BIOLOGY TZ1

(IB Latin America & IB North America)

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 30	31 - 40	41 - 52	53 - 66	67 - 78	79 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 28	29 - 39	40 - 53	54 - 66	67 - 78	79 - 100

Higher level and standard level internal assessment

Component grade boundaries

Higher level

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

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

General comments

Most schools used appropriate investigations of a good standard. Two problems persist, however, in some schools the complexity of the investigations is not up to IB standards, while other schools are setting investigations for assessment that give too much guidance.

In many schools the criteria are being applied rigorously but in a number of schools the teachers seem to be ignoring the descriptors of the different aspects. In these cases the moderators were marking down.

Ethics

In many schools the IB Animal Experimentation Policy (available of the OCC) is adhered to rigidly while in others it seems to be somewhat disregarded. 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 in the numbers of animals involved, or to ultimately replace of the use of animals by using cells, plants or computer simulations.

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

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

Behavioural experiments or experiments on animal physiology are frequently quoted as examples.

Experiments in these areas are still possible so long as they remain within the normal tolerance limits of the animal. Thus, 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.

It goes without saying that wild animals 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 no longer appropriate. Thus, fruit fly genetics must be replaced by, for example, rapid *Brassica* plants, *Sordaria* mould, maize cobs or simulations, such as the virtual fly lab (though this would mean that as a simulation it could not be assessed using the IA criteria).

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

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

The approach to experiments on human physiology should be reconsidered by a lot of teachers. Using fellow students for investigations into the effect of exercise on the heart rate can be considered unsafe if the health status of the students 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.

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Some inappropriate examples quoted by moderators include:

- Exposing mud worms to caffeine, heat stress, extreme pHs, medication,70% ethanol.

- Exposing *Daphnia* to solutions of nicotine, caffeine or ethanol.

- Exposing "volunteer" students to "unhealthy" food, fear and even medication (paracetemol)

Clerical procedure

Earlier versions of the 4/PSOW form are **still** being used by some teachers. These do not provide space for the moderator's and senior moderator's marks. The latest versions (available on the OCC) should be used. The 4/IA form and list of students is often absent.

It is disconcerting to see that there are teachers who do not appear to be consulting the Handbook of Procedures. This is published and updated each year.

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

There is a recurrent problem concerning the information provided by the teacher. This directly affects the progression of the moderation. Teachers MUST enclose all the instruction sheets and/or summaries of oral instructions for the investigations in the moderation sample. Most schools complied with this requirement for the investigations involving DCP assessment. It is also necessary, however, for investigations where Design is being assessed and a significant number of teachers are not doing this. Furthermore, when Data Collection and Processing is being assessed the method (designed by the student or provided by the teacher) is required. When Conclusion and Evaluation is being assessed all the steps in the scientific process are needed for moderation.

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

Atypical candidates should be replaced in the sample. These 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.

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.

Areas of strength

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

The use of ICT in the areas of **1** Data logging, **2** Graph plotting software and **3** Spreadsheets is good though some schools have efforts to make in the use of data bases and spread sheets.

Areas of weakness

Trivial, simplistic investigations that do not generate sufficient data to permit adequate assessment of data processing were too often used for assessment. If there is one significant area of weakness it is in the processing of data. Students are 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. Sometimes teachers point out the errors to their students and still give full marks.

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

Where teachers apply the criteria rigorously and clearly 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.

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

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

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Rules applied by the moderator

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

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

Candidate performance against each criterion

Design

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

- Group work presented as individual work - all candidates with same plan, same data values.

- Teachers using standard labs and saying they are designed by candidates: for example, effect of antibiotics on bacteria (standard selection of antibiotics on discs put on agar petri dishes and then measure zone of inhibition).

Little research is evident or investigations that are designed with little or no consideration of biological principles. It may be a small point but it would be useful for the student to give the scientific name of the organism being used or the organism that was the source of the material. The trivial name at least must be given.

Research questions need to be focussed. 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 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 and what is a control experiment. Sometimes unrealistic controls are being proposed when a control experiment would be appropriate (e.g. set room temperature to 21.1 °C).

The investigations are frequently too simplistic. The range of values of the independent variable was insufficient to establish a trend. The number of repeats was insufficient to permit statistical analysis. 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. Moderators made the following comments:

- Not enough values being used in plans to establish a trend

- Planning very simplistic labs e.g. find the number of people in the school of Chinese heritage with dimples.

