May 2014 subject reports

Biology Time Zone 1

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 28	29 - 39	40 - 52	53 - 65	66 - 78	79 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 30	31 - 42	43 - 54	55 - 67	68 - 79	80 - 100

Time zone variants of examination papers

To protect the integrity of the examinations, increasing use is being made of time zone variants of examination papers. By using variants of the same examination paper candidates in one part of the world will not always be taking the same examination paper as candidates in other parts of the world. A rigorous process is applied to ensure that the papers are comparable in terms of difficulty and syllabus coverage, and measures are taken to guarantee that the same grading standards are applied to candidates' scripts for the different versions of the examination papers. For the May 2014 examination session the IB has produced time zone variants of Biology HL/SL papers.

Higher level internal assessment

Component grade boundaries

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 internal assessment

Component grade boundaries

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

General comments

Most schools used appropriate investigations of a good standard. A serious problem persists however in some schools that are setting investigations for assessment that give too much guidance or insufficient latitude.

From the 2016 IA submission, the Individual Investigation, the internally assessed component of the new program, will require an individual approach. Students cannot work in groups or work on the same investigation on this assignment.

In most schools the criteria are being applied rigorously but in a few schools the teachers seem to be ignoring the descriptors of the different aspects. In these cases the work had to be marked down.

Ethics

Moderators continued to comment on investigations that were unsafe or unethical.

In many schools the IB Animal Experimentation Policy (available of the OCC) is adhered to while in a few it seems to be disregarded. These schools should review the investigations carried out in light of this policy and ensure that all experiments are considered from an ethical point of view.

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 student based on its ethical implications and how to refine the experiment to alleviate any harm or distress to the animal; to reduce the number of animals involved, or to ultimately replace the use of animals by using cells, plants or computer simulations. Any call for human volunteers in experiments must be accompanied by a consent form. Investigations on human subjects must not place the volunteers at risk. Moderators are reporting investigations that are quite inappropriate, for example the sampling of a wound to obtain bacteria to test for antibiotic resistance. This should not happen if the teacher is properly supervising the students.

These rules equally apply to those student-designed investigations that are not intended to be followed through in a practical session. Some teachers and students still seem to think that if it is not followed through they can ignore ethical principles. In these cases the teachers are clearly not counselling their students on what is ethically acceptable.

Exposing animals to conditions normally experienced in their natural environments is permissible. It is good practice to include a discussion with the students 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. Exposing them to caffeine, alcohol or energy drinks is not appropriate. Exposing them to conditions outside their normal environmental tolerance limits is not appropriate.

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

Situations that deliberately demand the euthenising of animals are not 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 assessed using the current IA criteria).

Dissections are a special case in biology. The guidelines are quite clear on this. The practice of dissections because they are a traditional part of biology course is not an adequate reason for including them. 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. Nevertheless, this kind of investigation would be inappropriate for assessment as it rarely produces quantitative data.

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.

Teachers should carefully consider the approach to experiments on human physiology. Using fellow students or other people for investigations into the effect of exercise on the heart rate can be considered unsafe if the health status of the volunteers is not determined first. Some schools are already expecting their students to use a proforma for the signed consent of the participants in experiments. This is good practice but it is still uncommon and moderators are still commenting on the absence of consent in designed investigations involving human subjects.

For the IA submitted from 2016, the new internal assessment criteria have a provision for ethical practice, safety and environmental impact. Therefore in future, inappropriate practice should directly impact on the teacher's mark or it will affect the moderation factor.

Recommendations for IB procedures, instructions and forms

Clerical procedure

The latest versions of the 4/PSOW form (available on the OCC) should be used. The 4/IA form and list of students is often absent in the samples received. Only one 4/IA form is required per school.

Moderators are reporting that the electronic version of the 4/PSOW that can be downloaded from IB is frequently incorrectly filled in. The criteria for the sampled work might be flagged using a cross but the actual marks are not filled in.

Teachers are regularly including the “complete”, “partial” and “not at all” breakdown of their marks. When this is combined with comments and feedback to the candidates it makes it very clear how the teachers were awarding marks. There are a large number of teachers that 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 students will reap the benefits. It is a lot easier for a moderator to support a teacher’s marks when there are clear, readable 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 the instruction sheets and/or adequate summaries of oral instructions for the investigations in the moderation sample. Most schools complied with this requirement but moderators are reporting that not all do this.

Only a few teachers are failing to design practical programmes with sufficient numbers of hours. Some, however, have been observed to grossly inflate the time spent on an activity.

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

When the only marks appearing on the 4/PSOW form are the two marks required for the internal assessment, it causes concern amongst the moderators. There is no indication that the students were marked a number of times using the criteria. One wonders how these students 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 4/PSOW form. This should be verified before it is sent.

Some schools are sending photocopies of the student’s work. Usually these are of good quality. The problem is that graphs and diagrams using colour can be confusing. The originals must be sent and a photocopy kept back.

The range and suitability of the work submitted

Trivial, simplistic investigations that do not generate sufficient data to permit adequate assessment of data processing were sometimes used for assessment. Students are sometimes missing quite obvious conventional points (e.g. indicating uncertainties in their data) as well as limiting their processing to the calculation of a mean. Teachers are also missing these points and marking over generously. Occasionally moderators are surprised to find that teachers point out significant errors to their students yet still give full marks.

Choice of inappropriate labs by the teacher was often a cause for differences in the level awarded by the moderator.

Where teachers apply the criteria rigorously and clearly, the moderators make relatively small adjustments to the marks. In schools where the descriptors of the aspects are ignored, the moderation can reduce the marks quite severely.

Some schools have a way to go in the use of databases and simulations to fulfil the ICT requirement. Simulations are also a weakness because what teachers are calling simulations are often just animations.

Literature sources are not consulted when 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 not being carried out. Moderators observe 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 students 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 Students could have identified their own control variables
Design	It is clear that the students 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 students have used a photocopied data table with headings and units.	c; c; c = 6	p; c; c; = 5 Student could have added uncertainties or relevant qualitative observations
Data Collection & Processing	The students 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 student 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

The areas of the programme in which candidates appear well prepared

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

The use of ICT in the areas of **1** Data logging, **2** Graph plotting software and **3** Spreadsheets is good.

The use of data logging in investigations now seems quite well established. In many schools the students (and teachers) seem to be at ease with their systems and they are being used more often in student-designed investigations. However there are schools where teachers are assessing work done using the manufacturers' worksheets. This is inappropriate, as it is too heavily guided.

Candidate performance against each criterion

Design

Too many teachers are setting general themes with little scope for different investigations. The result is that the whole class of students selects the same variables and investigates the same system.

For example, in the same investigation presented by a school, all of the students in the sample had exactly the same research question. They were all investigating the effect of temperature on the activity of catalase using the same range of temperatures, the same intervals and the same protocol for measuring the dependent variable. All of the students in the sample had produced almost the same Design.

These teachers appear to be boxing the students in to perform the same investigations. This is approach is not appropriate and it need not happen.

For example, if enzyme activity is the theme to be assessed for the criterion Design, there are a whole range of enzymes to choose from, enzymes from different sources, different substrates, different potential inhibitors, different limiting factors and different methods for determining the rates of reaction. When a moderator is confronted with a whole class that is investigating the same enzyme, from the same source, using the same independent variable and using the same method to determine its activity, then it is not surprising that collusion or excessive guidance is suspected. The teacher's moderation will be affected by this. The same problem has been observed in all the classic themes for Design such as transpiration, osmosis, photosynthesis, fermentation, surface area to volume ratio and bacterial growth.

This practice is not restricted to teachers who are new to the IB. There are sometimes moderator comments in the feedback that go back over several sessions. Either the teachers are not receiving this feedback from their coordinators or they are stubbornly ignoring it, all to the cost of their students.

Research questions need to be focused. A research question that lacks focus will have an impact right through the rest of the investigation. For example students 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 names of the species used or the source of material (e.g. sources of enzymes) are often missing.

The three categories of variables must be clearly identified. It is clear that students 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, that ensures fair testing, and what is a control experiment that can establish the effect of a variable that is not controlled. Sometimes unrealistic controls are being proposed when a control experiment would be appropriate (e.g. set room temperature to 21.1°C). It is not certain that some students are aware of the existence of water baths, heat shields or buffer solutions.

Research questions often state that the aim is to investigate the influence of the independent variable on the rate of change of a dependent variable. Unfortunately the protocol does not explain how this rate is to be calculated.

The investigations are often too simplistic**.** The range of values of the independent variable is insufficient to establish a trend. The number of repeats is insufficient to permit a statistical analysis that will allow a firm conclusion to be drawn. 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 students when they design their investigations. We are not expecting them to re-invent the wheel. These standard protocols however, must be duly referenced and significantly modified or applied to the student's own investigation. For example, if osmosis is being investigated and the student uses the method of change in mass of tissue to monitor the effect of solutions of different concentrations on a tissue, this is legitimate but if the investigation simply determines 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, the investigation becomes more substantial. Why stick to the traditional potato? Try carrots, yams, cassava, apple, sweet potato.

The two point discrimination test for touch receptors on the skin continues to be frequently used. All too often this ends up a repeat of a text book classic when it is possible to give it a more original or personal approach e.g. Does skin sensitivity change with different levels of exercise?

In field work, the control of sampling procedures is almost totally ignored by the students. 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. However the link between what the probe measures and the dependent variable 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 students to follow through their own designs. Some schools seem to have their students design an investigation that remains theoretical. The result is often an unrealistic investigation. Even when a teacher does decide to follow through a student designed investigation the result may be an unrealistic investigation. An example that keeps reappearing is measuring the effect of music genre on heart beat rates. This is almost impossible to control and students ought to be counselled against it from the outset. They might be advised to use a metronome instead (they should be left to work out for themselves that the volume and the frequency can be controlled).

