BIOLOGY

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 32	33 - 43	44 - 55	56 - 67	68 - 78	79 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 29	30 - 41	42 - 54	55 - 67	68 - 80	81 - 100

Internal assessment

Component grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 22	23 - 27	28 - 33	34 - 38	39 - 48

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 22	23 - 27	28 - 33	34 - 38	39 - 48

The range and suitability of the work submitted

Most schools used appropriate investigations. Two problems persist however; in some schools the complexity of investigations is not up to IB standards and other schools are setting investigations for assessment that are too heavily directed.

The structured investigations often originate in collections of laboratory exercises that were not intended for use in assessment. Careful editing of the instructions is necessary if they are to be used for assessment. Some schools are using these investigations without providing instruction sheets to the moderators. The moderators are quite familiar with available material and are seeing cases where it has been copied by candidates.

In many schools the post 2009 criteria are being applied rigorously but in a number of schools the descriptors of the different aspects seem to be ignored. In these cases the moderators have to mark down. The Group 4 Project can only be used for the assessment of Personal Skills and none of the other criteria. Fortunately very few schools this session seemed to be ignoring this rule.

Ethics

The IB has now published a document called Animal Experimentation Policy which is available on the OCC. Both this and the Ethical Practice Poster, also available on the OCC, are being applied to Internal Assessment moderation. Some teachers still need to make adjustments to their Practical Scheme of Work.

The IB does not wish to inhibit investigations but it does want to stimulate a responsible attitude towards experimentation on animals. Any proposed experimentation involving animals, including humans, should result in a discussion between teacher and candidate based on its ethical implications and how to refine the experiment to alleviate any harm or distress to the animal, to reduce the numbers of animals involved, or to ultimately replace the use of animals by using cells, plants or computer simulations.

These rules apply equally to candidate-designed investigations not intended to be followed through in a practical session. It is inappropriate to think that if it is not followed through, ethical principles can be ignored.

Moderators continue to comment on investigations that are unsafe or unethical. Behavioural experiments or experiments on animal physiology are frequently quoted as examples.

Experiments in these areas are still possible as long as they remain within the normal tolerance limits of the animal. Thus, exposing animals to conditions normally experienced in their natural environments is permissible. It is good practice to always include a discussion with the candidates on the tolerance limits of the animal and how these could be established. There are plenty of sites on the web that will help here.

It goes without saying that wild animals should be returned to their natural environment soon after the investigation. Animals obtained from a supplier should be kept under safe and healthy conditions.

Situations that deliberately demand the euthenising of animals are no longer appropriate. Thus, fruit fly genetics must be replaced by, for example, rapid *Brassica* plants, *Sordaria* mould, maize cobs or simulations, such as the virtual fly lab (though this would mean that as a simulation, it could not be submitted for IA moderation).

Dissections are a special case in biology. The guidelines are quite clear on this. Practising dissections because they are a traditional part of biology course is not in itself an adequate reason. Including them, however, in order to study form and function in the distribution of organ-systems, organs and tissues is valid. Much of this can be done using simulations or dissections of organs purchased in butchers shops.

Fieldwork often involves the sampling of animal populations. This should take place with the minimum of disruption to the environment. The animals should be sampled using techniques that do not cause injury and which limit their stress. The animals should be returned, with due care and attention, to the places where they were collected.

The approach to experiments on human physiology should be reconsidered by a lot of teachers. Using fellow candidates for investigations into the effect of exercise on the heart rate can be considered unsafe if the health status of the candidates is not determined first. Some schools are already expecting their candidates to use a proforma for the signed consent of the participants in experiments. This is good practice.

Some inappropriate examples quoted by moderators include:

- Exposing pill bugs to extreme pH.
- Exposing *Daphnia* to solutions of nicotine, caffeine or ethanol.
- Exposing "volunteer" candidates to water at 100°C

Clerical procedure

Earlier versions of the 4/PSOW form are still being used by some teachers. These do not provide space for the moderator and senior moderator marks. The latest versions (available on the OCC) should be used.

Teachers who include the "complete", "partial" and "not at all" breakdown of their marks are providing helpful information to the moderators. This, combined with comments and feedback to the candidates make it very clear where the teachers are awarding marks. There are a large number of teachers who take a lot of time and trouble to prepare their Internal Assessment sample. This effort is very much appreciated. They should be congratulated for their efforts and their candidates will reap the benefits. It is a lot easier for a moderator to support a teacher's marks when there are clear notes accompanying the sample.

There is a recurrent problem concerning the information provided by the teacher. This directly affects the progression of the moderation. Teachers MUST enclose all of the instruction sheets and/or summaries of oral instructions for the investigations in the moderation sample. Most schools comply with this requirement for the investigations involving DCP assessment. It is also necessary, however, for investigations where Design is being assessed and a significant number of teachers are not doing this. Furthermore, when Data Collection and Processing is being assessed, the method (designed by the candidate or provided by the teacher) is required. When Conclusion and Evaluation is being assessed all of the steps in the scientific process are needed for moderation.

Some practical programmes are not designed with sufficient numbers of hours. In other cases, the time spent on an activity is credited as far longer on the 4PSOW than is warranted. It should also be noted that the Group 4 Project can only count for 10 hours on the 4PSOW.

Atypical candidates should be replaced in the sample. These would include candidates whose work is incomplete, or transfer candidates where a substantial part of their work has been marked by another teacher.

When the only marks appearing on the 4PSOW form are the two marks required for the internal assessment, it causes concern for the moderator. There is no indication that the candidates have been marked a number of times using the criteria and it is hard to justify how these candidates receive the necessary feedback to improve their performance.

Some moderators commented on transcription errors between the marks indicated on the work and the mark on the 4PSOW form. This should be checked and verified before it is sent.

Some schools are sending photocopies of candidate work. Often, these are of good quality but graphs and diagrams using colour can be confusing. The originals should be sent and a photocopy kept back.

Areas of strength

The variety of investigations, the duration and coverage of the practical programme were generally good.

The use of ICT in the areas of:

1) Data logging,
2) Graph plotting software and
3) Spreadsheets

is good, although some schools need to use data bases and spread sheets more.

Areas of weaknesses

Although the vast majority of schools are adapting to the requirements of the criteria, there are many that are still presenting similar investigations to the previous programme. This was particularly apparent in those used to assess DCP, which is now more demanding.

Trivial, simplistic investigations that do not generate sufficient data to permit adequate assessment of data processing are too often used for assessment. If there is one significant area of weakness it is in the processing of data. Candidates are missing quite obvious conventional points (e.g. indicating uncertainties in their data) as well as limiting their processing to the calculation of a mean. Some teachers are also missing these points and marking over generously. Sometimes teachers point out errors to their candidates, yet still award full marks.

Where the criteria are applied rigorously and clearly, the moderator makes relatively small adjustments to the marks. In cases where the descriptors of the aspects are ignored, moderation can reduce marks quite severely.

Literature sources are not always consulted where they could provide valuable background information in determining the initial research question and in the discussion of the results.

In some schools, cross moderation between colleagues in biology is clearly not being carried out. Moderators have observed quite different standards of marking between colleagues presenting work in the same sample.

Rules applied by the moderators

In the event of the teacher providing too much guidance to the candidates or ignoring the criteria the following scale is applied by the moderators:

Criterion	Problem	Teacher awards	Maximum moderator can award
Design	Teacher gives the problem or research question.	c; c; c = 6	p; c; c = 5 Candidates may have identified their own control variables
Design	It is clear that the candidates have been told precisely what apparatus and materials they require and have not modified it.	c; c; c = 6	c; c; n = 4
Data Collection & Processing	The candidates have used a photocopied data table with headings and units.	c; c; c = 6	p; c; c; = 5 Candidate may have added uncertainties or relevant qualitative observations
Data Collection & Processing	The candidates have been told, on the method sheet, to draw a graph from their raw data and which variables to plot or process the data in a particular way.	c; c; c = 6	c; n; c = 4
Conclusion and Evaluation	The candidate has only indicated as a criticism that they ran out of time and their only suggestion as an improvement is that they should repeat the investigation.	c; c; c = 6	c; n; p = 3

Candidate performance against each criterion

Design

Some schools are setting general themes with little scope for different investigations. The result is that the whole class of candidates selects the same variables and investigates the same system.

