May 2013 subject reports

Biology (timezone 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 - 64	65 - 77	78 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 30	31 - 41	42 - 54	55 - 67	68 - 79	80 - 100

Higher and 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 problem persists however in some schools that are setting investigations for assessment that give too much guidance or insufficient latitude.

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

In many schools the IB Animal Experimentation Policy (available on 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 numbers 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 effect of smoking or alcohol on heart rate.

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 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.

Moderators continue to comment on investigations that are unsafe or unethical. However, this is getting less frequent.

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 internet sites that will help here. Exposing them to caffeine, alcohol or energy drinks is not appropriate

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

Situations that deliberately demand the euthenising of animals are no longer appropriate. Thus, fruit fly genetics must be replaced by, for example, rapid *Brassica* plants, *Sordaria* mould, maize cobs or simulations, such as the virtual fly lab (although 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.

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 pro-forma for the signed consent of the participants in experiments. This is good practice but it is still too rare and moderators are still commenting on their absence in designed investigations involving human subjects.

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.

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 as to how the teachers were awarding marks. There are a large number of teachers who take a lot of time and trouble to prepare their Internal Assessment sample. This effort is very much appreciated. They should be congratulated for their efforts and their 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 for the investigations involving DCP assessment. It is also necessary, however, for investigations where Design is being assessed and a significant number of teachers are not doing this or their information is very limited.

Only a few teachers are not designing practical programmes with sufficient numbers of hours, however, some are overestimating the time spent on an activity. It should also be noted that the Group 4 Project can only count for 10 hours on the 4/PSOW.

Atypical candidates should be replaced in the sample. These 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 still sending photocopies of the students' 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 areas of the programme and examination in which candidates appeared 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.

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

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 teachers point out the errors to their students and still give full marks.

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

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

Some schools need to make better use of databases and simulations to fulfil the ICT requirement. Simulations are also a weakness because what some teachers are calling simulations are often just animations.

Literature sources are not always 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 clearly 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 strengths and weaknesses of the candidates in the treatment of individual questions

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. Examples of comments made by moderators this year:

All students used the same design for a catalase lab leading the moderator to question how much guidance was provided.

Although the independent variable was manipulated, the cell respiration was essentially the College Board AP biolab with no independent changes to the protocol.

In this same lab all of the students in the sample have the exact same research question. They all are comparing the fermentation of lactose, sucrose and fructose. The same issue is present with the reaction time lab. All of the students in the sample have done almost the exact 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 excessive guidance might be suspected. 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 novices 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 form their coordinators or they are for some reason 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 variable 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 and what is a control experiment. Sometimes unrealistic controls are being proposed when a control experiment would be appropriate (e.g. set room temperature to 21.1°C).

The investigations are often too simplistic. For example, the range of values of the independent variable was insufficient to establish a trend; the number of repeats was insufficient to permit statistical analysis. 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 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, this is legitimate but if the investigation is simply to determine the isotonic solution of one tissue then it remains trivial and it repeats many textbook investigations. If the investigation is used to determine the effect of the salinity of irrigation water on different root crops, 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 as a repeat of a text book classic when it is possible to give it a more original or personal approach. For example, 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 their own designs through. 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. For example, 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 (for example °C not °F and cm not inches). Spoonfuls and cupfuls should also be discouraged.

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

Data Collection and Presentation (DCP)

A consistent problem relayed by moderators 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 seen as collusion. 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.

Moderators often had to reduce the marks of the teachers who had missed the following points:

- Data (raw or processed) that is inadequately presented (for example with superficial titles)
- Units missing in the table column headings (note: decimal units should be used)
- No uncertainties given in the column headings of tables of data collected using measuring instruments.
- Inconsistent decimal places in tables
- The decimal places did not correspond to the precision of measurements
- The absence of associated qualitative observations where they are valuable. For example an ecological field investigation is incomplete without some kind of description of the site used. This appears to be a common problem.
- 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 when plotting graphs)
- The absence of statistical treatment of the data when it was possible
- When statistical treatment is applied with no consideration of its appropriateness. For example calculating standard deviations when there were only 2 or 3 measurements
- 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, were not explained.
- A majority are putting a linear line of best fit even when the data is clearly S-shaped or has some other non-linear pattern.

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.

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 a poorly designed investigation that collects a limited amount of data 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, especially the assessment of this criterion. It is not always possible to evaluate the method.

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 by the teacher, then Conclusion and Evaluation cannot be moderated.

Manipulative skills

Evidence on the 4/PSOW forms indicates that 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.

ICT coverage

Many schools seem to have made an effort to equip themselves with the necessary materials to carry out data logging. There are signs that the material 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 MS Excel. 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.

On the other hand, under the current criteria the used of databases and simulations are not appropriate for assessment of Design, DCP or CE.

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 and guidance for the teaching of future candidates

- Share the criteria with the students and explain them.
- Read feedback from the previous session and act upon it.
- Consult the Online Curriculum Centre (OCC) for teacher support material (TSM)
- Apply the internal assessment criteria rigorously.
- 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.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 15	16 - 21	22 - 26	27 - 30	31 - 35	36 - 40

General comments

Of the teachers who responded on the G2 forms, more than 95% thought that the level of difficulty was appropriate. Most thought that he level of difficulty was similar to that of last year and almost all considered both the clarity and presentation of the paper to have been satisfactory or good.

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

The statistics showed that there ten questions answered correctly by fewer than 50% of candidates. Three questions were both answered correctly by few candidates and had a low discrimination index, indicating that some of the stronger candidates were among those who answered incorrectly. The topics of these three questions were the *t*-test, calculation of actual cell size from a micrograph with the scale bar, involving conversion from micrometres to millimetres and bulbs as a storage organ.

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

The statistics showed that there were ten questions that more than 80% of candidates answered correctly and though they had relatively low discrimination indices so were not of much use in separating the weaker and stronger candidates, they did indicate many areas in which the candidates were well prepared. These topics included eukaryotic cell structure, base sequences of RNA produced by transcription, the effect of substrate concentration on enzyme activity, glycolysis, karyotype analysis, and the inheritance of ABO blood groups and skin colour.

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

Question 1 is usually an easy warm-up question but in this paper it was quite a demanding statistics question that was not very well answered. Candidates were expected to understand that a probability of between 0.15 and to 0.25 is too great for the difference between two

means to be regarded as significant. Many candidates instead thought that it indicated an insignificant difference.

Question 3 was answered much less successfully than expected. Some teachers reported on G2 forms that it was too difficult without calculators, but the math was in fact very easy. A large number of candidates were unable to convert 70µm into 0.07mm by moving the decimal point three places to left. Students should be taught that S.I. units are increased by a factor of 1000 so conversion from micrometres to millimetres is accomplished by dividing the length by 1000.

Question 4 had a very low discrimination index which sometimes indicates a problem with a question. In this case it merely showed that a high proportion of candidates answered the question correctly, despite the fears expressed by some teachers in G2 forms that the micrograph was not clear enough.

Questions 7, 8, 10, 11 and 12 also had relatively low discrimination indices because a high proportion of candidates answered them correctly, indicating either good knowledge or that these questions proved to be rather too easy.

