May 2015 subject reports

Biology Time Zone 1

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 16	17 – 29	30 – 40	41 – 53	54 – 66	67 – 78	79 – 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 17	18 – 31	32 – 41	42 – 54	55 – 66	67 – 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 2015 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

The range and suitability of the work submitted

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 are now 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.

Trivial, simplistic investigations that do not generate sufficient data to permit adequate assessment of data processing were sometimes used for assessment; "DNA extraction", "osmosis of gummy bears or worms", "water evaporation of towels". 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.

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. They will have a very negative impact on the new Individual Investigation.

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 solute concentrations on the osmosis of potato tissue, 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 range or categories of the independent variable should also be given.

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 using the air conditioning controls). It is not certain that some students are aware of the existence of water baths, heat shields or buffer solutions. Several moderators commented on the lack of control of temperature. Some students seem to think that temperature can be controlled by a thermometer. It was also noted that students who were varying the pH as the independent variable, rarely tried to measure the pH that the system was actually working at.

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.

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?

In experiments on seed germination the phenomenon of germination was often confused with that of post germination growth of the seedling.

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. For the dependent variable to be correctly identified this link needs to be made.

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 frequently complained about the use of the word “amount” which is often used by the students. It is not always clear whether 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 could have decided not to mark the investigation for DCP or CE. It also could be the product of an investigation set by the teacher, which is more problematic.

It should be understood that the use of pooled data is inappropriate for the assessment of individual investigations assessed for the new IA, 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 and desirable
- 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 straight 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. Those using spread sheets such as MSExcel should consider taking screen shots.

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, up to now, 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. Moderators were also concerned about candidates who did not take time to clearly interpret their data. They boldly stated a conclusion leaving it to the reader to verify if the data actually supported it. Weaker candidates also failed to refer back to the original research question.

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. They fail to evaluate the significance of the weaknesses that have been identified. The weaknesses they identify are often 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 unrealistic, 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. It is clear that those students evaluating their own experimental designs tend to do a better job than those following a worksheet or a method given by the teacher.

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, or any investigation where there insufficient data to justify a trend line.

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 and give a breakdown of the marks awarded.
- 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 individual 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.
- Make sure that you are using the most up-to-date version of the 4/PSOW form (available 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.

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 sometimes 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. Unfortunately a growing trend has been observed of clean copies with no comments on at all but 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. Although some teachers are having problems applying recommendations given in the feedback, there are encouraging signs that many are responding to the feedback

- 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. or that they are so cursory that they are not much use at all.
- 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.

New features of the Internal Assessment that need to be considered:

It may sound obvious but from now on in the new programme the new criteria need to be applied. These can be found in the latest biology subject guide available on the OCC. The nature of the science investigations has not changed, so teachers should recognize many of the same skills being expected of the candidates. Nevertheless the mode of application has changed significantly. There are no separate aspects to the criteria and the mark range for some criteria has been extended. The marking is arranged by bands, which may take a little getting used to. Example investigations on the Teacher Support Material should help here.

There are number of new features that teachers should be aware of:

- The purpose of the investigation needs to be expressed clearly in the report and there

needs to be clear evidence of personal engagement (see next point).
- The investigation cannot be a simple repeat of a classic investigation or one that is listed as part of the skills. However, it is possible to adapt and extend from a prescribed investigation.
- The assessment of manipulative skills may no longer be part of the internal assessment but evidence of the consideration of safety, ethics and environmental impact is expected for the Exploration criterion. Evidence that consent forms have been used will be expected where human volunteers are used.
- Given that 10 hours are allocated to the Individual Investigation, a significant amount of data should be collected. This will impact on Personal Engagement, Exploration, Analysis and Evaluation.
- Citations as footnotes are preferable for specific facts such as literature values. Correct format of citations/bibliography is necessary. URLs alone are insufficient. This will contribute to the Communication criterion
- Page length is limited to 6-12 pages. In addition format, e.g. font size and sizes of images and graphs will contribute to the Communication criterion. Text and graphs should be large enough to read clearly.
- As well as suggested improvements to modify the investigation, suggested extensions to the study are expected for the Evaluation criterion. As with the improvements they need to be realistic and precise.

Further comments

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. More details on the preparation for the new internal assessment criteria will be found at the end of the report.

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 using the death rate of fish as a dependent variable. This should not happen if the teacher is properly supervising the students.

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.

Higher level paper one

Component grade boundaries

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

General comments

Nearly 95% of the 113 teachers responding on G2 forms felt that the level of difficulty of this paper was appropriate. The others thought almost equally that it was either too easy or too difficult. When comparing the paper to last year's, 65% of teachers thought the standard similar. Over 80% of the teachers felt that the clarity of the wording was good to excellent. The proportions were similar about the presentation of the paper, with a few more finding it excellent

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

The questions that were answered least successfully were on motor neurons, water as a coolant, HCG, the greenhouse effect and transcription.

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

In this paper the questions that were answered most successfully were on xylem transport, the mean and standard deviation, the effect of high temperatures on enzymes, polygenic inheritance and codominance in genetics.

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

This was on the whole a very successful paper with many high discrimination indices, but comments are included here on the questions that proved controversial or which seemed to catch out students unexpectedly.

Question 4

There were comments from some teachers about the electron micrograph used in this question. The mitochondrion that candidates had to identify has a sigmoid shape rather than the classic ovoid shape of a textbook diagram, but the internal structure is clearly the same as ovoid mitochondria elsewhere in the micrograph and cristae are visible, so there should not have

been any confusion. Students should be able to recognise mitochondria in micrographs from the densely stained matrix and the invaginated inner membrane. The statistics show that some of the stronger candidates misidentified this organelle as a lysosome, but there are other single-membraned structures visible in micrograph that are more densely stained and nearly circular in outline and these are the lysosomes.

Question 6

This question also elicited some criticisms from teachers, who felt that there were two correct answers. Water cools living organisms when it evaporates so B was the correct answer. Water does conduct heat away from active muscles when blood flows through them and the heat is lost to the environment when the blood passes to the skin, but this can be regarded as a means of redistributing heat in organisms rather than actual cooling.

Question 15

Though nearly three quarters of candidates answered this question correctly, the discrimination index was poor suggesting that some of the abler candidates chose the wrong answer. Perhaps weaker candidates simply chose the correct answer because it included the word ‘energy’ and the question referred to a pyramid of energy while abler candidates recognised things in the other answers that reminded them of what they had been taught, even though the statements were all incorrect.

Question 16

This was answered correctly by only a third of candidates, and the distribution of wrong answers revealed two popular misconceptions. The first is that the greenhouse effect is caused by pollution, when the teacher’s notes for assessment statement 5.2.3 state that it is a natural phenomenon that is merely enhanced by the emissions of greenhouse gases. The second misconception was that it is shorter wave radiation that is trapped in the atmosphere. The same teachers note states that students should be aware that it is longer-waver radiation that is trapped.

Question 18

Some teachers found this question confusing and it is true that the precautionary principle is not the easiest. The teacher’s notes indicate that in this context the precautionary principle dictates that if the effects of a human-induced change would be very large, those responsible for the change must prove that it will not do harm before proceeding. In this question proceeding would be continuing to emit greenhouse gases. Answer B implies that emissions should continue until there is evidence of harm, so it does not follow the precautionary principle. The expected answer is C, which states that measures should be taken to reduce emissions before waiting for further evidence of harm to be produced.