Little research is evident, or investigations are designed with little or no consideration of biological principles. It may be a small point but it would be useful for the candidate to give the scientific name of the organism being used or the organism that was the source of the material. The trivial name at least must be given.

Research questions need to be focused. A research question that lacks focus will have an impact throughout the rest of the investigation. For example, candidates who decide to investigate several independent variables at once such as the effect of pH, temperature and substrate concentration on the activity of an enzyme.

The three categories of variables must be clearly identified. It is clear that candidates need to be taught what the different variables are and what their relationship is. Moderators have observed that there is sometimes confusion over what is a controlled variable and what is a control experiment.

Investigations are frequently too simplistic, including the following:

- The range of values of the independent variable is insufficient to establish a trend.
- The range of values of the independent variable is insufficient to permit statistical analysis. E.g. testing the effect of pH on an enzyme using an acidic environment, a neutral environment and a basic environment will not establish an optimal pH.

Standard protocols will, no doubt, be used by the candidates when they design their investigations; they are not expected to re-invent the wheel. These standard protocols however, must be significantly modified or applied to the candidate's own investigation. For example, if osmosis is being investigated and the candidate uses the method of change in mass of tissue to monitor the effect of solutions of different concentrations on a tissue, this is legitimate. If the investigation is simply to determine the isotonic solution of one tissue, then it remains trivial and it repeats many textbook investigations. If the investigation is used to determine the effect of the salinity of irrigation water on different root crops, then it becomes more substantial.

In field work, the control of sampling procedures is often almost totally ignored by the candidates. If a random sample is to be obtained how can it be ensured that it is random?

Planning to use data loggers for the measurement of variables is becoming more common. This is a good thing. The link between what the probe measures and the dependent variable however, is often left up to the reader. For example a pressure sensor may be used to measure the effect of catalase on the breakdown of hydrogen peroxide. The fact that a gas (oxygen) is produced by this reaction and that its accumulation in a vessel will cause a pressure change needs to be explained.

It is good practice for candidates to follow through their own designs. Some schools ask candidates to design an investigation that remains theoretical. The result is often an unrealistic investigation (although even when a candidate designed investigation is followed through, the result may be an unrealistic investigation). For example, measuring the effect of music genre on heart beat rates. This is almost impossible to control and candidates ought to be counselled against it from the outset.

Data Collection and Presentation (DCP)

It may be that class data is required in order for the candidate to gain access to sufficient data for significant data processing and the determination of uncertainties. The moderators understand this, biological systems are often difficult to coax and slow to yield data. If class data is to be used and DCP is to be assessed, a number of precautions must be respected. The candidates must present their own data or clearly identify which is their own data in a pooled data table. The candidate must plan and produce their own data table. Copying a table from other candidates will be counted as collusion and the school's IA work will be subject to an enquiry. Teachers who provide candidates with a pre-formatted data table can expect their candidates to be moderated down.

Despite clear warnings in the subject guide, some schools are still providing instructions on how to present the data and how to process the data. Their marks will be moderated down. The classic investigations (e.g. mark and recapture, chromatography of leaf pigments, rates of photosynthesis using the sunken leaf disks, rates of reaction of catalase and osmosis) often create problems. Teachers are using standard textbook protocols without modifications. A little imagination and editing could easily solve the problem.

Moderators often have to reduce the marks of the teachers who miss the following points:

- No quantitative data collected
- No uncertainties given in tables of data collected using measuring instruments.
- Inconsistent decimal places in tables
- Decimal places do not correspond to the precision of measurements
- No associated qualitative observations where appropriate. E.g. an ecological field investigation is incomplete without some kind of description of the site used
- Raw data plotted in graphs that do not actually reveal anything (e.g. maxima, minima, optima or intercepts)
- Raw data plotted when the mean should have been calculated and plotted (often the mean is actually calculated and then ignored by the candidate for graphing)
- No statistical treatment of the data when it would be appropriate to do so
- No consideration of appropriateness when statistical treatment is applied
- No presentation of uncertainties in graphical data either by using trend lines or error bars
- Error bars, when used, are not explained.

When calculations are made it is important that the pathway to the answer is clear. This does not mean there has to be a worked example but a result that springs up out of nowhere should not be credited.

Conclusion and Evaluation (CE)

Investigations that lead to trivial amounts of data will lead to limited discussion of results and weak conclusions. Insufficient data will not reveal uncertainties and this has an impact on evaluation, so although each criterion is marked on its own merit; a poorly designed investigation that collects a limited amount of data will lead to a weak conclusion and evaluation.

Some teachers are using simulations instead of real biological investigations in work that is submitted for IA moderation. These are very useful for training in data collection and processing as they generate large amounts of data quickly. They are not suitable however for assessment, especially the assessment of this criterion. It is not possible to provide a biological explanation in these cases.

Overall literature values or the theoretical background are not consulted enough by the candidates. When they are consulted the sources are often not correctly cited. The information on the correct way to cite a reference in the Extended Essay Guide is very helpful.

Candidates in some schools show that they have developed a mature sense of criticism of the investigation. Their evaluation of results is based upon a balanced critical analysis of the data. Candidates who have not developed this skill tend to remain superficial in their evaluation.

The weaknesses they identify are hypothetical (“the seeds could have been dead”) without evidence to back it up. For weaker candidates the experimental weaknesses are restricted to having a limited amount of time or errors in their own manipulation that once again remain hypothetical (“I could have incorrectly measured the temperature”). Evaluation is a good discriminator of the high achieving candidates and teachers would do well to remember this when they are marking their candidates.

Suggested modifications are sometimes superficial and yet marked over generously.

As stated above in clerical procedure, if the method and the data used by the candidate are not made available to the moderator, then CE cannot be moderated.

Manipulative skills

There is evidence of the candidates being exposed to a sufficient range of investigations. This ensures that the manipulative skills can be assessed correctly.

ICT coverage

This was adequately covered by the majority of the schools.

Schools have made an effort to equip themselves with the necessary materials to carry out data logging. The use of this material however, in investigations for internal assessment of the criteria, is not always appropriate. Teachers and candidates are strongly advised to read the relevant section of the subject guide.

Graph plotting using software is perhaps the easiest and most widespread for schools to apply. However there are signs that some candidates still need to be taught the correct conventions of graphing. There is a tendency amongst the weakest candidates to use bar charts for everything, perhaps because it is the default setting. Legends (keys) are not always necessary and many candidates do not seem to know how to de-select them. When they are needed, some candidates often have difficulty labelling them appropriately; candidates often present the different curves as “series 1” and “series 2”. When candidates use scatter plot, a trend line is not always used where appropriate. It is good practice to train candidates to plot graphs manually before using a graphing program.

The use of spreadsheets for data processing is less apparent in the sampled investigations. When spread sheet tables are inserted into document files, the conventions of presenting tabulated data are often ignored or forgotten (e.g. centring numbers, adjusting the number of decimal places, column headings).

Some schools are not fulfilling the requirement for a range of ICT applications to be used in their practical programme. It is the use of databases and computer modelling/simulation that are most often missing.

The Group 4 Project

It needs to be repeated for a very few schools now that the Group 4 Project can only be used for the assessment of Personal Skills. Indeed, this is the only occasion when it is assessed. The Group 4 Project cannot be used for the assessment of Design, DCP, CE or Manipulative Skills.