In contrast Questions 9, 24, 28 and 32 had very high discrimination indices. Each required secure knowledge the details of HL Biology, which diligent and capable students acquire but others tend not to.

Question 18 was relatively poorly answered. Large numbers of candidates thought that two species with the same specific names but different generic names were of the same species. In fact some common specific names such as album or vulgaris are used for large numbers of different species.

Question 19 was criticised by some teachers. The programme specifies three phases in a sigmoid growth curve: the growth phase, transitional phase and plateau phase. Some teachers felt that X could have been indicating the plateau phase. A significant minority of students did choose the plateau phase as their answer, but as a plateau phase is indicated by a horizontal line on the graph and X was not close to the horizontal section, this was not accepted. It could have been argued that X was on part of the growth phase as the population was still rising, but only a very small percentage of candidates chose this answer. The transitional phase is required understanding and was without doubt the best answer here. However, the question would have been better if a bracket label had been used to indicate the transitional phase.

Question 20 was criticised because students are only expected to know one source of amylase and this could be the salivary glands, but it if they knew that the substrate of amylase is starch and the product is maltose the only possible answer was the correct one.

Question 21 was also criticised because there is an iso-volumetric phase at the start of ventricular systole when both atrio-ventricular and semilunar valves are closed. However, the examining team felt that during most of ventricular systole the atrio-ventricular valves are closed so one of the four answers was clearly the best.

The correct answer in Question 25 was contested by some teachers who thought that LH both stimulates follicle development of follicles and ovulation. This view is not supported by the evidence, which shows that LH promotes secretion of estrogen by cells in the developing follicle but that follicle development is stimulated by FSH. The two pituitary hormones FSH and LH have distinctly different roles and it is not correct to lump them together in an explanation of the menstrual cycle. The LH surge is such a good predictor of ovulation for couples wanting to conceive because LH stimulates ovulation.

Question 26 was answered correctly by fewer candidates than expected. Channel proteins are needed for facilitated diffusion of charged and polar substances, so polar amino acids can be expected to line their pores.

Some teachers felt that Question 27 required specific knowledge of malonate as an inhibitor of succinate dehydrogenase. This was an example of a question where one answer is distinctly the best. Although increases in substrate concentration reduce the effect of both competitive and non-competitive inhibitors, the effect is greater with competitive inhibitors. Students seemed to have less of an issue with this question than teachers with two thirds answering it correctly and the discrimination index being high.

Question 31 was poorly answered with fewer than 20% of students choosing the correct answer and the discrimination index also being low. According to the existing programme, candidates are expected to know that bulbs are storage organs that consist of modified leaves. However, it must also be said that small pieces of factual knowledge such as these are perhaps not important enough to justify testing and that the new programme that will be taught from 2014 onwards will emphasise deep understanding more.

In question 37 a substantial minority of candidates thought that ATP is used to make cross bridges rather than break them. The development of rigor mortis is an indicator that energy from ATP is directly used to break rather than make cross bridges.

Recommendations and guidance for the teaching of future candidates

Paper 1 is very wide ranging and the most important recommendation for the teaching of candidates is to ensure complete coverage of the syllabus in lessons and thorough revision in the weeks leading up to the exams.

Comments on G2 forms showed that some teachers expect one answer to each question to be utterly correct and alternatives to be completely incorrect. In many questions there is indeed one clearly correct answer and three indubitably incorrect alternatives. However, in a small number of questions there may seem to be elements of truth in several of the possible answers. In these questions there will always be one answer that the examining team consider to be wholly correct and therefore the best choice and candidates should be encouraged to search for this.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 22	23 - 33	34 - 43	44 - 54	55 - 72

General comments

More than 95% of teachers who commented on G2 forms thought that the level of difficulty on this paper was appropriate and others were split evenly between those who thought it too difficult and too easy. Most felt that it was similar in difficulty to last year's paper but of those

who did not, more thought it easier than more difficult. Most teachers felt that the clarity of wording and presentation of the paper were good and all the rest thought it satisfactory.

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

The candidates found the relationship between Mendel's law of independent assortment and meiosis very difficult. Many candidates found it membrane fluidity, end-product inhibition, models of enzyme activity and definitions of autotroph, heterotroph and saprotroph difficult.

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

Many candidates were well prepared for data analysis questions. There was widespread understanding of the inheritance of hemophilia.

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

Section A

Question 1: This question had parts that ranged from easy to very challenging and there was a wide range of scores on it.

In (a) candidates were tested on their knowledge of methods of measuring the rate of photosynthesis. Most answered it correctly. A few candidates made vague statements about growth or suggested that use of water could be a measure of photosynthesis. Neither of these answers was accepted.

Part (b) was also testing knowledge rather than data analysis skills. There were some good explanations of why heat may reduce photosynthesis rates, including the idea that stomatal closure would reduce carbon dioxide uptake. Enzyme denaturation was accepted although photosynthesis rates drop at much lower temperatures in most plants than could be due to denaturation. Candidates were not expected to know about photorespiration and the reactions that are catalysed by rubisco at high temperatures.

Part (c) was intended to be an easy question and almost all candidates answered it correctly.

Answers to (d) were more mixed. The command term 'describe' requires a detailed account to the marks were not awarded simply for stating that there was a fall in isoprene emissions during drought and a rise during recovery. There had to be some qualification, such as the changes in the rate of rise or fall, or an indication of whether recovery was complete. Some candidates stated that the emissions 'spiked upwards' during recovery. This was allowed but strictly speaking a spike is a sharp rise and fall, not just a rise.

Part (e) was quite well answered but relatively few candidates scored both marks. Fewer candidates than in the past simply described the results for 25°C and then for 35°C, without proper comparison, but there were some simple comparisons on the mark scheme that most candidates missed. The best approach was to think about the difference between the results at each time during drought and recovery, not to overcomplicate things by trying to compare rates of change.

Part (f) was intended to be an easy lead in to the third graph, but a higher than expected proportion of candidates stated that heat treatment increased the rate of photosynthesis rather than decreased it. The arrows on the graph show when the heat treatments were administered and at these times there is clearly a decrease but some candidates thought that the rise following the times indicated with an arrow showed that the heat treatment had positive effects on photosynthesis.

By part (g) of the question some candidates were starting to struggle. There were two independent variables in this experiment; temperature and presence or absence of fosmidomycin. Marks were only awarded if the effects of fosmidomycin were related to the heat treatments.

Part (h) of the question was also found difficult by some candidates. Marks were awarded for conclusions about the effect of heat on photosynthesis, but not for conclusions about fosmidomycin. This chemical was used in the experiment as a means of investigating the effects of isoprene so the expected conclusions were about the protective effect of isoprene during heat treatments. There were some excellent answers from the stronger candidates who understood the experiment and were able to analyse its results effectively.

Few candidates had any problem with part (i) and calculated the difference in percentage recovery successfully.