Question 21

This was a very badly answered question with less than 20% of candidates answering it correctly. This is lower than the expected 25% success rate from guessing. Some teachers felt

that it was not part of the HL program, but the correct answer could be deduced from Assessment Statements 6.5.2 and 6.5.3 and the answer could also be identified by eliminating the three distractors using understanding gained from of these Assessment statements. Students who had studied Option E were at a slight advantage. Every effort is made to avoid advantages in Paper 1 for those who have studied a particular Option, but in some cases where the Option amplifies part of the Core or AHL it is almost inevitable. The commonest answer was D, which was the incorrect statement that relay neurons form synapses with receptors, but many candidates also chose A which stated that relay neurons transmit impulses from motor to sensory neurons. At least some candidates will have misread the question and chosen it without going on to read the other choices.

Question 26

This was answered less successfully than expected. Many candidates thought that channel proteins are used to convey hydrophobic molecules across a membrane when it is hydrophilic particles whose diffusion has to be facilitated.

Question 32

This question promoted some vigorous debate on the Online Curriculum Centre, with some teachers claiming that both answer A and B could be correct. The examining team did not accept this. Long periods of daylight will keep phytochrome in the P_{fr} form. In short day plants P_{fr} acts as an inhibitor of flowering, explaining the need for long nights to induce flowering during which all or most P_{fr} will revert to the P_r conformation. Answer A was clearly incorrect because P_{fr} does not promote flowering in short day plants. The use of the word 'daylight' in the question implied that the plants were in a day-night regime rather than an experimental regime of artificial light and dark, so the long period of daylight could be taken to imply short nights and hence non-flowering in short day plants. This will always be a tricky area of plant physiology with errors of understanding widespread.

Question 33

Some teachers suggested that the topic was not on the program and although gene mapping by recombination frequency is not, autosomal linkage is included in the AHL. In any case, the answer could be found by eliminating the other three answers which were certainly incorrect.

Question 40

This was a poorly answered question with less than 30% of candidates knowing that the embryo itself is the source of the HCG that is needed to maintain the pregnancy. The program requires that the role of HCG should be known (Assessment statement 11.4.10) but this inevitably includes the idea that the embryo signals its presence to the mother by means of secreting this hormone.

Recommendations and guidance for the teaching of future candidates

- Students should be advised to read all the answers. In some cases answer A is chosen

by more candidates than expected including some of the better prepared candidates because it is a superficially plausible but incorrect answer and the candidate did not read the other answers.

- Use electron micrographs in teaching so students are familiar with the appearance of organelles. There are straightforward recognition features for all the commonly occurring eukaryotic organelles that work even if the organelle does not exactly resemble a textbook diagram.
- Check teacher's notes carefully and include everything in your teaching that the notes say students should know. Teacher's notes are intended to help by stating clearly what should and should not be included, in places where teachers might not know the expected depth of coverage.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 7	8 – 10	11 – 13	14 – 17	18 – 21	22 – 25	26 - 30

General comments

Nearly 97% of the 84 teachers responding on G2 forms felt that the level of difficulty of this paper was appropriate. The others thought that it was too difficult. When comparing the paper to last year's, 58% of teachers thought the standard similar. Over 80% of the teachers felt that the clarity of the wording was good to excellent. The proportions were similar about the presentation of the paper, with a few more finding it very good to excellent.

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

The questions that were answered least successfully were on water as a coolant, synaptic transmission, the greenhouse effect, ventilation of the lungs and hormonal control of the menstrual cycle.

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

In this paper the questions that were answered most successfully were on the mean and standard deviation, populations and communities, test crosses, codominance and functions of the gut.

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

As with the HL paper, this was on the whole a successful multiple choice question paper with many high discrimination indices. Comments are included here on the questions that proved controversial or which seemed to catch out students unexpectedly. With questions that were common with the HL paper detailed comments are included in the HL report and a brief comment only is made in this report.

Question 3

Two thirds of candidates answered this question correctly and it discriminated quite well between stronger and weaker candidates, but there were criticisms from teachers about the use of the word 'scale' and also the use of the word 'magnification' for drawings smaller than the actual object. Use of both of these terms in the same question did cause some confusion and it was regrettable. Numerically scale and magnification are the same, but in IB Biology the term scale has usually only been used in the context of scale bars. Magnification means literally making something larger, so it is perhaps perverse to use it for a measure of how much smaller something has been made, but this is accepted practice.

Question 4

This is a common question with Question 4 of the HL paper. Nearly 70% of candidates answered it correctly on the SL paper with a reasonable discrimination index.

Question 5

Slightly less than two thirds of candidates gave the expected answer to this question. The discrimination index was relatively low, showing that some of the abler candidates did not answer the question as expected. There were criticisms from teachers about the use of the word 'across' in this question in relation to concentration gradients. In retrospect this word was inappropriate as it is ambiguous. Answers C and D could easily be eliminated but some of the stronger candidates chose answer A rather than B. This was understandable though pumps do not just control whether substances do or do not enter a cell. In answer B the words 'up' or 'against' would have been preferable to 'across' which implies neither up nor down the gradient.

Question 7

This is a common question with Question 6 of the HL paper. It was answered correctly by only 20% of SL candidates.

Question 10

There were criticisms of this question from teachers who felt that the correct answer was not concerned with energy storage. Despite this the other three answers were definitely wrong so C could be identified without doubt as the expected answer. More than half of candidates answered correctly and the discrimination index was very high.

Question 19

This was another question criticised by teachers, with some justification. Three answers could be eliminated relatively easily on the basis of ecological theory, but the remaining answer was that a principle of food webs is that primary consumers eat only plants. This is

not entirely true as photosynthetic bacteria and protoctists can also be at the base of food webs. This was still the best answer and nearly 60% of candidates chose it with quite a high discrimination index.

Question 20

This is a common question with Question 15 of the HL paper. Two thirds of SL candidates answered the question correctly but the very low discrimination index suggests that the stronger candidates were scarcely more successful than the weaker ones if choosing the expected answer.

Question 21

This is a common question with Question 16 of the HL paper. Only 30% of SL candidates answered this question correctly.

Question 27

This was a poorly answered question with fewer than 25% of candidates selecting the correct answer. Many candidates thought that neurotransmitters cross the synapse to reach the postsynaptic membrane in vesicles. The expected answer was that they reach it by diffusion. Presumably candidates were confusing presynaptic with postsynaptic, either because they couldn't remember the difference or through reading the question carelessly.

Question 29

This was also poorly answered, with only slightly more than 30% of candidates selecting the correct answer. Knowledge of the mechanism of ventilation is often patchy, with candidates either muddled or lacking in knowledge of the details of muscle contraction.

Recommendations and guidance for the teaching of future candidates

- Students should be advised to read all the answers. In some cases answer A is chosen by more candidates than expected including some of the better prepared candidates because it is a superficially plausible but incorrect answer and the candidate did not read the other answers.
- Use electron micrographs in teaching so students are familiar with the appearance of organelles. There are straightforward recognition features for all the commonly occurring eukaryotic organelles that work even if the organelle does not exactly resemble a textbook diagram.
- Check teacher's notes carefully and include everything in your teaching that the notes say students should know. Teacher's notes are intended to help by stating clearly what should and should not be included, in places where teachers might not know the expected depth of coverage.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 9	10 – 18	19 – 24	25 – 35	36 – 46	47 – 57	58 - 72

General comments

The overall quality of answers was similar to previous sessions with a wide range from very good to very poor. Of the teachers commenting using a G2 form, two thirds thought that the paper was similar in difficulty to that of last year and, of the others, more thought it was slightly harder than thought it a little easier. In fact, using the mark scheme that was devised for this paper, the mean score was slightly higher than last year. Over 90% of teachers thought that the standard was appropriate, with slightly less than 10% thinking that the paper was too difficult. Teachers were mostly happy with the clarity of wording and presentation, though rather more than usual thought that the clarity was only fair or was poor, perhaps because of some of the parts of question 1.