Recommendations for the teaching of future candidates

- Read feedback from the previous session and act upon it.
- Consult the Online Curriculum Centre (OCC) for teacher support material (TSM)
- Apply the internal assessment criteria rigorously.
- Ensure that the open-ended theme set has enough scope to provide a variety of research questions.
- Give the candidates experience in identifying independent, dependent and controlled variables.
- Be sure that investigations used for assessment produce quantitative data.

- Encourage candidates to make additional observations about their experiment. It is good practice for them to keep a log book.
- Ensure that investigations have the potential to generate sufficient data for substantial processing.
- Teach the candidates that plotting graphs of raw data is often insufficient.
- Encourage candidates to carry out research into the background literature both before starting an investigation and once the results are complete.
- Do not use simulations for assessment.
- Do not use the Group 4 Project for assessment of D, DCP CE or MS. Only use it for Personal Skills. Inappropriate use will be sanctioned.
- Make sure that you are using the most up-to-date version of the 4PSOW form (available on the OCC).
- Check that all the parts of the 4PSOW form are completed correctly.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 15	16 - 21	22 - 25	26 - 29	30 - 33	34 - 40

General comments

Of the 21 G2 reports received by the time of grade award, 7 thought that the paper was of a similar standard to that of last year, 7 that it was a little more difficult and 4 that it was much more difficult. Almost all teachers thought that the level of difficulty was appropriate. Most teachers thought that the syllabus coverage and presentation were satisfactory or good, although a few felt that the clarity of wording was poor. Many thanks go to the centres who submitted G2s. It should be pointed out that this is based on a small sample. Teachers are urged to submit G2 forms as comments from them provide very useful feedback and are discussed as part of the Grade Award process.

There were many discriminating questions on the paper and a small number of questions that performed less well. It is surprising that many questions were not answered at all by candidates, as no marks are deducted for wrong answers.

The strengths and weaknesses of the candidates in the treatment of individual questions

Many questions performed in a predictable way and no comments need to be made about them. The comments that follow relate to questions where candidate performance was very good or very poor or to questions that aroused comment from teachers on G2 forms.

Question 3

There were some complaints on this question respecting its fairness. All the data was provided and all the candidates needed to know is how the t-test is applied. Not many candidates answered this question correctly, showing that this is a topic that needs to be covered in more depth while teaching. The question itself could be a good teaching resource.

Question 4

This question seemed to be easy for the candidates. It has been suggested that it would have been better if the word only had been bolded.

Question 7

This question had a very good discrimination index, showing that more capable candidates were able to answer it correctly and weaker ones were not. This question tested candidates on their knowledge of disaccharides and the enzymes digesting them. It also tested knowledge of the use of lactase in the production of lactose free milk. Many candidates wrongly chose B as the correct answer.

Question 10

This question had one of the best discrimination indices of the exam. Weaker candidates wrongly believed that lymphocytes only contain the genes to produce antibodies, not understanding that all of the genes are present and that only some are turned on.

Question12

This question proved very easy for most candidates.

Question 13

This question had the best discrimination index in the entire exam, testing assessment statement 7.3.2, sense and antisense strand of DNA. Weak candidates chose the complementary strand of DNA

Question 14

Although there were some complaints regarding the wording of this question, most candidates answered it correctly.

Question 15

This question was answered correctly by the majority of the candidates. Although many of them might not have known what argon is, there was no option for I and II alone, therefore the only possible answer was B.

Question 16

There were complaints about this question, stating that A, C and D were all correct answers. Although A is a true statement, it does not explain why resistance appears. C is also incorrect as it is not true that resistant bacteria reproduce faster than non-resistant bacteria; they tend to reproduce more slowly due to the fact that they contain plasmids generating resistance to antibiotics which need to be duplicated and at the same time they are growing under conditions that are not the most favorable for the bacteria. This question was a very good discriminator.

Question 17

This question proved quite easy for candidates yet at the same time, a good discriminator, showing that the question was generally well understood.

Question 20

Some candidates wrongly believed that antigens can be found in the cytoplasm of the cell.

Question 30

Many candidates wrongly believed that in the light independent reaction of photosynthesis, NADP is reduced.

Question 33

This question tested assessment statement 9.3.6. It was a good discriminator, yet quite an easy question.

Question 34

Some candidates did not believe that independent assortment was involved in recombination, therefore answering C instead of A. Mutations do not produce recombination; what they produce is a new characteristic. The answer could have been found without the last column, although this may have helped candidates in their decision.

Question 38

This question proved to be difficult for most candidates and was also a bad discriminator. Most candidates wrongly chose answer A. The question is based on assessment statement 11.3.6, where an explanation of the process of reabsorption of glucose is expected. This means that candidates should know about the cotransport of sodium.

Question 39

This question tested assessment statements 11.4.1 and 11.4.3 and the function of Sertoli cells was expected.

Question 40

Many candidates thought that the reference to germinal epithelium cells was to primary oocytes and spermatocytes and answered D. It was decided to accept both A and D in order to be fair to the confused candidates, although A is the correct answer.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 11	12 - 23	24 - 30	31 - 39	40 - 49	50 - 58	59 - 72

General comments

There were 25 G2 forms received, one more than last year. Many thanks go to the centres who submitted them. Over 80% of the replies thought that the paper was at least as demanding as last years, with all replies describing the difficulty of the paper as appropriate (85%) or too difficult (15%). 88% thought that the syllabus coverage was at least satisfactory, with the other 12% thinking that the questions were too heavily weighted towards topic 9 (plants). There was some criticism of the clarity of wording (21%) and the presentation (9%). It should be pointed out that this is based on a small sample. Teachers are urged to submit G2 forms as comments from them provide very useful feedback and are discussed as part of the Grade Award process.

The areas of the programme and examination that appeared difficult for the candidates

Antibiotics, monoclonal antibodies, population graphs, menstrual cycle, food chains/webs, and flower structure and pollination. Especially topics 4 and 9.

The areas of the programme and examination in which candidates appeared well prepared

Almost every question produced large numbers of very good answers from candidates who were adequately prepared. Q6 was often the choice of the weaker candidate and it showed.

The strengths and weaknesses of the candidates in the treatment of individual questions

Question 1

There were a few comments on the G2 forms that as question 1 was ‘about plants’, that the whole paper was biased towards topic 9. The main theme of Question 1 was genetics and of course data analysis, but it was based on data about plants.

a) The word ‘increment’ seemed to confuse the weaker candidates who stated a value rather than a range. In addition there were a large number who omitted or misquoted the units. In spite of being clearly stated in topic 9.3.5, very few candidates correctly gained the mark in part (iii) for saying that the amylase catalysed the breakdown of starch to maltose. Many answered glucose instead of maltose, but a surprising number did not even realise that amylase is an enzyme.

b) Most of the better candidates realised that it was a simple monohybrid cross (although several thought it was dihybrid) and realised that 25% would produce dwarf plants, but did not explain the consequences on potential yield in sufficient detail for the third mark.

c) In spite of doubts from the G2 forms, candidates had little difficulty in interpreting the photograph.

In part (i) most correctly answered *Sub1C.*

The answers to (ii) tended to be descriptive, not making clear differences, as asked.

d) Most candidates correctly identified *Sub1A* with a correct reason.

e) Most answered correctly that it increased the time before flowering.

In (ii) almost every correct answer was from the first two mark points.

In (iii) most candidates identified it as a short-day plant with reasons.

f) This was poorly answered. Many gained a mark for saying that if codominant then an intermediate phenotype would be expected for the heterozygote, but did not give sufficient justification from the given data. Weaker candidates confused the terms gene and allele.

g) In spite of the stem saying 'using all the data', most of the answers were very vague and did not use the data. The ideas that the mutant *gid1*-1 should be avoided as it produces sterile plants and those modified with *Sub* 1A would withstand seasonal flooding were missed by most candidates.