Answers to part (j) were very varied, with fewer candidates scoring both marks than expected. There were separate marks for stating that recovery was faster with isoprene than without (an all or nothing effect) and for stating that the higher the isoprene concentration the faster the recovery. There was also a mark for stating that these trends were evident both after one hour and 24 hours.

Part (k) was another two mark question where most candidates scored either one or no marks. Two reasons were required, with four interrelated reasons on the mark scheme. Few candidates suggested that some plants might lack the genes for isoprene synthesis and almost none that there is a cost to synthesis in terms of energy or resources so there will be selection against it in areas where hot conditions are never experienced.

Question 2: (a)(i) About half of the candidates identified the structure correctly as Golgi apparatus, with the others mostly suggesting rough endoplasmic reticulum even though there were no ribosomes on the outside. (ii) Again about half of candidates answered correctly with endocytosis or a variant of this process. A wide range of other answers was given by other candidates.

(b) This question was answered moderately well. Candidates were expected to link the fluidity of the phospholipid bilayer to the movement involved in vesicle formation.

Question 3: (a) Almost all candidates gave a correct answer, probably because there was a strong hint in the diagram. End-product or non-competitive inhibition was accepted, or references to feedback.

(b) Candidates found this part of the question quite hard and it exposed a wide variety of misunderstandings of the interactions between enzymes, substrates, active sites, allosteric sites and end-product inhibitors. Many candidates failed to relate their answer to pathways used to synthesise essential metabolites in cells.

(c) Answers here were weaker than expected. Candidates were expected to name the lock and key model and the induced fit model and state how each explains substrate binding.

These are the names of models used in the programme and other terms such as hand in glove were not accepted.

Question 4: (a) Nearly all candidates knew something about autotrophs and heterotrophs but answers tended to be too loose to score many marks. A common error was to suggest that plants make energy.

(b) Fewer than half of candidates were able to state what a saprotroph is. Answers had to make it clear that saprotrophs feed on dead organic matter by external digestion, to exclude detritivores that ingest dead matter.

(c)(i) and (ii) Candidates were evenly divided between those who had no idea of the external features or Cnidaria, Annelida and Mollusca, those who knew some of their features but failed to score marks because they did not give both sides of the comparison and those who gave correct and full comparisons.

Section B: Question 5 was the least popular in Section B and tended to be chosen only by stronger candidates. Questions 7 and 8 were the most popular.

Question 5: (a) The best candidates had no difficulty in scoring full marks for a plan diagram of leaf structure. A surprisingly large proportion of candidates drew stem structure rather than leaf. Comments from G2 forms show that some teachers are unfamiliar with the term 'plan diagram' and thought that there was a typographical error with the question intended to state 'plant diagram'. Plan diagrams are specified in Assessment Statement 9.1.1 and show areas of tissue in an organ without any individual cells being drawn.

(b) Well prepared candidates gave thorough and high scoring accounts of metabolic processes that follow water uptake in geminating seeds.

(c) This was another high scoring part of the question for stronger candidates. A few misread the question and wrote about light-dependent reactions. The use of the abbreviation GP is discouraged as it is ambiguous in accounts of the Calvin cycle.

Question 6: (a) There were many general accounts of the sealing up of cuts with clotted blood but what was needed here was the process that leads to clotting. The programme specifies which stages in the cascade of reactions are expected and better answers included these and scored full marks without difficulty.

(b) Marks for this part of the question covered the whole range. Among weaker candidate there were various misunderstandings about gene transfer and many confused gene transfer with gene therapy, describing the transfer of the Factor IX gene to haemophiliacs rather than to bacteria. In almost every case the method of gene transfer described in successful answers was that using plasmids. There were some detailed and accurate accounts of this process.

(c) Almost all candidates knew something about the inheritance of hemophilia. The mark scheme rewarded a wide range of relevant points as long as they were clearly made. Punnett grids to be used to illustrate particular points but they did not score marks in themselves. One area of confusion among weaker candidates was the difference between genes and chromosomes, with answers referring to dominant or recessive X chromosomes or implying that X was the gene for hemophilia.

Question 7: (a) There were some good accounts of the types of evidence for evolution. Nearly all mentioned fossils and many also included homologous structures. One fault in some answers was to include examples where natural selection can be used to explain a

phenomenon but which in themselves do not provide convincing evidence for evolution because there are other possible explanations.

(b) This was the most problematic question of all for candidates who chose it. Understanding of Mendel's law of independent assortment was hazy in most cases and non-existent in some. There was often an account of meiosis, but not in relation to independent assortment. There was too much focus on linked genes and crossing over, when independent assortment only occurs with unlinked genes. There were very few impressive answers to this question, partly because it was relatively difficult and partly because stronger candidates mostly avoided question 7.

(c) Answers to this part of the question were also poor in many cases. Science must be based on evidence that is as strong as possible. This is especially true with evolution, where many non-scientists remain to be convinced. Much of the evidence presented by candidates here would convince no-one, with inaccurate and in some cases invented examples. Only cases based on known environmental change were accepted, so for example supposed increases in the height of trees and a consequent lengthening of the necks of giraffes was not accepted, nor hypotheses about human evolution. There were many very vague accounts of Galapagos finches which did not include any reference to environmental change. El Niño and La Niña cause environmental change in the Galapagos archipelago and evolution in response is well researched but this evidence was rarely included in answers. The case of the peppered moth was often cited and some answers described it well. The other case that was successfully described was the development of antibiotic resistance in bacteria.

Question 8: (a) There were some excellent diagrams of mitochondria that scored full marks but also many incorrect ones. A frequent fault was to show the cristae as an extra membrane, rather than as part of inner membrane. Some diagrams showed so many gaps and overlaps in the membranes that a mark was lost. The weakest candidates depicted in their diagrams whole cells with eukaryote features.

(b) There were some strong answers to this relatively easy question that quickly gained the six marks. Other answers lacked precision and so scored less highly. One common misunderstanding is that it is the spherical shape of alveoli that give the lungs a large surface area for gas exchange. In fact a sphere has the less surface area for a given volume of any shape and it is the small size and large number of alveoli that gives the large surface area.

(c) This was a standard and relatively straightforward question and strong candidates scored full marks. As with other questions on this paper, the weaker candidates revealed a wide range of misunderstandings. Cause and effect were confused in some answers, so it is that movement of air into the lungs that causes the diaphragm to move down rather than vice versa. One particularly common misapprehension is that pure air is breathed in and pure carbon dioxide breathed out. Were this to be possible it would make gas exchange much more efficient but unfortunately it is not.

Recommendations and guidance for the teaching of future candidates

- Candidates should be encouraged to read questions very carefully as one word or even a letter or two can change a question into an entirely different one. For example in this paper some candidates wrote about the light-dependent reactions of photosynthesis rather than light-independent.
- In questions involving giving differences, it is necessary to give both sides of a comparison, so in a question involving distinguishing molluscs and annelids it is not

enough to say only that annelids are segmented; an answer is only complete if it includes that molluscs do not show segmentation.
- Guesswork and invented case studies should not form the basis of answers on this or any other paper. Science has to be based on solid evidence or non-scientists will not trust scientific work in the future. This is particularly important with research into evolution.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 4	5 - 9	10 - 14	15 - 19	20 - 23	24 - 28	29 - 40

General Comments:

The comments on the G2 forms indicate that 68% of the respondents felt the paper was of a similar standard to last year's paper while 8% felt it was easier and 11% felt it was more difficult. As for the paper's level of difficulty, 97% felt it was at the appropriate level of difficulty. The clarity of the wording and the presentation of the paper were found to be suitable or good by 99% of respondents. 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 has improved over previous sessions but is still very small with only 131 respondents at the time this report was written. Option E was the most commonly chosen option and very few chose Option F.

