November 2015 subject reports

Biology

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 30	31 - 41	42 - 54	55 - 68	69 - 80	81 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 17	18 - 30	31 - 41	42 - 53	54 - 65	66 - 78	79 - 100

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

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. 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 result.

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. 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 rules for collaboration between groups of students are quite strict in the new syllabus. A group may build up a collective database e.g. a large ecological survey of an ecosystem but their research question needs to be unique and they will be assessed on their method for the selection of data.

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 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 is 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

Clerical procedure

- 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 together in groups and be assessed on the same method. However, as stated above, they may collaborate to build up a database from which they then select data that is relevant to their individual research question. 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 euthanasing 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 - 18	19 - 23	24 - 28	29 - 33	34 - 39

General comments

Most of the 39 teachers answering the G2 report believed the difficulty of the examination was appropriate (74%) and only a few believed it was too difficult (26%). Compared to last year, most believed it was of similar standard (39%) or a little more difficult (36%) while some believed it was a little easier (7%) and some much more difficult (13%). The suitability of the paper in

regards to clarity and presentation in general was good. The clarity of wording was excellent (13%), very good (31%), good (31%) and fair (8%) while some believed it was poor (15%) or very poor (2%). The presentation of the paper was considered to be excellent (28%) very good (33%), good (23%), or fair (10%). Only 5% believed it was poor. The mean mark for this paper is down by 3.52 from last year.

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

Difficulty indices showed that many of the candidates found this to be a tricky paper. One question was discounted and two answers were accepted for a second.

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

Question 2: Due to the fact that all the different options could be considered to have emergent properties, this question was considered to be unfair and has been cancelled.

Question 3: This question was answered well by half the candidates and the discrimination index was very high, this means that capable candidates studied the extracellular function of glycoproteins well.

Question 4 and 5: a high discrimination index and a high difficulty index shows these questions proved to be difficult to many candidates but at the same time, good students answered them well.

Question 6: This question was too easy so did not discriminate well.

Question 7: usually candidates do not answer multiple completion questions well, but in this case, more than 60% of the candidates were able to answer it correctly and the discrimination index was high.

Question 11: This question proved to be too hard for all candidates. Most candidates answered that the mutation for sickle-cell anemia is found in blood plasma. This is probably because they know anemia is related to blood, but failed to realize that plasma has no cells, therefore no DNA (6.2.6 in guide). Many candidates also went for gametes with X chromosome; probably wrongly believing this is a sex-linked disease. Others believed every gamete has the mutation, forgetting that gametes only have half the genetic information, so in a heterozygous individual, not all gametes receive the mutation. All nucleated cells in the body (except half of the gametes) have the mutation; therefore the only possible answer was brain cells.

Question 12: although most good candidates answered this question well, some candidates had different number of chromosomes in a disjunction. Unlike what happens in plants, the probability of having more than one chromosome suffering non-disjunction in humans in very low, let alone the whole set of chromosomes.

Question 13: many candidates failed to read that the question was referring only to type A blood. In the guide, in section 4.3.3 it says: State that some genes have more than two alleles (multiple alleles). We can say that multiple alleles refers to more than 2 alleles, therefore answer C is incorrect.

Question 14: two answers have been accepted in this question. As stated in a G2, since no example is specified for gene transfer in the guide, candidates could have studied examples that start with mRNA or from a gene in DNA. Since the former would not use enzymes to cut DNA, candidates would choose D, whereas those who had studied a DNA example would choose A, so both answers A and D have been considered as correct.

Question 16: some comments mention this question is tricky, especially in the use of the term "stage" of food chain. This did not seem to confuse candidates, as only a few answered A. This answer is not correct, as tertiary or quaternary consumers are the final stage of the food chain.

Question 17: most candidates were able to realize that methane from agriculture is a greater contributor to the greenhouse effect than carbon dioxide from volcanoes. Some candidates did believe it was the carbon particles from engines, failing to realize this is not a gas.

Question 18: the only possible answer to this question is decreasing natality, as all other options either increase or do not change the world's population. The graph clearly shows that although it is still increasing, there is a decrease in the growth rate.

Question 19: this proved to be a very easy question. Only a few candidates failed to realize that the *Acacia* are Angiosperms (flowering plants).

Question 20: there have been complaints about the translation into German of this question.

Question 24: most candidates answer this question well, although the question stated body temperature instead of blood temperature.

Question 26: the image was not needed to answer the question, but seemed to have misled some candidates to answer four polypeptide chains instead of genetic information determining the primary structure.

Question 27: this question had the highest discrimination index and a high difficulty index.

Question 29: there were many comments in the G2s on this question. Most good candidates answered that protons accumulate in the lumen. This is the best answer to the question, as there are many protons throughout the lumen. Photolysis occurs in the photosystem II, in the oxygen-evolving complex; therefore oxygen is produced in the inner surface of the membrane (so A is the correct answer).

Question 35: this question proved to be too difficult for many candidates and was a poor discriminator. Many candidates just guessed the answer.

Question 36: there has been a complaint that this topic is not in the guide. In section 11.1.5 the guide says to "Describe the production of monoclonal antibodies", so the production of hybridoma can be tested. This question is a good discriminator.

