November 2012 subject reports

BIOLOGY

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 29	30 - 42	43 - 54	55 - 68	69 - 81	82 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 30	31 - 43	44 - 56	57 - 68	69 - 81	82 - 100

Internal assessment HL/SL

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.

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.

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.

When Data Collection and Processing is being assessed, the method (designed by the student or provided by the teacher) is required. When the Conclusion and Evaluation criterion is being assessed, all the steps in the scientific process are needed for moderation. This is essential information. Without it the student’s work becomes impossible to interpret. Feedback from the moderators suggests that this is still a problem.

A few teachers are not designing practical programmes with sufficient numbers of hours, others 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.

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

The range and suitability of the work submitted

Areas of strength

The variety of investigations, the duration and coverage of the practical programme were generally good. The use of ICT in the areas of 1 Data logging, 2 Graph plotting software and 3 Spreadsheets is good though some schools have efforts to make in the use of databases. 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 problem here is that some students copy the user manual instructions for the material into their design when this is not entirely necessary. Settings such as frequency of sampling or colorimeter frequencies should be presented but not all the technical details.

Areas of weakness

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 major cause for differences in the level 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.

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

In some schools, cross moderation between colleagues in biology is 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

Candidate performance against each criterion

Design

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

- Group work presented as individual work - all candidates with same plan and often with the same data values.
- Teachers using standard labs and saying they are designed by candidates: for example, effect of solute concentrations on the osmosis of potato tuber

These teachers appear to be boxing the students in to perform the same investigations. This is approach is not appropriate and it need not happen. For example, if enzyme activity is the theme to be assessed for the criterion Design, there are a whole range of enzymes to choose from, enzymes from different sources, different substrates, different potential inhibitors,

different limiting factors and different methods for determining the rates of reaction. When a moderator is confronted with a whole class that is investigating the same enzyme, from the same source, using the same independent variable and using the same method to determine its activity, then it is not surprising that collusion or excessive guidance 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.

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. 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. Osmosis was often presented this year as a Design investigation theme without any modification from a textbook method.

The two point discrimination test for touch receptors on the skin is 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).

Although ignorance of this is rare in the November session schools, 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” 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 the majority of 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.

The classic investigations (for example, rates of photosynthesis using sunken leaf disks, rates of reaction of catalase and osmosis) often create problems. Some schools are using standard textbook protocols without modifications. A little imagination and editing could easily solve the problem.

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)
- There are no units in the table column headings (note: decimal units should be used)
- No uncertainties were given in the column headings of tables of data collected using measuring instruments.
- There were inconsistent decimal places in tables
- The decimal places did not correspond to the precision of measurements
- There were no associated qualitative observations. 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 were plotted in graphs that do not actually reveal anything (for example, they can be used to derive maxima, minima, optima or intercepts)
- Raw data were plotted when the mean should have been calculated and plotted (often the mean is actually calculated and then ignored by the student when producing graphs)
- There was no statistical treatment of the data when it was possible
- When statistical treatment is applied there is no consideration of its appropriateness. For example, calculating standard deviations when they had only made 2 or 3 measurements (many teachers marked this as complete and made no comment about it on the student work)
- There was no presentation of uncertainties in graphical data either by using trend lines or error bars or uncertainty ranges on the axes.
- The error bars, when used, were not explained.
- A majority are putting a linear line of best fit even when the data is clearly S-shaped or clearly has a 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.

There seems to be some confusion over where to assess the use of sample calculations and decimal places in processed data.

The use of sample calculations, where they are necessary, would be assessed under aspect 2, given that these would be necessary to follow the processing of the data. However, it is not always necessary to give a sample calculation. For example, a column of raw data with mean and standard deviation clearly indicated at the bottom would not require sample calculations. Their correct unambiguous presentation would be assessed in aspect 3.

The attributing of an appropriate number of decimal places (significant figures) is assessed under aspect 3 as stated in the clarifications in the subject guide.

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

There is evidence of the students 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 a tendency to use bar charts for everything amongst the weakest students, perhaps because it is the default setting. 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.

It might be an idea to train the students to plot graphs manually before using a graphing program.

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.

Recommendations and guidance for the teaching of future candidates

- Share the criteria with the students.
- Read feedback from the previous session and act upon it.
- Consult the Online Curriculum Centre (OCC) for teacher support material (TSM)
- Apply the internal assessment criteria rigorously.
- Ensure that the open-ended theme that you set has enough scope to provide a variety of research questions for the whole class.

- Counsel the students on the safety issues, ethics and feasibility of the investigations they design.
- Guide students away from repeating classic investigations or working on the same research question when they design their own investigations.
- Give the students experience in identifying independent, dependent and controlled variables.
- Be sure that investigations used for assessment produce quantitative data.
- Encourage the students to make additional 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 often 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.
- 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 for your school's sample.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 16	17 - 22	23 - 27	28 - 31	32 - 37	38 - 40

General comments

Of the teachers who responded on the G2 forms, 91% thought that the level of difficulty was appropriate, 94% thought that it was of a similar standard or slightly easier or harder than last year's paper and all thought the clarity of wording and presentation were satisfactory (25%) to good (75%). This was a successful paper with many questions that discriminated effectively between stronger and weaker candidates. There were no problematic questions. The spread of marks was very wide but there were some very high scores indicating excellent knowledge and understanding from those candidates.

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

Question 3

Only two thirds of candidates answered this apparently easy question on the differences between prokaryote and eukaryote cell structure correctly. This was most likely due to candidates not reading B carefully enough and choosing it as their answer, even though they did know that prokaryotes contain DNA. If they had carried on and read D they would probably have chosen it.

Question 8

This was a multiple completion question. This type of question needs to be constructed carefully and thought about very carefully by candidates. In this case answers B and D could be eliminated because the energy absorbed by chlorophyll is not used to fix CO_2 directly, it must be used to produce to ATP first. The only question was then whether splitting of water is a direct use of energy absorbed by chlorophyll. The expected view was that it is, as water is not split unless excited electrons have been given away by chlorophyll in Photosystem II. An illustration of this is the rapidity with which pondweed stops producing bubbles of oxygen when light intensity is reduced.

Question 9

More candidates than expected thought that the stage of meiosis shown was Telophase I. It could be identified as the second division of meiosis because two

dividing cells within one circular wall were visible. Several of the chromosomes were not yet at the poles so this was late Anaphase II.

Question 12

Plant classification was tested in this question. The discrimination index was very high showing that the stronger candidates tended to answer it correctly but the weaker ones did not. The description of the newly discovered plant made it clear that it was a filicinophyte.

Question 13

A relatively low discrimination index for this question suggests that some of the stronger candidates were unaware that pyramids of energy are showing energy flow, which must be over a period of time. The time period conventionally is one year, so the answer was B.

Question 14

It would have been clearer if the term cell respiration had been used rather than respiration in this question. However this did not affect the answer that candidates should have chosen and the question was effective.