Students should use decimal / SI units (e.g. °C not °F and cm not inches). Spoonfuls and cupfuls should be discouraged.

Moderators complain about the use of the word “amount” which is frequently used by the students. It is not always clear if they are referring to volume, mass or concentration.

Data Collection and Presentation (DCP)

A persistent problem is the presence of trivial investigations that do not generate sufficient quantitative data for adequate processing. This sometimes stems from investigations that are poorly designed by the students themselves. In this case the teacher can decide not to mark the investigation for DCP or CE. It also can be the product of an investigation set by the teacher, which is more problematic.

It may be that class data is required in order for the student 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 give data. If class data is to be used and DCP is to be assessed a number of precautions must be respected. The students must present their own data or clearly identify which is their own data in a pooled data table. The students must plan and produce their own data tables. Copying a table from other students could be counted as collusion and the school’s IA work will be subject to an enquiry. Teachers who provide the students with a pre-formatted data table can expect their students to be moderated down.

It should be understood that the use of pooled data is inappropriate for the assessment of investigations assessed for Design as these are supposed to be the student’s own individual effort.

As in previous sessions moderators have had to reduce the marks of the teachers who had missed the following points:

- Data (raw or processed) that is inadequately presented (e.g. with superficial titles or headings)
- Units missing in the table (note: decimal units should be used)

- No uncertainties given in the tables of data collected using measuring instruments.
- Inconsistent decimal places in tables
- The decimal places that do not correspond to the precision of measurements
- The absence of associated qualitative observations where they are valuable. E.g. an ecological field investigation is incomplete without some kind of description of the site used. This appears to be a common problem still.
- Raw data plotted in graphs that do not actually reveal anything (Note: raw data can be plotted to derive maxima, minima, optima, rates, intercepts or to reveal correlations)
- Raw data plotted when the mean should have been calculated and plotted (often the mean is actually calculated and then ignored by the student for graphing)
- The absence of statistical treatment of the data when it was possible
- When statistical treatment is applied there is no consideration of its appropriateness. E.g. calculating standard deviations when they had only made 2 or 3 measurements.
- There was no presentation of uncertainties in graphical data either by using trend lines or error bars or uncertainty ranges on the axes.
- The error bars, when used, are not explained.
- Adding a linear line of best fit even when the data is clearly shows a curved distribution.

Complete may not mean perfect but when the mistakes are consistent they will have an impact on the moderated marks.

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.

Several moderators commented on the lack of qualitative observations to support the measured data.

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 merits there will be a knock-on effect through an unfocussed research question to a poorly designed investigation that collects a limited amount of data, permitting limited processing, leading to a weak conclusion and evaluation.

Some teachers are using simulations instead of real biological investigations. These may be useful for training data collection and processing as they generate large amounts of data quickly. However they are not suitable for assessment under the current criteria, especially the assessment of this criterion.

In the new programme, for IA submitted from 2016, results from simulations will be acceptable, so long as the simulation produces realistic data that can be processed. Simulations are particularly useful if results from a virtual experiment can be compared with those generated by a real one.

Overall, there was not enough consultation of literature values or the theoretical background by the students. When they were consulted the sources were often not correctly cited. For guidance on the correct way to cite a reference in the Extended Essay the guidelines are very helpful.

Students in some schools show that they have developed a mature sense of criticism of the investigation. Their evaluation of their results is based upon a balanced critical analysis of the data. Students 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 students 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 students and teachers would do well to remember this when they are marking their students.

Suggested modifications were sometimes superficial and yet marked over generously.

If the method and the data that have been used by the student are not provided in the sample, then Conclusion and Evaluation cannot be moderated.

Manipulative skills

The evidence on the 4/PSOW forms indicates that the students are being exposed to a sufficient range of investigations. This ensures that the manipulative skills can be assessed correctly. However, a large number of moderators notice that some schools are attributing 6/6 for the whole sample for this criterion. There is no discrimination between the candidates yet the moderated marks suggest that that the students in the class do not all have the same capacity for experimental work.

Non-moderated criteria will no longer be present in the new programme with IA submission from 2016.

ICT coverage

Many schools seem to have made an effort to equip themselves with the necessary apparatus to carry out data logging. There are signs that the equipment is being used frequently and in student designed investigations.

Graph plotting using software was perhaps the easiest and most widespread for schools to apply. However the signs are that the students still need to be taught the correct conventions of graphing. There is still a tendency to use bar charts for everything amongst the weakest students, perhaps because it is the default setting of MSExcel. Bar charts are appropriate for data in categories but not for continuous variables where there are enough data points to establish a trend. Legends (keys) are not always necessary and students do not seem to know how to de-select them. When they are needed the students often have difficulty labelling them appropriately – students often present the different curves as “series 1” and “series 2” When the students used scatter plot, a trend line was not always used when it was appropriate. Note: joining the points dot-to-dot may be appropriate where the trend cannot be predicted. This can happen for series of measurements taken in field work.

It might be an idea to train the students to plot graphs manually before using a graphing program. Sketching a graph of the data before using a graphing program can be very helpful and save a lot of time.

The use of spread sheets for data processing was less apparent in the sampled investigations. When spread sheet tables are inserted into document files the conventions of presenting tabulated data were 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.

The Group 4 Project

It needs to be repeated for a very few schools now, the Group 4 Project can ONLY be used for the assessment of Personal Skills. Indeed it 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. Once again it is evident that some teachers are awarding full marks 6/6 to all their students without any discrimination.

Recommendations for the teaching of future candidates

- Read the feedback on your sample from the previous session. This is available from your IB Coordinator.
- Share the criteria with the students and explain them.
- Consult the Online Curriculum Centre (OCC) for teacher support material (TSM)
- Apply the internal assessment criteria rigorously.
- Give the students experience in identifying independent, dependent and controlled variables.
- Ensure that the open-ended theme that you set has enough scope to provide a variety of research questions for the whole class.

- Guide students away from repeating classic investigations or working on the same research question when they design their own investigations.
- Counsel the students on the safety issues, ethics and feasibility of the investigations they design.
- Be sure that investigations used for assessment produce sufficient quantitative data.
- Encourage the students to make additional qualitative observations about their experiment. It is good practice for them to keep a log book.
- Ensure that the investigations have the potential to generate sufficient data for substantial processing.
- Teach the students that plotting graphs of raw data is insufficient if nothing can be derived from them.
- Encourage the students 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. Simulations used in conjunction with hands-on investigations producing “real data” are however to be encouraged.
- 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 4/PSOW form (available from the Handbook of Procedures on the OCC).
- Check to be sure that all the parts of the 4PSOW form are completed correctly.
- Complete one 4/IA form signed by all the teachers for your school’s sample and cross moderation between colleagues is essential.
- Familiarise yourself with the new programme’s requirements for practical work and internal assessment.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 14	15 - 19	20 - 24	25 - 28	29 - 33	34 - 40

General comment

This was a successful paper with many questions that discriminated effectively between stronger and weaker candidates. There was one problematic question (question 25) where two answers were accepted as correct. The spread of marks was very wide but there were some very high scores indicating excellent knowledge and understanding from those candidates.

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

2. This question was based on assessment statement 2.1.7. Not all candidates were familiar with the concept of emergent properties, but the very high discrimination index shows that the stronger candidates were able to answer it correctly.

3. There were a relatively large number of comments from teachers on G2 forms about this question. The low discrimination index and the low percentage of correct answers (46%) show that it was answered incorrectly by some of the stronger candidates. The use of the interrogative adverb 'why' was probably inappropriate. The answer that was accepted was that stem cells are useful in repairing diseased organs because they reproduce, which is not a complete explanation. Also answer A was ambiguous; it could have either meant that stem cells are specialised from the outset, which would be incorrect, or that they are made into specialised cells, which would be incorrect. This was one of the least successful questions on the paper.

7. Several teachers commented that this question was unfair or lacking in relevance. A relatively small percentage of candidates answered it correctly but the discrimination index was very high suggesting that these were mostly the stronger candidates and the examining team were confident that it tested assessment statement 3.2.7 effectively.

9. There were some concerns about this question, but again the discrimination index was very high and 70% of candidates answered it correctly. The commonest wrong answer was D, suggesting that candidates were either confusing transcription with translation or mRNA with tRNA.

10. There was no criticism of this question from teachers but it performed relatively poorly, with large numbers of candidates choosing answer B instead of A, showing that they thought that the chromosome number is halved in the second division of meiosis rather than the first division. The first division is of course the reduction division and this point should be stressed in the teaching of HL candidates.

11. Candidates found this question very easy and inevitably the discrimination index was poor. However, it showed that the concept of codominance is widely understood.

12. Far more candidates than expected chose answer D. If the answer had been 'identical twins' this would have been understandable but most twins are dizygotic and not genetically identical. Also the answer 'clone' in B was clearly correct.

13. Only 26% of candidates answered this question correctly and unsurprisingly the discrimination index was low. Candidates are expected to select the best answer when more than one answer seems to be valid. Candidates are advised to read all of the four possible answers even if they have found what appears to be the correct one before reaching D. In this question many candidates seemed to have stopped reading when they got to C, because the observation that nucleic acids contain the same bases in all species provides weak evidence for the universality of the genetic code. The expected answer was D. It was perhaps worded awkwardly and candidates may have thought it referred to the redundancy of the genetic code rather than the universality. This was another of the less successful questions on the paper.