Question 39: most good candidates correctly answered that microvilli are found in the proximal convoluted tubule.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 9	10 - 12	13 - 16	17 - 19	20 - 23	24 - 29

General comments

Most of the 39 teachers answering the G2 report believed the difficulty of the examination was appropriate (90%) and only a few teachers believed it was too difficult (10%). Compared to last year, most believed it was of similar standard (59%) while some believed it was a little easier (3%) and some a little more difficult (28%). Only a few believed it was much more difficult (8%). The suitability of the paper in regards to clarity and presentation in general was very good. Most teachers were happy with the paper as they said the clarity of wording was excellent (10%), very good (28%) or good (33%) and fair (18%) while some believed it was poor (10%). The presentation of the paper was considered as excellent (21%), very good (36%), good (25%) and fair (18%).

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

In general the questions seemed reasonable for most candidates and had a good discrimination index. One question was cancelled. Here are a few comments on the questions that arose queries or problems.

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

Question 2: Due to the fact that all the different options could be considered to have emergent properties, this question was considered to be unfair and has been cancelled.

Question 3: This question was answered well by half the candidates and the discrimination index was very high, this means that capable candidates studied the extracellular function of glycoproteins well.

Question 4: a high difficulty index shows this question proved to be too difficult to many candidates in SL.

Question 5: this question was too easy so did not discriminate well.

Question 6: usually candidates do not answer multiple completion questions well, but in this case, more than 50% of the candidates were able to answer it well and the discrimination index was high.

Question 8: there has been a mistake in the diagram that will be corrected for publication but did not affect the answer. The 3' end should not have a phosphate group.

Question 9: this question was too easy so did not discriminate well.

Question 11: many candidates (including good ones) wrongly believe that anaerobic respiration does not produce ATP.

Question 12: This question proved to be too hard for all candidates. Most candidates answered that the mutation for sickle-cell anemia is found in blood plasma. This is probably because they know anemia is related to blood, but failed to realize that plasma has no cells, therefore no DNA (6.2.6 in guide). Many candidates also went for gametes with X chromosome; probably wrongly believing this is a sex-linked disease. Others believed every gamete has the mutation, forgetting that gametes only have half the genetic information, so in a heterozygous individual, not all gametes receive the mutation. All nucleated cells in the body (except half of the gametes) have the mutation; therefore the only possible answer was brain cells.

Question 14: although most good candidates answered this question well, some candidates had different number of chromosomes in a disjunction. Unlike what happens in plants, the probability to have more than one chromosome suffering non-disjunction in humans in very low, let alone the whole set of chromosomes.

Question 15: many candidates failed to read that the question was referring only to type A blood. In the guide, in section 4.3.3 it says: State that some genes have more than two alleles (multiple alleles). We can say that multiple alleles refers to more than 2 alleles, therefore answer C is incorrect.

Question 18: this question proved too easy.

Question 20: there have been some complaints about the use of the word "relative" before role. Although this word was not needed, it does not invalidate the answer to the question. This question had a very low discrimination index and only 40% of the candidates were able to answer this question correctly. The answer was quite easy, as one can see all arrows leaving from carbon dioxide in the atmosphere and the only arrow going back to carbon dioxide in atmosphere is the one coming from photosynthesis, therefore this must be the most important as it is equivalent to the addition of all the other arrows in order to balance the cycle.

Question 21: most candidates were able to realize that methane from agriculture is a greater contributor to the greenhouse effect than carbon dioxide from volcanoes. Many good

candidates did believe it was the carbon particles from engines, failing to realize this is not a gas.

Question 22: this proved to be a very easy question. Only a few candidates failed to realize that the *Acacia* are Angiosperms (flowering plants).

Question 23: the word “probable” was not the best choice, as “likely” sounds better. This does not affect the answer to the question.

Question 24: there have been complaints about the translation into German and Spanish of this question, but these did not affect the answer to the question.

Question 27: most candidates answer this question well, although the question stated body temperature instead of blood temperature.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 17	18 - 25	26 - 35	36 - 46	47 - 56	57 - 72

General comments

This paper represents something of a landmark as it is the last to test the version of the IB Biology programme that is being replaced by a radically new and different programme. The equivalent paper next year will have some significant differences, which are described in the programme guide and are exemplified in the specimen paper. Some command terms have changed and there are many differences in the knowledge expected.

Of the teachers who commented on the paper, over 90% felt that it was appropriate in difficulty, with the others thinking that it was too difficult. Three quarters considered it to be of a similar standard to last year’s paper with most of the other teachers thinking that it was a little easier. Teachers’ views corresponded with the outcome of marking, with the mean for the paper two marks higher than last year. There was a wider standard deviation, with marks spread over almost the entire range.

80% of teachers thought the clarity of wording was good, very good or excellent and the corresponding percentage for the presentation of the paper was 83%.

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

Few candidates knew the role of polysomes and many were unable to deduce recombinants in a test cross involving gene linkage. The structure of the human egg cell was not widely known and many candidates had insecure knowledge of aspects of heart structure.