The areas of the programme which proved difficult for candidates

Topics which proved difficult were:
- How isolation of a gene pool leads to evolution
- Cultural and genetic evolution were treated in too general a manner
- cladograms
- bioremediation
- distinguishing biosphere and biome
- biogeographical features of nature reserves
- control of gastric juice secretion

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

Many candidates produced very good scripts and it was obvious they had been given sufficient time and instruction to cover the options thoroughly. They were able to both analyze the data in Question 1 as well as indicate their level of subject knowledge in the short answers in Question 2 and the longer response Question 3.

However, some scripts indicated only a superficial familiarity with the options. Interpretation of graphs and identification of trends were generally stronger than content knowledge.

One area of difficulty continues to be the interpretation of the command verbs and thus knowing what precisely is required to answer accurately. 'Discuss' and 'Distinguish' were often problematic on this particular paper.

Another difficulty was the precision of expression and the ability to use subject-specific vocabulary. There were many vague and unspecific answers which were seen particularly in answers to Question 3 in each section.

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

Option D – Evolution

Although this was a popular option, candidates did not do very well on it.

Question 1 (a) Most candidates were able to get 2 marks for comparing the effectiveness of the two amino acids but few seldom received the third marking point.

(b) Candidates seldom obtained more than 1 out of 3 marks for this question. They often described the work by Miller and Urey rather than evaluating the experiment described in the data. Being familiar with the Miller and Urey experiment, they should have been able to then evaluate the one given in this data-based question.

(c) Most candidates were able to state two other locations such as hydrothermal vents or extraterrestrial origins via comets.

Question 2 (a) Many candidates were able to correctly state two of the assumptions of use the Hardy –Weinberg equation.

(b) Candidates struggled to outline how isolation of a gene pool can lead to evolution. Very vague responses were seen with seldom any reference to different selective pressures on the isolated populations.

(c) Candidates in general did very poorly on this question with many only able to give examples of cultural and genetic evolution but not distinguish between the two processes in relation to how they are inherited, what actually changes in each and the time frame involved.

Question 3 While some candidates had an idea that cladograms were used to show evolutionary relationships, they were not able to clearly indicate what clades were and how cladograms were used. Some candidates confused cladograms with dichotomous identification keys. Candidates seldom received more than 3 out of 6 marks for this question.

Option E – Neurobiology and behavior

This option was very popular and candidates tended to score well on it.

Question 1 (a) Almost all candidates read the diagrams correctly for the 1 mark.

(b) Most candidates were able to correctly distinguish between the effects of red and green light on robin behavior.

(c) Many candidates repeated their response to section (b) in this question and did not get the 1 mark.

(d) Almost all correctly deduced that the robins migrated in daylight but only some could clearly explain why for the second mark.

(e) Most candidates were able to get at the 1 mark for this.

Question 2 (a) It was disappointing how many candidates could not label the diagram of the eye correctly.

(b) Although many were able to get 1 mark for understanding that a lack of pupil response to light indicated no brain processing and therefore brain death, few were able to get a second mark. Many were using incorrect terminology to describe what happened to the pupil in response to light. A persistent misconception seemed to be that the pupil 'detects' light and not the retina.

(c) In general, candidates did poorly on this question with many only getting one mark. Many were incorrectly saying cocaine is a neurotransmitter or that it caused more dopamine to be produced rather than it caused dopamine build up in the synaptic cleft due the fact it blocks the reabsorption of dopamine. Many were relying on general 'street' knowledge rather than any biological information.

Question 3 Although many candidates could give examples of organisms that showed altruistic behavior (naked mole rat and vampire bats were the most commonly used), few were able to actually discuss the evolution of altruistic behavior which is what the question was asking. The fact that one of their examples dealt with colonies of related individuals and the other dealt with a colony of unrelated or distantly related individuals was seldom made clear. Many were also confusing altruism with parental care.

Option F- Microbes and biotechnology

This was the least popular of the HL options but it was encouraging to note some schools studying it with some good standards seen.

Question 1 (a) Almost all candidates read the graph correctly for the 1 mark.

(b) Many candidates correctly identified BPT3 as the bacteria that should be used to treat the water but some could not give a reason so missed the mark.

(c) The better candidates were able to correctly compare the effects of sulphide and chromium ions on the inhibition of BPT3. Weaker candidates gave very confused and unclear answers.

(d) Many were able to get two marks for why denitrification of raw sewage before release into rivers was important with many mentioning eutrophication, algal blooms and reduced oxygen levels as problems of high nitrate levels.

Question 2 (a) Most candidates were able to get a mark for mentioning the high salinity that halophiles can withstand. Although the question clearly said to outline other extreme environments inhabited by Archaea, many candidates still listed the anaerobic conditions of methanogens, which was in the stem, and thus did not get a mark.

(b) The description of methane production from biomass was done well by the better candidates who were able to give the products the various bacteria produced, often with

correct equations. The weaker candidates only knew that methanogenic bacteria produced methane.

(c) A surprising number could not answer this simple question on locomotion in *Euglena* and *Paramecium*.

Question 3 Many candidates knew that bioremediation used bacteria to remove contamination from soil, such as happens during an oil spill. Only better candidates were able to actually explain how bacteria used the contaminants in their own metabolism and what the source of these bacteria was. Many were incorrectly describing the nitrogen cycle. Perhaps candidates had been taught bioremediation of high nitrate content ground water by bacteria but expressed it, incorrectly, as the nitrogen cycle.

Option G – Ecology and conservation

This was also a very popular option but not very high scoring in many cases.

Question 1 (a) Almost all correctly identified the trophic level as herbivores (primary consumers) and thus were able to get this mark.

(b) Many were able to score 1 mark comparing levels of mercury in herbivores and detritivores with the better candidates scoring full marks.

(c) Many found this section difficult as they did not explain the large 'range' of mercury concentrations in piscivores but instead explained why there was a high level, which was not what the question asked. It was thus discriminating with only good candidates receiving the 2 marks.

(d) Candidates often gave vague answers to this section and thus seldom were awarded more than 1 mark.

Question 2 (a) Very few were awarded the mark as they struggled to distinguish between biome and biosphere (AS G2.9). They were not really clear what either was or knew one but not the other.

(b) The responses to this question were very vague with some candidates unable to name biomes, let alone outline their characteristics. Any three would have been suitable, although the syllabus lists six different biomes they should be familiar with.

(c) This was poorly answered by most candidates as they did not seem to understand (or ignored) "biogeographical features". Instead some talked about in situ and ex situ conservation.