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

Candidates found several parts of Question 1 difficult. Many candidates seemed to have found these topics difficult: the male reproductive system, contraction of skeletal muscle, ventilation of the lungs, bonding in the secondary structure of proteins and differences between fibrous and globular proteins.

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

The parts of the exam that were well answered by most candidates, suggesting good preparation, were on phloem transport, the human genome project, structure of the plasma membrane and factors affecting the rate of photosynthesis.

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

Question 1

(a) This proved to be quite a discriminating first question with relatively few candidates scoring both marks. There were two common faults in answers: comparing males and females rather than control and IKO mice and describing very small differences in means as though they were

significant. Candidates should be encouraged to pick out significant trends from data and here it was that the four means being compared were all almost the same.

(b) Answers to this question were very varied and as in the previous question, some candidates made the wrong comparison. Here the comparison should have been between young and old mice, not between males and females or IKO and control mice. The data showed significantly higher blood glucose concentrations in older mice than in younger, leading to the deduction that stress increases blood glucose levels.

(c) Generally candidates fared better here, with most making the correct comparison of IKO with control mice. However, the data showed a clear difference between younger and older mice and answers were expected to include it. As in (a) some answers did not distinguish between significant and insignificant differences. The mean in young females was higher in the IKO than the control groups but the difference was insignificant so it was not appropriate to say that all IKO means were higher than controls except in young males.

(d) The wording of this question proved to be ambiguous, so a mark scheme was devised that allowed any valid interpretation and method of calculation. About half of candidates calculated one of the accepted answers. Marks were lost unnecessarily by some candidates, either for not showing any working, or for rounding up or down the answer in the wrong direction.

(e) There was some concern among teachers that it is not possible to deduce a correlation from present/absent data, but candidates mostly did not have difficulty understanding what was expected here. A very common mistake was to give an answer for pancreatic hormones in general rather than for insulin and glucagon separately as was essential because the lack of Fox01 had opposite effects on the two pancreatic hormones.

(f) About half of candidates answered this question successfully. To answer it correctly candidates had to realise that the change referred to was between the younger and older mice and that the answer had to be valid for both control and IKO mice as neither was specified. A common error was to answer with a type of mouse, such as older females rather than a group of cells.

(g) This question was generally well answered with candidates able to make at least one and sometimes two valid comparison between the percentages of cell types in younger and older mice and thus what the effects of aging are. For most of the answers it was necessary to specify either control or IKO mice as the trends were different.

(h) This question was intended to encourage candidates to bring together conclusions from the various data sources in the question, in order to evaluate a hypothesis. For nearly all candidates this proved to be too hard a task. Nevertheless, many candidates made some valid points and these were rewarded with marks. As so often in discussing a hypothesis there were valid arguments both for and against the hypothesis.

(i) Candidates found this question very difficult and only a small number were able to use the information in the stem of the question about Fox01's role as a transcription factor, together with the effects of a lack of Fox01 shown by the data in the question, to suggest a possible role.

Question 2

(a)(i) About half of candidates knew that polygenic inheritance contributes to continuous variation.

(ii) This question was generally well answered with stronger candidates able to score full marks. A few confused lactase with lactose and the products of lactose hydrolysis were not always known.

(b)(i) About a quarter of candidates knew the names of the two secondary structures.

(ii) Few candidates stated that hydrogen bonds stabilise secondary structures and even fewer earned a second mark for giving a detail of the hydrogen bonding.

Question 3

(a)(i) About two thirds of candidates answered correctly, which given that there was a 50% chance of guessing correctly implies that only one third of candidates knew that the potato was a dicotyledon rather than a monocotyledon.

(ii) This was generally well answered with many candidates scoring two marks. The answer ‘tap root’ was accepted because there was a structure in the drawing that resembles one; in fact it is a stem that grew from the planted tuber.

(b)(i) Few candidates labelled a tuber as the storage organ and either used the wrong name, labelled the wrong structure or both.

(ii) About half of candidates wrote confidently about phloem transport and many of these candidates scored full marks. The other half of candidates tended to have little knowledge of the translocation of products of photosynthesis, with xylem given as the transport tissue by many.

Section B

The four questions in this section were chosen by candidates in approximately equal numbers.

Question 4

(a) Structure of the male reproductive system

As so often in past papers, the diagrams of the male reproductive system were very poor. Many candidates were worryingly ignorant about the internal structure, with organs shown incorrectly or not at all. Connections between the parts of the reproductive system were often incorrect and the position of the prostate gland was almost always wrong. Many male students in later life will suffer from an enlarged prostate with difficulties in urination because the urethra passes through the prostate. For this and other obvious reasons, students should learn in detail about the structure of the male and female reproductive systems. Too many students are too ignorant in this area, despite what they and their teachers may think they know.

(b) Spermatogenesis and oogenesis compared

Most candidates found at least one or two similarities or differences between gamete production in males and females but very few scored really highly on this question. Many answers were constructed in the form of a table with two columns, which made it easier to confine the answer to genuine comparisons, but even so in some answers the statements in the left and right column did not correspond. Other answers consisted of long paragraphs about spermatogenesis and then separate paragraphs about oogenesis. The onus is then on the examiner to find the comparisons within the answer when this is actually the candidate's task. Few candidates reached 8 marks on this question, which was a challenge but perfectly possible.

(c) Consequences of overproduction of offspring

Some candidates wrote only about humans, with the focus on large families and overcrowded housing. They should have realised that this is not a biological answer to the question and that a general answer about all species was expected. There were some very good answers that tied in populations rising above the carrying capacity to competition for resources, increased mortality, variation and the survival and reproduction of the better adapted individuals, hence evolution of the species by natural selection.

Question 5

(a) First division of meiosis

Most candidates knew the names of the four phases and many knew some of the events in them, but there were few really convincing accounts and some confusion between mitosis and meiosis. Few candidates made it clear in their answer than the two nuclei produced in the first division are haploid. The chromosome/chromatid terminology in mitosis and meiosis is rather awkward, but was expected to be used correctly in answers to this question. In past mark schemes there has often an easy mark for simply mentioning crossing over, whether in context or not. In this case candidates had to say that it occurs between non-sister chromatids.

(b) DNA replication in prokaryotes

Some candidates were confused by the specification that replication should be described in prokaryotes. This is of course the only type of replication included in the IB Biology program. There were some very good answers and stronger candidates did not have difficulty in reaching full marks. Abler candidates seemed to have chosen question 5, perhaps because they knew they could cope with the complexities of DNA replication and knew that they had enough to say for 8 marks.

(c) Outcomes of the human genome project

There were some good answers to this question also. Candidates often referred to the complete sequencing of the genome, evidence on human ancestry and the discovery of genes causing diseases or of genes that increase the incidence of a disease.

Question 6

(a) Structure of a motor neuron

Diagrams ranged from very good, with 4 marks easily scored, to extremely poor. Motor end plates were rarely drawn correctly and some candidates used other names for them. The mark scheme only allowed this name as it is specified in the teachers' notes. Although no mark was awarded for indicating that the diagram only shows the two extreme ends of the neuron, with almost all the axon omitted, it is worth explaining this to students. The vast length of the axon is perhaps the most remarkable feature of a motor neuron.

(b) Contraction of muscles

Perhaps because Question 6 tended to attract many of the weaker candidates, accounts of muscle contraction were mostly very poor. Some candidates missed the point and wrote about reflex arcs instead. The way in which ATP releases its energy and how this energy is then used was very rarely correct. Diagrams helped with some answers but only where there was full annotation.

(c) Ventilation

Stronger candidates wrote full and accurate accounts and often scored full marks but others wrote error-strewn and confused accounts. A popular misconception was that the gas breathed in is oxygen and the gas breathed out is carbon dioxide.

