May 2014 subject reports

Biology Time Zone 2

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0-16	17-31	32-45	46-56	57-70	71-81	82-100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0-15	16-30	31-43	44-55	56-67	68-79	80-100

Time zone variants of examination papers

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

Higher level internal assessment

Component grade boundaries

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

Standard level internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7

Mark range:	0-8	9-16	17-22	23-27	28-33	34-38	39-48

General comments

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

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

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

Ethics

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

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

The IB does not wish to inhibit investigations but it does want to stimulate a responsible attitude towards experimentation on animals. Any proposed experimentation involving animals, including humans, should result in a discussion between teacher and student based on its ethical implications and how to refine the experiment to alleviate any harm or distress to the animal; to reduce the number of animals involved, or to ultimately replace the use of animals by using cells, plants or computer simulations. Any call for human volunteers in experiments must be accompanied by a consent form. Investigations on human subjects must not place the volunteers at risk. Moderators are reporting investigations that are quite inappropriate, for example the sampling of a wound to obtain bacteria to test for antibiotic resistance. This should not happen if the teacher is properly supervising the students.

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

Exposing animals to conditions normally experienced in their natural environments is permissible. It is good practice to include a discussion with the students on the tolerance limits of the animal and how these could be established. There are plenty of sites on the web that will help here. Exposing them to caffeine, alcohol or energy drinks is not appropriate. Exposing them to conditions outside their normal environmental tolerance limits is not appropriate.

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

Situations that deliberately demand the euthenising of animals are not appropriate. Thus, fruit fly genetics must be replaced by, for example, rapid *Brassica* plants, *Sordaria* mould, maize cobs or simulations, such as the virtual fly lab (though this would mean that as a simulation it could not be assessed using the current IA criteria).

Dissections are a special case in biology. The guidelines are quite clear on this. The practice of dissections because they are a traditional part of biology course is not an adequate reason for including them. Including them, however, in order to study form and function in the distribution of organ-systems, organs and tissues is valid. Much of this can be done using simulations or dissections of organs purchased in butchers shops. Nevertheless, this kind of investigation would be inappropriate for assessment as it rarely produces quantitative data.

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

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

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

Recommendations for IB procedures, instructions and forms

Clerical procedure

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

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

Teachers are regularly including the "complete", "partial" and "not at all" breakdown of their marks. When this is combined with comments and feedback to the candidates it makes it very clear how the teachers were awarding marks. There are a large number of teachers that take a lot of time and trouble to prepare their Internal Assessment sample. This effort is very much appreciated. They should be congratulated for their efforts and their students will reap the benefits. It is a lot easier for a moderator to support a teacher's marks when there are clear, readable notes accompanying the sample.

There is a recurrent problem concerning the information provided by the teacher. This directly affects the progression of the moderation. Teachers must enclose all the instruction sheets and/or adequate

summaries of oral instructions for the investigations in the moderation sample. Most schools complied with this requirement but moderators are reporting that not all do this.

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

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

When the only marks appearing on the 4/PSOW form are the two marks required for the internal assessment, it causes concern amongst the moderators. There is no indication that the students were marked a number of times using the criteria. One wonders how these students receive the necessary feedback to improve their performance.

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

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

The range and suitability of the work submitted

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

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

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

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

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

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

Rules applied by the moderators

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

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

The areas of the programme in which candidates appear well prepared

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

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

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

Candidate performance against each criterion

Design

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

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

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

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

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

Research questions need to be focused. A research question that lacks focus will have an impact right through the rest of the investigation. For example students who decide to investigate several independent variables at once such as the effect of pH, temperature and substrate concentration on the activity of an enzyme. The names of the species used or the source of material (e.g. sources of enzymes) are often missing.

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

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

The investigations are often too simplistic**.** The range of values of the independent variable is insufficient to establish a trend. The number of repeats is insufficient to permit a statistical analysis that will allow a firm conclusion to be drawn. E.g. testing the effect of pH on an enzyme using an acidic environment, a neutral environment and a basic environment will not establish an optimal pH.

Standard protocols will, no doubt, be used by the students when they design their investigations. We are not expecting them to re-invent the wheel. These standard protocols however, must be duly referenced and significantly modified or applied to the student's own investigation. For example, if osmosis is being investigated and the student uses the method of change in mass of tissue to monitor

the effect of solutions of different concentrations on a tissue, this is legitimate but if the investigation simply determines the isotonic solution of one tissue then it remains trivial and it repeats many textbook investigations. If the investigation is used to determine the effect of the salinity of irrigation water on different root crops, the investigation becomes more substantial. Why stick to the traditional potato? Try carrots, yams, cassava, apple, sweet potato.

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

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

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

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

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

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

Data Collection and Presentation (DCP)

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

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

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

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

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

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

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

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

Conclusion and Evaluation (CE)

Investigations that lead to trivial amounts of data will lead to limited discussion of results and weak conclusions. Insufficient data will not reveal uncertainties and this has an impact on evaluation. So although each criterion is marked on its own merits there will be a knock-on effect through an unfocussed research question to a poorly designed investigation that collects a limited amount of data, permitting limited processing, leading to a weak conclusion and evaluation.

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

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

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

Students in some schools show that they have developed a mature sense of criticism of the investigation. Their evaluation of their results is based upon a balanced critical analysis of the data. Students who have not developed this skill tend to remain superficial in their evaluation. The weaknesses they identify are hypothetical ("the seeds could have been dead") without evidence to back it up. For weaker students the experimental weaknesses are restricted to having a limited amount of time or errors in their own manipulation that once again remain hypothetical ("I could have incorrectly measured the temperature"). Evaluation is a good discriminator of the high achieving students and teachers would do well to remember this when they are marking their students.

Suggested modifications were sometimes superficial and yet marked over generously.

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

Manipulative skills

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

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

ICT coverage

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

Graph plotting using software was perhaps the easiest and most widespread for schools to apply.

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

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

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

Some schools are not fulfilling the requirement for a range of ICT applications to be used in their practical programme.

The Group 4 Project

It needs to be repeated for a very few schools now, the Group 4 Project can ONLY be used for the assessment of Personal Skills. Indeed it is the only occasion when it is assessed. The Group 4 Project cannot be used for the assessment of Design, DCP, CE or Manipulative Skills. Once again it is evident that some teachers are awarding full marks 6/6 to all their students without any discrimination.