16. This question attracted more comments from teachers than any other on the paper. The examining team considered all the comments, most of which concerned whether candidates can be expected to recognise the phyla of animals from photos and whether III and IV were clear enough. There seems little point in studying Assessment statement 5.5.4 if students cannot then identify the phyla of animals from specimens or images. Also, candidates only had to recognise that the sea anemone in I and the jellyfish in II were cnidaria to be able to answer the question correctly. More than 60% of the candidates did this, with a very high discrimination index.

18. This was another question with a low discrimination index due mainly to it being very easy, with both weaker and stronger candidates able to answer it correctly.

21. This question had a low discrimination index, but for the opposite reason to the previous one: it was answered correctly by far fewer candidates than expected. Large numbers, including some stronger candidates thought that an action potential can only occur in the axon of a motor neuron, when of course it can also occur in the dendrites and the cell body, so the answer was that it can occur anywhere on the cell membrane.

22. This question was answered correctly by fewer than 40% of candidates. There were complaints from teachers that more than one answer is correct but the examining team was satisfied that the best answer was LH and the discrimination index was high, showing that the stronger candidates tended to pick the expected answer.

23. The discrimination index was relatively low for this question. The expected answer was that testosterone and both an X and Y chromosome are needed for a fetus to develop into a normal male. 75% of candidates chose this answer but some stronger candidates chose answer B which was that only the X and Y chromosomes are needed for male development. Presumably these candidates were unaware of the production of testosterone early in fetal development and its role in causing male development.

24. Only 27% of candidates answered this question correctly, which is scarcely more than the expected percentage from guesswork. The high discrimination index shows that the stronger candidates tended to answer the question correctly. The role of nucleosomes in regulating translation is part of assessment statement 7.2.3 but this seems to be a relatively neglected part of the biology program.

25. The photo credit beneath the image here included the term ‘replication bubbles’ which allowed answer B to be eliminated. The expected answer was C as the two strands of DNA

are parted both for replication and transcription. Answer D can be eliminated because translation does not occur in the eukaryotic nucleus. Both A and C were accepted as answers because the examining team decided that it was not reasonable to expect candidates to know whether transcription might possibly have been occurring at the indicated points or not.

26. The discrimination index was relatively low here suggesting that some of the stronger candidates did not use their understanding of protein structure effectively enough to answer the question correctly.

29. There were large numbers of comments from teachers about this question. The main complaint was that the word 'overall' was confusing. Perhaps 'net'; would have been a better word. Although only about half of candidates answered the question correctly, the discrimination index was very high, so the stronger candidates were able to choose the correct answer.

31. The low discrimination index and high number of candidates choosing answer C suggests that many candidates, including some of the stronger ones, did not know that pollination delivers pollen to the stigma rather than the ovary.

32. Less than a third of candidates knew that the carbohydrate that maltose is the carbohydrate that moves from the cotyledons to other parts of the embryo during germination. This is stated in the teacher notes for assessment statement 9.3.5.

33. Most candidates answered this question correctly, despite the smaller percentage that correctly answered the related question 10.

36. This question had a surprisingly low discrimination index, given that it seemed suitable in difficulty according to the percentage answering correctly. It suggests that the structure and function of synovial joints had not been emphasised enough in some schools.

39. The relatively low discrimination index suggests that some of the stronger candidates were not clear enough about the structure of myofibrils and thought that either the sarcolemma, sarcoplasmic reticulum or nuclei are contained within myofibrils rather than being between myofibrils or on the outside of a whole muscle fibre.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 10	11 - 14	15 - 18	19 - 22	23 - 26	27 - 30

General comment

This was a successful paper with many questions that discriminated effectively between stronger and weaker candidates. There were no problematic questions. The spread of marks

was very wide but there were some very high scores indicating excellent knowledge and understanding from those candidates.

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

3. Most questions on this paper discriminated very well between the weaker and the stronger pupils, but this one did not. Some of the stronger candidates chose answer B, indicating that they thought that differentiation allows cells to come from pre-existing cells, rather than cytokinesis which was the expected answer. Specialised cells are produced by differentiation from pre-existing unspecialised cell, but this was not what the question was asking about.

9. This was an extremely good discriminator, which is not surprising as it was a biochemistry question that was straightforward for candidates who had prepared carefully and knew Core topics such as this, but could not be guessed by weaker candidates who were not as well prepared.

12. This question was another relatively poor discriminator, which is surprising as stronger candidates should have been able to reject the distractors because they each included a substance used rather than made in photosynthesis that is not used an energy store. Sometimes questions are poor discriminators because they are too easy but in this case 25% of candidates answered incorrectly so it was not a very easy question. Presumably some of the stronger candidates made a careless error and chose one of these obviously incorrect answers.

13. This question attracted the more comments from teachers than any other on the paper. The main criticism was that allele change does not occur during gene mutation, because of same sense mutations. It could be argued that a same-sense mutation does give rise to a new allele even if when translated the amino acid sequence is unchanged and in any case, none of the three other answers was correct. The discrimination index was rather low. This may be because some of the stronger candidates chose answer D, which was that evolution occurs during gene mutation. Some teachers commented that they considered this to be a correct answer. The examining team did not agree. Gene mutation provides the variation needed for natural selection but evolution only occurs when natural selection changes allele frequencies.

14. About half of the questions on this paper were common with the HL paper, including this one. As with the HL paper, this question was answered correctly by a far smaller percentage of candidates than expected. The commonest mistake was to think that the number of chromosomes is halved in the second division of meiosis rather than in the first division. The low discrimination index shows that some of the stronger candidates made this mistake so teachers are recommended to emphasise more in the future that it is the first, not the second division of meiosis that is the reduction division.

15. This was another common question with HL and as on that paper a very high percentage of candidates answered correctly showing good knowledge of codominance.

18. This was yet another common question with HL and again the outcome was similar. At SL only a quarter of candidates answered it correctly and the most popular answer was C, which was incorrect. As mentioned in the HL report, candidates should be encouraged to read all of the four possible answers and not stop if they think they have reached the correct answer. In this case many seemed to have stopped at C even though it offered weak evidence for the universality of the genetic code, and the correct answer was D.

19. This was not a popular question with several teachers who felt that it was not clear which organism in the photo was the subject of the question and also that it was unfair for candidates to realise that it was a fungus. About half of the candidates answered the question correctly and the high discrimination index showed that this included most of the stronger candidates, so the question worked successfully. The most common wrong answer was detritivore but it was hard to see how the organism in the photo could have been ingesting dead wood.

26. Multiple completion questions do not always discriminate well, and this was an example of one that did not. The term 'involved in' is a rather vague and implies that any direct or indirect role is valid, so the answer here was that the pacemaker, hormone secretion and nerves are all involved. It is usually better to use a less vague term and some candidates were obviously misled here. Many thought that nerves were not involved, presumably because of the myogenic nature of cardiac muscle contraction and some also thought that hormones were not involved, perhaps because they had forgotten about the involvement of adrenalin.

28. This was a surprisingly poor discriminator, with only about 40% of candidates answering it correctly. The question was based on Assessment statement 6.4.5 and was fair. The common mistake made by candidate was to think that the abdominal muscles contract during inhalation. Students often find the mechanism of ventilation hard to understand and the outcome of this question indicates that it needs to be given more emphasis in some schools.

29. Candidates found this question hard, both at SL and HL. Only a quarter answered it correctly which is no better than could be achieved by guesswork. Not unexpectedly the discrimination index was therefore very low. Many candidates thought that an action potential only occurs in the axon of a motor neuron, when it must also occur in dendrites and the cell body, as it must pass through these parts of the neuron to reach the axon. It might have been expected that candidates who had studied reflex arcs in Option E would gain an advantage here, but the percentage answering the question correctly was so low that no advantage seems to have been gained; all candidates found the question very difficult.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 23	24 - 34	35 - 45	46 - 56	57 - 72

General comments

As ever, thanks are due to teachers who completed a G2 comments report form. Of those who commented, 87% thought that the paper was appropriate in difficulty, 9% thought it too difficult and 4% too easy. This corresponded to comments on relative difficulty compared with last year's paper: nearly 75% of those were able to make this comparison thought the standard similar, 16% thought it more difficult or much more difficult and 9% a little easier or much easier. Views on the clarity of wording were mostly positive, with less than 1% thinking it poor or very poor and more than 80% thinking it good, very good or excellent. None of the respondents thought that the presentation was less than fair and over 90% thought it good, or better than good.

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

The areas that candidates appeared to find difficult were the details of translation including polysomes, the structure and function of specific cell types in the testis, test crosses, and also the process of genetic modification and its effects.

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

Many candidates were well prepared for magnification calculations and questions on xylem transport, synaptic transmission, diabetes and cell respiration.

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

Question 1

This was a data analysis question based on proteasome inhibitors and their possible use in the treatment of cancer.

(a) Most read the percentage correctly from the graph. The most common incorrect answer was 55, despite the top of the bar being clearly below this level. Perhaps candidates thought that their answer had to correspond to one of the catch marks on the y-axis.

(b) This question required a judgment to be made about the trends in the data that are significant. Too many candidates focused on the small increase from 5 to 7.5 nmol dm^{-3}, which is unlikely to have been significant. The second mark was only given to candidates who commented on the small decreases from 5 to 10 and the much larger decrease at 20 nmol dm^{-3}. Candidates are advised to look at mark allocations. Some candidates made only one statement when the mark allocation for this question was two. Some candidates included an

explanation of the results, which was not necessary as the question only asked from an outline.