Question 7

(a) Structure of the plasma membrane

Of the three diagrams tested on this exam paper, this was drawn most successfully with many candidates scoring full marks. Some candidates misinterpreted the question and drew a diagram of a whole eukaryotic cell with a plasma membrane around its margin. On diagrams showing the expected structure the commonest errors were to place particular types of proteins or cholesterol in the wrong position.

(b) Light-dependent reactions of photosynthesis

Answers were polarised with strong candidates writing accurate and detailed accounts of the light dependent reactions but other candidates revealing very little knowledge. Diagrams were sometimes included at the start of the answer but they often didn't help because they were not annotated fully enough to make any of the points on the mark scheme.

(c) Factors affecting the rate of photosynthesis

Only light intensity, temperature and carbon dioxide concentration were accepted here. Candidates could score two marks for any two of these factors by showing the trend in a graph or by describing it in text but for other marks the answer had to include a cause of the effect of the factor, for example rising temperature increasing the activity of enzymes in the Calvin cycle. Denaturation was not accepted as a cause of decreasing photosynthesis at higher

temperatures because the decreases happen at much lower temperatures than would cause denaturation.

Recommendations and guidance for the teaching of future candidates

- When analysing data, think carefully about which trends are significant and which are not. The repeats in an experiment are only a sample. If we take several samples from the same population, the means of the samples will almost certainly be different, but the differences are not significant. In biology especially, where variation is expected and indeed with natural selection depending on it, we need to be able to judge differences are likely to be significant or not in data analysis.
- The structure of the male and female reproductive system should be carefully taught and it should not be assumed that candidates already have this knowledge at the start of the diploma program. It would be better for teachers to assume total ignorance among their students. Any potential embarrassment over teaching this topic needs to be overcome as it is information that helps adults remain healthy.
- Use firm lines when doing pencil drawings as faint lines do not show on scanned exam scripts.
- If graphs or diagrams are included to help in an answer, other than a question asking only for a diagram, then annotations should be included around the diagram, not just names of structures. Only annotations can give sufficient information to help with an answer.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 6	7 – 13	14 – 17	18 – 24	25 – 30	31 – 37	38 - 50

General comments

There was evidence of good preparation across a wide range of topics. Some candidates reached very high overall scores.

Thanks goes to the schools that returned G2 forms, providing valuable input. Most comments indicated that teachers felt that the test was a fair one. A few people commented that it did not provide broad coverage of the topics they had anticipated. When considering coverage, it is important to realize that there are two types of coverage. There is topical distribution which was exhibited on paper 1 and the other type of coverage is the assessment of the depth of understanding of concepts and the application of skills which is done primarily on paper 2 for

Core topics. To reach this objective, paper 2 will necessarily cover fewer topics as it must focus on depth.

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

Section A

In the data-based question candidates answered questions about previously unseen data and responded to it showing an ability to analyze data and apply information learned in Topics 1 and 6. Many questions were worth 2 marks and the majority of candidates got one of the two marks. Weaker candidates could not see the patterns in the data and so were confused. The confusion showed itself in the restating of the data rather than stating something about the pattern of the numbers. However, there were a few candidates for who scored most of their marks for this question. Some did not recognize that two pairs of groups were a control while the other two pairs of groups were experimental. Candidates were asked to examine these sets of data through multiple views. Only two parts of question 1 required recall from the syllabus. They were recalling that correlation does not establish cause, and the functions of insulin and glucagon. Weaker candidates tried to put other recall into their answers when not called for by the question. Many candidates got the functions of glucagon and insulin badly muddled.

Among the short answer questions, many candidates failed to apply knowledge that they surely knew. Lactose, being a sugar, provides energy. It does not make strong bones, provide calcium, or any other of the many answers that were read. This somewhat new setting for considering the function of sugars assessed application of factual knowledge to another factual answer perhaps not learned directly. On the other hand, all of the questions on the nervous system were direct recall. Only the top students got marks for these questions. Treatment of photosynthesis by candidates was surprisingly poor with candidates showing memorized graphs (unrelated to photosynthesis) with sigmoid cures or curves of an optimum, rather than thinking about what actually happens in photosynthesis. Almost universally, candidates failed to explain how to measure the rate of photosynthesis. A rate requires a time component. Although most students knew what to measure and how to measure it, they did not put the measurements into a situation where time was taken into consideration.

Section B

Drawings were poorly organized and sloppy, with labeling arrows failing to touch the part being labeled. In order to earn marks on drawings, candidates needed to have approximately the correct shape for the structure and have it placed in a correct relationship to other parts in the diagram. Candidates should be drawing labeled biological diagrams - often diagrams were too sketchy lacking clear, crisp lines.

For the other extended answers, poor answers resulted when candidates did not respond to the command terms as they constructed their answers. Although less importance appears to be placed on command terms in the structure of the new syllabus, command terms will continue

to be used in the writing of exams. There are changes to some of the command terms which are found at the end of the new course guide, pages 166-167.

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

Section A

For the data-based question, most candidates were able to read and analyse the graphs presented. Weaker candidates often scoring one mark where better candidates scored two or three marks. Thus, the data-based question did a good job of differentially assessing the skill levels of candidates.

Differences in absorption of red, blue and green light by chlorophyll were noted by almost all candidates as was the production of oxygen or use of carbon dioxide as dependent variables in experiments to measure the rate of photosynthesis.

Section B

The three parts of the extended answer questions (Q5, Q6 and Q7), were diverse, being connected only loosely to a theme. Nevertheless, students performed well on all three of the parts of the question suggesting that candidates were well-prepared. The selection of questions was fairly evenly distributed with Q5 being chosen most frequently.

Of the drawings, the best were of prokaryotic cell structure and structure of water molecules.

Many students showed good answers on how the body defends itself against pathogens and the genetics questions as well as the effects of global warming on arctic ecosystems. Although the natural selection of antibiotic resistance in bacteria is tricky to answer well, many students demonstrated excellent understanding and had worked out how to explain the phenomenon without producing a Lamarkian explanation.

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

Section A

Question 1

(a) Most candidates achieved one mark. This was an unusual *compare* question as the similarity was that the data showed only slight differences and the differences were actually not significant. The correct answers less often given included the added notation that there was no significant difference, the observation that the data were clustered around a mean value of 0.8 mg ml^{-1} and the observation that there is nearly the same spread of data (least often noted).

(b) (i) Most candidates achieved this mark.

(b) (ii) Many candidates got one or the other of the marks; better students got both by stating their answers as a formal deduction. The formality was not required for the mark, but seems to have been achieved by those who did.

(c) Many saw the relationship between older control and IKO mice but failed to comment on the relationship between younger control and IKO mice.

(d) There are 2, possibly more, correct answers, depending upon the emphasis of the finding being discussed. So, the mark scheme limited acceptable answers to two possible numeric answers because, of the candidates who responded correctly, about half responded with 53% and the other half responded with 35%. There at least 5 ways to work through this problem correctly so the marking point for the working, was very generous. Partial working counted: all the way from extracting the correct data from the graphs (minimum) to display of all steps to an answer. All of these variations received marks for working. Numbers from the graph such as 2.3 and 1.5 were seen often but poor working. The mark was given anyway because necessary numbers were read from the graph. Working with percentages is an expectation given in the Mathematical Expectations in the course guide. Many candidates work with percentage change and percentage difference in their practical work. This is seen in the IA samples where schools are providing complex activities in the practical scheme of work.

(e) As mentioned on the G-2 forms, this was an unusual format for asking candidates to detect correlations. However, where the answers really grappled with the idea of correlation, they usually performed well. They had to recognize that there are actually two correlations expected in the answer.