Recommendations for the teaching of future candidates

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

- Counsel the students on the safety issues, ethics and feasibility of the investigations they design.
- Be sure that investigations used for assessment produce sufficient quantitative data.
- Encourage the students to make additional qualitative observations about their experiment. It is good practice for them to keep a log book.
- Ensure that the investigations have the potential to generate sufficient data for substantial processing.
- Teach the students that plotting graphs of raw data is insufficient if nothing can be derived from them.
- Encourage the students to carry out research into the background literature both before starting an investigation and once the results are complete.
- Do not use simulations for assessment. Simulations used in conjunction with hands-on investigations producing “real data” are however to be encouraged.
- Do not use the Group 4 Project for assessment of D, DCP CE or MS. Only use it for Personal Skills. Inappropriate use will be sanctioned.
- Make sure that you are using the most up-to-date version of the 4/PSOW form (available from the Handbook of Procedures on the OCC).
- Check to be sure that all the parts of the 4PSOW form are completed correctly.
- Complete one 4/IA form signed by all the teachers for your school’s sample and cross moderation between colleagues is essential.
- Familiarise yourself with the new programme’s requirements for practical work and internal assessment.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-10	11-16	17-23	24-27	28-32	33-36	37-40

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. As the amount of questions addressing AHL material was less than previous years, the exam seemed slightly easier than past exams. There were some challenging questions as they were new in style.

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

Question 1: there were some complaints on the wording of this question. It did not prove to be a good discriminator as many candidates answered that the mean or standard deviation is necessary to add error bars, while what is needed is range or standard deviation.

Question 2: although "naked DNA" refers to DNA without histones, some students thought that it was naked because it was not surrounded by a nuclear membrane. This definition is found in the teacher's notes, so should not have been confusing.

Question 3: this question turned out to be a very good discriminator, this means good candidates answered the question well, while candidates that were not that good did not. Many candidates chose answer C, but active transport involves the use of energy, not passive diffusion. This answer would have been appropriate for facilitated diffusion.

Question 4: there were a few complaints on the quality of the electron micrograph, but the good candidates did choose the correct answer. This question was a good discriminator.

Question 5: Many candidates believed glycerol was a fatty acid. This confusion could have arisen caused because glycerol is part of a triglyceride together with fatty acids. There were some complaints that able candidates might consider glycerol to be a sugar, meaning that none of the options were correct. This is incorrect, as the ratio of elements Carbon: Hydrogen: Oxygen (1:2:1) needed to be considered a sugar is incorrect (3:8:3).

Questions 6 to 8 seemed to be very easy for most candidates, therefore not very good discriminators.

Question 9: there are some complaints about the use of the word "segregation" in this question. Although not in the guide, it is a valid term. DNA that segregates during Meiosis I is not identical, as crossing over has already occurred.

Question 10: this question was easy. The discrimination index was very high showing that the stronger candidates tended to answer it correctly but the weaker ones did not.

Question 11: Most candidates answered this question well, showing Punnett grids and multiple alleles are in general well understood.

Question 12: This question has a high discrimination index. Weaker candidates chose 25% instead of 50% as an answer. This could be because they failed to realise that colour blindness is sex-linked.

Another reason could have been that they incorrectly did not consider each pregnancy as an independent inheritance probability.

Question 13: some candidates failed to realize that what was expected from this question is to explain how from a very small sample, enough information could be obtained to obtain a reliable DNA profile.

Question 14: Answers to this question seemed to mislead some strong candidates. Although it is true that a lot of pollen needs to be consumed to kill other insects, this is the most correct answer.

Question 15: This question was too easy.

Question 16: this was an easy question. Some candidates did not read the question well; as they answered options that are true for effect of increase in greenhouse effect, but do not explain increase in carbon dioxide.

Question 17: This question proved to be easy to most candidates. The increase in predation would cause the exponential phase to level out to the plateau phase. An increase in species diversity would not increase competition directly and increased natality would only increase the exponential phase. In the long run, due to competition things might change, but not immediately after exponential stage.

Question 18: an easy question, therefore a bad discriminator.

Question 19: this question proved to be a very good discriminator. Many weaker candidates answered B, showing they do not understand the hierarchy in classification.

Question 20: Although it is true that a greater surface area means there are more enzymes (answer C), this only affects absorption indirectly. The fact that blood vessels are close to the surface (answer D) directly affects absorption; therefore this is a better answer.

Question 21: a very easy question.

Question 22: This was a multiple completion question. This type of question needs to be constructed carefully by the examining team and thought about very carefully by candidates. In this case answer A and D could be eliminated, as phagocytes do not produce antibodies. Many candidates chose answer B, probably failing to recognize the capacity of phagocytes such as macrophages of leaving blood vessels.

Question 24: Most textbooks explain action potential in the axon. This could explain why many candidates incorrectly believed neurotransmitters only act in axons.

Question 25: This question was in general well answered, confirming there is good knowledge about action potential.

Questions 26 and 27: these questions were too easy and most candidates answered them correctly.

Question 28: The discrimination index was very high showing that the stronger candidates tended to answer it correctly but the weaker ones did not.

Question 29: This question proved to be very difficult and a bad discriminator. It was aimed at seeing whether actin is used or not in the muscle cells. Probably candidates found it difficult to link knowledge with understanding. Many candidates incorrectly believed that actin was produced in the

sarcoplasmic reticulum, failing to realize it is smooth endoplasmic reticulum. Others believed it was produced in rough endoplasmic reticulum, failing to realize it is used in muscle cells.

Question 30: this was a very straightforward question and a very good discriminator.

Question 31: A good discriminator. Some candidates confused oxidation (answer A) with reduction (answer C).

Question 32: This was a good question. It was different to what has appeared in other exams. Most strong candidates were able to answer it correctly.

Question 33: There was a translation issue in the Spanish scripts. Instead of saying at 425 and 670 nm it said between these wavelengths. As all the other answers were incorrect, the only possible answer was still C. The answers for these students was checked and strong candidates did choose the correct answer.

Question 34 and 35: these were very straightforward questions and very good discriminators.

Question 36: although it is true that genes on X chromosome but not on Y chromosome could be linked, this is not the definition of linked genes, as they could be in any other chromosome. Linked genes do not necessarily affect the expression of each other.

Question 37: the role of thrombin is expected in the guide and mentioned in the teacher's notes.

Question 39: there was poor knowledge on the structure of the mature spermatozoan.

Question 40: An easy question.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-7	8-11	12-16	17-19	20-23	24-26	27-30

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. There were some challenging questions as they were new in style. Some wording was considered too complicated for students whose first language is not English.