(c) (i) and (ii) These numerical questions were well answered by most candidates.

(d) Weaker candidates described the curves for systolic and diastolic area for the treatment group and not the differences between them and the control group curves. They therefore deduced that the diastolic area was increased when in fact it was decreased. Despite the stars on the graph showing which differences were statistically significant, few candidates pointed out that the proteasome inhibitor had a significant effect on systolic but not diastolic areas.

(e) This was a harder question that discriminated very effectively. Most candidates got the mark for the decrease in the systolic area after the treatment had ended, or even slightly before. Some commented on the overlap between the error bars on Day 42, but the second mark was only awarded to candidates who pointed out that there is still a significant difference between the treatment and control groups on this day at the end of the experiment so the effects of the inhibitor are not fully reversed.

(f) This was mostly well answered but some candidates missed the mark by not commenting on the incremental decrease and merely stating that the treatment reduces oxygen consumption.

(g) This question revealed confusion in some candidates' minds between consumption/use and release of energy. Another common fault was to refer to production or creation of energy, ignoring the law of thermodynamics that energy can neither be created nor destroyed. Candidates should be encouraged to use the term 'energy release' for cell respiration. A wide range of arguments was given in answer to this question. Four statements were rewarded with a mark if they were included and coherent answers always seemed to include two or more of these.

(h) Candidate were instructed in this question to use the data in all of the graphs so the mark scheme was structured to reward either an argument for or against a risk based on each of the three graphs. Despite the question asking for an evaluation, most candidates focused only on evidence for the riskiness of using proteasome inhibitors. Even so, most candidates were successful in scoring at least one or two marks.

Question 2 (protein synthesis)

(a) About half of candidates named the peptide bond correctly. The answers dipeptide and polypeptide were not accepted, nor was covalent as this is the type of bond, not the name of the bond.

(b) Again about half of candidates got this, with others giving mostly tRNA or rRNA.

(c) There were varied answers to this question with some very good ones explaining each of the events in sequence. Weaker candidates were confused about the details, or in some cases did not know what the process was at all.

(d) Only about a quarter of candidates knew what a polysome was and there were some desperate attempts at finding the answer by guesswork.

Question 3 (testis histology)

(a)(i) The two cell types were not well known, with only about a third of candidates identifying them correctly.

(ii) Again this was not known by most candidates, with many suggesting a role in sperm production for the Leydig cells.

(b) About two thirds identified the type of cell division correctly as meiosis or the first division of meiosis.

(c) This was well answered, with most candidates calculating the actual size correctly from the size of the image and the magnification. Some candidates made order of magnitude errors which were mostly associated with use of centimetres rather than millimetres. The various suffixes used with IB units increase or decrease size by a factor of a thousand, making calculations easy, but centimetres do not fit this scheme and are best avoided.

Question 4 (Photosynthesis)

(a) About one third of candidates got the cross right. This involved understanding that in dihybrid test crosses a double homozygous recessive is used. Many candidates showed instead the results of a cross between two double heterozygotes, which would give a 9:3:3:1 ratio. Another common error was to show the gametes from one parent with two alleles of the gene A/a and the gametes from the other parent with two alleles of the gene B/b, when gametes from each parent should have included one allele of each gene. Some candidates got the 1:1:1:1 ratio but failed to state the phenotypes so lost this mark.

(b) This was generally well answered, with candidates marking links between loss of water from leaves by transpiration, the development of low pressures or tensions in xylem and the cohesion of water molecules due to hydrogen bonding allowing columns of water to be pulled up to the leaf. Few mentioned that it is in xylem vessels that most water is transported.

Section B

Question 5 (Motor neurons, synaptic transmission and control of the heart beat)

(a) The quality of drawings of the structure of a motor neuron varied from excellent to very poor. Neatness was generally good but marks were sometimes lost for unclear labelling. In some cases drawings could have been improved by making dendrites longer and narrower, by making the axon longer and by showing buttons on the end of the neuron that forms synapses with an effector. Many different names were given for these buttons, most of which were ambiguous and the only name that was accepted was motor end plates as this is the term given in Teacher's notes. In some drawings the myelin sheath was shown as a series of

blobs overlying the axon, which did not represent it clearly. Drawings of structures such as a motor neuron should be sectional, so the myelin sheath should appear above and below the axon, with clear gaps for the nodes of Ranvier.

(b) There were some excellent answers here giving detailed explanations of synaptic transmission. A few candidates wrote instead about how nerve impulses are propagated along an axon rather than from one neuron to another. Some candidates' answers were less clear than they could have been because the terms 'pre-synaptic' and post-synaptic' were not used to distinguish between the two neurons. An omission in most answers was the idea that the neurotransmitter diffuses across the synaptic cleft. A few candidates were confused about the nature of exocytosis and described vesicles passing through membranes rather than fusing with them.

(c) The control of heart rate was described less well than expected. Most knew something of the role of the sino-atrial node and where it is located, but there were relatively few clear explanations of the myogenic nature of heart muscle contraction and the links between the medulla oblongata and the heart.

Question 6 (structure of DNA, DNA profiling and genetic modification)

(a) Almost all candidates got the base pairing correct and most labelled hydrogen bonds between bases. The key to getting the rest of the DNA structure diagram correct was to show deoxyribose as a pentagon not a hexagon and the two strands antiparallel.

(b) Answers to this question on DNA profiling were varied. Few mentioned that satellite DNA is used or that restriction enzymes cut the DNA into fragments. Most knew that PCR is used to amplify the DNA and that gel electrophoresis separates DNA fragments by size. Few described the pattern of bands produced clearly. In the best answers this was illustrated with a diagram of banding. Weaker answers included vague accounts of comparing DNA from different sources or karyotyping.

(c) This was poorly answered by many candidates. There was much confusion between genetic modification, cloning and artificial selection. Even the strongest candidates tended not to give a definition of genetic modification, which was the ideal way to start an answer. The question asked for the effects of genetic modification to be discussed using a named example. In many cases no clear example was included and in others many examples were mentioned briefly rather than one example thoroughly. Some examples had obviously been invented, because when checked by examiners no evidence of them could be found, for example the transfer of a gene from fish to plants to make the crops grow better in damp conditions. A charitable interpretation of such answers is that they were based on hopeful guesswork but of course in science, fabrications such as these should be discouraged.

Question 7 (Kidney structure and diabetes)

(a) Most candidates drew a diagram of a section through the kidney with the ureter and renal artery and vein attached. A minority drew a diagram of a nephron instead, perhaps thinking that the 'associated vessels' in the question referred to this. The kidney diagrams varied in

quality. Cortex and medulla were often represented clearly, but pelvis less often, with the connection to the ureter then unclear.

(b) There were some clear and informative answers to this question on type II diabetes. The point on the mark scheme that was most often missed was the symptoms that might alert a person to the development of this condition. Many candidates were too categorical in stating that Type II diabetes is caused by eating high sugar diets. They would ideally have stated only that there is a link or that such diets are one of a number of risk factors. Many candidates correctly stated that control of diet is a part of the treatment of the disease but often the diet was too loosely described, for example low carbohydrate diet instead of low sugar or low glycemic index diets.

(c) This part of the question was more challenging and it was very pleasing to see some clear and perceptive explanations of glucose concentrations in urine of treated and untreated Type I diabetics.

Question 8 (Carbon cycle, photosynthesis and respiration)

(a) There were some excellent carbon cycle diagrams, showing all the main biological processes. The weakest diagrams represented the organisms in the cycle with cartoon pictures without labels, linked by unlabelled arrows. To convey as much information as possible the forms in which carbon exists should be stated, for example carbon compounds in plants, together with the processes that convert carbon from one form to another.

(b) There were two parts to the question here and a mark total of only four, so it should have been relatively easy to score full marks, but few candidates managed this. Most candidates scored some marks for outlining the relationship between carbon dioxide concentration and the rate of photosynthesis, though terminology in many cases was imprecise. Carbon dioxide concentration is preferable to amount, level or quantity. Marks were available for the rationale behind measuring the rate of photosynthesis by oxygen release and also for some practical details, but many candidates did not attempt this.

(c) The challenge with this question was to summarise the whole of aerobic and anaerobic respiration without missing out any of the significant features. There were some very long and detailed answers but the eight marks could be scored with much briefer answers.

Recommendations and guidance for the teaching of future candidates

- In data analysis questions candidates should bear in mind statistical significance. Small differences are unlikely to be significant so are usually not worth mentioning. Where results of significance tests are given, they should be used in analysis and evaluation.

- Candidates should be able to distinguish between correlations and relationships that are directly or indirectly proportional. Usually biological data shows correlation and not proportionality, because of the many factors that affect results.

- Millimetres are preferable to centimetres when measuring size, as a millimetre is a

thousand micrometres and one thousandth of a metre, so calculations with these units are least likely to lead to errors of one or more orders of magnitude.

- Candidates should check what equipment is needed for each exam and in particular bring a ruler and a calculator to the HL2 paper.

- Candidates should check the mark allocation for each question and make sure that they have made at least as many points in their answer as there are marks for the question. In a question with two marks for example, an answer consisting of a single statement is unlikely to earn more than a single mark.

- As ever, candidates should be aware of the differences between the command terms and tailor their answer to the command term used. For example 'outline' and 'explain' require very different styles of answer.

- In questions asking for an evaluation, candidates should try to write an assessment that weighs up the evidence, rather than an argument that is entirely pro or anti.

- Labelling lines on diagrams should point directly to the structure being labelled, with the end of the line inside the structure, not on the edge at the junction with another structure. Bracket labels can be used but if they are, it needs to be clear to which structure or structures the bracket refers.