Question 3 Many were able to get 3 or more out of 6 marks, which made this Question 3 higher scoring than in some of the other options. The marks were usually for giving examples of agreed international conservation efforts such as maximum sustainable yields, but many candidates discussed pollution control and the monitoring of fish stocks rather than focusing specifically on conservation measures.

Option H – Further human physiology

Question 1 (a) Most used the graph correctly to estimate the change in arterial saturation. However, some candidates are incorrectly giving a range of values rather than calculating a

single value. Perhaps this comes from looking at past paper mark schemes in which a range of values is given within which examiners can accept an answer as correct.

(b) (i) Most candidates earned 1 out of the 2 marks, and many received both marks.

(ii) Fewer candidates were able to suggest a reason and get the mark for this section.

(c) Some candidates were incorrectly discussing myoglobin and missed the simpler points available for such modifications as increased ventilation rate.

(d) Few candidates could clearly explain an effect of high altitude on oxygen transport by the blood. Answers were vague or talked about symptoms of altitude sickness.

Question 2 (a) The better candidates were able to clearly distinguish between steroid and peptide hormones.

(b) The control of gastric juice secretion by nerve impulses and the hormone gastrin was poorly done in general with few getting the 2 marks.

(c) Candidates did better on this section with many getting 1 or 2 marks and the stronger candidates scoring the full 3 marks.

Question 3 Some candidates did well on this longer response question with many scoring 3 marks. However, there were also many responses that were vague and lacked detail.

Recommendations for the teaching of future candidates

- Teach two options only based on the subject area in which the teacher feels most confident. Do not leave this up to candidates to do independently.
- Teach the vocabulary necessary for a High Level biology course. Candidates must have access to a strong vocabulary of subject-specific words and concepts. If they are at a loss for words they will be unable to express their ideas with clarity.
- Where the syllabus asks for an unspecified example, detailed examples need to be covered (e.g. non-human examples of altruism).
- Teach students how to use tables when comparing or distinguishing between two things so that they make a point by point comparison. Too many candidates are still describing one and then the other item with no comparison being made.
- Use the command terms or action verbs in homework, tests and exams to make candidates familiar with the question stems so that they understand what is required of them when they are asked to ‘describe’, ‘compare’, ‘evaluate’ or ‘explain’.
- Practise 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 to look deeper into the data to identify features they may not see at first glance.
- 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.
- Encourage candidates to plan their answers for the number of marks stated in each question. Encourage candidates to pause and plan their responses so they are fully aware of the demands of the question and do not include irrelevant information.
- As all scripts are now e-marked, candidates need to write in black or blue ink as pencil does not scan well. Also, do not write outside the answer box as writing outside the box will not be scanned. Extra sheets should only be used when necessary.

- There is no need to waste space by repeating the stem of the question.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 11	12 - 15	16 - 20	21 - 24	25 - 27	28 - 30

General comments

More than 90% of teachers who commented on G2 forms thought that the level of difficulty on this paper was appropriate and others were split evenly between those who thought it too difficult and too easy. Most felt that it was similar in difficulty to last year's paper but of those who did not, more thought it easier than more difficult. Most teachers felt that the clarity of wording and presentation of the paper were good and all the rest thought it satisfactory. Many questions on the exam performed very well with a high discrimination index indicating that stronger candidates had answered correctly with weaker candidates tending to choose the distractors rather than the correct answer.

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

Many candidates found questions on binomial nomenclature, the mechanism of ventilation and calculations involving conversion from micrometres to millimetres difficult. Questions found difficult by a wide range of candidates including some of the stronger candidates included those on the *t*-test and responses to overheating in the human body. The difference between the functions of LH and FSH in the menstrual cycle was not known by some candidates

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

Candidates showed good knowledge of eukaryotic cell structure, karyotype analysis, products of anaerobic respiration and ecological efficiency.

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

Some questions performed in a predictable way, so no comments need to be made about them. The comments are related to questions where candidates did very well or very poorly or that aroused comments on the G2 forms.

Question 1 elicited more negative comments than any other on the paper. Candidates were expected to understand that a probability of between 0.15 and to 0.25 is too great for the difference between two means to be regarded as significant. Many candidates instead thought that it indicated an insignificant difference.

Question 5 included the term xylem, which is not specifically mentioned in the SL Biology programme, but Assessment Statement 3.1.6 indicates that candidates should understand the relationship between water's properties and its use as a transport medium. These include water's cohesive properties and thus its movement under tension in plant transport. Even if candidates were uncertain whether the answer including xylem was correct, they should have been able to eliminate the other three alternatives. More than 75% of candidates answered this question correctly and the discrimination index was high.

There similar complaints from a few teachers about Question 9. At Standard Level students are not expected to have studied transpiration, but the examining team felt that the answer referring to water moving from a leaf into the atmosphere could have been eliminated without knowing details of transpiration because movement of water molecules from a liquid state inside the leaf to the gases of the air outside cannot be osmosis.

Several teachers commented that the term lacteal is not specified in the programme and should therefore not have been tested in Question 25. This question was based on Assessment Statement 6.1.7, which specifies that students should be able to explain the relationship between the structure of the villus and its functions in absorption and transport. There is no teacher note accompanying this question so no specific structures are included or excluded and the examining team's view was that it was reasonable to expect knowledge of lacteals which have an important role in transport of absorbed. Two other labels on the diagram were the epithelium and capillaries and well-prepared candidates should have been able to eliminate them even if they then had to guess between the other two answers. In fact nearly 60% of candidates answered this question correctly and the discrimination index was good.

Question 28 was another one in which there was criticism of the vocabulary used. In this case it was felt that the word chest should have been used instead of thorax. It is true that only one third of candidates chose the correct answer to this question, but the discrimination index was excellent showing that many of the stronger candidates had been successful. It was possible to deduce that the thorax must be equivalent to the chest if it was known that contraction of external intercostal muscles and the diaphragm cause inspiration. The answer to the question could then be deduced –that the pressure decreases and the volume increases. Many candidates thought that contraction of these muscles caused the opposite; an increase in pressure and decrease in volume.

Question 30 was also part of the HL Paper 1. It attracted the similar comments from SL as HL teachers, who contested the answer. Some teachers thought that LH both stimulates follicle development of follicles and ovulation. This view is not supported by the evidence, which shows that LH promotes secretion of estrogen by cells in the developing follicle but that follicle development is stimulated by FSH. The two pituitary hormones FSH and LH have distinctly different roles and it is not correct to lump them together in an explanation of the menstrual cycle. The LH surge is such a good predictor of ovulation for couples wanting to conceive because LH stimulates ovulation.

Recommendations and guidance for the teaching of future candidates

The best advice for candidates, given many times before in reports on Paper 1 is to prepare thoroughly and ensure that every assessment statement has been studied and the topic described by it understood. In the current style of paper some questions test details of knowledge and others test depth of understanding. In the new programme which will be taught from 2014 onwards there will be greater emphasis on lasting and transferable understanding and less on easily forgotten details.