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

Question 1: This was a very easy question; most candidates gave the correct answer.

Question 2: although "naked DNA" refers to DNA without histones, some students thought that it was naked because it was not surrounded by a nuclear membrane. This definition is found in the teacher's notes, so should not have been confused.

Question 3: this was an easy question and most candidates spotted the function of proteins as channels for diffusion of molecules in passive transport.

Question 4: there were a few complaints on the quality of the electron micrograph, but the good candidates did choose the correct answer. This question was a good discriminator.

Question 5: Although most candidates recognized fructose as a monosaccharide, many candidates believed maltose was the monosaccharide.

Question 6: Many candidates believed glycerol was a fatty acid. This confusion could have arisen caused because glycerol is part of triglycerides together with fatty acids. There were some complaints that able candidates might consider glycerol to be a sugar, meaning that none of the options were correct. This is incorrect, as the ratio of elements Carbon: Hydrogen: Oxygen (1:2:1) needed to be considered a sugar is incorrect (3:8:3).

Question 7: although most candidates recognized complementary base pairing as an important feature to conserve DNA sequences, some erroneously believed the unwinding by helicase was the correct answer.

Questions 8: seemed to be very easy to most candidates, therefore not very good discriminator.

Question 9: some candidates believed respiration requires energy.

Question 10: there were some complaints about the use of the word "segregation" in this question. Although not in the guide, Mendel's first law is called Law of Segregation, therefore we believe it is a valid term. DNA that segregates during Meiosis I is not identical, as crossing over has already occurred.

Question 11: this question was easy. The discrimination index was very high showing that the stronger candidates tended to answer it correctly but the weaker ones did not.

Question 12: Most candidates answered this question correctly, showing Punnett grids and multiple alleles are in general well understood.

Question 13: This question has a high discrimination index. Weaker candidates chose 25% instead of 50% as an answer. This could be because they failed to realize that colour blindness is sex-linked. Another reason could have been that they incorrectly did not consider each pregnancy as an independent inheritance probability.

Question 14: some candidates failed to realize that what was expected from this question was to explain how from a very small sample, enough information could be obtained for a reliable DNA profile.

Question 15: Answers to this question seemed to mislead some strong candidates. Although it is true that a lot of pollen needs to be consumed to kill other insects, this is the most correct answer.

Question 16: this question did not suit its purpose, as strong candidates did not choose the correct answer. Many candidates confused plasmid with prokaryotic chromosome.

Question 17: This question was a good discriminator.

Question 18: this was an excellent discriminator. Strong candidates recognized that the decomposition of organic matter would increase carbon dioxide in the atmosphere. Weaker candidates answered option D, melting of ice from glaciers. This is a clear example of candidates not reading the question properly and only focusing on the first part of the question, where the effect of temperature increases on arctic ecosystems was expected.

Question 19: an easy question.

Question 20: the wording of the question caused some confusion, especially in non-native speakers. Some candidates opted for answer C, as over-population could in the long run cause unfavourable conditions. Nevertheless, this was a good discriminator, so weaker candidates went for this option.

Question 21: Candidates have shown this topic is not well known. Some candidates argue that platyhelminthes can have a mouth, but the answer mentions both mouth and anus, therefore answer C would not be correct.

Question 22: This was a multiple completion question. This type of question needs to be constructed carefully by the examining team and thought about very carefully by candidates. In this case answer A and D could be eliminated, as phagocytes do not produce antibodies. Many candidates chose answer B, probably failing to recognize the capacity of phagocytes, such as macrophages, of leaving blood vessels.

Question 23: an easy question most candidates answered correctly.

Question 24: This was the best discriminator in the whole exam. Weaker candidates went for option A.

Question 26: This question was in general well answered, confirming there is good knowledge about action potential.

Question 27: this question was easy and could be answered just out of common sense.

Question 28: this question was too easy and most candidates answered it correctly.

Question 29: a good discriminator, where weaker candidates went for options B and C. Candidates knew that both muscles did not relax, but failed to realize both contract.

Question 30: The discrimination index was very high showing that the stronger candidates tended to answer it correctly but the weaker ones did not.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-8	9-16	17-26	27-36	37-47	48-57	58-72

General comments

Thanks go to the 230 teachers that returned G2 forms. Over 95% thought the level of difficulty to be appropriate with the others evenly spread between too easy and too difficult. 64% thought that it was of a similar standard to last year's, with the others again being equally distributed in the easier and harder camps. Less than 1% thought the clarity and presentation were poor, with well over 90% describing it as good or better. There were a few comments implying that Question 1 was harder than last year's data analysis. The candidates seemed to find it quite straightforward, and there was good evidence (underling etc.) that most had read it carefully.

Some teachers commented on the amount of SL material on the paper, especially in Section B. The fact that it is from the core syllabus, does not mean that it is any less challenging for HL students. Topics 2 (Cells) and 5 (Ecology and Evolution) do not have any HL extension. The students are expected to have a thorough knowledge of the complete syllabus.

Most candidates managed to answer within the correct boxes, with fewer additional sheets used. There were some comments that the boxes in Question 1 could have been larger.

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

Calculations of magnification and use of photomicrographs (Q2), Use of pedigree charts (Q4) , Levels of protein structure (Q5), differences between aerobic and anaerobic respiration (8a), genetic modification examples (6c)

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

The understanding of the command terms continues to be improving, with evidence (circling, underlining etc.) that the students were reading the questions more carefully. There also seemed to be a better understanding of the higher skills, with an improvement in the 'evaluate' skills. The general level of diagrams (6a) has continued to rise.

The details of the substitution in sickle cell anaemia was well remembered, if not entirely understood.

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

Question 1

This was a data analysis question based around the diving behaviour of pinnipeds. Most gained the mark for 42% in (a) with most of the remainder misreading it as 41, or 59 as they mixed up the fur seal and the sea lion. Part (b) usually gained a mark , although simply being 'epipelagic or benthic' was not credited as correct as it was too close to the stem of the question. There were a few comments about EAL students having trouble accessing the words pinnipeds, benthic etc. However the explanation in the introduction was clear. In (c) most gained the mark for stating the answer in the correct range. In (d) most commented on the positive correlation between length of dives and oxygen store. There were some comments about the paucity of data points, and many candidates also pointed this out. Part (e) confused some candidates. The first part was looking for answers about the dives, but many candidates answered in terms of temperature differences, which is what was looked for in the second part. In (f) marks were often lost for incorrect descriptions of vasoconstriction of - arterioles, and vague expressions of 'more fat stored', rather than a layer under the skin. In (g) there was a tendency to forget that the question was asking about the temperature difference, not simply the temperatures. In (h) most gained marks for the limited oxygen reserves and the possible effects of the continued loss of heat.