Question 15

Nearly four fifths of candidates answered this question correctly, showing good understanding of the nutrition terms used.

Question 16

This proved to be a very easy question with more than 90% of the candidates answering it correctly. A small proportion were not aware that the arrows in a food chain indicate the direction of energy flow, not what feeds on what. Inevitably this question was a poor discriminator as both weaker and stronger candidates were able to answer it correctly.

Question 17

Candidates had much more difficulty with this question and their understanding of the nature of exponential growth was not as strong as expected. Perhaps candidates understood the term to simply mean rapid growth and they therefore chose answer B. That answer included the transitional or deceleration phase of the graph, which is growth but not exponential growth. Candidates may have rejected the correct answer, which included the initial phase of slow growth, because they thought that it was a lag phase with growth slower than exponential. The graph does not show this and unless a log scale is used for the y-axis the early stages of sigmoid population growth will always look very slow.

Question 22

This was the question that elicited the smallest percentage of correct answers but it was an excellent discriminator. Knowledge of changes in the LH surge before ovulation is not well known among the weaker candidates.

Question 26

There were some comments from teachers about the clarity of the diagram. More than three quarters of candidates answered it correctly, and in fact all that was needed was the identification of the active site as the position at which a competitive inhibitor would bind. The diagram might be useful in future teaching as it distinguishes between the binding sites of three types of inhibitor: competitive, non-competitive allosteric and non-competitive non-allosteric.

Question 27

Some teachers felt that the 3' and 5' terminals should have been indicated, but this was not needed for candidates to answer the question. The most common incorrect answer was chosen by candidates who were confused about the difference between sense and anti-sense strands.

Questions 31, 32 and 33

These questions were excellent discriminators, with only the stronger candidates able to answer them correctly. Each of them tested an aspect of plant physiology. Neither was regarded as being particularly difficult but the percentage of candidates answering them correctly was lower than most other questions in this exam, especially question 32.

Question 38

This was another question with a very high discrimination index and a relatively low percentage of candidates answering correctly. More candidates than expected thought that calcium ions bind to actin and myosin filaments forming a cross-bridge. Although the candidates are not expected to know the roles of troponin and tropomyosin, they should understand that calcium ions cause the binding site for myosin heads to be uncovered on actin filaments.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 9	8 - 15	16 - 24	25 - 34	35 - 45	46 - 55	56 - 72

General comments

Nearly 90% of teachers who submitted comments on G2 forms considered that the paper was of an appropriate standard, with the other teachers mostly considering it to be too difficult. Of the teachers who were able to compare the paper with that of last year, 90% thought that it was of a similar standard and the other 10% that it was a little more difficult. Two thirds of teachers thought the clarity of wording was good, with almost all the others thinking that it was satisfactory. More than four fifths of teachers reported that the presentation of the paper was good and all the other teachers judged it to have been satisfactory.

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

There were no areas of the programme or examination that proved difficult for all candidates. One Section A question concerning concentration of solute concentrations in blood plasma, glomerular filtrate and urine was found difficult by many candidates. In Section B the weakest answers overall were in response to the questions on autosomes and sex chromosomes, ribosome structure and the placenta.

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

There was evidence of good preparation across a wide range of topics, with some candidates reaching very high overall scores. Almost all candidates showed at least reasonable data analysis skills in Question 1 and knowledge of the greenhouse effect in Question 3. In Section B prokaryote cell structure and glycolysis were mostly very well known.

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

Question 1

Parts of this question offered a real challenge to all candidates as it ranged in difficulty from relatively straightforward to very difficult.

Part (a) was an easy first question to give candidates confidence. Almost all answered it correctly. Most candidates also answered part (b) successfully. There

were plenty of possible comparisons to make and only two acceptable ones were needed for full marks.

Part (c) was the hardest part of Question 1. Most candidates described or drew a diagram of a phospholipid bilayer. This was not accepted as the question stated that the phospholipids formed a film on the surface of the moist lining of the alveoli. The phospholipids will therefore be in contact with the aqueous solution on one side and air in the alveolus on the other side. The expected answer was a phospholipid monolayer with the hydrophilic heads facing the water and the hydrophobic tails facing the air. Even the strongest candidates struggled with this.

In part (d) there were some very clear and accurate answers, but also many that showed either imperfect understanding of the data or ambiguous phrasing of the answer. The data showed that increases in the concentration of surfactant A caused greater and greater decreases in the growth of GBS. The ambiguous answers included statements such as “Surfactant A increased negative growth”.

The problem in part (e) was to cope with the large amount of data: the effects of three concentrations of three surfactants on the growth of three types of bacteria, though candidates should have only considered the highest of the three concentrations. The best answers worked systematically through the data by comparing either the effects of each surfactant in turn or the effects of the surfactants on each bacterium in turn. A fault in some answers was failure to make genuine comparisons and instead to describe only a single part of the data at once. Another common fault was to ignore the sizes of the effects on the bacteria and thus whether they were significant or not. Given that the y-axis scales were logarithmic, small bars above or below the zero line were not significant.

Part (f) was quite challenging. Some candidates failed at the first hurdle, which was to look at the table of data at the start of Question 1 to find out the protein content of each of the three surfactants expected in the answer here. Having done this, it was not too difficult to see that there was some evidence for the hypothesis from surfactant A. It contained the most protein and inhibited the growth of each species of bacterium, albeit only to a small extent with *Staphylococcus aureus* and *Escherichia coli*. The remainder of the data did not fit the hypothesis.

In part (g) the challenge was again to express relatively simple trends in a clear and unambiguous way. A common fault was to say simply that surfactant B had no effect on antibiotic V. This was not explicit enough and the expected answer was that increases in the concentration of surfactant B did not affect the concentration of antibiotic V needed to control the growth of *S. aureus*. Most candidates described the effect of increases in the concentration of surfactant B on antibiotic W effectively.

Part (h) of question 1 was challenging and it was very pleasing to see some candidates coping well with the complexity of the data. The weaker answers were mostly based only on the data in the previous graph, despite the instruction to consider all data provided in Question 1 to be considered. Candidates who did this successfully saw that the evidence supporting the use of antibiotic V was not the

same for the different bacteria. Few marks could be earned without distinguishing between GBS, *S. aureus* and *E. coli.*

Question 2

Part (a) involved labelling a diagram of the elbow joint. Most candidates were able to do this successfully, but some confused synovial fluid and cartilage. The specific names of the bone and muscle were expected, which not all gave.

In part (b) the functions of the biceps and cartilage were needed. Only about half of the candidates got both of these adequately. In many cases the function of the biceps given was rather vague. Lifting the arm was not accepted; bending the arm was, though flexing the arm at the elbow was preferred. Some candidates were unaware that muscles only do work when they contract.

Question 3

In part (a)(i), nearly all candidates could name a greenhouse gas.