Wrong answers often described a causal relationship. Candidates did not seem to understand that when writing about correlation, causation should not be implied. A verb such as increases or decreases implies cause. However, the adjectives decreased insulin and increased glucagon are acceptable because the adjectives describe the conditions of the correlation. As such, the question assessed an authentic understanding of Topic 1 AS 1.1.6

(f) This question expected an application of information learned in Topic 6 (AS 6.5.11) to the data given. The command term is *suggest* which opens the door to reasonable analysis. Of the candidates who understood what was being asked, most earned two marks. They could gain one mark by recalling the function of insulin on blood glucose levels and another mark by recalling the function of glucagon. There were three additional marking points for interpreting the data as it would affect blood glucose levels because of the mutation. There were some excellent responses to this question, however, there were some really poor answers too. Candidates described when insulin and glucagon were released but not what the hormones would do. Many regarded insulin as an enzyme that breaks down sugar. Some students stated that glucagon was broken down into glucose. Some attempted to insert diabetes into the answer while others added the concept of stress.

Question 2

(a) Most candidates got this one right. Wrong answers included answers like polysaccharide, sucrose, monosaccharide and ribose

(b) Too many missed the idea of "function" here. Even after getting the answer to part (a) right, some candidates confused lactose with lactase citing that it as an enzyme, or suggesting that it digests. Others gave a nutrient value of milk rather than recognizing that lactose is a component of milk with a singular function.

(c) This question could be interpreted as asking for the steps in a procedure (an acceptable expectation from Topic 3 AS 3.6.5) or it could be seen as asking the purpose of production of lactose-free milk (as found in the teacher's notes). Marking points were given for both possibilities. Most candidates earned one mark for statements about how lactose free milk is made and one mark for a reason for making it.

The old lactose/lactase/lactate confusion arose for weaker candidates. There was quite a bit of evidence for strict memorization here.

Many creative incorrect answers such as genetic modification of cows so they don't produced lactose or lactose is an enzyme that makes digestion difficult so lactose must be denatured.

Question 3

(a) The quality of answers was quite variable over whole range of candidates, from strong to weak. Most got "nucleus", then dendrites... Some answered "fiber" for III, which is vague but consistent with another part of the exam where the word "fibre" is used.

(b) The "motor" part of "motor neuron" did not seem to be understood. Few candidates knew its placement in a neural pathway or an action that it can cause. With remarkable frequency answers suggested that the function involved sending messages TO the brain. Some thought motor neurons transmit messages to DNA while others thought the messages are transmitted to organelles. Credit was given for stating that motor neurons stimulate movement or muscles or effectors. Some candidates mixed up effectors and receptors and stated that motor neurons stimulate receptors.

(c) Capable candidates recognized that the resting potential is when the neuron is not firing. Many low-end answers ignored context of question and used some form of physics answer regarding "potential", or potential energy. -70mV was often included in the answer without any reference to inside or outside of cell.

(d) Many low to medium scripts had answers which tackled this question from an anatomical or cytological rather than neurophysio point of view. There was confusion about the meaning of "along a nerve fibre." Many thought that a "fibre" was more than a single neuron. This lead to outlines of a neural pathway rather than the changes that occur within a single neuron as an impulse passes. Several candidates outlined synaptic transmission. This question could have been set for more marks. Consequently, the strongest candidates often earned more marks than the maximum that could be awarded, while most earned no marks.

Question 4

(a) Most candidates earned two marks for this two mark question. Most stated that blue and red are absorbed (one mark), but that green is reflected (another mark). Thus, they distinguished green from the other two colors. Very few candidates distinguished red from blue, which was listed as a third marking point.

(b)(i) A whole variety of poor drawings was seen from straight lines starting from 0,0 and going up at a 45° angle to sigmoid curves to bell-shaped curves. Many drawings lacked straight sections for the increase or plateau portions.

(b)(ii) Few candidates earned both marks here. The most common answers suggested measuring oxygen production or carbon dioxide uptake. Some added a method for doing so; others gave the rational for doing so. Only a handful suggested taking the measurements for a set amount of time, or taking a reading before and after a time interval. Hence, rate could not be calculated and the second marking point was not earned. As a teaching point, it could be observed that many of the experiments in our practical programmes involving rates, do not insist on rate calculations because a divisor of one (time unit) has been set in the procedure. That kind of shortcut hurt candidates in this examination.

Section B

Question 5

(a) Those that drew a prokaryotic cell did well but there were also quite a few eukaryotic cells as the diagram showed and labeled organelles such as mitochondria, lysosome and endoplasmic reticulum.

(b) There were a generous number of marking points for this question. However, candidates were expected to earn some of them describing the first and second lines of defence as well as some of them from the immune response. This answer was generally done well when students weren't confused by extra material, many students had been over taught this area and confused the functions of macrophages / B cells / T cells / memory cells. Terminology and concepts found in HL were presented by students. Those were not accepted in the mark scheme as there were sufficient marks allotted to show understanding of the broad picture expected at SL. Those who used the HL material successfully generally had most of the marks in the mark scheme plus HL information. Unfortunately many got muddled as stated above.

(c) Capable candidates answered this question very well and with clear explanation. The best responses extended their answers to include the occurrence of multiple-antibiotic resistant bacteria. Weaker and mid-range candidates mentioned that bacteria evolve to gain resistance to antibiotics but rarely that it occurs through gene mutation or suggested that mutations that give resistance occurred because bacteria required them rather than randomly. There were many vague answers as candidates seemed to have some grasp of the mechanism but difficulty explaining it.

Question 6

(a) There were many good drawings. However, there were too many sloppy ones. Often the sperm duct and urethra were shown without double lines. The physical proximity and connections of sperm duct, prostate gland, and urethra were usually drawn incorrectly. In a few cases the female reproductive system was drawn.

(b) DNA profiling for paternity cases was answered well by many candidates. However, many had the procedures quite poorly sequenced. Little attention was given to selectively breaking up the DNA, or use of restriction enzymes. Weaker answers would have benefitted from more precise terminology such as DNA fragments or DNA bands rather than just DNA. There was fair understanding of gel electrophoresis. Many candidates missed out as they failed to mention DNA from the mother must be used as well as DNA from father and child. Almost no responses included why one might do this process.

(c) Inheritance of colour blindness seemed to be pretty well answered by many. There was better attention to correct notation than in the past. There was good use of annotated Punnett grids to clarify answers. However, the candidate needed to label or explain the Punnett grid in order to earn marks. It was surprising that many did not include the genotypes in their explanations. Marks were lost by incorrect use of the term gene when allele should have been used.

Question 7

(a) Almost all candidates knew the V shape for water molecules but few labeled covalent bonds and still fewer were exact in describing the negative charge on O as partial or the positive charge on H as partial. The mark scheme assumes a stick model of water. Answers often used a bubble diagram, undercutting one possible mark. Even so, full marks could be earned. Bonding within and among water molecules was the part most often neglected.

(b) This question was generally well answered displaying good knowledge of the effect of global warming on arctic ecosystems. Often this answer was reasonably well started, but often did not have enough follow-through. Weak answers included some odd understandings. It is not melting glaciers that are the issue, it is the melting ice cap and the sea ice. Some answers were glib, repeating the cases made by the public media rather than research-based information regarding the plight of endangered animals. There are no penguins in the Arctic.

(c) This question expected students to approach the topic from a slightly different position than the usual. As such, it discriminated well between stronger and weaker candidates. Many students misinterpreted what was being asked and wrote long detailed answers on structure of the cell membrane and how transport occurs through the proteins - rather than concentrating on the properties of the phospholipids which give the cell membrane its structure. Answers needed more attention to interaction of phospholipid with water. Few knew that the phospholipid head is glycerol and phosphate and virtually nobody mentioned anything about non-polar amino acid side chains being attracted to (hydrophobic) tails.