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

Drawing skills were generally strong with many neat and accurate representations of biological structures. Differences between plant and animal cells were mostly well known, as was the appearance of a cell in anaphase of mitosis. The structure of the elbow joint and the functions of tendons were well known. Methods of gene transfer, the effects of abiotic factors on transpiration and the importance of water to living organisms were also widely understood.

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

Question 1 Data based question on growth and development in Sockeye salmon

- (a) Most candidates read off the two numbers from the bar chart and added them together correctly, though some misread the intervals on the x-axis or read off the values on the y axis incorrectly.
- (b) The essential skill in questions such as this is to pick out significant features in the data. The answer should tell the reader the overall differences between the two populations and not simply quote values. There was some overlap between the two populations in fork length but the winter 2009 population had a larger sample size, larger average length and larger maximum and minimum fork lengths. It also had a smaller range of fork lengths than the autumn 2008 population. In future exams the command term ‘compare’ will mean only similarities, not similarities and/or differences.
- (c) Most candidates suggested two acceptable factors that could affect distribution.
- (d) Candidates found it hard to read off values from this scatter graph, perhaps because of the large size of the squares and diamonds used for the data points. Candidates should be reminded that it is the centre of any data point that indicates the precise value, not the upper or lower edges. Because of the difficulties, a relatively wide range of answers was accepted, but even so only about half of candidates gave an acceptable range.
- (e) This was generally well answered with candidates stating that there was a positive correlation in Autumn 2008 and no correlation in Winter 2009. The commonest mistake was to state that there was no variation in total lipid content in Winter 2009: there was, but no clear trend lipid content according to fork length.
- (f) Candidates gave a wide range of reasons for the differences in lipid content. The best answers were from candidates who had read all the information in the question about the biology of Sockeye salmon and had used it to deduce the reason for depletion

of lipids in the salmon in winter.

- There was confusion in some candidates' minds between cause and effect, with statements such as that the sea water is colder in winter so the salmon are less active, need less energy and therefore have smaller stores of lipid. If we applied this sort of logic to humans, the reason for obesity would be a need for more stored energy reserves in obese people because they are more active. Some candidates assumed erroneously that the physiology of fish is the same as that of mammals, with constant high body temperature and subcutaneous storage of lipids for heat insulation.
- (g) Most candidates correctly stated that there is a positive correlation between PCB concentration and distance upstream.
- (i) This proved to be quite a discriminating question, with the strongest candidates working out that if lipids are used up, but PCBs cannot be removed from the body, then the concentration of PCBs in lipids will increase.

Question 2 Mitosis, magnification, plant and animal cells and polysomes

- (a) (i) About half of candidates calculated the magnification of the image correctly. Those that did not were usually one more orders of magnitude away from the answer. A common problem was the use of centimetres rather than millimetres to measure the size of the scale bar image. This very often leads to an error of one order of magnitude.
- (ii) This was well answered with more than 90% of candidate recognising that the cell was in anaphase.
- (iii) This was also well answered by many candidates with each of the three statements in the answer referring both to honey bee cells and to onion cells. A few only mentioned one organism or the other so failed to score any marks. It is not enough to imply a difference in questions such as this – the difference should be stated explicitly.
- (b) This was very poorly answered with fewer than 25% of candidates knowing that polysomes are groups of ribosomes that are translating the same mRNA, which indicates that the cell needs multiple copies of one particular polypeptide.

Question 3 Elbow joints, muscle contraction and the link reaction

- (a) (i) Well prepared candidates had no difficulty in naming the humerus and the synovial fluid. For the latter structure certain other answers were accepted because, given the three dimensional structure of the joint, it wasn't entirely clear what the labelling line was touching.
- (ii) Nearly all candidates knew the function of tendons.
- (b) Some candidates confused synaptic transmission with muscle contraction and wrote about the former, but there were plenty of accurate explanations of how calcium is used within muscle fibres to trigger off contraction. Details of troponin and tropomyosin were not expected, but with the new program they will be.
- (c)(i) Many candidates were able to label the matrix as the site of the link reaction.
- (ii) There were few really strong answers to this question. A common misconception was to think that coenzyme A is an enzyme, rather than a carrier of the acetyl group that acts as a substrate of enzymes. In many answers it was not clear that coenzyme A first accepts an acetyl group and then passes it to an intermediate (oxaloacetate) in the Krebs cycle.

Question 4 Gene linkage, test crosses and recombination

- (a) Nearly all candidates successfully determined the phenotype.
- (b) Answers were variable, with some excellent ones that distinguished between linked and unlinked genes, their position on the same or different chromosomes and the implications for recombination.
- (c) About half of candidates knew that the double recessive parent in a test cross would contribute a chromosome with the alleles ab and that recombinants would have new combinations of genes on their other chromosome, either Ab or aB.

Section B

Question 8 was the most popular, followed by Question 7 and then Questions 5 and 6. There was a trend for candidates to answer either Questions 5 and 7 or 6 and 8. Each question involved drawing a diagram of a structure, so there was no escape for candidates who find this difficult.