Question 2

Of all the comments received from the G2 forms, question 2 received by far the most. Most said that the photograph was difficult to interpret. If it had been in colour then it would have been far easier. However, as none of the candidates would have seen it in a book, it was fair for everyone.

a) A surprising number of candidates failed to gain any marks at all, not managing to identify I as the sepal, II as the ovary or receptacle and III as the petal. At the other end of the scale there were several centres whose candidates gained full marks. It seems that the teaching of Topic 9, Plant Science is very varied.

b) About half of the candidates correctly stated that the plant was an angiosperm, with most of the other half saying that the phylum was dicotyledons. Most stated that the violet petals would attract animals/insects, but did not 'comment on the hypothesis' as instructed. Many mentioned nectaries which could not be seen in the photograph. Few stated that the stigma was inside the flower (not evident from the central two flowers, but evident from the one shown in profile), so the pollen could be rubbed off as the animal entered. A surprising number replied that it was not due to animals, but due to insects.

c) Only about half of candidates were able to gain the mark for stating genus for *Campanula* and species for *persiciflora*. Fewer gained a second mark for saying that all members of C. *persiciflora* share unique features or that is a worldwide nomenclature.

Question 3

a) The two definitions of passive immunity and pathogen were quite well known.

b) The topic of monoclonal antibodies was very centre specific, with some centres missing it out of their schemes of work.

c) The effectiveness of antibodies against bacteria due to specific metabolic inhibition, as opposed to viruses (or their hosts), whose metabolism is not inhibited was not always fully understood.

Question 4

a) Most candidates gained some marks here with knowledge of functions of proteins with examples. However many answers were very descriptive rather than ‘stating with an example‘ as asked.

b) Most knew about the two ribosome subunits and the mRNA binding site. Very few knew that they were made from protein and rRNA. Several answered that there were 3 binding sites, but not what was bound there (tRNA) or what they were called.

c) The process of transcription was well known by most candidates who attempted this question.

Question 5

a) For assessment statement 11.4.6, candidates should be able to draw a labelled diagram of a mature sperm. These were 4 straightforward marks for well-prepared candidates, others gaining no marks. One common mistake was the drawing of a small nucleus, rather than one filling at least half of the head.

b) Well prepared candidates were able to explain the roles of FSH, estrogen, LH and progesterone. Others were totally confused. Many tried to answer with the textbook graph of the monthly hormone levels. An answer like this is acceptable if it includes sufficient annotation and can be clearly read.

c) Most candidates knew about transmission of HIV, although many still think that AIDS not the HIV is transmitted. The social implications were also quite well known, but correct biological answers gaining full marks for the cause were rare.

Question 6

a) Most candidates gained some marks for the shape of the sigmoid growth curve, but many lost a mark for not labelling the axes correctly, or due to inaccurate labelling of the stages. The command term used was label. Many candidates instead wrote at length trying to describe what was happening at each stage. In some cases this affected the ‘clarity of expression’ quality mark.

b) Food chains and webs seem to be concepts that candidates had come across, but had great difficulties explaining them. Examples given should be realistic and contain specific animals and plants (5.1.4 to 5.1.8), not just ‘insect’ and ‘bird’.

c) An alarming number of candidates still think that the greenhouse gases are kept in by the ozone layer or are part of the ozone layer. Most could identify some greenhouse gases, but few were able to explain the difference between the short wave solar radiation and the much longer re-radiated waves from Earth which are trapped by the gases.

Question 7

a) Many candidates automatically lost points for not showing the bacillus shape and/or including eukaryotic organelles. Diagrams are meant to be an accurate representation of the organism. Pilli and flagellae floating around outside the cell, not even touching the cell wall did not gain marks.

b) The process of mitosis was well known by the majority of candidates answering this question. Common errors were pairing the homologous chromosomes and explaining meiosis rather than mitosis. Many candidates included neat labelled diagrams for which marks could be awarded.

c) Many candidates were able to describe the link reaction, Krebs cycle, electron transport and chemiosmosis with almost textbook precision. Others tried to draw half remembered diagrams, hoping for the best and not scoring many, if any, marks.

Recommendations and guidance for the teaching of future candidates

Topic 4 – Ecology and evolution and Topic 9 – Plant Science. Sufficient time does not seem to be spent on these topics in many centres. This was very evident from the answers to Q2 and Q6. Even experienced teachers do need to revisit the specification periodically to ensure complete coverage. The candidates should also have a copy of the syllabus.

Examiners can take marks from clearly labelled diagrams, thus aiding candidates who like to answer in a more visual way.

The understanding of the command terms used at the start of each question has improved over the last few years. Too many candidates however, think 'if I write everything I know about the topic, then the answer will be in there somewhere'. Teachers should ensure that candidates have a copy of the command terms and that they understand them.

As in previous years many candidates did not answer in the space provided, requiring several extra answer sheets. Whilst some candidates have very large writing, and others will always want to add another sentence, the space provided should be an indication of the maximum length of response. Many candidates repeat the root of the question before starting their answer, thus using up a significant number of lines. If an answer is continued on an extra sheet, the candidate must indicate this at the end of the space provided for the question or they will run the risk of the continuation being missed by the marker (due to the rigorous checking procedures this is very rarely a significant problem but it could happen). It was encouraging to see well prepared candidates who collected their thoughts by writing a few key words in the margin before starting to answer, or used a highlighter to aid their comprehension of Question 1. However the use of highlighters in the body of the answers should be discouraged, as with the advent of e-marking, highlighted words and crossed-out words may appear the same in a scanned document.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 10	11 - 14	15 - 19	20 - 23	24 - 28	29 - 40

General comments

There were 23 G2 forms completed. All respondents felt that the paper was similar to or a little more difficult than last year's paper. As for the level of suitability, 19 felt that it was at the appropriate level of difficulty while 4 believed it was too difficult. The majority felt the syllabus coverage was satisfactory or good. The clarity of the wording was found to be suitable or good by most of the respondents as was the presentation of the paper.

Teachers' comments are all considered at the Grade Award Meeting and all teachers are encouraged to fill out the G2 Form at the end of each examination session. The actual percentage of teachers who do this is very small. Options D, E and G were the most commonly chosen options. Option H was frequently chosen while very few candidates chose Option F.

The areas of the programme and examination that appeared difficult for the candidates

In data-based questions, candidates found difficulty in the evaluating. In many cases, answers to questions were given without referring to the actual data. The data based questions in Options F and H were particularly difficult for candidates. Divergent and convergent evolution proved to be a topic that candidates found difficulty in understanding. Candidates were not able to provide clear definitions of allele frequency and gene pool, nor were they able to provide an outline on how variations in specific molecules can lead to phylogeny. There were very poor answers in the explanation of bioremediation of water. In Option H, recognition of the cells in the micrograph proved difficult.

The areas of the programme and examination in which candidates appeared well prepared

Many candidates could not answer questions to the depth required by the mark scheme. Graphs and tables were read well in general but analysis and evaluation was poor. Some candidates showed knowledge in only one option. Other candidates attempted to answer all the options, inevitably scoring very low marks.

The strengths and weaknesses of the candidates in the treatment of individual questions

Option D

Question 1

Many candidates responded correctly to (a) and (b), although some candidates only stated one of Ile and Glu. For (d) the better candidates said the evolution was convergent, rather than divergent, because a different ancestor and a similar function (analogous structures versus homologous structures as in the mitochondrial and bacterial dismutases) seemed more likely. Many lost points by simply indicating that evolution was divergent without a reason. Many candidates were familiar with the endosymbiotic theory and gained marks in (e).

Question 2

Definitions tended to lack some detail or not be fully correct. The assumptions of Hardy-Weinberg were known to the majority, but candidates had trouble with the question regarding how variations in molecules can lead to phylogeny, confusing the study of evolutionary relationships with the actual development of the relationships themselves.