The explanations of the greenhouse effect in (a) (ii) were on average better than when this question had been asked before. Some candidates were still confused between the greenhouse effect and the effects of the ozone layer but many successfully described the difference between short and long wave radiation in penetration of the atmosphere. The absorption of short wave radiation by the Earth's surface and emission of longer wavelengths by the heated surface were less well described.

Part (b) (i) was an easy question and many candidates scored both marks. Candidates should be encouraged to write more than a short phrase as an answer to an "outline" question as in some cases too little had been stated for one of the points on the mark scheme to have been earned.

Part (b) (ii) is another question where it was safer to write one or two sentences than just a word or short phrase. Many candidates outlined the effect of global temperature rises on photosynthesis. Only those who stated that photosynthesis rates would rise were given a mark. Those that predicted a fall, based this on a prediction that enzymes used in photosynthesis would be denatured. The temperature rise due to the enhanced greenhouse effect is unlikely to be large enough to cause this. Smaller temperature rises might cause an increase in photorespiration but this was not the reason for a fall that candidates were giving.

Question 4

Many candidates were able to name the glomerulus and the loop of Henle in (a)(i).

Part (a) (ii) is another question where brief answers did not always gain the mark. A simple statement that glucose is reabsorbed in the proximal convoluted tubule was not enough. Two types of qualification were needed; either that reabsorption is selective or that nutrients are reabsorbed by active transport.

For part (b) there were some comments from teachers suggesting that knowledge of actual concentrations of solutes in glomerular filtrate and urine should not be expected. The question did not expect concentrations to have been memorized. Both of the marks could be gained if the candidate knew that protein is not filtered out of the blood, but that urea is, and that glucose is all reabsorbed but urea becomes more concentrated as water is reabsorbed from the filtrate.

There was some confusion among candidates in part (c) about the meaning of the word medulla in this question. A common error was to assume that it meant the medulla oblongata and ascribe a role in the maintenance of water balance to this part of the brain. In fact the question referred to the medulla of the kidney, with the hypothalamus and pituitary gland as the regulatory centres. There were some excellent answers to this question showing a very secure understanding of kidney physiology.

Question 5

A usual guideline for examiners is to have 50% more points on the mark scheme than raw marks in Section B questions. There were fewer points than that for part (a) of this question and only the strongest candidates found enough to say to reach a total of four. A point that was almost always missed was that males and females do not differ in the autosomes that they possess. This is a significant distinction between the sex chromosomes and autosomes.

For part (b), a small proportion of candidates forgot or did not know that hemophilia is a sex linked condition and so scored few marks here. Most candidates who did know that sex-linkage is involved used the expected notation of an upper case X to represent the X chromosome with superscript upper case and lower case letters to show the alleles. If an upper case Y is also shown, even though it does not carry a copy of the gene, it makes mistakes much less likely when working out possible outcomes from a cross between two parents. The most significant cross is one between an unaffected male and a carrier female as this is how almost all cases of hemophilia are derived. Most candidates showed this. Parental genotypes were often missing and gametes on the Punnett grid were usually shown but not labelled as gametes. The best answers showed the phenotypes of each possible type of offspring, together with the genotype on the Punnett grid. It was also useful to add a ratio or percentages below the grid. Candidates who showed a series of different crosses rarely scored any more marks after the first cross.

Part (c) is a standard question but even so, answers were very variable, probably because meiosis is complicated and there are multiple causes of genetic variety, which some candidates struggle to understand. Terminology was sometimes used rather loosely. The best candidates distinguished between random orientation of bivalents in metaphase I and independent assortment of genes due to random orientation or crossing over, depending on whether pairs of genes are on different or the same type of chromosome.

Question 6

In part (a), most candidates had no difficulty in naming four mineral elements that are needed by living organisms and giving a role for each. Carbon was not accepted as an answer, as conventionally it is not regarded as a mineral. In plants minerals are absorbed from soil or water. In animals minerals are absorbed in an inorganic form from food or drinking water.

Part (b) of the question was not answered as well as expected. There was some confusion between absorption from the soil into roots and movement through the soil to the roots. As a result, many candidates suggested that minerals could be absorbed by mass flow along with the water that was being absorbed. This shows that the selective nature of mineral absorption has not been understood. Another common fault was to suggest that diffusion is the main method of mineral absorption. If plants are able to absorb water by osmosis, they must have higher solute concentrations inside their cells than outside and this can only be achieved by active transport.

There was generally good knowledge of the stages of glycolysis in part (c). To make the marking of this question fair in relation to other choices, there was a restricted set of points on the marking scheme, but the more able candidates were still easily able to score full marks.

Question 7

This was by far the most common choice of question in Section B, with more than three quarters of candidates choosing it. The other questions were each chosen in approximately equal numbers.

In part (a), most candidates drew an appropriate diagram of a prokaryote cell and there was a continuation of the improvement in the quality of diagrams that has been seen over recent years. In a few cases, eukaryote structures such as mitochondria had been included. Pili and flagella were not always distinguishable.

Replication is a complicated process and candidates were expected to be able to describe it in detail in (b). The strongest candidates did this admirably well, but weaker ones tended to reveal misunderstandings or gaps in knowledge. It is usually possible for examiners to distinguish between those who have developed a genuine understanding and others who may have memorized some key phrases but are unable to use them correctly in context.

The emphasis in the answer to part (c) of the question needed to be on ribosome structure, rather than the process of translation. There were some detailed descriptions of translation that made only passing reference to structure and so scored poorly. Diagrams were often included but they needed to be annotated fully to gain marks for a particular idea. Some of the best answers included the idea that ribosomes are composed of both protein and ribosomal RNA, with the RNA having a catalytic role in translation.

Question 8

Part (a) was another question where it rapidly became clear to examiners how well the candidate understood the biology involved. Weaker answers often included many details of how sperm travel from the male reproductive system to the oviduct of the female. This was not needed as the events of fertilization were considered to start with the arrival of sperm at the surface of the oocyte. There were many full accounts, including the acrosome reaction and the cortical reaction.

A full range of answers to (b) was seen, from muddled brief accounts confusing the placenta with the amniotic sac, to very full and detailed explanations of structure and function. The best answers included accurate descriptions of blood flow, with a clear distinction between fetal blood flow through capillaries in the placenta and maternal blood flow through the sinuses.

Part (c) of the question also elicited answers of very variable quality. Many candidates remembered that a positive feedback mechanism was involved but not all could describe it correctly. Some discussed cervical dilation but did not mention uterine contraction. In questions of this type it is always worth mentioning the source of the hormones involved, in this case the pituitary gland as the source of oxytocin.

Recommendations and guidance for the teaching of future candidates

- In data analysis questions, candidates should think carefully before starting to write the answer to each part of the question. The phrasing used in the answer should be as clear and full as possible. For example, in describing what the data in a graph tells us about the effect of a factor, a full account should be given, with nothing implied but unstated.