- Where diagrams are used as part of an answer to a section B question, they should be fully annotated, as marks are rarely awarded for simply showing the name of a structure unless the question specifically asks for this.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 13	14 - 18	19 - 24	25 - 31	32 - 37	38 - 50

General comments

There was evidence of good preparation across a wide range of topics. Some candidates reached very high overall scores. Thanks go to the centres that returned G2 forms.

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

Some concern was raised by teachers that the examination lacked syllabus coverage because Topic 3: The chemistry of life and Topic 5: Ecology and evolution were thinly

covered. With a limited number of questions and an effort to provide themes and continuity among questions, it becomes very difficult to achieve the kind of syllabus balance that some teachers may desire or expect.

Section A

In the stem of the data analysis question, there were some candidates who did not seem to understand the relationship between tadpoles and frogs. The description "of tadpoles as an (aquatic larval stage) and frogs" offered only limited help since life cycles/larva are not in the syllabus. A lack of precision in reading values on the graphs hampered some candidates from gaining easy marks. Rounding off numbers or adding uncertainties that fell outside of the permissible range set in the mark scheme meant lost marks. As in previous exams, some candidates quoted numerical values from the data without qualifying their meaning. It was left to the examiner to draw conclusions so marks were lost because of incompleteness. Those data analysis questions that required application from the bar chart or graphs or maps were the most difficult for students. This was seen where higher order command terms were involved such as "compare" in 1b, "suggest" in 1c or "predict" in 1g. Finally, in data analysis some candidates did not seem to understand the concept of density.

Among short answer questions, the artery and vein identification caused much confusion. Candidates could not identify the blood vessels and were uncertain about the X and Y letters added to the micrograph. The cell magnification calculation appeared difficult for many. There was weak understanding of antibody production by lymphocytes. A lack of careful reading led many candidates to incorrectly state the total number of chromosomes in different gametes of a person with Down syndrome.

Section B

Diagrams of the carbon cycle were often incomplete and somewhat vague. Explanations of carbon dioxide production in anaerobic and aerobic respiration gained very few marks because of missing details. Knowledge of how to measure the rate of photosynthesis through carbon dioxide uptake was nonexistent. Many candidates struggled with their explanations of how vesicles transport proteins. For the most part, diagrams of the female reproductive system were poor. Discussions of the ethical issues of IVF were usually unbalanced and favored the negative position. The quality mark for structure of answer was not awarded very often and illegible handwriting remains as a nagging problem. Unfortunately, a few candidates provided answers to a mix of questions. One candidate answered 4b, 5c and 6a.

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

Section A

Among the data analysis questions, many candidates could successfully state the values of data points seen in the graphs. Understanding of a predator prey relationship was evident in the answers about differences in tadpole density in the two lakes. Candidates were able to

contrast trend lines in different graphs. Some success was seen in candidate ability to integrate data from a map and graph in order to make a prediction.

In the short answer questions, crossing over, Down syndrome, the Punnett square and sickle cell anemia were generally known.

Section B

In general, candidates did better on Section B questions than Section A. There was widespread knowledge of the effect of carbon dioxide concentration on the rate of photosynthesis. Diagrams of plasma membrane structure with labels were generally good. Finally, most candidates knew at least two differences between eukaryotic and prokaryotic cells and could express a few of the ethical issues associated with IVF. The quality mark for clarity of expression was frequently awarded (probably heavily influenced by the full and serious attempt to answer all parts component.)

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

Question 1

(a) Most candidates achieved the mark. Those who missed did not inspect the graph carefully enough. Using a ruler and determining the intervals between numerical values on the X axis led to the required precision. Correct answers for “with trout” and “without trout” were needed for the mark.

(b) Most candidates saw that more tadpoles/frogs existed in lakes without trout. Some went on to repeat the idea by giving the vice versa but for no further credit. Few candidates gained the second mark by recognizing that “trout decreased tadpole numbers more than frog numbers.” Candidates who just stated numbers of tadpoles and frogs in each lake gained no marks. They also needed to include comparative words such as more, greater, or less etc.

(c) Candidates commonly answered that tadpoles/frogs were eaten by trout. A few candidates stated that trout could introduce disease/change breeding sides that affect frogs and tadpoles. Either answer was sufficient for the mark.

(d) As in 1(a), two correct answers were needed for the mark and close inspection of the graph was needed. For Lower LeConte Lake, many candidates gave rounded answers, such as 6 or 7, which were outside the acceptable range of 6.1 to 6.8. Candidates should not assume that since the graph intervals were in whole numbers, their answers should also be in whole numbers. Through the use of a ruler/straight edge it could be seen that the data points did not line up with the whole numbers shown on the X axis.

(e) The mark scheme was generous with many different ideas available for the mark. However, “lake size” was unacceptable and indicated a misunderstanding of the concept of density. Also, answers such as “trout presence” or “limited resources” were too general and unacceptable. Stronger candidates astutely observed that Upper LeConte Lake had a

supply stream with tadpoles and frogs while Lower LeConte Lake did not or that trout could have been reintroduced to both lakes from neighboring streams. Such thinking easily earned the mark.

(f) Many candidates saw in the graph that the population/density of frogs increased in both lakes. Some also saw that in the upper lake the increase was followed by a decrease whereas in the lower lake there was no decrease, only a continuing increase. It was pleasing to see that some candidates applied their knowledge of population growth to describe the increase as exponential. Very few candidates noticed that the frog increase in the upper lake was greater than in the lower lake. Although this question was about frogs, some candidates included tadpoles in their descriptions.

(g) The idea in this question was to take a position, based on evidence cited from the data, to support or deny the hypothesis. A second mark was gained by providing some reasoning to explain the evidence. The problem was that some candidates never took a position in support or denial of the hypothesis. Other candidates did state their position but did not use the data to support it. There was also the possibility of saying that no prediction was possible because of contradictory or missing data.

Question 2

(a) This question produced inaccurate answers from most candidates. It required an application of knowledge about the cross-sectional structure of arteries and veins. Although the micrograph did show clear differences in lumen width, the differences in wall thickness of the coronary blood vessels were unclear. Thus, many candidates were uncertain and reversed their labeling. Also, the X and Y confused many candidates who thought the letters, themselves, indicated where labels were to be placed.

(b) Candidates who described an observable characteristic for the correctly labeled artery and vein in 2a were awarded the mark. The problem was that many candidates had reversed their labeling in 2a so that what should have been correct answers in 2b were actually inconsistent/contradictory to 2a. In those cases, no mark was awarded. An ECF was awarded if the characteristics in 2b were consistent with the incorrect labeling in 2a. Finally, those candidates who just wrote “thick/thin” with no reference to wall or “bigger/smaller” with no reference to lumen received no mark.

(c) (i) The question stem related back to the micrograph and role of the coronary artery. However, the immediate question was how oxygen enters the blood. The accepted answer just involved key terms, either diffusion or gas exchange. Unfortunately, many candidates became preoccupied with the stem and went on to describe blood circulation through the heart and surrounding blood vessels. Others went astray by writing about inhalation, the ventilation system and respiration. Some candidates just left a blank space.

(c) (ii) The topic of antibody production by lymphocytes is rather complex for 3 marks. The mark scheme attempted to summarize the essential ideas expected from SL candidates. Some candidates had clearly been exposed to HL information and gave

complicated incomplete answers which were too vague for any marks. For example T cells and B cells were confused. Most often, the marks awarded were for lymphocyte/antibody specificity to an antigen and the idea that antibodies can attack/disable/inactivate or kill (okayfor bacteria) the antigen. Outstanding answers also included the ideas that lymphocytes and clone/copy themselves and that, by doing so, they can produce many antibodies. If a candidate wrote that "lymphocytes produce antibodies" no mark was awarded as the answer just repeated the question.

(c) (iii) Many candidates seemed puzzled by the term substance even though the question stated "other than oxygen and antibodies." Formed elements such as blood cells and platelets were not accepted. Also, plasma was not accepted as it is a mixture of substances. Glucose, proteins, hormones, water all qualified as a substance. Even carbon dioxide was accepted since a small percentage is carried as a gas in the blood from respiring cells.

(d) The calculation refers back to the X and Y labels in 2a. Candidates failed for a variety of reasons: inaccurate/incomplete calculations, improper (inches)/missing units or even no ruler to do the calculation. One candidate actually wrote a note about this on the exam. Though unrealistic, a mathematically correct answer in μm was accepted.

Question 3

(a) (i) The concept of crossing over was well understood and the term often appeared for the mark. Many different incorrect answers were given such as disjunction, non-disjunction, mutation, anaphase and differentiation. The question was also left blank in a few cases.

(a) (ii) This was a difficult application question which very few candidates got correct. They did not read the question carefully. It asked for the total number of chromosomes in the gamete represented by diagrams K and L, not for the 21st chromosome as shown in the diagram. Thus, instead of K=24 and L=22, candidates most often answered K=2 and L=0. This was an unfortunate example of where candidates did not read the questions carefully. They mistakenly assumed the diagrams represented the gametes/real cells, yet the opening sentence of the questions stated that the diagram showed meiosis of chromosome pair 21 in humans.

(a) (iii) Down syndrome/trisomy 21 was usually known.

(b) (i) Many candidates completed the Punnett square accurately for the two marks. Failure to recognize color blindness as a sex-linked condition was usually the demise of those candidates who struggled. Because they treated color blindness as an autosomal condition, X or Y chromosomes were never shown, only upper and lower case letters appeared. Some candidates who were aware of the sex-linkage erred by showing superscripts/alleles on the the Y chromosome.