Question 2 (electron micrographs and cells)

Part (a) was very poorly answered. This is a topic that is covered in the practical as well as the theory programme in most schools. The correct answers of between 5000 and 6000X and between 7.0 and 8.8 µm were not very common.

Part (b) In spite of the correct answer printed in the source (thanks to those who pointed it out) evading the entire editing process, fewer than half of the candidates were able to label the (rough) endoplasmic reticulum and state its function.

In part c the concept of 'relationship' confused many, with incorrect statements such as 'as the cell grows, its surface area gets smaller'. More precision was required.

Question 3 (ecology and evolution)

Most, but certainly not all were able to correctly identify *Geospiza* and *Camarthynchus* using the key and most could identify bird Y in part (b) with a reason. Part (c) was really about interspecific competition, focusing on variation in beaks, leading to greater survival rate and reproductive success. There were several comments that the word 'stout' may not have been known to some. Students should have access to a translation dictionary in the examination. It did not seem to be a problem in the answers.

Question 4 (genetics)

In (a) recessive autosomal (or not sex linked) was looked for. Many thought that it was sex linked and answers claiming that it was polygenic or linked genes were surprisingly common.

Better candidates correctly identified Nn for A and nn for B. A common mistake was to incorrectly show it as attached to the X and Y chromosomes as A referred to a male and B a female. (XnXn).

SECTION B

Question 5 (Proteins)

- Many answers lacked detail. For example primary structure is not just 'a string of amino acids'. The idea of sequence or order was required.
- Most were able to gain some marks for the descriptions of the lock and key and induced fit models of enzyme action.
- Most remembered about the Calcium ions and the sarcoplasmic reticulum and the revealing of the binding site. Common errors were in the function of the ATP, often stating that it made the cross bridges, rather than breaking them.

Question 6 (DNA, mutation and GM)

- Very few papers failed to score at least 2 marks out of the 5 available. Common errors were the incorrect naming of the sugar and failure to show as antiparallel.
- The actual mutation was well known, but candidates should make it clear whether they are talking about the DNA or the mRNA sequence. Very few gained the mark for saying that the mutation is in Haemoglobin, not just 'a protein'. Sickle shaped haemoglobin instead of erythocyctes was another common error.
- Syllabus statement 4.4.10 states that the students should be able to 'discuss the potential benefits and possible harmful effects of one example of genetic modification'. There were some excellent answers on golden rice, Bt maize etc. However answers involving selective breeding or cloning were surprisingly common.

Question 7 (Amylase, energy flow and glucose control)

- Better candidates gained 4 easy marks here. Weaker ones confused the words amylase and enzyme, giving for example pepsin as an example of an amylase! The most common error was stating glucose as the product. (syllabus section 6.1.3)
- This was quite well answered, with most knowing what happens to the energy. A common mistake was forgetting to say that light is the original source, not simply 'the sun'.
- Better candidates could clearly explain the production of and actions of insulin and glucagon. Common errors were implying or stating that the hormones have a direct effect on the glycogen or glucose molecules. Very few were able to state that it is the pancreas that monitors the blood glucose levels, not the hypothalamus, or pituitary etc. Many complicated their answers by insisting on writing about diabetes which was not required. An alarming number thought that the kidney played a major role in glucose regulation.

Question 8 (Respiration)

- The command term was 'distinguish between', rather than 'compare', so the answer was only looking for differences. Good answers included a table, with each point on the same line. Weaker candidates wrote a paragraph about aerobic and then one about anaerobic, leaving

the marker to make a connection. A correct answer should have both cases in the same sentence.

- Germination of seeds was generally well known.
- There were some extremely comprehensive answers about the Krebs cycle. If answering this type of question with a diagram, it should be clearly annotated. Many weaker candidates seemed to draw a half remembered diagram, hoping that the examiner would find some marks in it.

Recommendations and guidance for the teaching of future candidates

- Make sure that key works are incorporated into the answers. For example remembering to use the expressions ‘active site’ and ‘substrate’ in enzyme answers.
- Make sure that all candidates have access to the syllabus and are familiar with the command terms included with each syllabus statement.
- Do not try to spot questions. The candidates must be familiar with the entire syllabus. If you are going to go beyond the syllabus, make sure that you have covered everything else first.
- All answers should fit in the boxes provided. Try to avoid repeating the stem of the question in the answer as this can occupy two lines of the box without the possibility of any marks.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-5	6-11	12-17	18-24	25-30	31-37	38-50

General comments

According to the general comments of all examiners, the exam was straightforward to answer, and of a similar standard to previous exam papers. Spanish scripts showed a much lower understanding than the English scripts. Conclusions from graphs are not always drawn properly, mainly because they fail to finish the comparison or because they decribe in detail, instead of focusing on the general trends. Calculations from micrographs is something that it seems to be a problem for many candidates. Identification of organelles and diagrams, still seems to be very difficult for many students.

From section B the most popular chosen question, was by far Q5. Very few candidates chose Q6 or Q7.

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

There were some areas of the programme or examination that proved difficult for all candidates.

Question 1

(b) (ii) was a graph which challenged some students, given that at a first glance they didn't identify the descending arrow at the right, so they failed to answer correctly. In many cases this was corrected, for which they obtained the marks. Only a few spotted the correct answer right from the beginning.

(f) and (g), which required reason or discussion, scored poorly.

Question 2

Performing calculations is an area which seems not to be worked on thoroughly, very few students were capable of obtaining marks in (a) (i) and (ii).

(c) Again, memory works against scoring marks for this answer, because candidates sometimes explained the function of a cell's surface area for volume and vice versa.

(d) was a difficult question to answer, thinking that the SL syllabus requires only superficial information about this topic. Only the very good students were able to obtain full marks for this answer.

Question 3

In (b) the diagram was sometimes confused with cnidaria.

Question 4

Many students had difficulties in the way they showed a sex linked trait.4

(c) was also poorly scored, given that the candidates needed the information shown in (b) in order to answer (c) correctly. In some cases the information was not properly shown in the suggested boxes, for which they did not obtain the mark.

Question 5

(c) was a difficult question to mark, given that there are many examples of genetic modifications and sometimes students mix up information from different examples.