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. HOWEVER these standard protocols must be significantly modified or applied to the student's own investigation. For example, if osmosis is being investigated and the student uses the method of change in mass of tissue to monitor the effect of solutions of different concentrations on a tissue, this is legitimate. If the investigation is simply to determine the isotonic solution of one tissue then it remains trivial and it repeats many textbook investigations. If the investigation is used to determine the effect of the salinity of irrigation water on different root crops, the investigation becomes more substantial. Osmosis was often presented this year as a Design investigation theme without any modification from a text book method.

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

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

It is good practice for students to follow through their own designs. Some schools seem to have their students design an investigation that remains theoretical. The result is often an unrealistic investigation. Even when a teacher does decide to follow through a student designed investigation the result may be an unrealistic investigation. For example measuring the effect of music genre on heart beat rates. This is almost impossible to control and students ought to be counselled against it from the outset.

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

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Data Collection and Presentation (DCP)

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

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

Despite the clear warnings in the subject guides, teachers are still providing instructions on how to present the data and how to process the data. Their marks will be moderated down. The classic investigations (e.g. mark and recapture, chromatography of leaf pigments, rates of photosynthesis using the sunken leaf disks, rates of reaction of catalase and osmosis) often create problems. Teachers are using standard textbook protocols without modifications. A little imagination and editing could easily solve the problem.

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

- Data (raw or processed) that is inadequately presented (e.g. with superficial titles)

- There were no quantitative data collected

- There are no units in the table (note: decimal units should be used)

- No uncertainties were given in the tables of data collected using measuring instruments.

- There were inconsistent decimal places in tables

- The decimal places did not correspond to the precision of measurements

There were no associated qualitative observations. E.g. an ecological field investigation is incomplete without some kind of description of the site used

Raw data were plotted in graphs that do not actually reveal anything (e.g. maxima, minima, optima or intercepts)

Raw data were plotted when the mean should have been calculated and plotted (often the mean is actually calculated and then ignored by the student for graphing)

There was no statistical treatment of the data when it was possible

When statistical treatment is applied there is no consideration of its appropriateness. E.g. calculating standard deviations when they had only made 2 or 3 measurements (many teachers marked this as complete and made no comment about it on the student work)

There was no presentation of uncertainties in graphical data either by using trend lines or error bars or uncertainty ranges on the axes.

The error bars, when used, were not explained.

A majority are putting a linear line of best fit even when the data is clearly S-shaped or clearly has a non-linear pattern.

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

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

Conclusion and Evaluation (CE)

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

Some students seem to have trouble in analysing their data. There is often confusion over what directly proportional means. Every potential straight line is described this way, even when not true

Some teachers are using simulations instead of real biological investigations. These may be useful for training data collection and processing as they generate large amounts of data quickly. However they are not suitable for assessment, especially the assessment of this criterion. It is not possible to provide a biological explanation in these cases and evaluation is very superficial.

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

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

Suggested modifications were sometimes superficial and yet marked over generously.

As stated above in clerical procedure, if the method and the data used by the student are not provided by the teacher then CE cannot be moderated.

Manipulative skills

There is evidence of the students being exposed to a sufficient range of investigations. This ensures that the manipulative skills can be assessed correctly.

ICT coverage

This was generally covered adequately by the majority of the schools. Schools seem to have made an effort to equip themselves with the necessary materials to carry out data logging.

Graph plotting using software was perhaps the easiest and most widespread for schools to apply. However the signs are that the students still need to be taught the correct conventions of graphing. There is a tendency to use bar charts for everything amongst the weakest students, perhaps because it is the default setting. Legends (keys) are not always necessary and students do not seem to know how to de-select them. When they are needed the students often have difficulty labelling them appropriately – students often present the different curves as "series 1" and "series 2" When the students used scatter plot, a trend line was not always used when it was appropriate.

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

The use of spreadsheets 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. It is the use of databases and computer modelling/simulation that are most often missing.

The Group 4 Project

It needs to be repeated for a very few schools now, the Group 4 Project can ONLY be used for the assessment of Personal Skills. Indeed it is the only occasion when it is assessed. The Group 4 Project CANNOT be used for the assessment of Design, DCP, CE or Manipulative Skills.

Recommendations for the teaching of future candidates

- Share the criteria with the students.

- Read feedback from the previous session and act upon it.

- Consult the Online Curriculum Centre (OCC) for teacher support material (TSM)

- Apply the internal assessment criteria rigorously.

- Ensure that the open-ended theme that you set has enough scope to provide a variety of research questions.

- Give the students experience in identifying independent, dependent and controlled variables.

- Be sure that investigations used for assessment produce quantitative data.

- Encourage the students to make additional observations about their experiment. It is good practice for them to keep a log book.