(b) (ii) Most candidates who were correct on 3bi were also correct on this question where the answer was 0 %.

(b) (iii) Again, most candidates who were correct on 3 (b) (i) were also correct on this question where the answer was 25 %.

(c) Candidates often gained at least one mark when explaining the cause of sickle cell anemia. Collectively, candidates used all the available marking points in their answers. Errors most often occurred when the base sequence of the mutated DNA was reversed. Candidates incorrectly stated that CAC mutated to CTC instead of CTC to CAC. Unfortunately, some were wrong when too much detail was given as in mutation of GAG to GTG in DNA of the transcribed strand. Also, a mark was lost when an answer stated that sickle cell anemia is characterized by misshapen blood cells instead of misshapen red blood cells. A few candidates thought that sickle cell anemia is sex linked. Very few thought the question required a genetic explanation so the last four marking points were rarely awarded.

Section B

Question 5 was highly favored, followed closely by Question 6. Question 4 was clearly the least popular.

Question 4

(a) Most carbon cycle diagrams were deficient in multiple ways. Parts of the cycle, i.e. conversions, were missing or arrows from one C reservoir to another were not shown or the processes they represented were unlabeled. Diagrams were rarely awarded more than three marks.

(b) The first part of this question was easy, since most candidates knew that as carbon dioxide concentration rises so does the rate of photosynthesis until a plateau is reached. Some showed this by sketching a graph but this was only had potential for marks when it was properly labeled or annotated. The major weakness for almost all candidates was their lack of knowledge regarding how carbon dioxide uptake can be measured, whether for a terrestrial or aquatic plant. Also, the idea that rate involves units of time was overlooked. It could be argued that candidate ignorance here can be explained by the teacher notes for assessment statement 3.8.7 which state “the recall of details of specific experiments to indicate that photosynthesis has occurred or to measure the rate of photosynthesis is not expected.”

(c) The mark scheme for this question included basic SL information. None of it favored candidates who studied Option C. The quality of answers varied considerably. Accurate detailed information was often missing. Candidates tended to know that glycolysis was common to both anaerobic and aerobic respiration and that anaerobic occurred without oxygen and aerobic with oxygen. After that, more was known about carbon dioxide and anaerobic respiration than for aerobic respiration. Links to the Krebs cycle were rarely made.

Question 5

(a) Many candidates produced very good drawings. A maximum mark was not uncommon. However, various shortcomings were seen in the drawings. For example, cholesterol was too large relative to fatty acids or the carbohydrate portion of a glycoprotein branched from a phospholipid instead of a protein or a peripheral protein was embedded and displacing a section of phospholipids. It should be noted that The SL guide uses the term “integral” not “intrinsic” in reference to trans membrane proteins.

(b) Since this question was “distinguish” between eukaryotic and eukakryotic cells, pairing of items was the best approach. Many candidates used a table to show the differences but some chose to write one long paragraph or even two shorter paragraphs, one for each cell type. The key was that a named item had to be mentioned with reference to each cell type. For example, marks were awarded if a candidate stated that eukaryotes have mitochondria and a nucleus and also that prokaryotes do not have these. Some candidates did not distinguish the differences in the cells through pairing or mixed up the differences between the eukaryotic and prokaryotic structures.

(c) Occasionally, beautifully sequenced answers were encountered for this question. These started with protein synthesis by ribosomes/rER, vesicle formation around the protein and ended with fusion of vesicle to plasma membrane and release of the protein. In between, there were references to transport and interactions between vesicles and Golgi apparatus. Weaker candidates knew which organelles were involved but were vague about vesicle formation. Some talked about getting proteins from outside the cell by endocytosis (not what the question asked) and then dwelled only on endocytosis and exocytosis. A few candidates never mentioned proteins.

Question 6

(a) Many damning adjectives could be used to describe most of the diagrams of the female reproductive system. There were missing parts or labels, oddly shaped structures, disconnections between organs, incorrect positioning, distortions of size etc. There were a few acceptable drawings, frontal view or sideways, but not many. Ovaries, fallopian tubes, and uterus were usually shown. The endometrium was often missing or its juxtaposition with the uterus rather vague. The vagina was sometimes shown and labeled, the cervix less often and rarely the vulva/labia.

(b) A few candidates wrote well balanced pro and con discussions on IVF but were challenged to have enough ethical issues for the 8 marks max. There were 7 marking points available for pro arguments and 7 for con arguments. Often there was heavy emphasis on the con/disadvantages of IVF, perhaps reflecting cultural bias in teaching IVF. Frequently, candidates rambled on about one particular issue rather than covering a range of issues. Common marking points were that IVF is unnatural/against some religious beliefs and that embryos are destroyed/killed. There was an overestimation of the power of screening for abnormalities to the extent of being able to select for favorable traits (designer babies). Some even thought that embryos could be modified through IVF. Another false notion was that sexual intercourse and IVF are mutually exclusive.

(c) In describing the application of DNA profiling in paternity investigations, many candidates only mentioned the DNA from the child and potential father with regard to

sampling or analysis for matches. The importance of the mother's DNA was omitted. The technical/laboratory aspects of band/fragment preparation were rolled into a single marking point to allow more emphasis on application of the technique. Most candidates missed any legal or personal reasons to establish paternity. Analysis of a pattern of bands/fragments and the idea that half of the bands will match the mother and half the potential father was not appreciated by many.

Recommendations and guidance for the teaching of future candidates

Candidates should

- Try to study all topics at an equal and reasonable depth.
- Know instructional verbs/command terms such as describe, compare, distinguish, label, list.
- Recall scientific language/terms (crossing over, Down syndrome); develop a glossary of important biological terms, especially those used in the guide.
- Study previous IB exams and markschemes to become familiar with the types of

  questions and discuss how to choose Section B questions.
- Read questions carefully and answer the question that is asked e.g. "how does oxygen enter the blood" does not mean "how does it enter the heart/lungs". Do not waste time on irrelevant information which will gain no marks; key words should be underlined before an answer is attempted; pay attention to information given above pictures and diagrams as it may guide your answer; if a question is not easy to answer at first sight, leave it to the end. avoid a shot-gun approach where many ideas are sprinkled into an answer hoping to score marks through positive marking (may backfire in that one part may contradict another).
- Label all essay sections a/b/c and avoid writing one continuous essay for all.
- Take care when drawing a diagram and make sure that labels reach their destination and are not just suspended; practise drawing the required diagrams/figures in the guide
- Write neatly or, if handwriting is not clear, print clearly, particularly when English is not a first language.
- Give units for calculated/mathematical answers
- Bring a ruler

Teachers should

- Try to teach all topics at an equal and reasonable depth.
- Where it applies, teach topics which have additional HL material (immunity and biochem) in a way that candidates know what is expected of them; they often attempt an answer that includes HL material but get that wrong and end up losing points.
- Help candidates improve their biological vocabulary e.g. the differences between antigen, pathogen, bacteria and viruses.
- Help candidate improve their biological diagrams with respect to labeling, scale/proportion, symmetry, connectedness, location of parts, lines that don't overlap and overall clarity.
- Teach candidates how to write genotypes for sex linked alleles; make sure candidates know which genetic conditions/disease are sex linked and which are not.
- Expose candidates to a variety of graphs for interpretation and to different micrographs for recognition of structures included in the guide; also have candidates practise magnification/image size kinds of questions so they are comfortable with those calculations.
- Teach candidates how to use rulers to help read and make graduations on a graph or chart for more precise answers;
- Refrain from introducing cultural bias in topics such as IVF.
- For topics with a sequence of steps/events, help students number the steps/learn what comes first i.e. (a) followed by (b), (c) etc. in that order.
- Be mindful of which IA investigation which may overlap and reinforce content/topics in the guide; candidates should know the concept of rate and methods of measuring the rate of photosynthesis; if possible, do pond weed experiments using a pH probes/data logger to measure the change in pH.
- Have candidates practice writing long response questions and then look at an answer key/markscheme to see the level of detail and what is missing; emphasize question answering techniques e.g. avoiding contradiction, irrelevance and, where necessary, creating connections in answers; remind candidates that an answer to a "discussion" question should include pros and cons.
- For distinguish questions, consider table formats where columns are labeled, and items are paired on each line.
- Candidates need to know about exam technique; if 8 marks is the max for a question, then the answer should ideally include at least 8 distinct and different points/statements; these don't need to long paragraphs for the mark; what counts most is a range of accurate detailed information.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 30	31 - 40

General comment

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 still small but improving with 136 respondents at the time the Grade Award meeting was held.

The comments on the G2 forms indicate that 97% of the respondents felt the paper's level of difficulty was appropriate. Of those respondents who had entered candidates previously, 83.5% felt the paper was of a similar standard to last year's paper while the rest were fairly evenly split between a little easier or a little more difficult. The clarity of the wording was considered good to excellent by 92% of respondents and the presentation of the paper was found to be good to excellent by 93% respondents. The suitability of the questions on the paper in terms of accessibility and cultural, religious or ethnic bias was felt to be accessible to all by 98% of respondents.

The comment was made on the G2s that the question(s) asked was "not quite specific to the wording of the assessment statement" (AS). The assessment statements are guidelines as to what topics or ideas may be assessed on the examination but is not necessarily the exact wording that must be used. A few comments were made to the effect that much of the option was not covered by the questions asked. This is the nature of Paper 3 as there are only 20 marks for each option and a data based question as well as a longer response questions are required. Candidates will always have learned more than they can be assessed on in the paper.

As in previous sessions, Option D and G were the most commonly chosen options, with options E and H also very popular. Very few chose Option F.