- In data analysis questions it is important to distinguish between decreases and reduced increases. For example, inhibition of growth in a population does not mean that the population has become smaller.

- Candidates should be encouraged to write more than a short phrase as an answer to an “outline” question. Although the answer does not need to be as detailed as a “describe”, a word or short phrase will rarely be sufficient.

- Diagrams are often worth including in answers, but they should be part of the overall answer, not a disjointed section at the end or the start. Candidates should not expect the reader of the answer to deduce what point they are intending to make from labels on a diagram –there needs to be full annotation so that the point is clearly made. Generally a diagram should only be included in an answer if it adds something. If it merely repeats a point made unambiguously in the text of the answer, then it probably is not worthwhile. Well annotated diagrams can nonetheless be very useful.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 16	17 - 21	22 - 27	28 - 32	33 - 40

General comments

Nearly 82% of the 33 teachers responding on G2 forms felt that the level of difficulty of this paper was appropriate. A minority thought that that it had been too difficult. When comparing the paper to last year's, most teachers thought the standard similar although some found it more difficult. Teachers felt that the clarity of the wording was satisfactory in the third of the cases and good in slightly less than two thirds of the cases, whereas this proportion reached 22% and 78% respectively about the presentation of the paper.

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

Writing complete and accurate definitions proved to be difficult for many candidates. Candidates often did not gain credit because they confused the tasks they were required to perform by the command terms, such as *explain* when they should describe data. Reading graphs accurately, interpreting them using the data and evaluating their significance was also difficult for many, regardless of the options chosen. Many candidates were unable to express their answers using appropriate terminology, neglected to include details that could have refined their answers (*e.g.* mention of alleles for sickle cell anemia) or introduced incorrect statements while using short cuts (*e.g.* sound sent to the brain through the auditory nerve). Briefly, these candidates limited themselves to the repetition of what they learned from manuals, with a range of ability to do so.

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

Most candidates seemed to know which two options they were prepared for and answered them thoroughly.

A large number of candidates displayed a comprehensive knowledge of factual information, demonstrated mainly by their answers to the last question in each option for which many gained all the available marks, especially in options E, G and H.

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

Option D - Evolution

Question 1

The majority of candidates read the graph correctly, but some stated incorrect values or only the difference instead of the range. They distinguished between the characteristics of *Australopithecus* and *H. erectus* properly and saw a positive trend between height and brain size, but could not back this up using the data for their evaluation. Most candidates could state two ways by which the two skulls appearance differed, but there were answers relating to brain volume.

Question 2

Whereas some candidates provided a complete definition for the term *gene pool*, other answers ranged from a few inaccuracies to irrelevant. A large number gained the mark for examples of barriers between gene pools, but there were unacceptable answers for one or both elements. A number of candidates failed to explain heterozygote advantage clearly, failing to point out that each of the two homozygotes were at a disadvantage owing to increased risks of malaria or sickle cell anemia; answers also lacked appropriate terminology in some cases. A large number of candidates knew the Hardy-Weinberg formula, but many multiplied by p instead of p^2, showing a poor understanding of it.

Question 3

Of the question 3s requiring longer answers, this one was the most poorly answered compared to other options but nevertheless, good candidates managed to gain all marks and even included more valid points. There were many unfocused answers containing irrelevant statements, especially about the endosymbiotic origins of live or evolution in general.

Option E - Neurobiology and behaviour

Question 1

Many candidates really did not seem to understand the underlying theory relating brain peptides to foraging strategy in bees and this question separated candidates who analysed data as a set and those that searched for details and lost the general picture. Whereas almost all candidates could identify the correct peptide in part (a) and most of them could distinguish the two groups in (b), the other parts appeared more difficult. Many candidates had difficulty evaluating the hypothesis although they could see the inversion of trends in (c). They frequently restated the question in the wording of their answer for (d), but many nevertheless gained the mark about increasing food collection efficiency.

Question 2

The majority of candidates could gain all the marks for this question based on factual recall but generally those who were not well prepared did not gain any marks. Some fell short at giving a complete definition for the term *reflex*, usually missing the word *rapid*.

Question 3

The majority of candidates scored very well for this question, although some answers could have been clearer.

Option F - Microbes and biotechnology

Question 1

Many candidates gave a correct answer in (a), but a large number stated 44 a.u. instead of 30 a.u., indicating a confusion between variables and axes. For (b), there were good answers, but many candidates did not relate to the number of days or were too vague in their description. There were mixed answers for (c). The significance of the relationship between C23O gene ratio and hydrocarbon degradation was missed by many weaker candidates who also had difficulty in other questions, including (d) and (e). A common error for (d) was "chemoautotroph".

Question 2

It seems that well prepared candidates had no difficulty with this question, but that there were a large number of unprepared candidates who did very poorly. A minority of candidates could draw *Anabaena* correctly, and sometimes introduced different degrees of distortion from textbook drawings. There were also many drawings of bacteria and blank answers. Definitions of epidemiology and distinctions between endotoxins and exotoxins were either correct, contained missing elements, or totally incorrect or absent. Part (d) was generally well covered but many suggested that the food was dehydrated instead of the microbes.

Question 3

Good candidates provided complete and correct answers. Others gained a few marks for listing spongiform encephalopathies and their general effects without mentioning any mechanism proposed by the prion hypothesis, whereas some didn't even answer.

Option G - Ecology and conservation

Question 1

Many candidates found interpretation of the graphical data about trawling challenging. Candidates frequently only gave enough to be awarded part credit. For (a) most candidates gave the correct answer. Most could compare the abundance values in (b), but many related to incorrect depth ranges and could not suggest one valid

reason for the difference. Many candidates stated that there was no evidence for the decline in biodiversity, but very few could back up their statement using the data correctly, some overlooking that the data were showing fish abundance, or others restated the wording of the question. There was a mixture of answers for (d), many containing only one valid element. Most candidates could define the concept correctly in (e), but add difficulty to gain a second mark.

Question 2

Many correct definitions were given, but there were also many answers with missing elements. Most candidates could calculate the GPP. They could also describe a technique to estimate the population of mice, but some answers lacked important elements of the process, mentioned quadrats or used the whole population instead of a sample.

Question 3

The vast majority of candidates were well prepared to write about *r*- and *K*-strategies with clarity and gained all the marks.

Option H - Further human physiology

Question 1

Many candidates calculated the correct percentage increase, but also many did not know how to carry out the calculation. Most candidates could state that one pH increased while the other decreased, but found it more difficult to state that it returned to the original value only in Hyde Park and to explain these changes; most explanations related to CO_2 triggering acidification. Many had difficulty to associate each symptom with one environmental factor in their evaluation. A large number of candidates gained the mark for factors causing asthma.