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 high overall scores. Many poor scripts, scored very well in question 1 where knowledge was not so much required, so they were able to score marks by simply drawing conclusions from the data based problem. Almost all candidates showed at least reasonable data analysis skills in question 1 and section B scored well in all those candidates that proved that they have studied.

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

1a. Most of the students obtained the mark. Some of them gave negative values, therefore no mark was awarded.

1 b (i) some students described in detail, instead of showing trends, so marks were not awarded.

1b (ii) a tricky graph for some students who could not spot the increasing respiration rate for exposure to UV in early stages, and slight decrease in control, describing them in the opposite direction.

1c nearly all students obtained the mark for the first marking point. Very few for the second. In many of the cases, this was not scored, for not making reference to increase or change in biomass.

1d most of the marks were for the first marking point, followed by the third and only a few made reference to the second.

1e again trends were not compared in many cases, just detailed explanations, so marks were not awarded.

1f some students did not obtain the mark for not having clear greenhouse concepts. A common mistake was observed when mentioning that CO_2 increased because there was an increase in respiration.

1g many students incorrectly stated that the Equator was the region more harmed, followed by wrong explanations.

2c the marks in these answers are sometimes difficult to spot, because the candidates have some knowledge about the topic, but the concepts are wrongly explained.

2d ideas were thrown, without giving complete explanations, so they did not obtain any mark for incomplete answers.

3 (a) and (b) Plantae and coral or cnidaria were among the most common wrong answers. Few students had the correct knowledge for identifying both phyla.

4) many students obtained some points for 4b with genes not shown as sex linked, but did not obtain the marks for 4c, for not showing sex linkage. Many student did not use the suggested notations, but used other instead, correctly showing sex linkage, so no mark awarded for a, but full marks were scored for b and c.

Question 5 was the most popular, chosen by most of the students.

5 a among the most common wrong answers were not to show antiparallel strands, bases were identified by the letter only and deoxyribose was not mentioned, labeling it as sugar instead.

5b clear examples of therapeutic uses were mentioned by a few, confusions with in vitro fertilization were sometimes observed, but the general concept of stem cells seemed to be clear for students who chose this question to answer.

5c many of the candidates gave more than one example, mixing up benefits and harmful effects, for which reason this type of answers scored rather poorly. The general concept seemed to be understood, but the examples chosen were in some cases too general e.g. Improve cow breeding.

A very low percentage of students chose Q 6 and 7 to answer.

6a this answer scored well in most of the cases.

6b long explanations for transcription were sometimes observed and also long explanations for translation with no relevant information, just guessing some marks, showing that they did not have good background information. Despite this, many candidates scored very well in this answer.

6c some of the candidates did not answer this question at all. Lymphocytes were not always mentioned so no marks were awarded.

7a many students obtained full marks, but some failed to obtain points for not giving a proper example.

7b most of the students scored marks for this answer.

7c pancreas was in many cases confused with liver and beta and alpha cells confused with hormones, but in general students scored well for this question. Many of them did not obtain marks for saying that insulin converted glucose directly into glycogen or that glucagon converted glycogen directly into glucose, for which they failed to obtain the marks.

Recommendations and guidance for the teaching of future candidates

- More data based problems, where different skills are stimulated, should be practised.
- Mock exams have proved to be very helpful. Special attention must be given to the marks scored for each question. Students should be fully aware due to previous practice that usually each mark awarded will correspond to a different concept.
- The questions should be read very carefully before answering them. If the student finds one question not particularly easy to understand at first sight, they should know by exam technique to leave that question till the end.
- “Hands on experience.” in experimental science, clarifies many of the questions the students ask themselves Some students learn more easily by actual experiment, than traditional teaching.
- Candidates must learn to restrict their answers to that which has been specifically asked and not waste time in information which can gain no examination points.
- Try to study all topics in equal depth.
- Identifying different components from a given diagram or performing calculations, were among the tasks students found difficult. More practice needs to be given in this area.

- When interpreting graphs or charts, in many cases, the interpretations were poor. Practising with data based problems, would benefit the students, although we realize that sometimes lack of time prevents teachers from doing so.

- The responses to some areas showed marked discrepancy in that some topics seemed to have been absorbed to considerable depth, whereas in other areas the knowledge was superficial.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-7	8-14	15-19	20-23	24-28	29-32	33-40

General comments

Comments were received about the English (90%), French (2%), Spanish (6%) and German (2%) versions of this paper, corresponding to a similar proportion of the candidates who sat it. Nearly 97% of the 230 teachers responding on G2 forms felt that the level of difficulty of this paper was appropriate. The others thought equally that it was either too easy or too difficult. When comparing the paper to last year's, 77% of teachers thought the standard similar. Nearly half of the teachers (47%) felt that the clarity of the wording was very good, the others ranking it either poor (0.4%), fair or good (34%), or excellent (18%). The proportions were similar about the presentation of the paper, with a little more finding it excellent.

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

Writing answers to demonstrate their true level of knowledge and understanding and thus to earn more marks, is probably the most difficult area for a majority of candidates. This includes the ability to use appropriate terminology, to write complete definitions, to add the details that make a difference (e.g. "osmoreceptors in the hypothalamus" instead of "the hypothalamus") and to structure their answers making sure that as many elements as possible are covered. For many, the problem is with focusing explanations with sufficient detail, not so much the lack of understanding. Simply put, there is a general lack of planning and attention to detail.

Candidates have more difficulty with higher than lower objective level questions, regardless of whether a question focuses on programme coverage or data analysis. It is more difficult for them to deal with concepts than to recall information. Options requiring a finer conceptual understanding such as options D and H appear more difficult for candidates. Some candidates also seem to repeat factual information as they learnt it from manuals or other sources without being able to adapt it to a question context or to use it to show their understanding.

Although most candidates did well at retrieving information from data, comparisons and analyses were more difficult. Too often descriptions of the data or statements of numerical values were given instead of comparisons between variables, leaving the comparison to be made by the reader.

Main areas of difficulty were:

- Option D: differences between divergent and convergent evolution, the usage of ^{14}C to estimate the age of fossils, and how speciation can happen due to polyploidy;
- Option F: the function of reed beds, the role of saprophytic bacteria and the outline of how viral vectors are used in gene therapy;
- Option G: difference between predator and parasite, definition of biomass and appropriate explanation of the usage of quadrats;
- Option H: activation of trypsin, control of gastric juice secretion and how the Bohr shift affects the dissociation curve of hemoglobin.

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, especially for the longer questions in options E, F and G. Candidates generally did well at retrieving information from graphs, displaying units and performing basic calculations. Option E, for this session, appeared easier for many candidates, probably because they could rely more on their recall of factual knowledge.