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

In general, a fairly large number of candidates struggled to express themselves clearly and concisely using appropriate terminology. This was often seen in definitions as well as in the second part of the data based questions and in the longer response questions. The second question in each option, which was often straight recall and should have been the easiest, was often weakly done due to poor content knowledge of the syllabus. There was often confusion between terms such as specimen, species and organisms.

Objective 3 command terms, such as 'explain', 'discuss', and 'evaluate' still remain problematic. Evaluation of hypotheses is often limited to the evidence supporting them, without mentioning implications and limitations.

Topics that appeared difficult to candidates include the following:

- Use of ^{40}K for dating fossils and rocks
- Hardy-Weinberg calculations
- Definition of clade
- Use of acids in food preservation
- Prion hypothesis
- How to obtain a reliable estimate of population of an animal species
- Hormonal control of gastric juice secretion

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

It was good to see that very few candidates attempted more than the two required options, although some are still using too many extra pages and not writing in the space provided. Candidates generally did well at retrieving information from graphs and performing basic calculations, even if they did not appear to really understand the graphs. Candidates who had studied for the exam were able to get marks for the longer response question in each option.

Topics for which candidates appeared well prepared include the following:

- Endosymbiotic theory
- How sound is perceived by the ear
- The development of bird song
- A named example of food poisoning
- Examples of steroid and protein hormones
- Erythrocyte breakdown by the liver.

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

Some candidates were clearly very well prepared and there were some quite outstanding scripts. Many IB centres deserve credit for the high standards that are being achieved. In contrast, there were a number of very low scoring scripts from candidates who seemed ill prepared for the examination.

Option D – Evolution

This was a very popular option.

Question 1

On the G2s the use of the word 'desiccated' in the stem was questioned as perhaps being unclear to all candidates. However, this word itself did not seem to be an issue.

a. Many did not seem to really understand the data or that the life span indicated the age at which the flies died. Flies with a life span of 16 hours were certainly alive at 8 hours.

Despite this, many were able to still get two marks for noting a similar peak in life span and similar range of life spans. Those who were able to compare were able to get three marks.

b. Many, but not all, were able to deduce that the south facing slope had a drier climate as the flies from there were able to live longer in conditions of drought stress.

c. This section was more difficult and discriminating with few good responses. Candidates found it hard to discuss clearly. Many had studied speciation mechanisms but were not able to apply their knowledge to answering the question. References to gene or allele frequencies and gene pools were rare.

Question 2

a. In (i) there were many vague definitions of half-life, often with no reference to radioactivity or isotopes. Likewise, in (ii) some very vague and confused responses were given regarding the use of ^{40}K for dating fossils, often referring instead to carbon dating. Those who did get points understood that ^{40}K decays into ^{40}Ar and that the ratio of these two determines the age of the rock if you know the half-life of ^{40}K.

b. Most struggled with the calculation using the Hardy-Weinberg equation in (i) and full marks were rare. The working was often disorganized. However, in (ii) almost all were awarded the one mark for stating the assumptions made when using the Hardy-Weinberg equation even if they could not do the calculation in (i).

c. Many vague answers were given as a response to define clade, often with reference to common characteristics. Clades always include all organisms with a same ancestor.

Question 3

This longer response question on endosymbiosis was answered fairly well with many able to get 3 or more marks, even if they struggled to express their answers with clarity. One common error was to incorrectly say the double membrane seen in mitochondria and

chloroplasts is a characteristic of prokaryotes. The double membrane is what is expected when a prokaryote with a single membrane is taken into a vesicle by endocytosis.

Option E – Neurobiology and behavior

Question 4

a. Almost all candidates were able to find the difference in mean rate of food collection using the graph.

b. Although the actual evaluations of the hypothesis were often poorly done, candidates were still able to get 2 marks by identifying the data to support the hypothesis or to not. Virtually no one referred to error bars or small sample size.

c. Almost all were able to suggest one reason for the day to day changes seen with many getting two marks.

Question 5

a. Sound perception by the ear was very well known with many candidates receiving full marks.

b.(i) While many candidates seemed to understand the differences between rods and cones and were able to get two out of three marks, they often had trouble expressing this clearly. One common problem was to see the statement that rods ‘detect black and white images’.

b.(ii) Explanations of the pupil reflex were surprisingly weak with many only getting one mark for the fact pupils constrict in bright light. A common error was to talk about the muscles of the pupil cause it to constrict rather than the muscles of the iris. Many were incorrectly discussing the role of the pupil reflex in brain death or the benefit of the reflex to protect the retina. Although candidates were not penalized for this, they should know the difference between constrict and contract in the biological sense.

Question 6

The development of birdsong was quite well understood with many candidates getting 3 or more marks and several getting the full six marks available. Those responses that did not score well often referred more to natural selection and why birdsong is needed for survival.

Option F- Microbes and biotechnology

This was once again the least popular of the options, with no comments on the G2 forms about this section. However, those that did do this option seemed to do fairly well.

Question 7

a. Almost all were able to read the graphs correctly and get the two numbers required.

b. Often candidates were imprecise about the months of the peaks and troughs. They had problems in making relevant comparisons using the graphs.

c. Many failed to notice the time lag with malaria peaking after peaks in rainfall, instead saying there was no relationship between the two. Once again, candidates did not evaluate well. Few received more than one mark.

d. The suggestion most often given was temperature fluctuations, earning one mark. A few mentioned breeding cycles of mosquitos.

Question 8

a.(i) This was well done by many candidates with food poisoning by *Salmonella* being the most commonly used example.

a.(ii) While candidates could often outline the use of high sugar concentrations in food preservation, they struggled to explain the use of acids.

b. This question was a very discriminating one with only the better candidates able to distinguish clearly between intracellular and extracellular infections.

Question 9

Candidates either were taught the prion theory and then even weak candidates were able to score 2 or 3 marks, with stronger ones could score 4-6 marks, or they did not appear to know it all.

Option G – Ecology and conservation

Question 10

Although there were comments on the G2s about the terminology in this data based question (fledging, hatching and breeding success) the candidates seemed to handle that aspect successfully for the most part.

a. Almost all were able to read the graph correctly for the one mark.

b. Many were able to see that hatching success generally increased between 1998 and 2006 but some missed the fact that it appears to plateau, instead giving minute description of the slight yearly fluctuations.

c. Many were able to get one or two marks for this comparison between fledging and breeding success.

d. The wording of this question did prove difficult and most candidates were not able to answer it as requested ‘using all the data’.

e. The most common suggestion was predation of chicks or parents with some also mentioning extreme weather conditions or reduced food sources.

Question 11

a. Almost all were able to list two factors that affect animal distribution in (i) for an easy two marks. However, most candidates struggled to clearly outline the competitive exclusion principle in (ii), even if they appeared to have some understanding of it. Stating that organisms were competing instead of species competing was a common error.

b. Most candidates understood the capture-mark-release-recapture technique to a degree but failed to note that the question asked how a 'reliable estimate' of population size can be made using this. Despite this, many were able to get one or two marks for the Lincoln Index equation and what each of the variables required was.

Question 12

The question on the impact of alien species turned out to be a difficult one as many did not know specific examples and confused alien species with invasive species using examples of native species that became problematic when they were invasive. Answers were often repetitive and poorly organized. Specific examples used were often only vaguely understood and not specific enough. However, candidates were still able to score two or three marks fairly easily on this if they could outline in general some of the types of impact such as interspecific competition or biological control of pest species.

Option H-Further human physiology

Question 13

Candidates seemed to struggle with most parts of this data-based question more so than those in other options. There were a few concerns expressed on G2 forms about the use of rats in this experiment as it was felt that they would have been exposed to undue stress when submerged in water that would be against the IB policy on animal experimentation. Some rats dive voluntarily so this was not exposing them to harmful conditions outside their tolerance limits. The data was taken from a scientific journal and the work was not carried out on behalf of the IB for the question. It was interesting that there were no comments made or problems seen with using the *Drosophila* fruit fly in the experiment in Option D.

a. Most candidates were able to use the graph to find the change in heart rate when rats dive. However, weaker or careless candidates incorrectly stated this as simply the heart rate of diving rats without looking at how this varied from the control group. The failure to compare with the control was also seen in other parts of this question.

b. An error made by many candidates was to ignore changes relative to the control and to compare swimming and diving directly to each other. Several were incorrectly linking changes due to increase pressure due to diving. The rats were not diving at such a depth.

c. Many candidates were able to get one mark for saying that diving rats hold their breath while swimming rats do not but they seldom were then able to expand on this to get the

second mark. It seemed that some candidates were guessing and trying to use common sense rather than biological knowledge. Again, too much emphasis was placed on the pressure exerted by the water rather than the physiological responses of the rats.

d. One mark was commonly awarded for greater heat loss through skin in cold water and therefore vasoconstriction was greater. Some were then able to get a second mark.

Question 14.

a.(i) There were many correct answers but the example of a protein hormone given was often erroneously as an enzyme.

a.(ii) For hormonal control of gastric secretion, many outlined nervous control instead, thus getting no marks. Gastrin was mentioned in only a minority of answers. This was surprisingly poorly done by many.

b. This section was also one with imprecise, vague answers. Some were discussing the Bohr Effect and not ventilation. One mark was common for increased CO_2 levels in blood or lower blood pH but only the better prepared and more able candidates seemed able to get two or three marks.

Question 15.

The best candidates answered this well, getting the full six marks. Even weaker candidates were able to do fairly well on this, and often scores of 4 or above were seen. Despite the high scores, responses were often not written with clarity or in an organized manner.