Recommendations and guidance for the teaching of future candidates

Candidates should:

- take time to absorb the full import of graphs. They need exposure to a variety of graphs and experience interpreting them, with good models to follow. Concepts such as correlation and significant difference need special reinforcement, with examples.
- practise writing responses to the command terms. Since command terms are not used in the new syllabus content as assessment statements, the understandings are open to various command terms. This can add richness to learning the material as students practise applying more than one command term to an understanding or skill.
- read questions carefully and answer the question that is asked e.g. “how does oxygen enter the blood” does not mean “how does it enter the heart/lungs”. Do not waste time on irrelevant information which will gain no marks; key words should be underlined before an answer is attempted; pay attention to information given above pictures and diagrams as it may guide your answer; if a question is not easy to answer at first sight, leave it to the end. Avoid a shot-gun approach where many ideas are sprinkled into an answer hoping to score marks through positive marking (may backfire in that one part may contradict another).
- label all essay sections a/b/c and avoid writing one continuous essay for all.
- take care when drawing a diagram and make sure that labels reach their destination and are not just suspended; practise drawing the required diagrams/figures in the guide
- write neatly or, if handwriting is not clear, print clearly
- give units for calculated/mathematical answers; show working--it may be worth a mark!
- bring a ruler and a calculator

Teachers should:

- As Louis Pasteur once said “chance favors the prepared mind.” Successful exam results for any candidate depends on two strengths:
    - their ability to interpret and analyze familiar as well as unfamiliar experimental data;
    - their ability to provide accurate detailed knowledge in response to questions about almost any part of the syllabus.

A variety of teaching methods can be used to help candidates achieve these strengths. However, it seems that teachers who promote active learning among their students achieve the best results. This is often done through small group interaction. For example, teacher could regularly have students practice interpreting and analyzing new data. Previous IB exams would be one source. These same exams could provide extended response questions for candidates to answer. Candidates could then mark another classmate's answers using the mark scheme provided with the exam. This type of activity is bound to activate student critical thinking skills about content they should be learning.

- encourage students to read questions more carefully and focus answers on what is being asked. More emphasis is needed on answering questions with regards to appropriate command terms. Teachers should encourage students to first outline their answers to questions in Section B before setting out to write their full response, avoid irrelevant answers, and place more focus on the question given.

- teach clear expectations for calculations, including number of decimal points and use of units. When doing calculations insist that students show workings. Guidance can be found in the Mathematical Expectations of the new syllabus as well as the TSM on the OCC for what calculations and statistical tools are expected.
- ensure students attempt every question - leaving blanks gets no marks.
- make sure that students know simple biological basics: -ase is an enzyme, -ose is the substrate. Biology is a vocabulary dense subject and vocabulary needs to be practised to be useful on exam day.
- ensure students learn the principles of biological drawings - don't sketch, shade - use crisp clear lines and label everything properly and carefully, with the arrow touching the structure being labeled.
- teach that rate must involve some concept of measurement over time.
- don't over-teach areas of the syllabus to standard level candidates unless they are clearly able to cope with it. This situation often occurs where HL and SL students are taught together so care must be taken to reduce the expectations for the SL students to avoid situations seen with Q5b.
- Evolution by natural selection is random, not granting organisms what they want.
- make sure when drawing Punnett grids that they are clearly annotated - matching offspring genotypes and phenotypes clearly.
- teach candidates what they need to know about exam technique: if 8 marks is the max for a question, then the answer should include at least 8 distinct and different points/statements; these don't need to be long paragraphs for the mark; what counts most is a range of accurate detailed information.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 5	6 – 11	12 – 16	17 – 20	21 – 25	26 – 29	30 - 40

General comments

Thank you to the teachers who filled out G2 forms. The actual percentage of teachers who do this is still small but improving. All teachers who enter candidates are encouraged to take a few minutes to fill out the form which can be found on the Online Curriculum Centre (OCC) immediately following the examination. The comments on the G2 forms indicate that over 90% of the respondents felt the paper's level of difficulty was appropriate. Of those respondents who felt able to comment, 65% felt the paper was of a similar standard to last year's paper with a sizable number (30%) feeling it was a little more difficult. The clarity of the wording was considered good to excellent by 85% of respondents and the presentation of the paper was found to be good to excellent by 91% of respondents. The suitability of the questions on the

paper in terms of accessibility and cultural, religious or ethnic bias was felt to be accessible to all by all respondents.

As in previous years, Option D and G were very popular and were often studied together. Option E was also very popular and was often, but not always, paired with option H. Option F was the least popular option but many schools prepared their candidates well for this option. Few candidates attempted more than the two required options, and most are writing in the spaces provided although some are still using several extra pages.

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

In general, a fairly large number of candidates struggle to express answers clearly and concisely using appropriate subject terminology. Objective 3 command terms, such as 'explain' and 'evaluate' still remain problematic.

Topics that appeared difficult for candidates include the following:

- Cladistics
- Control mechanisms including control of heart beat by medulla oblongata and control of gastric glands
- Effects of cocaine on neural pathways
- Differences between Archaea and Eubacteria
- Structure of cyanobacterium
- Distinguishing between use of a quadrat and a transect
- Uses of Simpson diversity index and biotic index
- Interpreting graph of pressure changes in heart
- Interaction of CO_2 with erythrocytes

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

Many candidates coped fairly well with the data-based question at the start of each option. Candidates generally did well at retrieving information from graphs and performing basic calculations, even if they did not appear to fully understand the graphs. Objective level 1 questions in which a simple 'state' or 'define' question is asked were often answered well by the majority of candidates. Candidates who had studied for the exam were able to get marks for the longer response question in each option.

Topics for which candidates appeared well prepared include the following:

- Definition of gene pool
- Reflex arc
- Trophic levels
- Equation for Simpson diversity index
- Function of gastric glands

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

Option D – Evolution

Although this was one of the most popular options, candidates who attempted this one seemed to find it more difficult than other options.

Question 1

There were some comments on the G2 forms regarding the graphs for this question being difficult to analyze or confusing. The names of the wolves and coyotes did sometimes lead to confusion. One problem was that many candidates misread the diagram and thought it showed proportions of areas instead of proportions of haplotypes. Despite this, Question D1 often scored fairly well.

a) Most candidates were able to get 1mark for either seeing that all Canis populations showed a mixture of haplotypes from 2 or more origins or for giving an example to support this. Only the better candidates were able to get 2 marks.
b) Most candidates again were able to get at least 1 mark, often for stating that both species had the same 3 haplotypes. Many were also able to get a second mark for telling how they differed in the proportion of these haplotypes.
c) Only better candidates were able to see there was no overlap in ranges and use the data to explain why.
d) This was often answered well with many able to get a mark for suggesting that more of the C1 haplotype gave more wolf-like features to the northeastern coyote.
e) Many obtained 1 mark for seeing that the eastern wolf was a common ancestor but few were able to get a second mark.

Question 2

a) Some candidates did know protobionts. Many that did were careless and incorrectly wrote ‘probionts’. There was a comment on the G2s that this structure could have several names and protocell and coacervate were other possibilities.
b) While many candidates were able to get 1 mark, and some 2, few wrote clearly or accurately about the endosymbiotic theory. The question was not asking for evidence of the theory which is what some candidates wrote about.
c) Two comments were made on the G2s about the wording of this question. While many were able to state in (i) that allele and phenotypic frequencies remained constant in non-evolving populations, others were discussing mutation and selection instead. The definition of gene pool in (ii) was answered better than in previous years.

Question 3

This was probably the most poorly answered of the longer response questions on this paper. Candidates did not seem to have enough knowledge about cladistics to allow them to respond adequately and marks above 2 or 3 were rarely seen. As they were unable to communicate ideas on clades clearly they waffled and were repetitive. Better candidates were able to discuss cladograms to some degree. Better teaching of this topic is required.