A general piece of advice for answering multiple choice questions is that if candidates cannot be sure of the correct answer to a multiple choice question they should try to eliminate as many of the incorrect answers as possible. It two or three possibilities then remain rather than one certain answer it is advisable to choose one of the answers by guesswork as no marks are deducted for incorrect answers and a question left unanswered cannot possibly be awarded a mark.

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

More than 90% of teachers who commented on G2 forms thought that the level of difficulty on this paper was appropriate and others were split relatively evenly between those who thought it too difficult and too easy. Most felt that it was similar in difficulty to last year's paper but of those who did not, more thought it more difficult than easier. Most teachers felt that the clarity of wording and presentation of the paper were good and all the rest thought it satisfactory.

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

Section A: In the data analysis question, some candidates had difficulty retrieving information from the graphs. They were not very exact in reading axis numbers to accurately determine ranges. This precision is especially important when "analyze" is the command term. When candidates are asked to "evaluate" data, trends and numbers can be quoted but it is essential to also comment on the implications and the limitations of the data rather than just describe it. There was limited understanding of membrane structure, fluidity and vesicle formation (Topic 2.4). Differences between autotrophs and heterotrophs were often poorly expressed or superficial (A.S. 5.1.2). A tremendous gap in knowledge was seen in classification (A.S. 5.5.4). Almost no knowledge was shown regarding the distinguishing external features of animal phyla. Candidates showed little mastery of understanding of how sexual reproduction contributes to genetic variation and evolution (A.S. 5.4.5, A.S.5.4.6)

Section B: Candidates struggled to apply knowledge of properties of water (A.S. 3.1.5, 3.1.6) to its role in blood (A.S. 6.2.7). The structure function relationship of blood vessels (A.S. 6.2.5) does not appear to have been taught well. Knowledge of the precautionary principle (A.S. 5.2.4) was terribly limited. Improper use of blood type notation was seen in ABO blood group outlines requiring Punnett grids (A.S. 4.3.4).

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

Section A

In the data analysis question, good mathematical application was seen in successfully completed simple calculations. Candidates generally knew active transport (A.S. 2.4.6) and knew enough about mitosis (A.S. 2.5.4) to draw diagrams of metaphase and anaphase.

Section B

Various properties of water (A.S. 3.1.5) were usually known. Most candidates had some awareness of differences of red, blue and green light absorption by chlorophyll (A.S. 3.8.4) and knew some consequences of global temperature rise as related to the greenhouse effect and CO2 increases (A.S.5.2.6). Understanding was seen in genetics definitions (A.S. 4.3.1) and ABO blood typing (A.S. 4.3.4). There were occasional good answers in hemophilia inheritance (7c)

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

Section A

Question 1(a) Most candidates gave answers within the accepted range of 0.37 – 0.39. Those who gave 0.40 were not credited.

(b) Many candidates recognized that as the RAChE to OP ratio increases, the symptoms decrease. Some others also saw that after a ratio of 0.4 (accept 0.38 – 0.42) there were no symptoms. Additional marking points were available but often not awarded because candidates did not think to give more details or were not precise enough when analyzing the graph. For example, for ratios between 0 and 0.16 (accept 0.14 – 0.18) the symptoms decrease; or, between 0.16 (accept 0.14 – 0.18) and 0.4 (accept 0.38 – 0.42) the symptoms are mild. The given tolerances provided adequate leeway to candidates who observed those features of the graph and made careful measurements.

(c) Much success was seen here. The prediction of 0.5 and “no symptoms” was very common. It was based on using the supplied data in a simple calculation.

(d) This additional calculation for candidates also produced widespread success. It involved finding a difference using box plot data presented in the second graph. There was a generous acceptable range for the answer (from 75 – 100 μm2). Units were required.

(e) Often, at least one mark was gained for describing the evidence. Candidates usually mentioned “highest median area of synapses” or “highest maximum area of synapses” or, sometimes, both for two marks.

(f) Again, many candidates gained at least one mark. In this case the task was to evaluate an hypothesis. True evaluative statements were not seen very often. A few candidates pointed out that the study was done on mice with no evidence that its results could extend to humans. Other candidates said that since humans and mice are mammals the RAChE might offer protection to humans. Both types of reasoning were accepted. The marks gained most frequently were for more descriptive answers such as “the higher the RAChE, the milder the symptoms” from the first graph or “RAChE decreases area of synapses” or “RAChE reduces the damage to synapses” from second graph.

Question 2 (a) (i) Most candidates correctly identified the organelle as Golgi apparatus; otherwise, it was usually mistakenly labelled as rough ER.

(a) (ii) Instead of answering “endocytosis”, candidates often stated “exocytosis” and lost the mark.

(b) This follow-up question involved application of knowledge about membrane structure. Sadly, candidates had trouble linking fluidity in membranes to vesicle formation. Though the phospholipid bylayer was sometimes mentioned it was not seen as giving fluidity/flexibility. Weak bonding between the phospholipid tails was rarely included. A few candidates did mention the presence of cholesterol in membranes but not much on their role in membrane fluidity. The idea that bends/kinks in the phospholipid tails prevents close packing, thereby contributing to flexibility, was never given. Some candidates confused fluidity with permeability.

(c) Many candidates gained partial or full marks on their explanations of active transport across membranes. Movement up/against a concentration gradient was often mentioned, along with the necessity of ATP. Energy, by itself, was rejected. There was confusion over protein pumps/carrier proteins and channel proteins. The latter were unacceptable since they are used in passive transport to enable solutes to diffuse down concentration gradients.

Question 3 (a) It was surprising that some candidates did not know enough about autotrophs and heterotrophs to earn at least one mark for their differences. Energy was often confused with food. Weak answers stated that autotrophs make their own energy or “feed off the sun.” The great majority of candidates failed to recognize that autotrophs use/require inorganic molecules while heterotrophs use/require organic molecules.

(b) (i) and (ii) These two questions were a disaster for most candidates. Different external features in Cnidaria, Mollusca and Annelida seemed unknown. Often no answers were given or only one word answers which were ambiguous. Parallel reasoning was required in which two phyla were compared with regard to one feature as in “Cnidaria have radial symmetry while Mollusca have bilateral symmetry.” Some candidates wrote that “Mollusca have a mouth and anus while Cnidaria have only a mouth.” This was not credited since Cnidaria have only one opening which functions as mouth and anus.

Question 4 (a) Various cellular processes occur during interphase. Any three of the following were accepted: growth (of cells), protein synthesis/translation, DNA replication, production of organelles or named normal activity (e.g. active transport, movement, secretion etc.). It was not necessary to name the sub phases such as G1, S or G2. If that was done the sub phase had to be linked to a correct process to achieve a mark. It should be noted that cells grow in all three phases by producing proteins and organelles. DNA replication, however, only occurs in the S phase.

(b) Many candidates were able to draw acceptable diagrams showing metaphase and anaphase in mitosis. A few diagrams fell short in that no spindle fibres were shown or chromosomes were not depicted as having 2 strands in metaphase and single strands in anaphase.