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

Option D - Evolution

Question 1

The majority correctly read Carboniferous as the period in which reptiles appeared. Many read the cumulative total instead of the mammal total, as required, in the graph. Most concluded that mammals evolved from reptiles and that scientists gathered data from fossils, but many failed to include their analysis. Candidates had a hard time discussing which evolutionary theory was supported by the data, although most thought correctly that it supported punctuated equilibrium.

Question 2

The majority could state that comets or meteorites could carry organic materials and identified the two properties of RNA. Most stated convergent as the origin of wings, but they had more difficulty stating a reason clearly, many omitting to provide one; some confused the word *convergent* with *divergent*. There were very few correct descriptions for ^{14}C dating, many gaining only a mark for the definition of

half-life or its value for ^{14}C, showing that the majority did not know how the ratio between ^{14}C and ^{12}C is applied; in fact, ^{12}C was rarely mentioned.

Question 3

The expected and provided answers were about polyploidy in natural conditions with no mention of hybridization, as mentioned in the subject guide. Most knew that polyploidy had something to do about the number of chromosomes, but knowing that it was having extra sets of chromosomes and providing correct explanations of its origin in meiosis or gametes and how this lead to sympatric speciation through reproductive isolation was more difficult. Some confused polyploidy with non-disjunction in one pair of chromosomes (e.g. Down Syndrome); there was a noticeable number of irrelevant answers, including even some mentioning sickle-cell anemia. Some of the weakest candidates did not answer.

Option E - Neurobiology and behaviour

Question 4

Most candidates could calculate the time and estimate the distance for the ant's journey, but some were 10 seconds short. Most comparisons of the journeys were fine, but some candidates considered only one aspect amongst the possibility of time, distance and direction. Most could correctly suggest how the ant knew the direction back and how the others could retrieve the food. Some candidates even related their answers to taxis or kinesis, which showed their knowledge although it was not expected for this question; there were nevertheless incorrect answers and some did not see that the ant could not follow the trail it left since it took another path for the return journey. Many mentioned communication with other ants without further detail, thus not gaining any mark. Most stated one advantage to live in a colony.

Question 5

Bipolar cells and the direction of light in the retina were correct for many, but there were also a number of incorrect answers. The structures of the middle ear were generally correct, but conversion to a nerve impulse was often not really understood. Most made an appropriate distinction between innate and learnt behaviour but explanations of the mechanism of birdsong development were more obscure, some candidates being unable to relate their explanation to the definitions they had just written.

Question 6

There was a wide range of answers, from some very well organized with excellent detail to very vague descriptions of experiments to identify the functions of the parts of the brain. Most candidates provided a learnt answer for this question; there were some inaccuracies about lesions and/or imaging. Most candidates did not engage in a real discussion about how the different methods could be used to determine brain function but nevertheless managed to gain many marks.

Option F - Microbes and biotechnology

Question 7

Temperature, relationship and comparison were fine for most candidates in this question. Most candidates referred to the overlap in data as a reason for not being able to distinguish the two groups

with this method but it was more difficult to qualify the overlap. The majority of possible habitats for methanogenic bacteria were correct.

Question 8

The role of the reeds in a reed bed seemed unknown for a large number of candidates. Often this question was left blank or the arrow just went straight across the gravel bed without suggesting that nitrates were taken up by reed plants. The role of saprotrophic bacteria was better known, but many still could not incorporate the words organic matter or nitrates in their answer. Most candidates could compare photoautotrophs and heterotrophs and state one fuel made from biomass. Many candidates confused gene therapy and gene transfer, and also replacing the effect of a gene and replacing a gene; many answers were unclear and examples were rare.

Question 9

Most candidates provided learnt answers for this question and could gain many marks without providing any real evaluation. It appeared that the section about pasteurization was not answered as completely, some confusing pasteurization with sterilization or not mentioning the principles of the methods used in pasteurization, although stating that all bacteria were not killed; there was confusion about which method had an effect on food flavour.

Option G - Ecology and conservation

Question 10

The majority of candidates realised that the rat control decreased the number of chicks eaten. Some made errors calculating the percentage of nests in which the eggs did not hatch, often forgetting to add the abandoned eggs to the ones eaten by predators. There were mixed answers about reason for change and evaluation; the relationship between a parasite and host was confused by some candidates. In some cases, candidates wrote that the rats were feeding on the parasites and in other cases that they were the prey. The reasons for population decline were fine.

Question 11

Surprisingly, there were many incomplete definitions for biomass, mainly because the reference to dry mass was often not included. Some equations were reversed. Most candidates were not able to explain efficiently how the population could be evaluated, missing that many quadrats of a known dimension had to be used and that the field dimension had to be known to make an appropriate calculation, showing that many had clearly never carried out this technique. They nevertheless managed to gain some marks. Most candidates could state that an advantage of *in situ* conservation was that the organism remained in its natural habitat, but they had difficulty adding more reasons to their discussion.

Question 12

Most candidates did not notice that the question was about the conservation of biodiversity and provided learnt answers about the conservation of rain forests, which nevertheless enabled them to gain many if not all marks.

Option H - Further human physiology

Question 13

The majority of candidates stated the correct time in (a) and calculated the difference correctly in (b), although some provided a concentration instead of the time and/or calculated a percentage instead of a simple difference. Most comparisons were fine but some were incomplete. The role of bile in fat digestion was generally well known, some candidates providing lengthy explanations that were not required. Most candidates could state that human milk causes lower bile salt concentrations, but could not carry the analysis any further; some reached the wrong conclusion that greater bile salt concentration with cow milk meant the babies were able to absorb more fats.

Question 14

Many candidates stated correctly the SA node's role, but some lost sight of its primary function of initiating the heart beat and "over answered", outlining the sequence of contractions that are stimulated. Many candidates stated correctly enteropeptidase or enterokinase, but there were also too many incorrect answers. There was a range of answers about the control of gastric juice, many candidates gaining a mark for stating the role of gastrin, but a high number of candidates did not refer to neurological control for the sight or smell of food and/or referred to the medulla or the hypothalamus for the release of gastrin when food reaches the stomach. Gastrin is released directly by cells of the gut into the bloodstream (it is a hormone), not by the medulla. There was also a range of answers about the control of ADH, many correct, but too many lacking accuracy or appropriate terminology to gain all marks.