Option E – Neurobiology and behaviour

Question 4

a) and (b) Almost all candidates were able to correctly answer both parts which involved directly identifying information from the data provided. Very few did not score both points.

c) Candidates did not do well on section (i) as they did not notice that Team A was not given a placebo. Most saw or invented effects of the placebo, with many thinking it was effective in all cases, when in fact the placebo did not have an effect. For section (ii) many simply repeated what was already in the stem so did not gain the mark.

d) A large number of candidates were able to gain 1 mark for seeing that pain tolerance went down in all groups during the week after competition but few were able to get a second mark.

Question 5

Many candidates found this to be a fairly straightforward question except for section (c) (ii).

a) The majority of candidates were able to correctly label the reflex arc.

b) Almost all could name mechanoreceptors.

c) (i) The majority correctly identified the cerebellum although occasionally cerebrum or brain stem was chosen, not earning a mark.

(ii) Few candidates gained more than 1 mark and many did not score any. The role of the medulla oblongata in modifying the innate rhythm of the pacemaker was not understood. Parasympathetic control and the role of vagus nerve were not often mentioned. Candidates frequently talked about flight-or-fight responses and the role of adrenaline instead. Another misconception was that the medulla oblongata actually was initiating each heart beat rather than overriding the SAN. This section seemed to be poorly taught.

d) Many could give some adaptive value to the deer behaviour described and earned the mark.

Question 6

While many candidates were able to identify cocaine as a psychoactive drug, few could actually discuss its effect on neural pathways. Answers resulted in descriptions of many different ways in which cocaine might act. Many gave vague general knowledge answers, not mentioning pre- and post-synaptic neurons, neurotransmitters or reuptake of dopamine. Those that did know dopamine was involved, incorrectly said cocaine stimulated release of dopamine. Weaker candidates commonly talked about endorphins or hormones. There was generally a lack of precise scientific knowledge and understanding.

Option F – Microbes and biotechnology

Question 7

a) The majority of candidates were able to identify the point required from the graph.

b) Candidates struggled to outline the trend for Amerindians in (i), perhaps due to the variation in the data. There was seldom reference to a plateau. Likewise, only the better candidates could clearly distinguish the trends in the 3 populations in (ii).

c) Usually only 1 of the 2 marks available was awarded, often for different food sources that would provide different bacteria. Many candidates did not mention environmental differences but individual habits.
d) A good number of candidates were able to make reasonable suggestions of how the knowledge of human gut flora could be applied despite this being a novel idea to most.

Question 8

a) (i) This question on Archaea and Eubacteria was very poorly done by the majority of candidates. Many seemed to guess.
(ii) Many candidates could name two roles of microbes but a surprising number were only able to give one correct role for microbes in ecosystems and thus did not get the mark.
(iii) Very few decent diagrams of a filamentous cyanobacterium were seen. Instead many drew what looked like a generic bacterial cell.
b) This was also poorly done despite the fact it was straight recall from the syllabus guide. Many did not mention Gram negative.

Question 9

There were many weak answers for this longer response question as many candidates seemed to rely on general knowledge rather than biological knowledge. Those who were able to get 3 marks often did so in either bread making or beer making but did not seem to have good knowledge of both.

Option G – Ecology and conservation

Question 10

a) Almost all candidates were able to get the 1 mark for reading the graph correctly.
b) This question also involved reading the graph correctly and most were able to get 1 mark. Many received a second mark as well.
c) The association between light, temperature and depth was problematic for many candidates. Many were able to get 1 mark usually for light avoidance.
d) There was poor reference made to the role of *Bythotrephes* as predator or prey. Many confused “position in food chain” for position in the lake in terms of depth.

Question 11

a) Candidates seemed to have very poor knowledge of the differences between a quadrat and transect and when each was used.
b) Both parts of this section were answered correctly by most candidates
c) (i) Many were able to get a mark for indicating that UV radiation caused skin cancer. Other effects were seldom mentioned.
(ii) This question on the environmental conditions that favoured r-strategists was very poorly answered. Many correctly received 1 mark for indicating that an unstable environment favored them but failed to go further and answer the question for a second point. Instead, many candidates described what r-strategists were.

Question 12

A few good answers were seen but most candidates struggled to give good, clear responses explaining the use of the two indices. Many candidates knew the equation of the Simpson diversity index but not that a high value means ecological health and how it could be used in environmental monitoring. Many knew the biotic index used indicator species and better candidates could talk about different species having different pollution tolerance levels and what that said about water quality. The majority of answers however were superficial, repetitive and vague.

Option H – Further human physiology

This seemed to be the most straightforward option for candidates.

Question 13

a) Almost all were able to use the graph to correctly identify the mean height difference of the two groups.
b) Most saw that the starting age of participants in the trial was related to puberty as children at 9 years had not yet started their growing spurt.
c) Candidates struggled to word this answer correctly. Many could get one mark for seeing that it caused a reduction in height but only the better candidates were able to get a second mark. Many seemed to confuse decrease in height with change in height difference between the groups.
d) Many were able to get one mark for seeing that the height difference persisted into adulthood but few got a second mark.
e) There were many possible suggestions for shortcomings of the data but there were few good responses.

Question 14

a) (i) Many were able to state one mechanism for absorption used by the ileum with facilitated diffusion and active transport being most common. The most common incorrect response was microvilli.
(ii) Surprisingly the role of the hepatic portal vein was poorly understood by many.
b) (i) Most could correctly identify the line on the graph representing ventricular pressure.
(ii) Even the better candidates struggled to use the graph correctly to find the total time the atrioventricular valves are open.
c) (i) Very few answered this section correctly; instead many repeated what was required in section (ii). Few mentioned carbaminohemoglobin.
(ii) Many were able to get the 2 marks for describing the formation of hydrogencarbonate ions in erythrocytes, usually giving the correct equations.

Question 15

Many candidates were able to score fairly well on this longer response question. The majority of marks awarded were mainly for the function of gastric glands rather than the control. Better candidates were able to discuss the role of both nerves and hormones in controlling secretions of the gastric glands. The weakest area seemed to be the role of gastrin.

Recommendations and guidance for the teaching of future candidates

Preparation of candidates:

- It should be stressed that teachers must teach the option topics thoroughly rather than leaving this to candidates to cover on their own.
- Use the action verbs in homework, tests and exams to ensure candidates are familiar with the question stems so that they understand what is required of them when they are asked to 'describe', 'compare', 'evaluate' or 'explain'.
- Teach the vocabulary of biology. Candidates need to use biology specific vocabulary clearly.
- Coach students on how to structure longer response questions, taking note of the number of marks available to guide their answers.
- In any quantitative answer, values are time, rates, percentages, sizes, distances, concentrations etc., but not 'amounts' which is too vague.
- Use past examination papers and mark schemes as well as the CD Question Bank to provide suitable questions so that candidates are familiar with the examination format.

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

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

Examination techniques need to be taught and practiced:

- Stress that the examiner can only mark what the candidate has written and cannot assume anything about knowledge or understanding.
- There is no need to repeat the question in an answer. There is not enough space to do this in the box provided and is a waste of time.
- Take a ruler to the exam and use it when reading from graphs.
- Read the question carefully and answer the question asked.
- Candidates need to be precise in their answers and not focus on trivial details, missing the obvious points.
- Candidates must write so the examiner can read their writing; they should slow down and make it legible. Poor handwriting is made worse by the scanning required for E-marking.
- Any writing outside the box or not on an extra page may not be picked up by the scanning used in E-marking.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 6	7 – 12	13 – 16	17 – 20	21 – 25	26 – 29	30 - 36

General comments

The comments on the G2 forms from 87 respondents indicated that 97% considered the paper to be of an appropriate difficulty, with 3% too difficult. In comparison to last year's paper, 63% thought it was of a similar standard, 8% a little easier and 14% more difficult. No respondents found the clarity or presentation of the paper to be an issue. There were several comments on the restricted content tested in the options, particularly C and G. Overall the paper was judged as being fair across all options.