(c) Explaining how sexual reproduction can lead to variation and then evolution challenged many candidates. Some candidates began with the premise that sexual reproduction produces variation, but did not explain how the variation occurs. This was the heart of the question. Others tried to answer what evolution is, instead of explaining how sexual reproduction allows it to occur. Too many answers just stated the terms independent assortment, crossing over, random fertilization and natural selection without further developing them, i.e. their effect on genes, allele combination or gametes. Sometimes mutation was mixed into the answer gaining no credit.

Section B

Question 5 (a) This question troubled the rote learner who was unable to apply a general idea to a specific case. Candidates knew key properties of water but could not specifically relate them to blood. Most candidates correctly answered that the polarity of water molecules makes water a good solvent but forgot to give examples of dissolved substances in blood or materials that blood transports. High specific of water was cited but not how blood temperature can remain steady because of it.

(b) Many candidates only wrote about the direction of blood flow through arteries, the heart veins. They completely missed out on the link between structure and function. Other candidates who did write about structural features of blood vessels failed to relate the features to function. Many confused the size of lumen with the degree of pressure in the vessels. Understanding of capillary structure and function appeared to be less than that of arteries or veins. Pores to increase permeability and allow lymphocytes to escape, extensive branching to increase surface area for exchange, and small diameters to allow capillaries to penetrate spaces between cells are examples of ideas often missed.

(c) Many candidates knew that leucocytes can recognize pathogens and engulf them by phagocytosis/endocytosis. More knowledgeable candidates mentioned production of antibodies with specificity to antigens on pathogens. Further details about antigen inactivation and lymphocyte cloning to amplify antibody production were seen only in the very best answers.

Question 6 appeared to be the most difficult question for candidates.

(a) Most candidates knew that chlorophyll absorbs blue and red light and virtually no green light which is consequently reflected. Very few candidates knew that blue light is absorbed most and that red light is absorbed in high amounts.

(b) Candidates frequently began with the idea that plants take in CO_2 through photosynthesis and that levels of atmospheric CO_2 can be lowered as a result. After that changes in atmospheric levels as a result of seasonal fluctuation was left undeveloped or confused with human production of CO_2 through deforestation etc. Candidates did know about global warming resulting from rising levels of CO_2. They knew a variety of consequences related to global warming which reflected awareness of similar IB questions on past exams. Some candidates still think that CO_2 weakens the ozone layer. It seems that no candidate knew about the enhanced greenhouse effect.

(c) Knowledge of the precautionary principle was woefully thin. Almost no candidate received full marks on this question. Some candidates mentioned it was something that scientists had to do when conducting experiments; that they had to be cautious when doing them as they might cause harm. Many candidates have the notion that this principle was developed to address environment issues, which it was NOT. It would be appropriate to say that the precautionary principle has take on new meaning in recent times with reference to environmental issues. Few candidates could give any specific examples of the application of this principle.

Question 7 was by far the most popular questions and it was answered well by many.

(a) Codominant allele, recessive allele and locus are all specifically defined in the guide so answers were only awarded credit when they closely matched the guide. For example, in locus allele was not accepted for gene. However, for sex linkage the guide offers no definition so trait and gene were equally accepted as being located on a sex chromosome.

(b) ABO blood group inheritance seemed to be well understood. Through the use of Punnett grids with different examples, candidates were usually able to show how a child could have a

different blood group from either parent. However answers were often penalized because of notation errors. This meant that in some cases Punnet grids seemed to show phenotypes rather than genotypes.

(c) This hemophilia question presented an organizational challenge to candidates. Often candidates had the knowledge to answer the question but struggled to connect meaningful statements to produce a coherent passage. Instead of splitting their answer into two sections (how males inherit hemophilia and how females can become carriers) candidates just tended to write on and on about hemophilia. Many carelessly said that hemophilia is carried on the X chromosome rather than the allele/gene for hemophilia.

Recommendations for the teaching of future candidates

Based on the June, 2013 exam, students should be able to:

- Identify trends in graphs and their exact numerical ranges.
- Know the correct notation for expressing genotypes in blood groups or hemophilia.
- Directly link structure with function and not mention function elsewhere in their response.
- Know the differences between allele, gene and trait.
- Outline how energy enters and moves through an ecosystem.

More generally, teachers need to:

- Take every opportunity to make candidates aware of the major biological theme(s) (p. 40subject guide) setting the context for specific content that is being learned. Structure and Function and Evolution were clearly evident this exam.
- Spend more time on classification. Learn the distinguishing features of phyla.
- Teach the precautionary principle using the published markscheme for examples of application other than the greenhouse effect.
- Make sure that candidates learn the command terms (p. 11-12 subject guide). Candidates need to respond differently to “analyze” as compared to “evaluate”. Candidates need more practice in evaluating a hypothesis based on given data
- Teach candidates to always ANSWER THE QUESTION ASKED with clear and relevant ideas.
- Teach candidates to write more different key points than the mark value shown for a question.
- Teach candidates how to make paired statements which show contrast for the same feature e.g. CORRECT: this thing has X whereas that thing doesn’t – INCORRECT: this thing has X whereas that thing has Y.
- Use exams and mark schemes from previous years to become familiar with types of
- questions.
- Have candidates originate mark schemes to IB questions and subject them to peer review.
- Point candidates to the “IB Prepared” series to see scaled responses to questions (how to earn a 1/6, 4/6 and 6/6 on, for example, an “explain” question etc.
- Teach candidates practice writing a logical flow of ideas in extended responses.
- Advise candidates to read questions very carefully before answering them. Candidates should look for KEY words/phrases. Maybe these should be underlined. After completing their answer, candidates should re-read the question to ensure that their answer directly responds to the question. Candidates should not waste time writing information which will gain no examination marks. If a candidate finds that a question is too difficult to understand at first sight, they should know by exam technique to leave that question until

the end. Candidates should note that bolded words in questions hint strongly at the tilt of the meaning. Follow the lead!

- Teach all topics in equal depth. Help candidates learn and effectively use key technical terms for each topic.

Standard level paper three

Component grade boundaries

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

General comments

Of the only 90 G2 forms submitted, approximately 70% thought that the paper was of a similar standard to that of last year, while approximately 20% though it was a little or much more difficult. Of the respondents, the vast majority thought that the level of difficulty of the paper was appropriate while a 9% thought it was too difficult. The raw mean for the paper was lower than the previous year in line with the feedback on the G2 forms.

Clarity of wording was thought to be good by 56% and satisfactory by 41%. 63% thought the presentation of the paper was good and 35% thought it was satisfactory.

It was disappointing that only 10% of schools returned G2 forms. These are vital for the Grade Award process in informing the senior examination team what students and teachers thought of the paper. On occasions they can result in alterations to the mark-scheme and they always inform the awarding of Grades. Please always submit a G2 for every paper that is sat for by your students.

There were differences in the degree of difficulty presented by the different options. The data in Option F was somewhat harder to understand for candidates.

As always Options A, E and G were the most popular. Option F was by far the least popular option in terms of the number of candidates who answered it.

The standard of performance showed a wide spread, but generally candidates showed reasonable achievement, and there were also some very good answers seen. Surprisingly, some candidates attempted more than the required two options, and some questions were still left unanswered.