Question 5 Structure of human eggs, gene transfer and evolution

- (a) Of the four drawings on this exam, the egg drawings were in general the weakest. The nucleus was in almost all cases far too large and cortical granules were often distributed throughout the cytoplasm rather than being located close to the plasma membrane. Structures outside the plasma membrane were often muddled, perhaps because it was necessary to use three or more concentric circles to represent them.
- (b) Strong candidates had no difficulty in scoring full marks here by describing gene transfer using plasmids, restriction enzymes and DNA ligase. The weakest candidates wrote on a wide range of other topics.
- (c) Answers ranged from impressive, with a secure understanding of evolution by natural selection and effective use of examples, to very confused. In contrast to some previous exams most candidates chose appropriate examples such as the evolution of antibiotic resistance in bacteria or the development of melanism in peppered moths. Descriptions of the development of the giraffe's neck or speciation in Galapagos finches were not accepted because they do not correspond with any specific environmental change for which we have good evidence. It is particularly important to base accounts of evolution on strong evidence rather than speculation, because of the objections to the theory that are still being raised.

Question 6 Structure of sarcomeres, nerve impulses and endocytosis

- (a) Most candidates scored three or four marks for the drawing of a sarcomere. The Z lines, actin filaments and myosin filaments were usually recognisable. Myosin heads were shown clearly in some diagrams. Light and dark bands were often incorrect. Some candidates showed but did not label titin filaments between the ends of the myosin and filaments and the Z lines. Usually these were distinguished from the myosin by being shown narrower and without heads.
- (b) There were relatively few really strong accounts of the passage of an impulse along an axon. Some candidates described synaptic transmission instead and others were confused about the sequence of events. Very few candidates explained how the impulse is propagated along the axon by local currents.
- (c) Almost all candidates knew something about endocytosis, describing the invagination of the plasma membrane and the formation of vesicles. A few had

confused endo and exocytosis and included descriptions of vesicle movement from the rough ER to the Golgi and on to the plasma membrane.

Question 7 Structure of leaves, abiotic factors and the importance of water

- (a) Leaf drawings were generally good with the upper and lower epidermis and the palisade and spongy mesophyll correctly positioned. Cuticle was sometimes also shown on the outside of the epidermis. It was often much too thick and labelling of cuticle and epidermis was sometimes confusing. The question asked for a plan diagram, in which no cells should be shown. Some candidates did not understand this and showed every cell. There were some beautiful detailed drawings including all the cells. These did not score any more marks than plan diagrams, but candidates were not penalised for failing to follow the instructions in the question.
- (b) Accounts of the effects of abiotic factors on the rate of transpiration were mostly good. Few candidates made the point that the air spaces inside the leaf are at or close to saturation with water vapour and very few knew that carbon dioxide concentration can influence transpiration rates through changes in stomatal aperture. Many accounts could have been improved by mentioning how steep concentration gradients are between the air spaces in the leaf and the air outside. This was relevant in relation to both atmospheric humidity and wind speed.
- (c) There were a lot of possible answers to this question on the importance of water so strong candidates had no difficulty in reaching five marks. Weaker answers were vague and incomplete and sometimes muddled up the properties of water such as coherence and adherence and the various thermal properties.

Question 8 Structure of the heart, control of blood glucose concentration and osmoregulation

- (a) Drawings of the structure of the heart were variable. Given the complexity it is not surprising that there were few flawless drawings. Common errors were to make the walls of left and right ventricles equal in thickness and in some cases also to make the atrium walls no less thick than the ventricles. A curious feature of some diagrams was to show a thin vertical ruled line instead of the septum between the left and right hand sides of the heart. This is not the ideal way to show the structural relationship between left and right sides and of course leaves nowhere for conducting fibres to run. Sections through the left and right ventricles of the heart show that the septum is equal in thickness to the rest of the left ventricle wall. Most candidates named at least some of the attached blood vessels correctly, though in some cases marks were lost because it wasn't clear enough which chamber was served by which vessel.
- (b) There was another very common error in this part of Question 8: many candidates stated that the hypothalamus monitors blood glucose concentration and when the concentration is high sends messages to the pancreas to stimulate insulin secretion. This is incorrect. The beta cells in the pancreatic islets monitor blood glucose concentration directly and the hypothalamus is not involved. This mistake might have been due to confusion with ADH secretion, but it was so common that it seems likely that teaching material used in some schools includes the error.
- (c) Many candidates found this question hard and answers were varied but mostly not very strong. Candidates were expected to describe the formation of glomerular filtrate by ultrafiltration and the reabsorption of nearly all water from it in the proximal convoluted tubule and the descending limb of the loop of Henle. They were then

expected to explain the secretion of varying amounts of ADH and the effect this has on the reabsorption of water in the collecting duct and changes to the volume and concentration of urine excreted. Many candidates included a diagram of the nephron but did not use it to help answer the question. Some candidates did score full marks but in other answers there were many gaps and misunderstandings, which perhaps we should expect because of the complexity of kidney physiology.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 16	17 - 23	24 - 30	31 - 37	38 - 50

General comments

Thank you to all the teachers who submitted G2 forms. 85% of the responses thought that the paper was of an appropriate difficulty, with nearly all of the others thinking it too difficult. 90% thought it was of a similar standard or a little more difficult than last year's paper. There was at least one comment that Genetics, Ecology and Evolution were given too great a coverage, at the expense of Chemistry of Life and Human Physiology. However far more praised the paper for its broad coverage. There was at least one comment that there was too much in the paper for the time limit. Markers however did not report that the candidates seemed to be rushing to answer the last questions.