Recommendations and guidance for the teaching of future candidates

Preparation of candidates:

- Even though it seemed that more candidates had studied no more than two option topics, it should be stressed that teachers must teach the option topics thoroughly rather than leaving this to candidates to cover on their own.
- Teach students how to use tables when comparing or distinguishing between two things so that they make a point by point comparison. While there has been some improvement seen, too many candidates are still describing one and then the other item with no comparison being made.
- Use the action verbs in homework, tests and exams to ensure candidates are familiar with the question stems so that they understand what is required of them when they are asked to ‘describe’, ‘compare’, ‘evaluate’ or ‘explain’.
- Ensure definitions are given, understood and learned. Candidates need to use biology specific vocabulary clearly.

- Coach students on how to structure longer response questions.
- Teach specific examples when required rather than assuming candidates will look these up.
- In any quantitative answer, values are time, rates, percentages, sizes, distances, concentrations etc., but not 'amounts' which is too vague.
- 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.

Practise interpreting data in different formats. Use scientific journal articles and past paper data analysis questions throughout the two-year programme to develop this skill. Encourage candidates when answering data interpretation questions to:

- Look for the big picture or overall trends
- Look for variations and deviations in overall trends
- Use biological knowledge to explain trends and differences
- Be able to evaluate scientific methods and understand the basic assumptions that are made and where there are limitations to reliability.

Examination techniques need to be taught and practiced:

- Stress that the examiner can only mark what the candidate has written and cannot assume anything about knowledge or understanding.
- There is no need to repeat the question in an answer. There is not enough space to do this in the box provided and is a waste of time.
- In extended response questions, candidates should be encouraged to plan their responses before writing, taking note of the number of marks available to guide their answers.
- Take a ruler to the exam and use it when reading from graphs.
- Candidates must write so the examiner can read their writing; they should slow down and make it legible. Poor handwriting is made worse by the scanning required for emarking.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 15	16 - 20	21 - 24	25 - 29	30 - 36

General comment

The comments on the G2 forms from 88 respondents indicated that 92% considered the paper to be of an appropriate difficulty, with 1% finding it too easy and 7% too difficult. In comparison to last year's paper, 75% thought it was of a similar standard, 6% easier and 9% more difficult. No respondents found the clarity or presentation of the paper to be an issue.

Options A and G were the most commonly chosen options, followed by D and E. Option B was less frequently chosen and F was very rare.

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

Vitamin C daily requirements

Repaying oxygen debt after exercise

Speed as a measure of fitness

Photosystems, proton pumps and chemiosmosis

Endosymbiosis

Using ^{40}K to date fossils/rocks

Problems in defining species

The effects of psychoactive drugs

Forming recombinant DNA from mRNA

Using transects and quadrats

Succession

Some command terms were not interpreted well, such as "suggest" and "discuss".

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

Food miles

Blood flow at rest and during exercise

Krebs cycle

Causes of drug addiction

Nitrogen cycle

Distribution of plant species

Candidates are improving in their approach to answering comparison questions, with many more answering point by point.

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

Option A – Human nutrition and health

This was again the most popular option and candidates had good knowledge.

Question 1

A few candidates read the wrong axis for the numerical question but the majority were successful. If it was recalled that a BMI of 30+ is considered obese, many scored well in b. Diet and exercise were frequently cited as reasons for differences between the data, but a third point was more rare.

Question 2

Many candidates used the terms inorganic and organic to distinguish correctly between vitamins and minerals. Other terms were inaccurate.

The sun was often quoted as a source of dietary vitamin D.

Some candidates focused on the experiments carried out on vitamin C requirements during WW2 and many answers were very vague.

Question 3

Candidates were imprecise in their answers, using the expression “fibre helps digestion” and many appeared not to understand that the effects of fibre are due to its retention in the alimentary canal.

There was sound knowledge of the advantages and disadvantages of consuming foods with low food miles.

Option B – Physiology of exercise

This was one of the least popular options.

Question 4

Most age categories were correctly identified. There were difficulties in comparing the pattern of muscle loss, especially in relation to the three classes. Most candidates suggested lack of exercise as a cause of severe muscle loss but no other reason. The benefits of exercise were imprecisely outlined, so that only one mark was generally awarded here.

Question 5

Some candidates referred to blood rather than air when defining tidal volume; others confused it with vital capacity.

Some candidates were able to link increased respiration during exercise to explain increased tidal volume.

The distribution of blood flow during exercise and rest was generally well known.

Question 6

The precise details of anaerobic respiration, lactate production and how it is removed, were not well known.

There was a range of knowledge about fitness and using speed to measure fitness, with few candidates scoring full marks. There were few references to fast twitch muscles.

Option C – Cells and energy

Question 7

Some candidates, even those with high scores, did not identify both aspects of the condition for greatest inhibition. Others did not recognize that both salts decreased the activity of the enzyme, or found the answer difficult to phrase. Answers to the comparison question often failed to include manganese dioxide-bound enzyme.

Candidates often referred to allosteric sites (instead of a site elsewhere from the active site) as where the copper compound would bind, where this term should ideally be reserved for reversible inhibition in metabolic pathways.

Question 8

The cytoplasm and mitochondrial matrix were generally correctly identified but the location of the electron transport chain was very frequently identified as the outer mitochondrial membrane.

The Krebs cycle was well known, with many candidates going into great detail, since a large space was allocated for the answer.

Question 9

The questions on photophosphorylation and chemiosmosis were poorly answered. In many cases, the answers indicated confusion with respiration, and often the answers to the last

question on chemiosmosis were offered for the question on proton concentration. This perhaps would have been better worded as "explain **how** the H^+ concentration builds up in the thylakoid interior".

Option D – Evolution

Question 10

Some candidates gave a single number by subtraction for the ranges of femur length. Few were disadvantaged by the large sized points on the graph. Candidates had difficulty in evaluating evidence fully, although most gained one mark. They were more successful in outlining why data might be unreliable.

Question 11

There was a wide range of suggested essential features of a protobiont, with some candidates mentioning a membrane but not its importance. Most candidates mentioned photosynthesis for producing an oxygen rich atmosphere. The endosymbiotic theory was well understood by many, but less often the present-day evidence.

Question 12

Some definitions of half-life did not refer to radioactivity. The use of ^{40}K was very poorly understood and its half-life often quoted as 10000 years. Most candidates quoted the accepted definition of species but could less often provide any caveats.

Option E – Neurobiology and behaviour

Question 13

The data analysis proved challenging to many candidates. Some did not make reference to the months of the year or events, in the first question. The months were sometimes incorrectly identified or similarities not recognized, in the second question. Very few candidates were able to suggest reasons for the percentage of males in groups, although there were occasional references to hierarchy/dominance and mating. The suggestions for stimuli were often vague, such as "climate", rather than a specific change in the weather.

Question 14

Most candidates had knowledge of sound perception sufficient to gain one mark. *Amplification* of vibrations by the ossicles was often not mentioned, and the term "message" rather than "nerve impulse" was frequently used. The differences between rods and cones

were well known by some candidates, but others had difficulty with expression, and there were many references to “black and white” vision.

Question 15

Examples of inhibitory drugs were almost always correct, although cocaine was sometimes picked. The effects of drugs on the brain are quite difficult to describe and many answers lacked clarity. The causes of drug addiction appeared well known.

Option F – Microbes and biotechnology

Very few candidates chose this option.

Question 16

This data analysis was challenging with three variables to consider, and few candidates were able to score highly. In questions b) and c), there would have been more success if the sodium chloride concentration had been specified. In the last question, candidates failed to specify reduction of food poisoning.

Question 17

Most candidates were able to describe diversity in viruses, although some confused them with bacteria. The use and examples of viral vectors were quite well known.

Formation of cDNA from mRNA was rarely described, although candidates gained other marks.

Question 18

The nitrogen cycle was well known. Most candidates scored well on the consequences of releasing raw sewage into rivers, even without discussing eutrophication.

Option G – Ecology and conservation

Question 19

The year of highest breeding success was successfully selected. Candidates managed to describe the trend in most cases but had slightly more difficulty in articulating the comparison between breeding and fledging success. Using the data to suggest a reason for low breeding success in 1998 proved very difficult and generally only one reason (predation) was given for the final question.

Question 20

Many candidates had little knowledge of ecological techniques and were unable to describe the uses of transects and quadrats (frequently called a quadrant).

Question 21

Nearly all candidates could identify factors affecting distribution of plant species, and there was a long list in the mark scheme. There was some understanding of the niche concept, but many candidates did not name a resource for which there is competition. The focus on the changes in the abiotic environment during primary succession proved problematical although many candidates could describe the biotic progression.

Recommendations and guidance for the teaching of future candidates

- Teach the command terms, in particular that the term evaluate requires candidates to assess the implications and limitations of the data and that discuss requires candidates to give an account that includes a range of arguments for and against the proposal. Suggest requires candidates to propose ideas rather than reiterate data from the question.
- Teach definitions so that student responses are precise and not vague.
- Use the details given in the Teacher's Notes section of the Guide to ensure that candidates have the knowledge to respond in sufficient detail.
- Practice past paper questions and go through the mark schemes with the students, not only before the exam but also whilst studying the Options. Expose the students to the wide range of data analysis questions available. In this way, they won't be thrown by a "strange" or unusual graph. With this kind of practice they will learn the detail that is expected in their responses.
- Stress to students that "bullet" type answers are preferable, so that responses are sufficient for the 3-mark questions. Questions should not be repeated in the answer.
- Advise students to plan their answers to fit into the spaces provided, and if more space is required, to use extra pages rather than answering underneath the box.