Question 3

The question was very poorly answered. It appeared that either the candidates did not understand the question or had not studied the incompleteness of the fossil record and the resulting uncertainties concerning human evolution. Most candidates gained only a few marks in this question mainly to fossils being formed, preserved and found being rare events.

Option E

Question 1

Most candidates performed well in the data analysis with (e) being the best discriminator of the better candidates. Some candidates had a hard time recognizing the importance of the timing of spawning to fertilization in part (b), or to avoiding cross-breeding in part (c) and instead related it to the presence of predators. In part (d), many candidates discussed the hypothesis, not in relationship to the data but rather to the potential causes of a possible chemical signal.

Question 2

Most definitions were incomplete. A large majority could list stimuli and receptors, but a significant number gave very general answers, for example sound in ears. Weaker candidates were more likely to describe the pain withdrawal reflex rather than how pain is perceived. In (c) most candidates earned at least one mark outlining how pain is perceived. The most common response was that endorphins act as painkillers.

Question 3

Generally question 3 was well-answered, although some candidates only wrote about cocaine and its effects, and weaker candidates discussed the effects of addiction rather than causes.

Option F

Question 1

Many could calculate the percentages correctly, but demonstrated a total lack of understanding of the data. There was quite a bit of confusion about the poultry being resistant to bacteria rather than the bacteria found in the poultry being drug resistant.

Question 2

This question was not very well answered by most candidates.

Question 3

Few candidates answered this question well. It is important to note that this option, in many cases, seemed to be answered by the occasional candidate within a school where the majority of candidates answered other options. Some understood that bacteria could decompose contaminants, but with no mention of oil, and certainly no differentiation between methods or details of any sort.

Option G

Question 1

About half of the candidates could relate the peaks at different times. Most read the week well and calculated the difference in peaks well, but the evaluation of the effect of increased precipitation was poor.

Question 2

Earthworms were recognized as primary consumers, many candidates could state the proportion of energy received and could indicate that the earthworms were using wastes to produce foods. The effects of UV radiation on living tissues were generally well understood.

Question 3

A good number of candidates gave fairly complete answers. Many candidates did not discuss any disadvantages of *ex situ* conservation.

Option H

Question 1

That initial dip in results was not recognized by a good number of candidates. The effect of moderate amounts of alcohol was rarely complete, and although many deduced the best marker, few could give a reason. For part (d) candidates focused on the causes and prevention of CVD therefore scoring hardly any marks.

Question 2

The cell types and structures in the micrograph of the liver were not well identified. The rest was answered well enough.

Question 3

There were some very complete answers and some very weak ones. Many talked about Bohr shift instead of explaining the graphs.

Recommendations and guidance for the teaching of future candidates

- Revise the command terms from the syllabus guide frequently and before the exam, e.g. discuss involves giving arguments for and against or stating advantages and disadvantages.
- Practise past paper data analysis questions using the corresponding published mark schemes.
- Concentrate on teaching and learning two options well, rather than more options superficially.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 11	12 - 14	15 - 18	19 - 22	23 - 26	27 - 30

General comments

Of the 23 G2 reports received by the time of grade award, 9 thought that the paper was of a similar standard to that of last year, 8 thought it was a little more difficult, 2 that it was much more difficult and 1 that it was a little easier. Most teachers thought that the level of difficulty was appropriate, and only 5 believed it was too difficult. All teachers thought that the syllabus coverage and presentation were satisfactory to good although 4 believed the clarity of the wording to be poor. Many thanks go to the centres who submitted G2s.

It should be pointed out that this is based on a small sample. Teachers are urged to submit G2 forms as comments from them provide very useful feedback and are discussed as part of the Grade Award process.

There were many discriminating questions on this paper. Many candidates left questions 9, 15, 23 and 27 blank. This is a shame, as no marks are taken off for wrong answers.

The strengths and weaknesses of the candidates in the treatment of individual questions

Some questions performed in a predictable way and no comments need to be made about them. The comments that follow relate to questions where candidate performance was very good or very poor, or to questions that aroused comment from teachers on G2 forms.

Question 3

Many candidates confused correlation with causation. They believed the increase in biomass in the worm was due to the increase in organic nitrogen. This is causation, when the graph is really showing a correlation between biomass of the worms and percentage of organic nitrogen.

Question 6

This question had the highest discrimination index in the entire exam. Weak candidates answered it incorrectly and stronger candidates correctly. The question refers to the amount of DNA during the cell cycle, so it can be assumed that it is per cell. Many candidates wrongly answered B as the part of the graph representing metaphase. The mass of DNA is measured in picograms. At this stage of mitosis, the amount of DNA has already been duplicated, so C is the correct answer.

Question 9

There was a complaint about the difficulty of this question. It tested thinking skills and complementary base pairing. Many candidates left this question blank.

Question 10

It was surprising to see that many candidates believed that freezing to -20°C could cause permanent lose of properties in an enzyme. Very few candidates answered hydrolysis, perhaps knowing that this is a function of enzymes, but thinking that they cannot be hydrolyzed themselves.

Question 11

This question had a very good discrimination index, showing that more capable candidates were able to answer correctly and weaker ones were not. This question tested candidates' knowledge of disaccharides and the enzymes digesting them. It also tested the knowledge of the use of lactase in the production of lactose free milk. Many candidates wrongly chose B as a correct answer.

Question 13

This question had one of the best discrimination indices of the exam. Weaker candidates wrongly believed that lymphocytes only contain the genes to produce antibodies, not understanding that all genes are present and that only some are turned on.

Question 14

Although there was a complaint about the clarity of wording in this question, yet it proved easy for most candidates.

Question 17

This question had one of the best discrimination indices in the entire exam, testing assessment statement 7.3.2, sense and antisense strand of DNA. Weak candidates chose the complementary strand of DNA.

Question 20

Although there were some complaints regarding the wording of this question, candidates seemed to have no problems answering it correctly.

Question 21

Most candidates wrongly believed that natural selection causes variation within a species.

Question 22

There were complaints about this question, stating that A, C and D were all correct answers. Although A is a true statement, it does not explain why resistance appears. C is also incorrect as it is not true that resistant bacteria reproduce faster than non-resistant bacteria; they tend to reproduce more slowly due to the fact that they contain plasmids generating resistance to antibiotics which need to be duplicated and at the same time they are growing under conditions that are not the most favorable for the bacteria. This question was a very good discriminator.

Question 23

Many of the weaker candidates wrongly believed that Platyhelminthes have segmented body while Annelids did not.

Questions 29 and 30

There was a comment that there were two questions on the female reproductive system and none on the male. Although they were different topics in the guide, thus still valuable questions, this suggestion will be kept in mind in future paper settings.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 19	20 - 26	27 - 33	34 - 40	41 - 50

General comments

There were 26 G2 forms received. Many thanks go to the centres who submitted them. 15 of the replies thought that the paper was at least as demanding as last year's. All thought that the syllabus coverage, clarity of wording and the presentation were at least satisfactory. It should be pointed out that this is based on a small sample.

Teachers are urged to submit G2 forms as comments from them provide very useful feedback and are discussed as part of the Grade Award process.

The areas of the programme and examination that appeared difficult for the candidates

In this paper, a disturbing number of candidates left questions unanswered. In other cases, answers were unworthy of a mark because of inaccuracies and/or inadequate depth. The following areas (relevant assessment statements noted) troubled candidates.

Percentage change calculations using bar graph data; error bar analysis in bar graph data (1.1.1); binomial system of nomenclature application to real data (5.5.1); gel electrophoresis data interpretation (4.4.2); how non-disjunction in meiosis can change the chromosome number (4.2.4); specific functions for membrane proteins (2.4.3); reasons for antibiotic effectiveness against bacteria but not viruses (6.3.2); and, polymerase chain reaction (PCR) use to copy and amplify DNA (4.4.1).