Question 2

There was a wide range of answers about factors causing CHDs and the majority of candidates gained all marks despite the fact that many answers did not really outline how these factors acted and could differ between the different populations. Candidates were not penalized for their obvious and general lack of knowledge about the habits of the two populations. Most candidates gained at least one mark for the digestive glands, but many answers contained incorrect (*e.g.* endocrine gland, liver, bile duct) or too vague (*e.g.* intestine) elements. They also knew about precursors but many answers stated that trypsin was activated by HCl and were awarded only one mark.

Question 3

The majority of candidates scored high marks for this question and many covered a sufficient number of elements to gain all the marks despite too vague or incorrect statements in some of their answers. Candidates overall had a good understanding of

the blood vessel connections to the liver. The only confusion was sometimes mixing up glycogen with glucagon. Several went well beyond the mark scheme (and sometimes the syllabus) with descriptions of hemoglobin breakdown, bile production and treatment of amino acids.

Recommendations and guidance for the teaching of future candidates

- Use of a ruler to measure values from a graph as data readings seemed poor in this respect.
- When interpreting data, teach candidates to describe the obvious (maximum, minimum and when those occur). Furthermore, candidates should look for flaws in the obvious; whether the range is extreme or the standard deviation is high.
- In describing trends remind candidates to be as accurate as possible; use the data presented and be precise. For example in G1 do not use “deep” or “shallow”, give values in metres.
- Tell candidates to read the questions carefully; avoid giving an explanation when the question simply requires a description of the trends (a problem with D1c in particular).
- Make sure that candidates know definitions which are accurate and learned thoroughly, possibly by preparing a glossary of definitions so that these are memorised correctly and fully without omitting sections or words.
- Candidates should follow the subject guide. Among the candidates examined in German, it seems that many were not aware of the recommendations in the subject guide.
- It is important that candidates understand and apply command terms.
- Candidates should learn actual examples for syllabus content.
- Formal definitions from the syllabus (in italics) are also important.
- Many drawings reproduced images from manuals, with various degrees of distortion: it would be an advantage if candidates had been shown microscope slides (live or from the Internet) to appreciate the differences between the various structures.
- Candidates need to look at the number of marks allocated to a question and supply answers accordingly, perhaps providing a few more elements than allocated marks if possible.
- Candidates must read the question carefully to understand what is being asked, otherwise they rush into a slightly off-target answer.

- Some answers are often too superficial for HL; candidates must use the appropriate terminology and pay attention to details and steps involved when explaining processes.

- It is good practice for candidates to always include units; they should always refer to values in their answers (percentages, sizes, concentrations, rates, etc.) and avoid using the word “amount” when dealing with quantitative answers.

- Examination papers are scanned and marked on screen: candidates must ensure that they write clearly in blue or black ink and that their writing does not show overleaf (their pens should not leak through the paper).

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 12	13 - 16	17 - 20	21 - 23	24 - 27	28 - 30

General comments

This was a successful paper with many questions that discriminated effectively between stronger and weaker candidates. There were no problematic questions. The spread of marks was very wide but there were some very high scores indicating excellent knowledge and understanding from those candidates. Of the 39 G2 forms received, 36 teachers believed this exam was at the appropriate level and only 3 that it was too difficult. Most believed it was of a similar standard as last year's exam. 5 teachers believed it was a little more difficult and 1 much more difficult while only 4 believed it was a little easier. Most teachers believed the clarity of wording and presentation of the paper was good, only 16 believed the clarity of wording was satisfactory and 12 that the presentation of the paper was satisfactory. Nobody believed any of these to be poor.

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 2

There were some comments about the quality of the electron micrograph. Although most candidates answered this question correctly, many believed X was pointing at the Golgi apparatus and others at the endoplasmic reticulum. The discrimination index was poor for this question, as many stronger candidates did not answer it correctly.

Question 3

This question was well answered by most candidates, showing that they could easily identify the mitochondrion form the micrograph.

Question 5

This question was too easy for candidates and not a good discriminator. This shows most candidates were familiar with the process of facilitated diffusion.

Question 8

This question had a very good discrimination index and did not prove to be too hard for candidates. Candidates seemed to be clear about the structure of a fatty acid.

Question 12

This was a multiple completion question. This type of question needs to be constructed carefully and thought about very carefully by candidates. In this case answers B and D could be eliminated because the energy absorbed by chlorophyll is not used to fix CO_2 directly; it must be used to produce to ATP first. The only question was then whether splitting of water is a direct use of energy absorbed by chlorophyll. The expected view was that it is, as water is not split unless excited electrons have been given away by chlorophyll in Photosystem II. An illustration of this is the rapidity with which pondweed stops producing bubbles of oxygen when light intensity is reduced.

Question 14

This question had a very good discrimination index and did not prove to be too hard for candidates, who seem to perform well at this type of simple sex-linked cross.

Question 15

Here is another example of a well-answered question, showing that monohybrid crosses seem well studied by candidates.

Question 16

A well answered question, as most candidates knew that Down syndrome is caused by a non-disjunction.

Question 17

Although there was a comment that the options to this question were difficult to understand, this question was well answered by most candidates and had a very good discrimination index. The comments are probably due to the fact that the distractors are correct statements but are not directly related to the answer of the question.

Question 18

Plant classification was tested in this question. The discrimination index was very high showing that the stronger candidates tended to answer it correctly but the weaker ones did not. The description of the newly discovered plant made it clear that it was a filicinophyte.

Question 19

A relatively low discrimination index for this question suggests that some of the stronger candidates were unaware that pyramids of energy show energy flow, which must be over a period of time.

Question 20

This question would have been clearer if the term cell respiration had been used rather than respiration. However this did not affect the answer that candidates should have chosen and the question was effective.

Question 21

Candidates had much more difficulty with this question and understanding of the nature of exponential growth was not as strong as expected. Perhaps candidates understood the term to simply mean rapid growth and they therefore chose answer B. That answer included the transitional or deceleration phase of the graph, which is growth but not exponential growth. Candidates may have rejected the correct answer, which included the initial phase of slow growth, because they thought that it was a lag phase with growth slower than exponential. The graph does not show this and unless a log scale is used for the y-axis the early stages of sigmoid population growth will always look very slow.

Question 22

Nearly four fifths of candidates answered this question, showing good understanding of the nutrition terms used.

Question 23

This proved to be a very easy question with more than 90% answering it correctly. A small proportion of candidates were not aware that the arrows in a food chain indicate the direction of energy flow, not what feeds on what. Inevitably this question was a poor discriminator as both weaker and stronger candidates were able to answer it correctly.

Question 25

This question was quite easy for most candidates, probably due to the fact that the lacteal is only present in the villus therefore very easy to spot the right answer.

Question 27

The events occurring at the synapse are usually complicated for candidates, but this did not seem the case. Most candidates recognized that calcium was diffusing into the neuron in X.

Question 28

In the past, candidates have had trouble distinguishing between type 1 and type 2 diabetes but they had no problems doing so in this question. Most candidates answered that in type 1, β cells do not produce sufficient insulin.