- Ensure that the investigations have the potential to generate sufficient data for substantial processing.

- Teach the students that plotting graphs of raw data is often insufficient.

- Encourage the students to carry out research into the background literature both before starting an investigation and once the results are complete.

- Do not use simulations for assessment.

- **Do not** use the Group 4 Project for assessment of D, DCP CE or MS. Only use it for Personal Skills. Inappropriate use will be sanctioned.

- Make sure that you are using the most up-to-date version of the 4/PSOW form (available from the **Handbook of Procedures** on the OCC).

- Check to be sure that all the parts of the 4PSOW form are completed correctly.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 15	16 - 19	20 - 24	25 - 29	30 - 34	35 - 40

General comments

Of the 180 G2 replies received at the time of grade award, 93% felt the paper was at the appropriate level of difficulty and 60% felt the paper was of a similar standard to last year's paper. As always some felt it was more difficult (16%) and some felt it was easier (24%). All teachers felt that clarity of wording as well as the presentation of the paper was satisfactory or good.

There were many discriminating questions on this paper and a few that did not perform as well. It was surprising that for each question, there were candidates who did not attempt to answer the question. Teachers are reminded that candidates are not penalized for an incorrect answer and therefore if some of the choices can be eliminated, it would be in the candidate's interest to attempt all questions.

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

Some questions performed in a predictable way and no comments need to be made about them. The comments that follow relate to questions where candidate performance was very good or very poor or to questions that aroused comment from teachers on G2 forms.

Question 2

Many candidates were not able to do this calculation correctly and convert μm to mm. Although the size of the drawing calculated was admittedly too small for a real drawing, there was no reason why the correct conversion could not be made. It did discriminate as the more able candidates got this correct while the others guessed between the other choices of answers.

Question 3

This question proved difficult. Many candidates answered the correct option C but many went for D. They seemed to equate the cell wall with only plant cells and did not consider that prokaryote cell walls exist as well.

Question 6

This question discriminated well. However, many candidates went for the incorrect choice, A. This showed a lack of understanding of covalent bonds and hydrogen bonds. The requirement for candidates to know that fatty acids do not dissolve in water because it is polar was questioned in a G2. This would be covered in 3.1.5 under solvent properties of water, 3.2.7 under use of lipids in energy storage and again in 2.4.2 when explaining hydrophobic in relation to phospholipids.

Question 7

This question discriminated well but many candidates found this difficult. Candidates did not seem to recognize the amino acids connected by the peptide bonds. Perhaps they were distracted by the real side groups indicated rather than simply "R".

Question 9

There were some comments on this question. At first A seems correct but many candidates also answered B. They were thinking of the RNA primers at the start of replication. Both answers were accepted.

Question 10

While this question was a good discriminator and was answered correctly by the more able candidates, it was worrying that so many incorrectly chose D. The weaker candidates answered that both water and carbon dioxide are sources of the oxygen produced by photosynthesis indicating that this had not been taught thoroughly.

Question 12

This question discriminated very well. However, many choose either B or D, both of which were incorrect showing a lack of understanding of what homologous chromosomes are.

Question 13

This question proved very easy for the candidates. There were some questions from teachers on G2s as to whether gel electrophoresis and DNA profiling would also be correct molecular techniques to distinguish plants homozygous or heterozygous for the trait in question.

Question 15

There was a G2 question about whether D could also be correct in light of modern fluorescent DNA sequencing which involves PCR. In questions such as this, candidates need to choose the most correct answer. This discriminated well and did not confuse candidates.

Question 18

While the majority of candidates chose the correct answer D, many candidates also choose the wrong answer C. This meant they did not know that oxides of nitrogen are also greenhouse gases. This is in section 5.2.3 of the syllabus.

Question 20

This question discriminated surprisingly well with able candidates correctly choosing B.

Question 21

This question was not well answered. Some G2 comments regarded the fact that celiac disease is not on the syllabus. That is true but this question is about absorption which is. To answer it does require reasoning but not knowledge of celiac disease.

Question 23

There were several comments about the clarity of the wording of the answers to this question. It is agreed that A could have been worded more clearly as antibodies are proteins with a quaternary structure consisting of four polypeptide chains.

Question 24

Candidates seemed to struggle with this. When looking for an explanation as to why so many chose the incorrect response it appears they were confusing glucagon and glycogen.

Question 26

While one comment on the G2 correctly stated that candidates do not need to know histones according to AS 4.1.1, that is the depth of detail for SL; however, for HL it is required as per AS 7.1.2.