Photosynthesis overview with details about light energy capture and the uses of light energy and consequent chemical energy (3.8.2-3.8.6); the significance of complementary base pairing, not only in replication but also in transcription and translation (3.4.1, 3.5.2, 3.5.4); sigmoid population growth curves with correct labelling (5.3.2); food chain and food web descriptions supported and clarified through specific examples (5.1.4, 5.1.5); the relationship of rising concentrations of named atmospheric gases with the enhanced greenhouse effect(5.2.3); details about heartbeat control (6.2.4); HIV as the infectious agent AIDS transmission and HIV mode of attack (6.3.7).

The areas of the programme and examination in which candidates appeared well prepared

Many candidates demonstrated basic data analysis skills by correctly answering the first question about the bar graph data and by gaining some of the marks for the questions derived from the data in the electrophoresis photographs. Quite a few candidates were able to correctly identify the phase of cell division occurring in the electronic images of an actual cell (2.5.4). There was modest recall of facts about the processes of mitosis and tumour formation (2.5.6, 2.5.2). Many candidates knew Down syndrome as an example of how non-disjunction changed the chromosome number (4.2.4). Excellent understanding was often seen explaining why digestion of large molecules is needed and sometimes seen outlining why antibiotics are effective against bacteria but not viruses (6.1.1, 6.3.2). Most candidates knew an application of PCR technology, although that was not the direction of the question (4.4.4).

Various elements and their respective roles in living organisms (3.1.2, 3.1.3) and four molecules transported by the blood were known well (6.2.7). Many candidates knew common means of AIDS transmission and thoughtful, sometimes eloquent, passages were written about the social implication of AIDS (6.3.8).

The strengths and weaknesses of the candidates in the treatment of individual questions

Question 1

a) (i) Generally well done. A few wrote only GMF.

(ii) Little understanding shown. Many divided the difference in height by 50 instead of 22.

b) Candidates often showed a general understanding of the error bar concept but the remaining marking points were rarely given, even by the better candidates. They did not observe that the error bars were about the same length for day 0 and day 11 nor did they fully understand that the overlapping bars indicated little difference in the data or that 68% of the plants fell within one standard deviation.

c) Many candidates worded generalized relationships such as the higher the tolerance, the less the growth or growth and tolerance were inversely proportional. Sometimes 'height' was given rather than 'growth.'

d) The designation of *Oryza* as genus and *sativa* as species was the only marking point that many candidate got correct in this question, although some candidates mixed up the terms calling *Oryza* the species and *sativa* the genus. Very few candidates went beyond to mention that *O. sativa* shared special features. Even fewer candidates mentioned that the varieties *japonica* and *indica* had differences in tolerance. Occasionally, a candidate mentioned that binomial nomenclature helps scientists communicate about the same plant or the worldwide acceptance for the terminology.

e) (i) Some candidates did not appreciate that the actual production of each gene was indicated by the intensity of the bands shown on the photograph of electrophoresis.

(ii) Since the question asked for differences in mRNA production for the three genes, it was important that candidates used quantitative wording such as *Sub1A* produces the 'most' mRNA or that *Sub1 B* produces the 'lowest' or 'least' mRNA to convey a sense of comparison. A few candidates noted that *Sub 1 A* produced mRNA for the 'longest' time/days 1 to 0 and/or that *Sub 1 C* produced mRNA for the 'shortest' time/days 3 to 7.

(iii) Many valid comparisons could be made comparing the mRNA production for the three genes. Most often given was that *Sub1A* only produced mRNA in *japonica* and/or never in *indica.* The two mark maximum was achieved frequently.

f) The question was poorly answered. Though *Sub1A* was sometimes correctly identified as the gene to modify GMFC, reasoning to support that answer was usually incorrect or missing.

g) Many candidates missed the question by trying to relate GMFs to drought conditions rather than flooding. GMFs offered tolerance to submersion enabling them to withstand flooding so that greater harvests/food production were ensured during flooding.

Question 2

a) Anaphase was usually given, perhaps Image II had not been studied in relation to Images I and III.

b) Some candidates understood the question to mean phases of mitosis. Others wrote ambiguous answers such as 'repair' instead of 'tissue repair'.

c) Mainly correct. It was essential to include the term 'uncontrolled.' A few candidates were unclear about tumour formation and answered 'mutation.'

d) There were very few descriptions of how non-disjunction in meiosis can produce a change in the chromosome number. However, the example of Down syndrome where there is an extra chromosome 21 was almost always given.

Question 3

a) Functions were asked for, not named structures. 'Channels' and 'pumps' by themselves were too vague to gain marks.

b) The idea of food breakdown to a small enough size for absorption was the easier mark achieved by many. Some candidates wrote that food had to be 'digested' but 'digestion' was written in the stem of the question and too vague for credit.

The idea of food breakdown for eventual reorganization/rearrangement rarely appeared in any answer, perhaps indicating a conceptual gap in candidate understanding of digestion.

c) There was a complete misunderstanding of this question. Almost no candidate seemed to realize that the question was asking for how the PCR can copy and amplify minute quantities of DNA. Thus, the process was either unknown or ignored so marking points were immediately lost. In contrast, almost every candidate knew forensic science as a use of PCR, thereby salvaging one mark.

Question 4

a) In general, well answered by those candidates who attempted the question. The syllabus content appeared to be well understood.

b) Most candidates mentioned the conversion of light energy into chemical energy during photosynthesis. Many candidates also referred to events of photolysis for additional marks. A common omission was reference to the wavelengths absorbed or reflected by chlorophyll. Finally, candidates wrote about fixation of carbon dioxide to make organic molecules but neglected to mention that the process requires ATP and hydrogen.

c) Reasonable accounts were given, though more emphasis was placed on replication than the other processes. Weaker candidates failed to mention identical nucleotide sequences in replication. For most candidates, the importance of complementary base pairing needed more development in transcription and translation. The complementarity of codons and anti-codons was often missed. Many times valid ideas were left undeveloped but then continued elsewhere in the essay. Some essays were embellished by good quality illustrations. Occasionally, understanding of the three processes was very muddled with some candidates describing mRNA as going into the nucleus to copy DNA.

Question 5

a) Candidates often drew poorly shaped sigmoid graphs in which the label lines did not clearly show each phase. The vertical axis was often simply labelled 'population' rather than 'population size' or 'population number'. Most identified the plateau correctly.

b) In general, a poorly answered question. Candidates drew simplistic or inaccurate food chains and rarely connected the concept of trophic levels with transfer of energy or nutrients. Reference to multiple producers in food webs was usually lacking.

c) Many answers did not distinguish between atmospheric gases and greenhouse gases. Few candidates were able to write about the shorter radiation from the sun and the longer radiation that is re-radiated. Some answers classically confused the greenhouse effect with the ozone layer.

There was no clear understanding of the effect of an increase in global temperature in leading to imbalance and climate change. Many answers were based around emotional arguments about the state of the planet.

Question 6

a) Generally this question was answered well. Weaker candidates did not give an example of a nutrient. The weakest candidates wrote about red blood cells, white blood cells and water being carried in the blood.

b) Some candidates mentioned that the heart is myogenic but most based heartbeat control on the pacemaker. Answers included stimulation of the atria but not the subsequent contraction of ventricles. Many did not seem to understand that the two atria contract simultaneously followed by simultaneous contraction of the two ventricles. Descriptions of neural control and hormonal control varied greatly. The idea that secretion of acetylcholine by nerves can reduce the pace was never given. A few candidates only knew heart anatomy so drew a diagram and described flow of blood through the heart, to no avail.

c) The AIDS question was generally answered well. Though the marks gained were spread over cause, transmission and social implications, there were gaps. Many candidates did not seem to understand how HIV affects lymphocytes. There was almost no mention of reverse transcriptase enabling DNA to be produced from RNA. Despite much detail about how the virus is transmitted, few candidates mentioned the uneven transmission of HIV throughout the world. Many candidates wrote in depth about the social implications of AIDS. Often, the ideas were exceptionally well-expressed.