Question 29

This was the question that elicited the smallest percentage of correct answers, but it was an excellent discriminator. Knowledge of changes in the LH surge before ovulation is not well known among the weaker candidates.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 13	14 - 20	21 - 27	28 - 33	34 - 40	41 - 50

General comments

Of the teachers who responded on G2 forms, 90% felt that the level of difficulty of the paper was appropriate, 98% considered it to be of a similar standard or slightly more difficult or easier than last year's and all found the clarity of wording and presentation of the paper to be satisfactory (37%) to good (63%).

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

Applying basic knowledge of phospholipids in a new context, analyzing data where three variables must each be considered in each of three different situations and using all data to evaluate an hypothesis. Developing a dichotomous key, recognizing different stages of mitosis in electron micrograph images and knowing what is occurring. Explaining the importance of complementary base pairing in DNA replication; providing a concise account of how natural selection can lead to evolution, outlining the effect of mutation on protein synthesis. Drawing a Punnett grid and using it to determine possible phenotypes, describing food digestion in humans. Knowing definitions of population and community, outlining the role of the pacemaker/sinoatrial node/SAN.

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

Overall, some improvement was seen in the comparison and evaluation questions relative to previous examinations.

Simple analysis of a data table, basic knowledge of alveoli, differences between animal cells and plant cells and relating uncontrolled cell division to tumours and cancer.

Many candidates seemed well prepared for Section B. Some received low marks for Section A but full marks for Section B. There was good understanding of condensation and hydrolysis, generally good explanations of how enzymes catalyze reactions and the effect of pH. There were many fine labelled drawings of a motor neuron.

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

Question 1

In (a) Almost all candidates correctly answered natural human (surfactant).

Though many candidates earned full marks in 1(b), there were other statements within the answers that showed poor ability to compare the composition of surfactants. For example, “not stated” does not mean “no cholesterol.”

Some candidates failed to obtain the mark for mentioning “thin membrane” instead of “thin wall” in 1(c), when describing a feature that adapts alveoli to gas exchange. Others lost the mark by inaccurately stating that the spherical shape of alveoli gives them greater surface area.

Almost every candidate lost the mark in 1(d) by imagining the film of moisture, lining alveoli, as being a phospholipid bilayer. They never considered the possibility of a phospholipid monolayer.

Part 1(e) asks candidates to identify the effect of increasing a factor on the growth of bacteria. Most candidates recognized that growth was reduced. However, some stumbled by carelessly stating that the *effect* decreased rather than the growth.

Many candidates seemed overwhelmed by the complex grid of data for 1(f), showing three types of surfactants with three types of bacteria at three levels of concentration, all depicted in histograms where some results are positive but most negative. Furthermore, candidates had to decide if various minimal effects were really positive or negative or not significant. The best answers reflected a systematic approach by candidates who started out by considering each of the three surfactants and their effect on each of the bacteria. Alternatively, some candidates started out with each of the bacteria and how each of them is are affected by each of the surfactants. The worst answers were a jumble of the two approaches; also, many candidates just quoted values from the grid, for two factors they were comparing. These answers were incomplete because no comparative statement was given. It was left to the examiner to interpret the meaning of the values.

For question 1(g), the data table and the graphical data had to be considered. The question required analysis of the data to support or reject the hypothesis. Often candidates cited data that supported or rejected, but they rarely declared what position they were actually taking. For many, this “evaluate” question provoked simple statements that did not tie protein concentration to growth and, in turn, to the hypothesis. Again, as in 1(f), some candidates offered repetition of information rather than its interpretation. For many candidates it was difficult to get three marks.

Question 2

Despite the simplicity of 2(a), this dichotomous key question drew out some remarkable weaknesses. Too often, answers included internal or physiological

characteristics as opposed to visible features of the organisms. Those candidates who did not have the proper knowledge of how to design a dichotomous key were the ones who gave a varied range of incorrect answers. Exoskeleton was accepted.

Most candidates correctly answered question 2(b). Some sloppy answers that gained no credit were: “Plant cells have chloroplasts. Animal cells have mitochondria” or just “Plant cells have chloroplasts” and nothing said about animal cells.

Question 3

Many correctly identified Phase A in 3(a)(i) but often missed Phase B.

Part 3(a)(ii) was usually well answered. Unfortunately, some candidates referred to homologous chromosomes when they meant sister chromatids; homologous chromosomes separate in Anaphase I of meiosis. Few mentioned centromeres splitting

Part 3(b) was very successfully answered. No credit was given for “mutation.”

Some candidates just wrote that “an exact copy of DNA is made” in 3(c) which is ambiguous and gained no credit; it was not clear that they knew that replication is a semi-conservative process where each of the new DNA molecules has a parent strand (conserved) and a new strand made by complementary base pairing. Also, full names, rather than just letters were required for the nitrogenous bases and both pairs were required.

Question 4

Much stimulus material is given about malaria and sickle-cell anemia in the stem for 4(a), yet the final question can be answered without any reference to the stem. This may have caused uncertainty among candidates. An effort was made to accommodate general answers about natural selection leading to evolution as well as those that included the malaria information given in the stem. Some candidates inaccurately used the term “sickle-cell anemia” when they should have written “sickle-cell allele.”

Few candidates recognized that a base substitution mutation causes the structural defect in hemoglobin which causes sickle-cell anemia for 4(b). Hemoglobin was rarely mentioned. A change in the codon of mRNA and the consequent attachment of a tRNA with a different anticodon and amino acid was just not given. There was almost no reference to codon or anticodon. Candidates proffered less detailed answers such as “a different amino acid is joined to the peptide” or “glutamic acid is replaced by valine”.

A few candidates confused sickle-cell anemia and Hb inheritance with sex-linkage in 4(c), perhaps because of wording in the stem. Some listed genotypes instead of describing phenotypes for the second part of the answer. All phenotypes had to be given for the mark. Since the guide (4.3.12) regards Hb^A and Hb^S as codominant

alleles, describing or stating the phenotype of the carrier is problematic since carrier status “appears” the same as homozygous normal. This problem was covered by the mark scheme as each of the following was accepted to describe the carrier phenotype: normal, normal carrier, intermediate, sickle-cell trait and symptomless. Regardless of how the carrier phenotype was described the phenotype of sickle-cell anemia/diseased had to be mentioned. Those who drew a correct Punnett grid usually did well in describing the phenotypes.

Question 5

In 5(a), most candidates clearly distinguished condensation and hydrolysis. A few candidates did not read the questions properly, giving examples of lipids or proteins instead of carbohydrates. Some marks were always scored.

Part 5(b) was an easy question for those who were well-prepared and most handled it well. Some candidates seemed to try to write everything they knew. They gave long explanations of factors beyond pH which can influence how enzymes catalyze reactions. In contrast, other candidates simply wrote that pH change can cause denaturation, without any further reference to change in active site or loss of biological function.