Question 15

This question on the Bohr shift was the most challenging and really tested the candidates' detailed knowledge and ability to focus on a specific part of a topic. Those who were well prepared where able to answer this correctly, but too often the answers were not focused on the Bohr shift and spent too much time about the affinity of oxygen for the hemoglobin molecule and the transport of CO_2; many answers did not relate dissociation of oxygen from hemoglobin to partial pressure of oxygen and others confused the curves for fetal hemoglobin or myoglobin with the Bohr shift; there were many misconceptions about cause (low PO_2) and effect (O_2 dissociation), and a poor understanding of how Bohr shift results in a higher supply of O_2 to respiring tissues. Including graphs was not necessary, but this could have provided some marks; too often the graphs were not correctly annotated when they were provided. Some of the weakest candidates did not answer.

Recommendations and guidance for the teaching of future candidates

- Teachers should be aware that the revised syllabus (first examinations in 2016) will focus on understandings, applications and skills and should therefore prepare candidates accordingly. The format of Paper 3 will be different, assessing applications and skills for the entire syllabus in part A, and the option coverage in part B. Memorizing material from manuals as seen for some of the questions of this present paper should no longer be sufficient, as focus will shift on the application of understandings. The following points apply to the present syllabus, but will nevertheless continue to be valuable in the future.

- Candidates should have a minimal vision of the syllabus structure in order to associate a part of the syllabus to the corresponding paper or question.

- Candidates should have practice with past examination papers during the two years of the

programme, along with the application of markschemes to evaluate their own work and those of other candidates. For the new syllabus, sample papers are available on the OCC.

- Candidates need more practice with data analysis, paying attention to accuracy when reading data. Varied presentations of data should be used as it requires considerable practice to master their interpretation. Data from previous examination papers, as well as data from all sources, can develop the required experience for interpretation. Candidates need practice at extracting data from graphs, using them to deduce trends, and analyzing them to provide evidence for and against a hypothesis and to interpret causality between variables.

- Throughout the two-year programme, enough time should be taken for consolidation; candidates should have plenty of opportunity for writing extended response answers and, with the revised syllabus, incorporating knowledge into the analysis of a situation.

- The display of knowledge from some candidates is not appropriate for HL expectations. Candidates should pay more attention to syllabus statements and, in the new programme, understandings and the guidance provided, to be prepared to apply the same level of detail in their answers.

- Accurate terminology does not only apply to definitions but also to all areas. Candidates should be prepared to apply appropriate language, whether it is for a definition or an explanation. Furthermore, recognizing a definition or a concept within the labelling of a question will enable them to focus their answer in the correct direction. A framework for the development of Cognitive Academic Language Proficiency is explained in the new Teacher Support Material, but can be used for both programmes.

- More attention should be drawn by candidates to read questions carefully and to recognize subtle differences in questions.

- Taking a few minutes to plan their answers could be a valuable strategy. It would help to increasing the number of elements in an answer and to avoid unnecessary repetition.

- Candidates need guidance and practice in considering the depth of their answers according to the mark allocations, the command terms, and also the amount of space provided (overusing additional booklets to repeat the same ideas due to a lack of planning, does not usually result in extra marks).

- Candidates should be encouraged to use a direct writing style, with attention to details and subject-specific vocabulary in their answers.

- Some theoretical knowledge should be integrated in arguments. Candidates should be aware that not all questions are based on repeating knowledge and should practise incorporating knowledge into the analysis of a situation.

Standard level paper three

Component grade boundaries

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

General comments

There were some very good scripts. Option A was better answered than the rest of the options. Although Option B and C data analysis was far harder than the other options, we had some very good answers. Very few candidates answered Option F, but unlike scripts seen in the past, these were fairly good.

Comments were received about the English (81%), French (3%), German (0.5%) and Spanish (15%) versions of this paper. Nearly 94% of the 176 teachers responding on G2 forms felt that the level of difficulty of this paper was appropriate. The other 5% thought that that it had been too difficult and 1% too easy. When comparing the paper to last year's, 75% of the teachers thought the standard similar, 6% though it was a little easier, 10% a little more difficult, 1% much easier and 2% much more difficult. About half of the teachers felt that the clarity of the wording was very good (46%), the others ranking it either as poor (1%), good (26%), or excellent (18%). About the presentation of the paper, the teacher believed it was very suitable; the proportions were 7% fair, 22% good, 47% very good, and 24% excellent. Teachers agreed that the paper was accessible to all candidates with learning support and/or assessment access requirements. The majority also agreed the questions were accessible to all candidates, irrespective of their region, gender and ethnicity.

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

Although most candidates show an ability to analyse data properly, they have more difficulty in questions requiring the skills of objective 3 command terms, such as 'suggest', 'explain', 'discuss', 'evaluate' and 'deduce'. Evaluation of hypotheses is often limited to the evidence supporting them, with no mention of what may not support them or what may limit their scope. Comparisons have improved compared to previous sessions, where most candidates used to merely state numerical data. Writing complete and accurate definitions prove to be difficult for many candidates. Many candidates are unable to express their answers clearly, using appropriate terminology, neglecting to include details that could refine their answers. Many limit themselves to the repetition of what they learnt from manuals, with a range of ability to do so.

The only difficult point, which was sometimes not well answered in Option A, was the function of the appetite control centre. In Option B, candidates had a difficult time recognizing the point of VO_2 max. In Option C, candidates struggled to distinguish absorption spectrum from action spectrum. The significance of polar and non-polar amino acids in proteins was not usually well known. Candidates were challenged in explaining the fate of pyruvate in cellular respiration. In Option D, most candidates could not identify the correct time period for human ancestors. Explaining the difference between excitatory and inhibitory neurons proved difficult in Option E. Another difficult point in this option was the description of contralateral processing of images. Very few candidates attempted Option F, those that did found it hard to suggest why industrial ethanol producers might choose different conditions. In

Option G, candidates had a difficult time explaining the impact of plants on primary succession.

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

Most candidates seemed to know which two options they had prepared for and answered them thoroughly. A large number of candidates displayed a comprehensive knowledge of factual information. Candidates generally did well at analysing graphs; they could answer the first question of all options without problem.

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

Option A – Human nutrition and health

Question 1

(a) Most candidates were able to state the change in body mass after 10 weeks of dieting.

(b) Many candidates recognised the positive trend. Some candidates were confused by the fact that the graph decreased, saying that the mass decreased at first. The mass was never below 0, therefore it is wrong to say that the mass decreased (as it always increased, although at a slower rate).

(c) The effectiveness of the high protein diet was usually well evaluated.