Recommendations and guidance for the teaching of future candidates

Teachers need to model key calculations, such as percentage change, with lab data in the classroom. Skills in using magnification and error analysis must be reinforced in the practical scheme of work.

Teachers need to make their candidates familiar with the command terms used in questions, so that their answer are more appropriate to the question. The command term “outline” can be a challenge when writing answers. Candidates must be able to summarize information or draw conclusions. This is especially true when looking for trends in graphs where individual fluctuations may preoccupy candidate thinking. ‘Compare’, ‘deduce’, ‘explain’ and ‘evaluate’ are listed as objective 3 in the guide and require more substantive answers.

Teacher should alert candidates to note the mark value for particular questions and advise them to supply at least one key idea per mark.

Class time must be devoted to data analysis questions. This will allow candidates to develop and practise their skills of interpretation and deduction.

Answering Section B questions should be practised so that candidates can learn to set out their ideas in a clear, concise fashion, without undue repetition of points. When a theme topic is given, such as in Q4c, it must be fully addressed and maintained throughout the essay,.

Candidates must be able to discuss environmental issues in a scientific fashion, without falling into the trap of emotional jargon. Past papers can be used with their mark schemes to foster better quality answers.

In teaching digestion, teachers should emphasize not only food breakdown to a size enabling absorption, but also the ideas that small sized molecules can be reorganized or rearranged.

In teaching ecology, do not allow candidates to use ‘man’ in biological food chains and webs. Food chains such as grass $\rightarrow$ cow $\rightarrow$ human are too simplistic. The greenhouse effect must be clearly distinguished from problems with the ozone layer.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 4	5 - 9	10 - 13	14 - 18	19 - 22	23 - 27	28 - 36

General comments

The comments on the G2 forms indicated that almost all of the 26 respondents felt the paper was similar to or easier than last year's paper. As for the paper's level of suitability, 25 felt it was at the appropriate level of difficulty with the remaining respondent thinking it too difficult. The majority, 24, felt the syllabus coverage was satisfactory or good. The clarity of the wording was found to be suitable or good by 25 of the respondents as was the presentation of the paper. Teachers' comments are all considered at the Grade Award Meeting and all teachers are encouraged to fill out the G2 Form at the end of each examination session. The actual percentage of teachers who do this is very small.

Options A, D and G were the most commonly chosen options. Options B and E were frequently chosen. Very few chose Option C or F.

The areas of the programme and examination that appeared difficult for the candidates

In data analysis questions, candidates did not explain or evaluate data when asked to; instead they often described the data which did not gain marks. Definitions were often poorly stated, even where they are clearly given in the syllabus.

Topics which proved difficult were: micrograph of striated muscle, effects of exercise long-term on the heart, date and distribution of *Australopithecus afarensis*, role of CNS in decision making, parts of cell wall of Eubacteria, production of soy sauce and the role of selection in processes such as in transient polymorphism or punctuated equilibrium

The areas of the programme and examination in which candidates appeared well prepared

Some candidates produced very good scripts and it was obvious they had been given sufficient time and instruction to cover the two options thoroughly. They were able to analyze the data in Question 1 as well as indicate their level of subject knowledge in the following questions.

In general, candidates tended to do well on the data analysis questions, with the exception being Option F.

One area of difficulty continues to be interpreting the command verbs and thus knowing what precisely is required to answer accurately. 'Evaluate', 'explain' and 'compare' were often problematic. Many candidates did not answer 'compare' questions correctly; they described the two items and hoped for marks that way. Also, when answering a question in which they were asked to 'discuss' an idea, candidates need to remember to include both positive as well as negative possibilities. There seems to be an emphasis on the negative factors only.

The strengths and weaknesses of the candidates in the treatment of individual questions

Option A

Question 1

This was a conceptually difficult question for many candidates

a) Most candidates read the graphs correctly to obtain the correct numerical values but a surprising number lost marks for not including units.

b) Most candidates were able to get two marks for recognizing that although both mutant and normal mice showed an increase in calcium levels over time, the normal mice had a greater increase which was rapid and then plateaued while the mutant mice had a more gradual increase. Candidates need to be careful that when they answer a compare question, that they actually compare the two items requested rather than simply describe each.

c) Candidates struggled with this question as they did not 'explain' the changes in blood calcium levels; they simply stated what was in the graph. Those who did attempt an explanation, understood that the mice with a low calcium diet would need to absorb more calcium and therefore the increase in blood calcium levels would be more. Very few commented on that fact that receptors were involved in some way.

d) Candidates also struggled with this question. Stronger candidates were able to get two marks for the support of the hypothesis shown in graph A or that it was not supported as shown in the lower absorption of calcium in high calcium diets in graph B. No candidates commented on the idea that that the investigation did not test mutant mice on different diets.

Question 2

a) (i) Many candidates were able to get 2 out of the 3 available marks for stating that the appetite control centre causes a sensation of being full and then stating one message sent to the centre after eating. Stretch receptors were often incorrectly stated as being in the small intestine or pancreas and few added that leptin was produced in response to fat storage by adipose tissue.

(ii) This question asked candidates to outline the implication of the given BMI. Therefore more was expected than simply stating that the person would be underweight.

b) This question was straightforward; the only problem being some vague answers just stating 'protein' without being specific for human whey, casein or albumin.

Question 3

There were some very good answers earning maximum of 4 marks; all possible marking points were given. In this case, stronger candidates did discuss positive and negative results of high food miles.

Option B

Question 1

a) All candidates saw the positive correlation in the data.

b) Almost all candidates were able to get the 2 marks for distinguishing between the HAD activity and mitochondrial concentration of non-swimming muscles of sea lions and fur seals.

c) Many candidates gained 1 mark for noting that swimming muscle had a greater mitochondrial concentration than non-swimming muscle but few received 2 marks. Only the better candidates saw that the range of HAD was similar in both muscle types. Many candidates incorrectly went through and listed the values of both muscle types in all of the Pinnipeds.

d) Most candidates struggled with this section and some were able to get two marks for understanding that more mitochondria mean more aerobic respiration and that the products of fatty acid oxidation could be used for respiration, without really understanding whether the data supported the hypothesis or not.

Question 2

a) Surprisingly few candidates were able to correctly label the micrograph of striated muscle. They confused myosin with actin and the dark band/A line with the sarcomere.

b) Most got this wrong, as they stated that vital capacity would increase significantly with training, when in fact the increase is slight if any. Most reports seem to indicate no effect of training on vital capacity although there may be increased efficiency of respiratory system which is not the same. Many also discussed effects of training on the heart which was irrelevant here.

Question 3

a) Candidates did not consider the long-term effects of exercise on either muscle or heart rate. They instead indicated what happened to these during exercise. Many gained one mark as they understood that different types of muscle fibres were involved in the different exercises but some did not mention that the different types of exercise stimulate development of these muscles. Very few candidates indicated that both types of exercise would result in decrease of heart rate at rest.

b) Many candidates were able to evaluate the risks and benefits of blood transfusions in sports and were thus able to get 3 or 4 marks.

Option C

Question 1

a) Candidates were able to correctly identify the enzyme activity using the graphs.

b) Most saw that the wild-type enzyme had greater activity than the mutant form.

c) There were some good responses earning 2 out of 3 marks but few responses earned full marks.

d) This question was difficult for the candidates and very few answered it correctly. A few candidates earned one mark for stating that the activity of the mutant enzymes without the inhibitor is always lower than the wild-type but they were not able to evaluate the data to identify differences in sensitivity to the inhibitor.