It should be noted that this paper, as with all Biology extended response scripts was prepared to be eMarked. Students should be made aware that it is essential to write their answer in full inside the boxes provided or on additional answer sheets if required. Examiners only see scans of the mark boxes and extra sheets as a general rule.

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

Answering questions calling for analysis, explanations, and calculations seemed to be the areas which proved more difficult to all candidates. Also, writing good definitions and knowing the difference between discussion and list or outline was an area of difficulty for many candidates. Few candidates were able to write concise answers. Candidates do not always read the question correctly and this can mean they get no marks for that question.

Options C and F seemed to provide the greatest challenge. The data in F proved difficult for the few candidates that attempted it.

Some candidates are still not responding to the command terms “explain” or “discuss” appropriately. The former needs explanations. Few candidates scored well on A3(b) where they were required to explain possible health consequences of diets rich in protein.

The levels of knowledge, understanding and skill demonstrated

Although there has been some progress, many candidates still have trouble reading graphs and using that information to make a calculation or to explain the results and its probable meaning.

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

Option A: Human nutrition and health

The data in A1 was understood by most candidates who were able to analyse the data and connect the vitamin C intake to changes in bone density. In A 1 (b) Many students failed to compare the data and only achieved one mark. In A1 (c) Few candidates evaluated the evidence provided. Practice of this style of question is invaluable in preparing for the examination.

A2 (a) was well answered by most, and in A2 (a) most candidates were able to define nutrient and non-essential amino acids. In A2 (b) the majority of candidates could perform the required calculation, but few were able to appropriately compare wheat flour and rice as sources of energy. In A2 (c) many candidates gave very long answers talking about the benefits of reducing cholesterol but did not connect them to heart disease.

In A3 (a) most students could outline the control mechanism for appetite, but few were able to achieve well in A3 (b), lacking the detail required of the consequences of protein rich diets.

Option B: Physiology of exercise

A relatively small number of candidates answered this option, but those who did generally achieved well.

In B1 (a) most answers were correct. In B1 (b) Almost all answers were correct, although some candidates failed to have enough detail for two marks. In B1 (c) Most answers were poor and tended to be descriptive rather than discussions as required.

In B2 (a) most answers were correct. In B2 (b) (i) most candidates could state the role of ligaments but in B2 (b) (ii) many had difficulty explaining what a torn ligament was.

B2 (c) was well answered but B2 (d) was not, with students failing to explain the changes in ventilation during exercise.

In B3 (a) the diagram of the structure of a sarcomere was well answered on the whole. In B3 (b) most candidates had difficulty explaining the roles of actin and myosin in muscle contraction.

Option C: Cells and energy

A relatively small number of candidates answered this option, but those who did generally achieved well.

For C1 (a) and (b) most candidates had these answer correct. In C1 (c) There were many good answers.

In C1 (d) few candidates evaluated the hypothesis. To evaluate, students are required to have arguments for and against. Few did.

In C2 (a) (i) most answers were correct. In C2 (a) (i) a comment on a G2 suggested that the examination should have used the abbreviation Rubisco as this is found in many texts rather than ribulose bisphosphate. Although many texts may use this abbreviation, the examination was based on the terminology used in the subject guide. Teachers who do not use the terminology of the guide may disadvantage students, as appears to have been possible with this question. In C2 (b) most candidates were able to describe the induced fit model. In C2 (c) in general candidates did know how non-competitive inhibitors work. This is a standard question that revision of past papers would have prepared candidates well for.

In C3 (a) Most candidates were able to outline glycolysis. In C3 (b) The question was generally poorly answered.

Option D: Evolution

In Option D candidates had little trouble with the data presented in this question and D1 was well answered.

D2 (a) (i) was well answered, but (ii) was not with few students being able to outline how dating fossils with ^{40}K is done. In D2. (b) in general candidates were able to outline the contribution of prokaryotes to an oxygen-rich atmosphere. In D2 (c) Most had little trouble describing major anatomical features of humans as primates.

D3 (a) was reasonably answered by most candidates, though many answers in (b) were very vague.

Option E: Neurobiology and behaviour

In E1. (a) and (b) almost all candidates had correct answers but (c) appeared to confuse most candidates. In (d) in general answers were on topic, but few students evaluated the hypothesis.

In E2, (a) was well done with most candidates being able to identify the structures of the eye appropriately. E2 (b) (i) and (ii) almost all answers were correct. E2 (c) was also well answered

In E3 (a) most candidates were able to explain the effect of cocaine at synapses, but the majority of responses to E3 (b) lacked appropriate detail.

Option F: Microbes and biotechnology

Few candidates answered this option.

In F1 the data was a challenge for students who attempted this option and responses to this section were quite poor.

In F2 (a) the answers to this question were very the best for the option. For (b), few candidates answered this question correctly, most only outlining the locomotion used in one organism or not connecting the mode of locomotion to organism.

For F3 (a) most candidates were able to distinguish between Archaea and Eukarya. In (b) most candidates only scored one or two marks in this question as few could explain the consequences of releasing raw sewage and nitrate fertilizer into rivers.

Option G: Ecology and conservation

This option was attempted by many candidates. The data was more challenging for some than in previous years but candidates on the whole responded well to it.

For G1 (a) (i) almost all answers were correct, though (ii) proved more difficult. For (b) candidates were able to list, but few were able to analyse as required by the question stem. For (c) in general, answers were correct.

G2 was well answered apart from G2 (c) where few candidates could outline the effect of UV radiation on biological productivity

In G3. (a) few candidates had any difficulty with this question. For G3(b) there were many full mark answers. Most candidates were able to give examples of biomagnification and explain the cause and consequences of it.

Recommendations and guidance for the teaching of future candidates

Candidates should read the questions carefully. This may seem obvious, but there are always candidates for whom this seems to have not happened.

The importance of understanding and being able to apply the command terms can never be overemphasized. Comparisons require comparatives (more, greater, fewer than….etc) or a clear table to distinguish differences (or similarities if relevant). Similarly “evaluate” a hypothesis requires information that supports or refutes it and the candidate must state as such, not just regurgitate data from the question.

More practice at answering questions that require the candidate to discuss or explain should be done. Invariably suitable examples are required in these questions - specific examples the candidates don't seem to have.

Many candidates run out of space for their answers; it is not a requirement to write full sentences nor is it necessary (or wise) to rewrite the stem of the question. Pertinent phrases that make the point are often better. Try to get candidates to avoid restating the words in the question because they will gain no marks.

Similarly explain to candidates why occasionally arbitrary units are used in expressing data.

Teachers should integrate the analysis of data in tables and graphs and calculations with units wherever possible throughout the SL course. Percentage calculations must be included.

Candidates must practise drawing the diagrams given in the subject guide. Attention should be given to accurate labelling, juxtaposition of structures and relative size.

It is recommended that teachers emphasize the importance of legible handwriting. If a candidate's answer is correct but unreadable, the candidate may lose marks if deciphering the handwriting is impossible and the examiner misinterprets the script. This is especially the case now that scripts are scanned for marking.