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

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

Effectively answering questions with the command terms explain, discuss or evaluate. For explain, candidates do not give reasons and for the others, opposing arguments are not provided.

Topics that were poorly understood:

- Explaining dietary advice given to a patient with type II diabetes
- Risks and benefits of using EPO to improve athletic performance by competitive athletes
- Relationship between VO_2 and the proportion of carbohydrate and fat used in respiration
- ATP production by muscle fibres during intense exercise
- Use of ATP to break cross-bridges and re-set myosin heads during muscle contraction
- Concept of controlling all variables in an experiment other than the independent
- The structure of a mitochondrion
- Process of adaptive radiation
- Correlation between brain size and diet in human evolution
- Role of sensory, relay and motor neurons in a simple reflex
- Use of a transect to investigate the distribution of plant species
- Changes taking place in the abiotic environment during primary succession

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

Questions requiring comparisons were well answered.

Topics that were well understood by the majority of the candidates:

- Food miles concept
- Nutrients,
- Symptoms of type II diabetes
- Factors affecting plant distribution
- Biceps and triceps function
- Induced fit model
- Causes of drug addiction
- Endosymbiotic theory
- Classical conditioning

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

Option A – Human nutrition and health

This was again a popular option and candidates had good knowledge.

Question 1

Candidates had some difficulty analysing the data in the graph and some misread the axes. If 1(b) was answered incorrectly, candidates had difficulty answering 1(d). The majority of candidates did not give reasons for and against choosing New Zealand cheese, and very few scored 3 marks here.

Question 2

Knowledge of nutrients and the need for iodine was sound, although the word goiter was not well known. There was also good knowledge of the benefits and risks of a high protein diet, though many candidates did not score full marks.

Question 3

Candidates knew the symptoms of diabetes but very few gave explanations for the dietary advice they suggested. Many mentioned the need for exercise, which was irrelevant, and answers such as “eat less sugar and fat” were common. This question was a good discriminator for the top grades.

Option B – Physiology of exercise

This was one of the least popular options.

Question 4

Candidates were generally able to analyse the data for the first two questions; however very few were able to suggest why the hypothesis that training increases EPO levels was not supported. There was little or no reference to the standard deviations. Candidates understood the physiological effects of EPO but appeared less knowledgeable about its risks.

Question 5

5(a) was very poorly answered, with very little understanding of the link between oxygen use and the substrate being respired. The effects of training were sometimes not related to the pulmonary system.

Question 6

Most candidates knew the functions of the biceps and triceps muscles. Many confused the following two questions. For 6(a) few candidates could supply information beyond anaerobic respiration and in 6(c) there was much confusion over the exact role of ATP in muscle contraction.

Option C – Cells and energy

This was a fairly frequently attempted option and many candidates had sound knowledge.

Question 7

7(a) was well answered but few recognized in (b) that there was not a constant difference between control and experimental plants. In 7(c) the majority of candidates failed to relate their answers to the data presented, although they did get credit for some knowledge of limiting factors.

Question 8

There was a very wide range of drawings, many well drawn and labeled, but more that were highly inaccurate. Quite often cristae were drawn as separate entities, rather than as extensions of the inner membrane. If the drawing was poor, then 8(b) on structure vs function was also poorly answered. This was an opportunity to show in-depth knowledge of aerobic respiration.

Question 9

Most candidates had some knowledge of induced fit but did not relate this to the process in the question. Almost no candidates recognized that there were two substrates and many found their ideas difficult to express. There was better knowledge of end product inhibition but again candidates found their explanations hard to express.

Option D – Evolution

Question 10

10(a) was almost answered correctly. Candidates did not read the graph carefully, so that the months mentioned in answers to the rest of the questions were incorrect. 10(d) was very poorly answered, as the majority of candidates wrote about sickle cell anemia and the benefits of the heterozygote condition, without any reference to the data.

Question 11

There was sound knowledge of endosymbiosis and a range of answers for protobionts. Surprisingly, some candidates did not relate oxygen production to photosynthesis.

Question 12

There were poor explanations in general for adaptive radiation, although many candidates could use Darwin's finches as an example. Some explanations for the evolution of human brain size did not relate meat to its nutrient content.

Option E – Neurobiology and behaviour

Question 13

Questions 13 a-c were generally well answered. In 13(d) most candidates commented on improved chances of finding food but other suitable answers were rare except for the top grades, which generally made reference to moths flying at night and therefore being unable to use light receptors. Answers involving inheritance were very rare.

Question 14

Nearly all candidates had sound knowledge of Pavlov's experiment, although many did not use the required terms. There was poor knowledge of the exact functions of neurons.

Question 15

The majority of candidates knew two excitatory drugs and could list effects on behaviour. There were good answers addressing reasons for drug addiction, with many explaining the dopamine effect.

Option F – Microbes and biotechnology

Very few candidates chose this option.

Question 16

The manure types and ratios were recognised but in (b) candidates answered too generally, without making reference to changing ratios. In (d), conditions for methanogens were not well known.

Question 17

There was poor knowledge of feeding in *Paramecium* and *Euglena,* although phagocytosis was described for *Amoeba*. In part (c) most candidates gained 2 out of the 3 marks.

Question 18

The catalytic action of reverse transcriptase was known but its use in gene transfer was not well described. Candidates recognised that cancer was a potential risk factor of gene therapy.

Option G – Ecology and conservation

Question 19

19(a) was answered correctly and most candidates scored at least 2 marks for part (b), with some responses being too vague, for example not making it clear that *Rissoidea sp* and *P. maculata* were not present at all at the *S. muticum* site. There was some confusion in part (c), where evidently the introduction to the data had not been properly read, as some candidates appeared to think that *S. muticum* was an animal.

Question 20

As in previous years, many candidates did not know what a transect is or its purpose and some were evidently confused with estimating a population size. In (b) many answers described the vegetative changes in succession rather than the abiotic. The mark scheme in (c) was generous in allowing lists of factors and/or elaborations, otherwise many would not have scored here.

Question 21

If candidates knew an example of biomagnification they were able to gain the three marks, but even so, many do not understand how and why a chemical becomes more concentrated in each successive trophic level. The best answers to explaining a niche appeared to be rote-learned, otherwise candidates had difficulty using their own words.

Recommendations and guidance for the teaching of future candidates

- Teach the command terms, with opportunities to practise them. In particular the term **evaluate** requires candidates to assess the *implications and limitations* of the data and **discuss** requires candidates to give an account that includes a range of arguments *for and against* the proposal. **Suggest** requires candidates to propose ideas rather than reiterate data from the question. **Explain** can mean give reasons, not just state.
- Teach definitions so that student responses are precise and not vague.
- Advise students to use a ruler and pencil to annotate graphs and extrapolate carefully for accurate answers.
- Use the details given in the Teacher's Notes section of the Guide to ensure that candidates have the knowledge to respond in sufficient detail.

- Practise past paper questions and go through the mark schemes with the students, not only before the exam but also whilst studying the Options. Expose the students to the wide range of data analysis questions available. Encourage them to highlight important pieces of information in introductions, which are often required for their answers.
- Stress to students that “bullet” type answers are preferable, so that responses are sufficient for the 3-mark questions. Questions should not be repeated in the answer.
- Advise students to plan their answers to fit into the spaces provided, and if more space is required, to use extra pages rather than answering underneath the box. If using extra pages, these should be clearly labelled.
- For option G, some familiarity with fieldwork is required, for students to answer effectively.