There seemed to be two points of Spanish translation (1g and 6b) which seemed to cause a little confusion. The Spanish mark scheme was adjusted to allow alternative complete answers (not an extension of the marking points), so the candidates were not penalised in any way.

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

Connections of gall bladder and pancreas to small intestines (4a.) Missing or not stating the obvious (Q1) calculations of magnification (2a) and percentage (3ciii), simple biochemistry (4c and 6c). The difference between ion pumps (active) and voltage regulated gates (passive) (Q7b)

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

The standard of the diagrams was generally good (apart from 4a), structure of DNA, translation (6b), neuron structure and nerve transmission (7)

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

Question 1.It should be noted that when describing relationships, marks will not be awarded for just stating numbers from a graph without their significance.

Question 1a. Most candidates were able to identify the most frequent fork lengths as 175 or 180 and 250 or 255. Weaker candidates lost the mark for stating values in between.

1b. Most were able to spot that the salmon were longer in Winter 2009.Weaker candidates just stated figures without qualification.

1c – many candidates compared the two ages of salmon, rather than answering the question.

1d – as a compare question, at least one difference and one similarity were needed. Most commented that the values for 2009 were greater than 2008. Surprisingly few noted that they both showed positive correlation. Similarly in the second part the large amount of overlap between the two ages was not well spotted.

1e. an answer that implied knowledge that protein was a structural component of the fish was sought, so more protein as part of the fish meant a bigger fish.

1f. Many lost a mark for not stating that shark had a larger mean mercury content. Large numbers commented that there were many more sharks than monkfish in the survey, but did not extend it to say that this meant that the data was more reliable for the shark.

1g most, but certainly not all were able to state that the shark showed the most variation.

Question 2

Once again a simple calculation resulted in answers that were both incorrect and illogical. Better candidates gained the mark for 45000x. Some lost the mark for incorrect units.

‘Binary fusion’ was the most common wrong answer.

Most knew that antibiotics are effective against bacteria, not viruses. An explanation was not required.

Saprotrophs -These were really definitions from the syllabus.

Question 3

Well prepared candidates could state ‘plateau phase and exponential growth or log phase’. A surprising number reversed the answers, probably due to carelessness.

There were many convoluted answers without substance. Most gained the marks by stating that fossils can be compared with living organisms with an example.

Most managed to give a reasonable explanation of genotype and phenotype. In part (ii) many missed the word ‘chromosomes ‘in the stem. The knowledge of naked v proteins or circular v linear was expected from the core. Using the data it was expected that the candidates could state that the human chromosomes were much bigger (divide by 46) or that there were many more base pairs as there was about 3 X 10^3 difference. Considering that everyone on the IB diploma course studies maths at some level, a surprising number left (iii) blank or gave answers that did not make sense.

A pleasing number were able to state that all 4 blood groups were possible in (i), and most had a reasonable attempt at explaining codominance in part (ii).

Question 4 (Digestion, Homeostasis and polysaccharides)

“Well I will just draw a diagram of the gastro intestinal tract and hope for the best”, seemed to be the idea of many, resulting in no marks. The connection from the pancreas and the gall bladder to the small intestine had to be shown clearly as ducts, not random lines. The indecision manifested itself in the fact that many candidates drew very feint diagrams, resulting in scanning problems. Point 6.1.4 from the guide states that the interconnections should be clearly shown.

Most well prepared candidates could outline the role of glucagon.

A disturbing number could not name two polysaccharides.

Section B

Question 5 (DNA, gene transfer and evolution)

Most gained some marks for the diagram. As it was DNA the nucleotides should be in two strands joined by H bonds. Many drew only one strand.

Marks were lost through lack of precision. The names of the enzymes were expected. Few stated that the same restriction enzyme was required for the plasmid and gene.

This was answered well by the better candidates. There were also disappointing numbers of Lamarkian answers from weaker candidates trying to explain the adaptation of individuals. Many answers were very general and would have benefitted from concrete examples.

Question 6 (Cell Cycle, translation and condensation)

This was the least popular question, with answers usually either very good or very disappointing.

Few managed to state that mitosis is the division of the nucleus/ genetic material and also lumped in cytokinesis as a part of mitosis.

Better candidates were able to explain the process of translation in very clear detail. It was good to see that very few candidates confused transcription and translation.

Most gained the mark for stating that water is eliminated in a condensation reaction. Unfortunately they could not explain the process in sufficient detail to gain any more marks. Even although the stem was about dipeptides, weaker candidates wrote about carbohydrates. There were some G2 comments that asking SL candidates to draw a dipeptide was beyond expectations. It is indeed on the limit of what could be expected from 3.2.2 and 3.2.5. However the candidates did have a choice of Section B questions.

Question 7 (Motor neuron, Nerve impulse transmission and endocytosis)

Most gained good marks for the diagram, which were generally of a good standard.

Most could explain the resting and action potential at a point on the axon. However only the best candidates could explain how it is propagated along the axon.

