multiply up to 1750 mm^{-3}. Which would mean $1750 \times 1000 = \underline{1.75 \times 10^6\ mm^{-3}}$ in the original beer.

Option 3 – Growth, development and reproduction

Question 1

(a) Generally, this part was well answered. Many candidates pointed out that this is because meristematic cells are undifferentiated and still able to undergo *mitotic* division. They are described as being totipotent or pluripotent (many answers included the term totipotent – few, if any, used pluripotent) and have the ability to differentiate into any type of plant tissue.

Many suggested that one reason is that these cells are free of viruses and other infections – though this is desirable, it was not regarded as being a reason why their use is necessary.

(b)(i) Many said the measurement of dry mass is more accurate. Clearly, it is perfectly possible to measure fresh mass accurately, so there was no credit for this. However, marks were awarded if it was made clear that it is a better measure of growth, on the basis that it measures only the amount of plant material present. Fresh mass, on the other hand, includes water content, which can vary according to environmental conditions.

(ii) It was common for candidates to gain maximum marks in this part. Most appreciated that it would be necessary to heat the samples in an oven (some other suitable method of drying was acceptable) at a temperature of 70 – 110°C. They would then be cooled in a desiccator, following which they will continue to be reheated until all the water has been removed and they reach a constant mass. It was not always pointed out that it would be important to take a number of samples and calculate a mean.

(iii) On the whole, candidates did not score as well on this part as might have been expected. As usual, one of the problems was that descriptions were somewhat vague – and appropriate figures were not quoted from Fig. 1.1, in order to substantiate the points made. Many candidates did point out the steeper rise in fresh mass with the increasing concentrations of cytokinin **A**, compared with **B** (curiously, some seemed to think that this was a rise over a period of time). However, it was not always made clear that **A** began its effect at a lower concentration than **B** – and that both **A** and **B** had the same effect at *both* extreme concentrations used in the investigation.

(c) Many candidates knew about the role of auxin in apical dominance – though they did not always seem to realise that the auxin is actually produced in the terminal bud and diffuses down the stem, inhibiting the growth of the lateral shoots.

Fewer seemed to know about tropisms – though a number did describe either phototropisms or geotropisms.

Further credit was given if answers included reference to the fact that the actions of auxin are brought about via its influence on cell elongation, together with an extra mark for detail of its action i.e. its effect on cell walls or water uptake.

Question 2

(a)(i) Most did seem to have little difficulty with Fig. 2.1, pointing out that it would appear that the honeybees preferred to visit daisies with crab-spiders (one mark). A second mark was given if they also remarked that this seemed to be irrespective of whether the scent was blocked or not. A further marking point was for quoting figures to back up this description.

(ii) Explaining the choices illustrated in Fig. 2.1 appeared to be reasonably straightforward – most pointed out that this would appear to be because the honeybees are attracted to the UV light, which is being reflected by the crab-spiders. Some also pointed out that the UV light appears to be much more significant than the scent – though the idea that the presence of the crab-spiders might produce some sort of contrast or pattern (equivalent to honeyguides) was rarely included in answers.

(iii) Here, some candidates suggested advantages to the plants, rather than the crab-spiders. Many others suggested that the main advantage is that it allows them to be camouflaged when in the flowers, which both enables them to be concealed from potential predators, as well as their prey i.e. visiting insects. Some correctly pointed out that the ability to reflect UV light would also reduce the chances of mutation (credit was given if it was made clear that they are reflecting harmful rays, without specific reference to mutation).

(b) A common mistake here (which appeared in many scripts) was the idea that self-pollination leads to genetically *identical* offspring – clearly, many candidates seemed to be under the impression that self-pollination is a form of asexual reproduction and answered the question on that basis.

In order to gain credit in this part, answers needed to refer to the fact that self-pollination leads to inbreeding, as a result of which there is less genetic variation (as compared with cross-pollination) and increased homozygosity, as well as a greater chance of loss of alleles and an increased degree of expression of deleterious recessive traits.

Some candidates answered this question on the basis of the outcomes of cross-pollination – this, of course, was perfectly acceptable as long as it was clear that a comparison was being made with self-pollination.

Question 3

(a) A majority of candidates answering this option gained both marks in this opening part. Most stated that the roles of LH include causing ovulation, stimulating the secretion of progesterone and development of the corpus luteum.

(b)(i) Generally, descriptions of the data summarised in Fig. 3.1 were good. Most pointed out that the injection of GnRH increases the levels of LH in both men and women, though the increase is greater in women and the levels in women remain higher than men throughout the investigation.

Further marks were awarded for quoting suitable figures from Fig. 3.1 – though such quotes needed to include both levels of LH and different times after injection of GnRH in order to make a valid comparison between men and women.

(ii) Most candidates had little difficulty in working out that the maximum level reached in men is 15 arbitrary units – so half that level is 7.5 (one mark for this). However, some then read the time this level is reached during the early stages when the levels are on the increase – or from the wrong line.

The correct answer was 105 minutes.

(iii) Many factors would have to be taken into account and it was rare that candidates did not gain this mark. Most stated that their age would have to be taken into account, or that they should be beyond puberty but not to have reached menopause. Others correctly suggested that they should, preferably, be at a similar stage of the menstrual cycle – and not pregnant.

Question 4

(a) Labelling of this part of the placenta should have been reasonably straightforward – however, labels were by no means always correct. As usual with this type of question, there were half marks for each label, with half marks being 'rounded up'. The correct answers were: **A** – endometrium (or lining of the uterus), **B** – fetal capillaries (or chorionic villus), **C** – umbilical vein, **D** – umbilical cord.