Question 27

This question was a good discriminator. Some candidates confused primase with primer and thus chose the incorrect response. Okazaki fragments are expected knowledge as per AS 7.2.2.

Question 28

There still seems to be some confusion in the topic of transcription as to which is the sense or antisense strand of DNA. The syllabus specifies how this should be treated in 7.3.2.

Question 30

While the majority of candidates correctly answered that chlorophyll is found in the thylakoid membranes, a sizable group chose the stroma instead. In AS 8.2.6 the structure and function of the chloroplast is covered. Photosystems embedded in the membrane would be expected.

Question 32

Some candidates seemed to confuse the position of xylem and phloem. The role of xylem in support is required in addition to its role in transport (9.2.4 and 9.2.6).

Question 33

There were some G2 comments on the chromosome diagram in this question. While it is not conventional, it is correct.

Question 34

There were comments on the notation used to show linked genes. This is the same notation as used in the syllabus. The candidates did not actually seem to have trouble with this.

Question 35

This question was a good discriminator which the less able candidates found difficult.

Question 36

There were several G2 comments on the answer choices for the sequence of events in muscle contraction. As release of calcium is the first stage, B is the only correct answer. The placement of ATP at the end of the list was confusing and many candidates chose A, making the assumption that use of ATP must be at the beginning of the sequence.

Question 37

This question did not discriminate well with many able candidates choosing the incorrect response. Candidates knew that Z was the cortex and were split in their choice of A and C. Osmoregulation refers to the whole kidney and is more related to distal convoluted tubule in the medulla. Bowman's Capsules in the cortex carry out ultrafiltration. In retrospect, this was not a good question.

Question 38

This was surprisingly the hardest question by difficulty index showing that candidates didn't know this topic. While there were concerns about the wording of answer A, the other three choices were the opposite of what happens in this situation given.

Question 40

While D was obviously the correct response as the mother's blood and baby's blood do not mix in the placenta, many were distracted by the B. In 11.4.12, the secretion of both estrogen and progesterone by the placenta is to be included.

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

One hundred and eighty G2 forms were returned. Nearly all respondents indicated that the paper was at the appropriate level of difficulty and most believed that it was of a similar standard to last year's paper. The majority of respondents responded that the presentation of the paper was good. Approximately equal numbers of participants responded that the clarity of wording of the paper was either satisfactory or good. Only four of the respondents believed that clarity of the wording was poor.

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

- Identifying the phylum of the trilobite.
- Explaining how polar and non polar amino acids play a role in channel proteins and enzymes.
- Stating accurate sources of stem cells for therapeutic use.
- Drawing the anti-parallel orientation of the nucleotide with correct connections.
- Constructing an effective comparison.
- Outlining the role of triose phosphate.
- Interpreting the ozone exposure histogram.

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

- Analysis of unfamiliar data.
- Discussing how fossils provide evidence for evolution.
- Outlining the structure of the ventilation system.
- Comparing spermatogenesis and oogenesis.
- Outlining the process of IVF
- Outlining functions of membrane proteins.

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

Section A

Question 1

a) (i) Most candidates were familiar with the concept of pH. Where students had difficulty, it was with the accurate use of language sometimes referring to the acidity of the rain in urban areas as being higher or otherwise muddling the distinction between pH and acidity.

(ii) Most candidates were able to generalize that levels of pollution were higher in urban areas. For some, it was difficult for them to articulate the distinct idea that each pollutant was higher in urban areas.

b) Most candidates experienced no difficulty with this question.

c) Few suggested that the relationship was likely to be correlation rather than cause and effect.

d) Interpreting the graph on page six was a challenge for many. Students muddled months, locations and numbers of sites with ozone exposure at various levels. Admittedly it was a difficult graph.

e) Many students would have improved answers if they explicitly signposted within their answers; e.g., 'my hypothesis is…'

Question 2

Most students could identify the cell as being in interphase and most gave the reason that the nucleus was clearly defined. Most could list one process that occurs during interphase. Students should be aware that protein synthesis will always be occurring within a cell and cannot be suspended during mitosis. Further, in some cells organelle production such as mitochondrial division does continue to occur through mitosis, though the mark scheme was flexible on this point.

When listing the properties of stem cells, few mentioned the fact that they retain the capacity to divide, which is not common in fully differentiated cells. Some teachers commented using G2 forms on this question. Two of the mark points were taken from the syllabus notes and most students did not experience difficulty with the question.

Students were weak in their knowledge about stem cell use with most giving theoretical or experimental techniques. Few could give accurate descriptions of the origin of stem cells for therapeutic use. Others were too vague in their word choice in terms of describing specific uses of stem cells.