Better candidates could explain endocytosis in detail. Weaker candidates confused it with exocytosis or just described molecules passing through the membrane. The word vesicle should be used for the structure formed by the membrane.

Recommendations and guidance for the teaching of future candidates

This was the last examination under the current specification. Please make sure that the candidates are aware of the form of the new examinations. Candidates should be reminded that answers may be amplified by the use of clear, annotated diagrams. However, poor half-remembered diagrams will not gain anything. Diagrams should be drawn boldly in dark pencil. Very feint diagrams can lead to scanning problems. Overall there seemed to be fewer candidates needing extra pages. Please continue to stress that if they are continuing outside the box, they are almost certainly writing too much. If they do go on to extra pages, then make sure that they state this at the end of their answer in the main text.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 13	14 - 17	18 - 22	23 - 28	29 - 33	34 - 40

General comments

Comments were received from 39 teachers about the English (72%), Spanish (13%) and German (15%) versions of this paper. Over 97% of the 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, nearly 80% of teachers thought the standard was similar. Nearly 70% felt that the clarity of the wording was very good or good, the others ranking it equally either fair or excellent. The proportions were similar about the presentation of the paper, with a little more finding it excellent. All these figures show a slight increase in satisfaction compared to last year's paper.

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

Answers in the different options have revealed a few areas of the programme which appeared difficult for candidates. In option D, many candidates had difficulty interpreting the cladogram and writing a proper discussion about gradualism and punctuated equilibrium. In option E, there was a general difficulty describing a coherent experiment to investigate taxis; this revealed a poor knowledge of organisms as many used *Euglena* instead of an appropriate invertebrate. The details of pasteurization and the role of bacteria in trickling bed water treatment were vague areas in option F. For option G, candidates had some difficulty discussing competitive exclusion from data and generally missed the change of abiotic conditions by organisms during primary succession, describing the succession instead. In option H, many candidates had difficulty with the transfer of hypothalamic hormones to the pituitary and displayed a poor understanding of the Bohr shift.

For all options, some candidates seem to have difficulty writing focused answers, using appropriate terminology and details. In some cases it would appear to be to a problem of reading the questions with more care in order to focus the answer with sufficient detail, not so much the lack of understanding of a concept. In some cases it was evident that the candidates had studied previous exams but did not notice the change in the focus of the question. Although a good number of candidates did well in comparisons of numerical data, others have difficulty in approaching them logically and methodically; there are still candidates only restating data without commenting on their relative importance.

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

Except for a few questions, candidates generally showed a good degree of knowledge in all options. Many did particularly well in describing the ear (although the question was about converting sound into nerve impulses), discussing the role of prions in spongiform encephalopathies and explaining the role of the liver (although some did not limit themselves to the role of regulating and storing nutrients, as asked by the question). Most candidates have read graphs accurately and were generally able to see trends in data.

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

Option D - Evolution

Question 1

The majority of candidates could interpret the data correctly, although there were some erroneous calculations and identifications of liver instead of heart as the organ using the greatest amount of energy per kilogram of body tissue (due to calculation issues). Most candidates displayed some knowledge when explaining the different organ sizes, but their understanding of cause and effect was sometimes not that clear.

Question 2

Most candidates were able to make an acceptable distinction between allopatric and sympatric speciation. A large number of candidates had some difficulty labelling the common ancestry in the cladogram correctly, either because their label was not precise enough, even if they understood it (e.g. label at the right of *Pambdelurion*), or because they could not interpret it at all. It was easier for them to identify the two species that evolved more recently at the bottom of the cladogram, although some might have done it by chance due to their position on the cladogram. Some of the answers about the evolution of photosynthesis were simply incomplete or too vague, but most candidates seemed to have a good general understanding of the process.

Question 3

There was a very wide range of answers on gradualism and punctuated equilibrium. Most showed good general understanding, but gave answers that were too incomplete, especially about the required indications of time, as well as magnitude of change.

Option E - Neurobiology and behaviour

Question 4

The majority of candidates did well on this question, although some had problems with clear, precise comparisons of data. Many candidates used examples of red deer mating in the fall, (grizzly) bears hibernating, or animals with nocturnal-diurnal behaviour as examples of rhythmical behaviour but some incorrectly used polar bears or, in a few cases, the waggle dance, completely misunderstanding the meaning of rhythm here.

Question 5

The majority of candidates did well in the first part of this question. Most had a general idea about describing an experiment to investigate taxis, but their design was often poor and sometimes more appropriate to investigate kinesis; too many used *Euglena*, which is not an invertebrate, and the choice of the invertebrate for others was sometimes not very focused for the purpose (e.g. earthworm).

Question 6

The majority of candidates obviously used information from previous examination papers instead of focusing on the actual question, but were nevertheless successful. There was a wide range of answers in terms of clarity, but most candidates showed good knowledge of the processes occurring in the ear, simply lacking clear details such as the use of vibrations instead of sound, or the movement of hairs (not the hair cells themselves) in the cochlea as well as the formation of the nerve impulse.