(b)(i) Some confusion here – though many candidates did gain all 3 of the marks available. In order to gain the marks, it was necessary to state both the method *and* the named substance.

Common correct answers included:

diffusion of carbon dioxide, oxygen or urea

osmosis of water

facilitated diffusion of glucose

active transport of amino acids, vitamins, ions or antibodies

phago- or pinocytosis, along with a suitable example was also acceptable.

(ii) Many answers picked up credit here for correct reference to the chorionic villi and microvilli creating a large surface area, as well as the fact that there is a very close association between the maternal and fetal circulations. Further marks were awarded for correct references to the maternal blood spaces and the large number of fetal capillaries, formed into knots or tufts.

Option 4 – Applications of genetics

Question 1

(a)(i) Of the candidates who attempted this option, a majority did know that a *gene mutation* is a change in the DNA code or nucleotide sequence, whereas a *chromosome mutation* is a change in the structure or number of chromosomes.

(ii) Here, also, most understood that resistance is an example of discontinuous variation, because it only involves a single gene and is an 'all or none' effect i.e. the mosquitoes are either resistant or not.

(iii) Explanations here were often thorough and enough to gain all of the four available marks. The main points to be made were that this is an example of *natural selection*, with much chloroquine being used and acting as a selective agent. This puts the resistant mosquitoes at a selective advantage, which means that they are more likely to survive (i.e. the susceptible mosquitoes tend to die out) and reproduce, passing the resistance allele (*pfcrt*) passed on to their offspring. The frequency of the resistance allele will then increase over several generations.

(b)(i) Generally, this was not well understood. Candidates were expected to add up the number of amino acid changes in the four CQR alleles (which is 26), then divide by four, giving an answer of 6.5.

If candidates made one simple error, they were still awarded 1 mark, if it was clear that they were attempting the correct calculation.

One very common mistake was to divide by 10, rather than 4.

(ii) Not well understood. Very few seemed to appreciate that such similar sequences could only be accounted for if they had arisen in common ancestors, which had spread across the continents of Africa and Asia, continuing to evolve in separate areas.

(c) Many answers suggested that candidates understood this, but were not able to explain it very clearly. Many picked up a mark for explaining that each amino acid is coded for by a triplet of bases, though they seldom made reference to the degenerate nature of the code, which means that the codes for some amino acids have two bases in common. If one of the first two bases changes, translation will then involve a different tRNA molecule, which means that a different amino acid will be incorporated in the polypeptide chain.

Question 2

(a) Generally well understood and answered. Most who attempted this option described the decreased genetic diversity, the loss of alleles (or reduction in the gene pool) and increased homozygosity (or decreased heterozygosity). A further mark was available for pointing out that there is a greater chance of the expression of deleterious recessive alleles.

(b) This part was less well answered – though many went into considerable detail about the process of genetic fingerprinting, they gained little credit, as this was not what the question was asking.

Credit was given if answers explained that genetic fingerprinting results in the production of banding patterns, which allows comparison between individuals. The extent of the similarities between individuals will then indicate whether they are simply related or inbred (some answers incorrectly stated that similarities would suggest inbreeding – though, of course, this might simply mean that the individuals are closely related, but out bred). The best answers pointed out that it is when genetic fingerprints show a much greater degree of similarity than might be expected, even amongst closely related individuals, that there is an indication of inbreeding.

(c)(i) Those who did this option had little difficulty in interpreting Fig. 2.1. Most realised that a greater degree of inbreeding leads to a greater susceptibility to infection (of all three types) and that those susceptible to herpes are those which are most highly inbred.

(ii) Less well understood. However, good answers did suggest that inbreeding will lead to a loss of alleles, which will mean that the individuals are likely to be less able to produce an effective immune response. Equally, the alleles which are lost may well be ones which help to confer resistance on those individuals. Reference to a reduced level of fitness in inbred individuals was also given credit.

Question 3

(a)(i) Answers here were very good indeed – Down's syndrome was clearly well understood. In this part, many candidates were able to explain that this is a result of a problem during meiosis (a problem during synapsis, involving the spindle and centromeres) which leads to the presence of an extra chromosome 21 in some gametes (known as trisomy 21).

(ii) Here, again, the idea of tranlocation was usually well explained i.e. the breaking of the long arm of chromosome and its transfer to another autosome (usually 13, 14 or 15).

(b)(i) Many did appreciate that the observed numbers do differ significantly from the expected numbers (for which they gained 1 mark) but were not always able to explain the evidence for this from Table 3.1.

Some did correctly point out that, in biology, the usual level of probability used is 0.05 – and in both of these cases, the probabilities of 0.00001 and 0.001 are considerable lower than this i.e. it is highly unlikely that these numbers of cases occurred by chance.

(ii) Here, also, it was necessary to make reference to the probabilities to provide the statistical evidence between the two diseases in these families. All too often this was not included in answers, which tended to be somewhat vague.

Question 4

(a) Generally, those candidates who attempted this option, explained this test-cross very well and gained all 3 of the available marks.

These were for correct parental genotypes (AaBb and aabb), the correct gametes (AB, Ab, aB, ab x ab) and the four correct genotypes and phenotypes.

When mistakes were made, it was usually that candidates attempted to perform a dihybrid cross and produce a 9:3:3:1 ratio.

(b) Although this was often well answered, it was rare for all 4 marks to be awarded. 1 mark was given if it was explained that this must be a situation involving linkage, as a result of which the alleles do not assort independently, but are inherited together.

The explanation for the offspring produced in small numbers (tall, mottled and dwarf, green) is that these represent recombinant classes, which result from crossing over during prophase 1 of meiosis. One or two very good candidates attempted to use the figures to calculate that these alleles are 12 units apart on the chromosome.