Question 2

a) Many candidates could correctly identify two products of glycolysis.

b) Many scored 2 or 3 marks on the movement of hydrogen ions during chemiosmosis. Candidates seemed to clearly understand the proton gradient and the role of ATP synthase in the production of ATP.

c) Most candidates were able to identify two limiting factors. Some were careless simply stating light rather than light intensity and therefore did not get the mark.

Question 3

Many candidates received 2 or 3 marks for differentiating between the globular and fibrous proteins shown as well as knowing either the differences in solubility or function. Candidates did not mention that hemoglobin consists of four polypeptides whereas keratin does not or that hemoglobin has a prosthetic/heme group while keratin does not. Many were incorrectly stating that keratin has only a secondary structure and hemoglobin has a tertiary structure which is not an accurate statement. The diagram showed links (disulphide bonds) between two alpha-helices to form the tertiary structure of keratin. Both have secondary and tertiary structure but they are different and this was not made clear.

Option D

Question 1

Many candidates did well on this data analysis question with many obtaining full marks.

a) Almost all indicated correctly that 11 amino acids were in the same position in the three dismutase sequences.

b) Most were able to correctly identify Ile and Glu as present in the same position.

c) Most were able to get two correct comparisons. Some carelessly indicated that the common element was magnesium rather than manganese despite the fact this was stated in the stem.

d) This was poorly answered by many candidates who seemed to guess. Those who did get the mark, got it for stating that this was most likely to be divergent evolution as the cytoplasmic dismutase shows a greater number of differences than the other three enzymes. One word answers for questions that ask candidates to outline or explain will not be enough to get a mark.

e) Most candidates received 2 marks for this section. Good descriptions of the endosymbiotic theory were often given.

Question 2

a) There was a good understanding of half-life although some incomplete definitions were seen which did not earn the mark. Most correctly saw that the half-life for strontium-90 was approximately 28 years.

b) This question was poorly answered with few getting any marks. Candidates were not always clear where *Australopithecus afarensis* was found; some vaguely said Africa but they needed to be more specific with East Africa. The range of dates was also inappropriate in many cases.

Question 3

a) Many received the full 3 marks for describing transient polymorphism but few mentioned the role of selection pressure specifically. The only example given by candidates was of industrial melanism.

b) There were some good answers to this section with many receiving 2 or 3 marks for the question on punctuated equilibrium. However, few mentioned the idea that rapid environmental change caused directional selection which leads to evolution. Some candidates incorrectly compared punctuated equilibrium with gradualism.

Option E

Question 1

a) Almost everyone correctly identified the range of spawning requested.

b) Few candidates were able to clearly express that the tight time frame of spawning of males and females of a species increased the possibility of fertilization. Many mentioned predators and carried this on into part (c) rather than looking at fertilization.

c) Many candidates gained 1 mark for suggesting that different spawning windows for different species avoided interspecific fertilization but few were able to get a second mark. Some were able to state that such cross-fertilization was usually non-productive.

d) Most candidates answered correctly that temperature would affect spawning. A few gave the time of sunset. Other possibilities such as the phase of the moon, time of year or season were seldom seen.

e) Many received full marks.

Question 2

a) The labelling of the spinal reflex was fairly well done. The structure that caused problems was the dorsal root ganglion with some indicating this was a sensory cell body.

b) This question proved difficult for many candidates. The role of excitatory and inhibitory presynaptic neurons was not clear. Candidates had difficulty articulating the idea of summation. Some instead discussed the idea of excitatory and inhibitory drugs; others described the reflex arc in part (a). None mentioned that different transmitter substances are produced.

Question 3

a) Almost everyone received at least two marks for the outline of Pavlov's experiment and many received the full three marks.

b) Most received the full 2 marks for this section on hearing as well.

Option F

Question 1

The few candidates who attempted this option struggled with this data analysis question. There was quite a bit of confusion about the poultry being resistant to bacteria rather than the bacteria found in the poultry being drug resistant. This caused problems in all parts of this question except (a).

a) Most were able to correctly do the calculation of percentage.

b) Few received more than 1 mark for this section. The only point that was made was that egg-laying hens had a lower incidence of antibiotic-resistance bacteria than chickens.

c) Inability to understand what the table indicated meant that few were able to discuss the hypothesis given.

d) Many were able to get the 1 mark here for accidental contaminated hand to mouth contact. Those who indicated humans received the bacteria from animals when eating meat did not mention this was caused from raw meat.

Question 2

Both parts of this question were poorly answered.

a) Many candidates were not able to distinguish between Archaea and Eukarya. A few mentioned the different size ribosomes but that was all.

b) Labelling the part of the Gram-positive and Gram-negative cell walls was a problem as many candidates did not know the names of the layers.

Question 3

a) There were surprisingly poor responses to the question on the production of soy sauce although this has appeared frequently. Those candidates that received marks mentioned fermentation and the addition of *Aspergillus* but were not clear what the main ingredients were or what the products of the fermentation were.

b) Some good answers gaining 3 or 4 marks were seen for this section on the consequences of releasing raw sewage into rivers. However, there was still quite a bit of confusion with ideas not being clearly expressed.

Option G

Question 1

a) The majority of candidates correctly stated that week 107 had the highest human biting rate (HBR).

b) The majority were able to correctly do the calculation.

c) Almost all candidates gained 1 mark for stating that both species show a relationship between elevated precipitation and higher HBR and many received a second mark, often for commenting on the lag between precipitation and increase HBR. Some were able to identify other effects as well.

d) There were many vague answers to this section which did little more than repeat the question without giving a specific reply. A specific action was required such as use of mosquito nets or spraying insecticides rather than stating that ‘protection is needed’.

e) Most were able to give a factor that could affect mosquito distribution.

Question 2

a) There were some very good answers to this question. Most candidates were able to distinguish between realized and fundamental niches.

b) The descriptions of primary succession were not clear or detailed enough. Few used the words pioneer or climax community. Many incorrectly referred to the first plants as mosses rather than lichens. Despite this, the generous mark scheme allowed many to gain 2 marks.

Question 3

a) Labelling the pyramid of energy was a very easy 3 marks for the majority of candidates.

b) Many candidates gave specific examples of alien species rather than discussing the impact of these on the environment. While describing examples however, candidates tended to touch on their impact and get 2 or 3 marks.

Recommendations and guidance for the teaching of future candidates

- Use the action verbs in homework, tests and exams to make candidates familiar with the question stems so that they understand what is required of them when they are asked to 'describe', 'compare', 'evaluate' or 'explain'.
- Practise good exam technique. There is no need to repeat the stem or question, as candidates will not get extra marks and this uses up the space needed to answer the question.
- Past papers should be examined and practised by candidates. Many did not follow instructions and instead of answering in the space provided, answered all sections on continuation sheets; this is poor examination technique, as they have no idea of the length of answer required or of the marks available. If extra sheets are used, this should be indicated at the appropriate point on the script.
- Sufficient time should be allotted for the teaching of the options. Teachers should choose the options according to their own strengths so that the candidates benefit by the knowledge and enthusiasm of the teacher.
- The options should not be left for self-study. It needs to be ensured that candidates acquire the depth of knowledge required to be successful on this paper. Discussing topics in general does not help.
- Practise interpreting data in different formats. Use past papers throughout the 2-year programme to develop this skill.
- Use past examination papers and mark schemes as well as the CD Question Bank to provide suitable questions so that candidates are familiar with the examination format.
- Where the syllabus asks for an unspecified example, teachers need to ensure that this is covered.
- Give guidance on the appropriate length of answers as candidates should not write as much for a 1 mark answer as they do for one worth 4 marks.
- Candidates should know that they answer in the spaces provided and that the number of lines is a guide to the length of answer expected.
- All teachers need to attend workshops periodically.