The weakest answers for question 5 appeared in 5 (c). The passage of food through various parts of the digestive system was frequently given rather than the breakdown of food. Accurate detailed information was scarce. Although digestion in the mouth was accurately discussed, there was a lack of clarity on digestion in the stomach and intestine. Most candidates discussed mechanical digestion without any attention to chemical digestion. Information on the conditions in each part of the digestion was sketchy. Very few candidates correctly included an example of enzyme source, substrate and product. The role of bile was not clear in most. Some made reference to absorption and egestion, instead of sticking to the question. Sadly, there were candidates who thought that as food progresses through the digestive tract, it stops at the pancreas.

Question 6

This question appeared to be very popular, especially among weaker candidates.

Many candidates were correct with all of their definitions in 6(a). Since these involved pure recall, it showed that candidates had studied the topic. Where trouble occurred, it was confusion between population and community.

Overall, 6(b) was well answered with very few outright errors. Energy flow was well understood with accurate terminology being used. The ideas most frequently missed were: sugars/organic compounds as products of photosynthesis and the loss of energy. The latter included loss by (cell) respiration, loss as undigested material/feces and loss through death of organism. Also, not many candidates wrote that energy is not recycled.

Although 6(c) asked for the benefits and possible harmful effects of genetic modification using one example, it was appropriate to begin the answer by explaining that genetic modification involves the transfer of genes among different species based on the universality of DNA. This was rarely done. When naming the example, the source of the gene was usually not included, whereas its function and the modified organism were often given. Several examples of non-existent GMOs were cited. Some have ceased to be manufactured while others have not got out of the research laboratory. Pros and cons tended to be generic instead of true applications of the arguments to the named GMO. Some candidates used different examples for different points in favour and against as opposed to discussing with one relevant named example. Finally, a few candidates confused GMOs with selective breeding or cloning.

Question 7

Stronger candidates appeared to choose Question 7 and it was answered well by most.

Most candidates drew a very clear well-labeled diagram of a motor neuron for 7(a).

The terms myogenic and pacemaker were clearly explained on occasion in 7(b). However, there was also confusion about the concept of being “myogenic” and the pacemaker as the structure which initiates the heartbeat. Sometimes candidates traced the pathway of the control signals through the heart in great detail rather than explaining how the nervous system and endocrine systems can control the heartbeat. When addressed, correct reference was made to adrenaline but usually not to the role of the medulla or nerves.

Part 7(c) was generally answered well, sometimes with nicely annotated diagrams. Most candidates had a good understanding of pre and post synaptic neurons, the role of Ca^{2+} ions and the concept of polarization/depolarization. Very few candidates mentioned removal of the neurotransmitter by enzyme or cholinesterase. Otherwise, accurate detail showed good knowledge and understanding.

Recommendations and guidance for the teaching of future candidates

Teach students to:

- construct dichotomous keys with visible characteristics
- identify phases of mitosis from electron micrographs
- clarify the importance of complementary base pairing
- discuss sickle-cell anemia with reference to natural selection, base substitution

  mutation and monohybrid inheritance

- explain the meaning and use of the term “allele” relative to genetics and evolution
- outline the effect of pH on enzyme action
- outline how energy is lost in an ecosystem
- discuss genetic modification with one named example
- outline the medulla and nerves control the heartbeat
- describe the events of synaptic transmission
- originate markschemes to questions for peer review and then use them in the classroom

In addition:

- Make sure that candidates use the command terms correctly. Candidates need to respond differently to “describe” than to “compare” or “explain”. “Evaluate” is still weak, especially with the inclusion of data.
- Give candidates data based questions where different skills are stimulated, particularly the interpretation of data. Just quoting two numerical values is not the same as saying that one is higher or lower than the other. Also, candidates need more practice in evaluating a hypothesis for given data (as mentioned above). Practise putting graphs/tables into words and describe apparent trends. There is a large bank of data based questions available from the IB, which can be useful in the classroom.
- Advise candidates to read questions very carefully before answering them. Candidates should look for key words and 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. Candidates should note that bolded words in questions hint strongly at the tilt of the meaning.
- Give mock exams for practice. Special attention should be given to the marks available for each question. Candidates should know that each mark awarded will correspond to a different concept/idea.
- 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 - 23	24 - 28	29 - 36

General Comments

The comments on the G2 forms indicated that 74% of the respondents felt the paper was of a similar standard to last year's paper while 18% felt it was easier and 8% felt it was more difficult. As for the paper's level of difficulty, 100% 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 all 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 is still very small with only 39 respondents at the time this report was written.

Option A was the most commonly chosen option with options E and G also frequently chosen. Very few chose Option F.

The areas of the programme which proved difficult for candidates

Use of nomograms; it seems that some centres did not teach this, from a few of the G2 comments. The use of nomograms is clearly listed with other Mathematical Requirements on page 124 of the syllabus. Outline of role of appetite control centre, cardiac output and stroke volume and reasons for a change in blood supply to various regions during exercise. Relating tertiary protein structure to enzyme function and adaptive radiation. The role of saprotrophic bacteria in the treatment of sewage and an example of biomagnifications.

The level of knowledge, understanding and skill demonstrated

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 Questions 2 and 3.

However, some scripts indicated only a superficial knowledge of 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 "explain" were often problematic on this particular paper.

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

Option A – Human nutrition and health

This was the most popular option on this paper and candidates tended to score highly. The only real issue was the use of the nomogram in Question 1 as some candidates did not know how to use the graph correctly.

Question 1

In 1(a), almost all candidates were able to correctly state the equation for BMI although some omitted the units.

In (b) (i) and (ii), candidates either got both correct or neither, depending on whether they knew how to use a nomogram.

Part (c) (i) was the same as (b), as the use of the nomogram was required to answer the question.

In (c) (ii), most candidates were able to state a correct reason for the BMI being too high or too low, although a few simply said underweight or overweight, which did not earn any marks.

The weakest answers in Question 1 were seen in (d). Many candidates received one mark, for stating that the appetite control centre in the hypothalamus makes a person feel satiated or full but few received a second mark.

Question 2

Despite concerns on some G2s that the chemistry required to answer question 2(a) would be difficult for SL candidates, this was not seen by examiners. Both (i) and (ii) were well answered by many candidates.

Many candidates repeated the stem about colds and infections in (b) (i), which did not earn a mark. Those who were able to gain a point, usually did so for “prevents scurvy” or for “wound healing”.

In (ii), some candidates understood the possibility of rebound malnutrition and some that there may be no effect as excess is excreted. In general though, this was poorly answered.

Question 3

Due to the mark scheme, many were able to get full marks in (a) for discussing some of the benefits of breastfeeding.

Part (b) on dietary advice for someone suffering from type II diabetes was a more discriminating question as many candidates could not explain the advice they were recommending. No marks were awarded for a short list.

Option B – Physiology of exercise

Question 1

Most candidates correctly used the graph in (a) to find the resting heart rate.

The calculation in (b) (i) was an easy mark for many candidates.