Option F - Microbes and biotechnology

Question 7

Candidates handled the data without problems although some of the comparisons were weak. Some gave very vague reasons for the changes such as more food, more bacteria, etc., without any explanation of why these changes could have occurred in 5 years. The most common answers were related to food preparation and types of food available. Most had some knowledge about pasteurization, but few included sufficient detail as to timing.

Question 8

Many mentioned *Vibrio fischeri* or *Pseudomonas aeruginosa* as an example of bacteria forming aggregates, but some gave far too vague categories, such as methanogenic bacteria. Most could state halophiles and *Azotobacter* for the other questions, although there was some confusion with *Rhizobium* in the latter. Many knew only that bacteria fix on the rocks, but did not give enough detail for more, showing poor understanding of the treatment of sewage.

Question 9

There were either very complete and comprehensive answers or either generally poor answers, with some scripts even left blank, or simply filled with simplistic, vague statements.

Option G - Ecology and conservation

Question 10

Some candidates simply did not read the questions with sufficient care and answered about sections of habitat that were not asked in the individual questions. Few candidates had difficulty stating the relative use for the Great Tit, but some did not address the two parts of the expected answer; some did not understand that the white spaces in the row of “bushes around trunk” were for lack of data, not “low” relative use. Most could compare the use of the habitat well although there was some difficulty in making clear, concise comparisons. Most could state how the distribution changes, but some in a very convoluted manner. Most candidates gave reasons as to food availability or the weakness of outer branches for heavier birds but some seemed to have understood the question the other way around. There were a considerable number of candidates who had a general understanding of competitive exclusion by realizing there is little overlap between the two species in the habitat, but only a few could define it correctly or provide opposite arguments.

Question 11

Most could either identify unstable environment as a condition favouring r-strategies or could not, but rapid reproduction was given as an advantage by most. There were mixed answers about habitat corridors. Many candidates apparently answered a previously asked question describing primary succession instead of focusing on the changes in the abiotic environment and the role of decomposition, resulting in generally poor answers.

Question 12

Although there were some very good answers, many candidates experienced some difficulty, partly due to poorly organized answers, repeated or vague examples and/or impacts.

Option H - Further human physiology

Question 13

Most could read a value on the graph correctly, but many had difficulty calculating the increase in risk. Most gave clear, good comparisons, although some compared within groups of men and/or women, another case of not reading the question with sufficient care. Nearly all gave genetic conditions as a reason for developing CHD if a brother had it, but some tried to give inherited characteristics as a second reason instead of lifestyle related reason

Question 14

Many candidates could not name the portal vein, but confused this with other neurosecretory paths. They provided good answers about the release of ADH. The answers about gastrin were often incomplete, with most recognizing gastrin as controlling the release of gastric juices, although some thought it was an enzyme; fewer candidates mentioned the need of the presence of food in the stomach for its release, some confusing it with the stimulus of the smell or sight of food and involving some control from the hypothalamus or medulla. Too many candidates do not understand the Bohr shift, incorrectly drawing it on the graph and/or being unable to explain it; many did not seem to understand the lowering of affinity of hemoglobin for oxygen is at the same partial pressure.

Question 15

Most answers were excellent, but many candidates did not focus on what was asked and provided further details about other roles of the liver, such as detoxification. Although there were some very vague answers and some that did not go beyond storage of glucose, most in general provided sufficient details about glucose regulation and addressed the storage of iron and Vitamins A and D.

Recommendations and guidance for the teaching of future candidates

Teachers should be aware that the format of Paper 3 will be different next year, adapted to the new syllabus, and that the students will prepare only one of the new options out of four. It is important that teachers provide a full coverage all topics from the core, AHL and the chosen option material. The following points will nevertheless continue to be valuable in the future.

Although the syllabus will be different, teachers should have candidates practise from past exams in order to correct their own work with the IB mark scheme to help them become more familiar with the requirements, according to the number of marks being given and the action verb used. All kinds of data should also be presented to candidates. This does not mean that they should memorize answers, as seen in this paper: this should be discouraged as new questions are usually worded slightly differently than previous ones and require answers to be adapted accordingly.

Candidates should be exposed to the appropriate meaning, as written in the subject guide, of command terms throughout their course. Candidates should be aware that describing data and stating values is usually not sufficient for a comparison or other types of level 3 questions.

Candidates answered poorly to question 5 (c), which was part of the present syllabus. With the new syllabus, they are expected even more to be able to transfer the skills learned from the practical programme to an examination context, in part A of new paper 3, in order to design valid and reliable experiments in which the independent, dependent and controlled variables are clearly identified.

Candidates must practise using appropriate terminology throughout their course. Writing style must be developed to focus directly on what is required and to include all the necessary detail for statements to be complete. Importance or magnitude of values must be written, even when it seems obvious: the candidates must communicate their understanding and assume that the reader will read only what is written. The best answers are usually short, but include all the information and fit in the provided box.

As examination strategies, highlighting key words in stem of data based questions and body of other questions helps drawing attention on the focus of questions. Taking some time to lay down answer elements on rough paper helps structuring answers and including the necessary information -- schools should provide rough paper and students should write rough notes on it, not on the examination paper.