(d) Most candidates scored full marks in this question, so this was not a good discriminator. The question could be answered without the data presented, so it cannot be considered data analysis.

Question 2

(a) (i) and (ii) definitions are hard, as sometimes part of the answer is missing. Many candidates had this answer correct, but many had it incomplete.

(b) (i) Many candidates incorrectly answered that the sunlight was a natural source of vitamin D in diets.

(b) (ii) Most candidates scored full marks. The effect of over exposure to sunlight and the risk of contracting malignant melanoma were well understood by most.

Question 3

(a) Many candidates knew the appetite control centre was in the brain and that it was controlled by hormones. Some candidates had sound knowledge on how it worked together with the digestive and endocrine systems.

(b) This question has appeared very often, therefore most (if not all) candidates scored full marks.

Option B – Physiology of exercise

Question 4

(a) and (b) Most candidates had these questions right.

(c) This question was a good discriminator, as many candidates did not deduce which ventilation rate corresponded to VO_2 max.

(d) Only very capable students realized that the cardiac output was affected by both heart rate and stroke volume until a ventilation rate of 40 $Lmin^{-1}$, after which only heart rate was affecting the cardiac output.

Question 5

(a) and b) They were able to recognize the Z line, however identification of dark band was more challenging.

(c) Most had it right, although some forgot to distinguish the fibres, therefore scoring no marks.

Question 6

The need of warm-up routines before exercise and the need of increasing ventilation volume and rate during exercise were well known by students.

Option C – Cells and energy

Question 7

(a) Mostly well answered, although the majority of the candidates failed to realise this was a logarithmic graph, they could still score marks.

(b) Most candidates mentioned that the rate deceases, but failed to mention at all substrate concentrations.

(c) Good candidates explained competitive inhibition using inhibition of tyrosinase by HK and decrease in inhibition when increasing substrate concentration.

(d) Answers were very incomplete, as candidates only recognised the inhibition effect of HK being more effective at low DOPA concentrations.

Question 8

(a) Mostly well answered. A few candidates confused it with a mitochondrion.

(b) Candidates confused absorption spectrum with action spectrum.

(c) This question was well answered for oxidation, however candidates generally lost marks in identifying what was lost/gained in reduction.

(d) Most (if not all) answered this question correctly.

Question 9

(a) Many candidates answered effect of polarity of amino acids on solubility, but failed to see the effect of interaction of amino acids with other molecules.

(b) Some good answers, but some candidates were challenged in explaining the fate of pyruvate in cellular respiration.

Option D – Evolution

Question 10

(a) and (b) mostly well answered. Not much analysis in the question.

(c) Very few candidates used the data in their suggestion, but still scored full marks.

Question 11

(a) This question was a good discriminator, as good candidates mentioned features that distinguished the skulls and the date when *H.erectus* appeared.

(b) (ii) There were some very good and some very bad answers. The definition of gene pool was sometimes very badly answered.

Question 12

(a) Some candidates produced some good answers, but many wrote a lot of irrelevant material.

(b) Most candidates were able to discuss the definition of the term species. Not contemplated in the mark scheme, many candidates mentioned the differences between actual species and fossils and others wrote about asexual reproduction in bacterial strains.

Option E – Neurobiology and behaviour

Question 13

(a) Most candidates found this data analysis question easy.

(b) (ii) Most identified overheating as an impediment to parents leaving the nest, however very few cited the low temperatures at night or predators.

Question 14

(a) Mostly well answered.

(b) Candidates were able to distinguish rods from cones successfully.

(c) Most candidates had clear knowledge of the structure of a reflex arc.

Question 15

(a) Very few candidates understood how contralateral processing occurs. Candidates generally lost marks due to a lack of specific information by generalizing that the information coming from the right eye being processed by the left side of the brain or by incorrectly identifying which side of the brain processed which visual field.

(b) Very few candidates were able to meet the criteria for this question. Only a few candidates scored

full marks. Many candidates failed to mention that this interaction occurs through neurotransmitters. Some candidates did not read the question properly and answered the question focusing on excitatory and inhibitory drugs.

Option F – Microbes and biotechnology

Question 16

(a) Mostly well answered.

(b) Many candidates were not able to interpret what was happening in the process. This could be a language interpretation problem, as many candidates confused cellulase with cellulose.

(c) and (d) Only very capable candidates were able to answer these questions. Having failed to understand that ethanol is produced from the fermentation of cellulose, the analysis of the data is very difficult.

Question 17

Some very good answers, showing recall of use of bacteria in different processes.

Question 18

(a) Food poisoning was well understood, therefore most candidates scored full marks. In some answers, candidates mentioned symptoms and treatment, without mentioning a specific food poisoning.

(b) Many candidates mentioned only the risk of cancer when using gene therapy.

Option G – Ecology and conservation

Question 19

(a), (b) and (c) were generally well answered.

(d) some very good answers using the data. Many candidates scored full marks without making reference to the data.

Question 20

(a) Some candidates are still not able to construct an energy pyramid.

(b) Many had correct definitions for biomass, but some referred to weight or amount instead of mass.

(c) Many candidates failed to realise a quadrat is placed randomly. Very few mentioned how population is calculated.

Question 21

(a) Whereas most candidates stated primary succession correctly, describing the effect of plants was difficult and resulted in a diversity of answers for which a few marks were gained.

(b) Many candidates still confuse thinning of ozone layer with greenhouse effect. A good discriminator, as only very capable students realized it was by-products of the breakdown of CFCs that affected the ozone.

Recommendations and guidance for the teaching of future candidates

- Candidates should pay more attention to syllabus statements and teacher notes that indicate the level of detail required for some answers. Some candidates performed quite poorly, especially in Spanish, due to a lack of information and knowledge.

- Candidates should have covered the full content of two options and attempt to answer only those two (This will change to one in the new syllabus, with exams from 2016). There were a few candidates who answered all the options on the paper.

- Candidates should be encouraged to use subject-specific vocabulary in their answers. Accurate definitions should be learnt, but candidates should also be prepared to apply them.

- Candidates should continue to be exposed to a variety of data and data presentations. Students should be challenged to explain the data and draw conclusions from it.

- Students should continue to practise answering questions by addressing the action verb used.

- Communication skills are an important part of the study of Biology, and a clear answer in legible handwriting is essential for communication. Candidates should be trained to write clearly.

Further comments

- Most candidates answered two options but a few attempted more than the required number of questions.

- Candidates should be reminded to use extra paper when needed, rather than to write outside the provided space.