Many candidates gave vague answers for part (ii) as well as part(c), simply referring to the fact that the person was untrained and therefore not used to exercise. Reference in b (ii) needed to be made to stroke volume or efficiency of each heartbeat.

Most candidates found (c) difficult as they did not connect stroke volume and heart rate.

Many candidates stated the correct blood change in (d) but did not get the marks, as they did not give a brief explanation.

Question 2

Almost all candidates were able to get 2 marks for (a), although the incorrect response “glycogen for energy” was also seen.

Many candidates were able to get 3 marks for the diagram of the sarcomere in (b), although some poor diagrams were seen; very good diagrams were rare.

Question 3

Some candidates confused tendons and ligaments in (a) but there were many correct answers for injuries such as sprains, torn ligaments and dislocation.

Many candidates obtained 2 of the 3 marks available in (b), although marks were often lost for stating a reason for warm-up routines, without any discussion of it.

Option C – Cells and energy

Question 1

Most correctly stated that there was a negative correlation in (a).

Many candidates carried out the calculation in (b) correctly.

Often 2 marks were awarded for (c) but seldom 3. Candidates saw that both show a decrease in net photosynthesis as temperature rises and that at each temperature

the 700 ppm CO_2 sample shows a greater rate. Only stronger candidates were able to get a third mark.

Most candidates saw that CO_2 was the limiting factor in (d) and why.

There were many wrong answers to part (e) which was a recall question from the syllabus.

Question 2

Candidates had difficulty describing the relationship between protein structure and enzyme function in (a) although many had a general idea of it but not enough to score marks.

(b) Some good responses by strong candidates were awarded the full 3 marks, showing a good understanding of end-product inhibition and allosteric sites.

Question 3

Drawings of the mitochondrion were often awarded full marks in (a).

Many candidates, however, found it more difficult to explain the relationship between structure and function of the mitochondrion in (b) but good candidates knew this.

Option D – Evolution

Question 1

Most candidates correctly stated the range in brain size in (a), although some were outside the lower end of range.

The full 2 marks were often awarded for (b).

Part (c) was a somewhat discriminating question with the better candidates gaining full marks.

Many candidates could get the 1 mark in (d) by stating one other way in which the skulls of the two species would differ.

Question 2

Part (a) was poorly answered in general. Candidates could have obtained the 2 marks if they had known what adaptive radiation was without any reference to pentadactyl limbs. Although this very common example is not actually specified in the SL syllabus, this question was thus not compromised.

There were some good answers to part (b) on speciation and a few very good examples of both allopatric and sympatric speciation. However, many answers were vague and good comparisons were seldom made.

Question 3

Answers were somewhat vague in (a) on the contribution of prokaryotes to the creation of an oxygen-rich atmosphere, but often received 2 of the 3 marks.

The general idea of the endosymbiotic theory for the origin of eukaryotes was understood by many for part (b) but few described this well; candidates were still able to gain 2 of the 3 marks

Option E – Neurobiology and behavior

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

Question 1

Almost all candidates read the graph correctly for the 1 mark in (a) and most candidates carried out the calculation in (b) correctly as well.

Many candidates were able to get at least 1 mark for (c), usually for seeing the positive relationship between frequency and minimum loudness that can be detected. Many answers suggested that candidates were not quite clear as to what minimum loudness actually meant.

Only the better candidates did well on (d), as many candidates found it difficult to make the comparison.

Most candidates were able to gain at least 2 marks and many 3 marks in (e) for explaining sound perception by the ear.

Many candidates were able to list three other types of receptors for the mark in (f).

Question 2

The question in part (a) has occurred frequently and it seems that many were able to distinguish between innate and learned behavior.

There were some very good outlines of Pavlov's experiments in (b) into conditioning in dogs. Many candidates were able to gain 2 marks, showing a good understanding of Pavlov's experiment.

Question 3

In (a), most candidates knew which psychoactive drugs are inhibitory and which are excitatory.

Many candidates were able to gain 2 marks and the better ones 3 marks for the effects of THC in (b). Some responses, however, seemed to rely on common street knowledge rather than any biological knowledge.

Option F- Microbes and biotechnology

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

Question 1

Almost all read the graph correctly for the 1 mark in (a) and although there were often poor descriptions given of the respiratory activity, many were able to obtain 1 mark in (b) for noting the rapid increase in the beginning.

Most candidates had difficulty explaining the evidence for the conclusion and thus (c) was discriminating with only the better candidates obtaining marks. For part (d), many candidates knew that halophiles are bacteria that able to survive in a saline environment.

Question 2

Many candidates were able to get full marks in (a) for outlining the diversity of viruses with regard to the capsid and nucleic acid present. Only the better candidates were able to clearly explain in (b) how reverse transcriptase is used in molecular biology.

Question 3

Many candidates were not able to distinguish between *Euglena* and *Chlorella* in (a), although this should have been straightforward.

In (b) (i), there were many poor responses on sewage and the role of saprotrophs. Candidates did better in (b) (ii), with many obtaining 3 marks for explaining the dangers of releasing raw sewage into rivers.

Option G – Ecology and conservation

This was also a very popular option and proved to be high scoring in many cases.

Question 1

Most candidates were able to read the graph correctly in (a) and were able to gain this mark. Many were also able to score the full 2 marks in (b) (i), showing good comparisons between the two periods. Candidates who obtained the mark in (ii) did so for suggesting overfishing as the reason.

Many found (c) difficult, as they did not see that there was no evidence that there are fewer species. It was thus discriminating with only strong candidates receiving the 2 marks.

Many candidates only listed one of the two things needed in (d), so did not get the mark.

Question 2

Although most candidates had a general idea of the competitive exclusion principle for (a), few could answer this question concisely and clearly. Most candidates however obtained 1 mark and many gained 2.

It was surprising the number of candidates who did not know about biomagnification for (b) (i) and there were very few accurate, real examples of biomagnification given in (ii).

Question 3

Many candidates were able to get 1 out of 3 marks for (a), usually for giving an example of each type of succession or by distinguishing between the land being newly formed or previously occupied. Very few obtained 3 full marks. Some candidates confused this topic with primary and secondary consumers.

Most candidates were able to get 2 out of 3 marks in (b) for outlining factors that affect plant distribution, although some only listed 3 factors with no other detail given, which did not earn marks.

Recommendations for the teaching of future candidates

- the use of nomograms and other mathematical tools is important. Please refer to the mathematical requirements at the end of the syllabus.
- where the syllabus asks for an unspecified example, detailed examples need to be covered (e.g. biomagnification, primary and secondary succession, speciation).
- teach students how to use tables when comparing or distinguishing, 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.
- stress that the examiner can only mark what the candidate has written and cannot assume anything about knowledge or understanding.
- use the command terms 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 more deeply into the data, to identify features they may not see at first glance.
- use past examination papers and mark schemes as well as the question bank CD to provide suitable questions, so that candidates become familiar with the examination format.