Most candidates write within the prescribed boxes and make a sensible use of extra answer booklets. All candidates should nevertheless be reminded that examiners view only scanned parts of the papers on screen at a time and anything outside the boxes or not referenced to answer booklets might not be seen; answers should be fully legible following the scanning process.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 13	14 - 17	18 - 21	22 - 25	26 - 29	30 - 36

General comments

Comments were received from 39 teachers about the English (49%) and Spanish (51%) versions of this paper. Over 92% of the teachers responding on G2 forms felt that the level of difficulty of this paper was appropriate with the others divided between too difficult and too easy. When comparing the paper to last year's, over 90% of teachers thought the standard was similar. Over 80% felt that the clarity of the wording was good or better. The proportions were similar for the presentation of the paper, with a few more finding it excellent. All these figures show a slight increase in satisfaction compared to last year's paper. The areas of the programme and examination which appeared difficult for the candidates.

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

The candidates were often let down by giving vague answers when more detailed answers were required. For example, when asked to discuss the possible benefits of warm-up routines, to say that it prepares the body for exercise may be correct but it is not a discussion of how it is a benefit.

The options appeared to be of equal difficulty with extended questions such as explaining the electron transport chain proving most difficult.

Option F was the least popular option.

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

Option A

- 1. Overall, the candidates performed well in the interpretation of the data though a few could not read the stacked bar chart.
- 1 (c) Weaker candidates were unsure whether to compare overweight and obesity or Australia and Morocco.
- 2 (a) Many candidates could list two natural food sources of Vitamin D. A common error was to give fortified cereals or just fish as an answer.
- 2 (b) Most good candidates scored full marks for their discussion on Vitamin D. Many

weaker candidates suggested Vitamin D came from the sun.
- 3 (b) A common error was to list and not explain the consequences of a high fat diet.
- 3 (c) Candidates were looking for far more complex answers than the straightforward answers required by the mark scheme.

Option B

- 4. The data section of this option discriminated well with only the better candidates scoring full marks.
- 4 (d) Many candidates confused VO_2 max with tidal volume
- 5 (a) There were some good diagrams and some poor diagrams of a sarcomere. Many candidates got all 3 marks
- 6 (a) Only the better candidates scored full marks in their outline of ATP production during exercise.
- 6 (b) Answers tended to be vague though some candidates did score full marks discussing warm up routines. Prevent injuries was most common answer.

Option C

- 7. The candidates performed well in parts (a) (b) and (c) of the data question but found (d) difficult with many not giving a reason why dehydration affects photosynthesis.
- 8 (a) Mostly correct but a few candidates gave structural and not functional differences.
- 9 (a) There was a range of diagrams of the chloroplast with the many achieving all 3 marks
- 9 (b) The electron transport chain was not well understood. Many candidates assumed it referred to the chloroplast from part (a).
- Option D
- 10. Most candidates scored well in their interpretation of the data.
- 11 (c) Overall the candidates performed well in their comparison of convergent and divergent evolution.
- 12 (a) (b) and (c) These questions discriminated well with most candidates scoring some marks and the stronger candidates achieving full marks.

Option E

- 13 (b) (i) Most scored 2 marks. A significant number did not compare as required
- 13 (b)(ii) Weaker candidates referred to temperature
- 14 (a) There was a range of diagrams of the reflex arc but the majority got all 4 marks
- 14 (b) Most candidates had difficulty scoring 3 marks in their distinctions between learned and innate behaviour.
- 15 (b) Many answers did not contain explanations of the effects of cocaine as required.
- 15 (c) Many candidates described the oval window.

Option F

- 16. Few candidates attempted Option F.
- 16 (a) (b) and (c) Most got all marks
- 16 (d) Discriminated well with most candidates scoring at least 1 mark and the better candidates scoring all 3.
- 17 (a) Many did not distinguish between eubacteria and eukaryotes as required and others confused the two terms

- 17(b) Many weaker candidates referred to Rhizobium
- 18 (b) There was often no discussion in the weaker answers but the better candidates could discuss the risks of gene therapy.

Option G

- 19. A popular option choice with most candidates scoring well on the interpretation of the data.
- 20 (b) Most candidates had some idea about succession but some referred to secondary succession and many answers came without explanations.
- 20 (c) Most candidates knew about biomes and the biosphere but answers outlining the temperature and vegetation in a biome were often vague.
- 21 (b) Nearly all candidates gave good answers explaining the concept of a niche though some confused it with habitat.

Recommendations and guidance for the teaching of future candidates

Although there are still many candidates who would appear to have no practice in drawing, there were many more good drawings than in previous years. It would appear teachers are giving this skill some importance.

The space allocated is sufficient for an answer worth full marks. Generally the candidates who write lengthy responses on extra sheets are the weaker candidates who write everything they know on a topic and are not focused on the answer.

Candidates should not write on the question paper outside the box provided. These responses may not be seen by the examiner.

Candidates should practise answering questions requiring them to distinguish or compare. Both require contrasting statements, not two separate descriptions. For example, saying that breast milk has antibodies is correct but not worth a mark if the candidate is asked to distinguish breast milk from artificial milk. An answer saying artificial milk has iron is not worth a mark but stating more iron makes it a distinction.