Question 3

b) A surprising number left the answer to 3 b) blank. Common problems included connecting the base to a bond rather than to a carbon in the sugar and not representing the phosphate in an anti-parallel fashion.

c) An unfortunate number stated replication as their example despite being advised by the stem to choose something else.

d) In general, this question was well answered. Most earned at least one mark for PCR. Many confused gel electrophoresis with PCR. Some teachers expressed concern on G2 forms that this question was not justified based on the teacher notes. However, the markscheme was drawn in part from the teacher notes and most students earned two marks.

Question 4

a) This question was challenging for students in terms of their familiarity with phylum names but more could identify features of significance such as bilateral symmetry, exoskeleton, segmentation and jointed appendages

c) A surprising number of students suggested that large eyes could develop from small within a single organism. Also, a very large number mis-read the question and discussed how eyes had become smaller over time.

Section B

Question 5

a) Students were successful at listing examples of the functions of membrane proteins but had more difficulty accurately describing peripheral and integral proteins.

b) This question was poorly done with students writing descriptions involving vague language. Overall, there was very little knowledge of how polar and non-polar amino acids aid channel proteins and enzymes.

c) Students displayed adequate knowledge of the two types of inhibition, but did very poorly on the comparative aspect.

Question 6

a) Along with question 7, this was a popular question. Many students were thrown off by the first line of this question and went into detail explanation of urine production and ventilation. Rarely did students mention that it is arterioles specifically that are dilating. Students interchange the terms specific heat with specific heat capacity. Specific heat is the property of a volume of substance; e.g., one litre of water has less specific heat than two litres of water. Specific heat capacity is the property of a substance; e.g., water has a higher specific heat than copper. Many students discussed inappropriate details of ventilation and osmoregulation. This suggests that teachers may be overstating the importance of making links between the sub-parts of questions to achieve quality marks.

b) Many students do not know how ADH affects the collecting ducts. Often students new urine volume was related to permeability of the collecting duct but did not connect it to ADH. Many thought that the ducts are normally permeable to water and when water levels drop, they would be less permeable to conserve water. Very few discussed the role of the medulla or salt concentrations. References to other parts of the nephron were irrelevant and represented an area where quality of construction marks were lost. Students also described the effect of ADH as increasing urine production.

c) Even though a diagram was not necessary to achieve full marks, many students earned marks from well constructed diagrams. Some problems with diagrams included diagrams of alveoli that were only slightly smaller than the lungs. A very large number of students did not read the question carefully or did not understand that the question was asking for the mechanism of inhalation and gave long descriptions of the ventilation mechanism.

Question 7

a) Question 7 was a popular choice of candidates. Here students had detailed knowledge of the two processes and did a better job of comparison than those that answered the enzyme comparison question.

b) Some did not recognize the variation of the traditional question of how sexual reproduction promotes variation. However, a large number were able to outline the role of crossing over and independent assortment. Fewer recognized the role of meiosis II in generating variation.

c) Most students did not state that it is an embryo or blastocyst that is implanted into the uterus. This coincides with the very general terms that were used by many. Many students spent a lot of time discussing the ethical issues involved which would have loss to a deduction of a quality mark for the inclusion of irrelevant material.

Question 8

a) Not many student choose this question. If students used a diagram to aid in their description, most of the time the diagram did not have sufficient labels that could adequately replace a text.

b) Most students did not have any idea of the function of triose phosphate. Many confused triose phosphate with ATP.

c) The main problem with answers to this question was the vague use of language. It is not adequate to say that seeds need water to germinate, or that it moistens things. Many answers contained lists of required materials without providing specific reasons or mechanisms. It was surprising how many students suggested that sunlight was necessary for germination.

Recommendations and guidance for the teaching of future candidates

- Discuss with students criteria for judgment when deciding on whether differences are significant. Question 1a (i) and 1 c (i) could be used an example.

- Encourage students to use the number of allocated marking points as a guide to the number of distinct ideas that need to be given.

- Students need to be encouraged to state what might seem rather obvious. Question 1 a (ii) might be used as an example.

- Review the concept of correlation versus cause and effect. Question 1 c (ii) might be useful for illustrating this.

- Practice data based questions where more than two variables are involved. The graph for question 1 d could be useful for this.

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- Remind students that comparisons within data based questions require 'the big picture' rather than a description of quantitative information.

- Students should be encouraged to more explicitly sign post within their answers; i.e., 'my hypothesis is…'. Teachers could use 1 e to illustrate this point.

- Teach the details of stems cells more completely. Question 2 would make a good revision exercise after the teaching of this topic.

- Encourage students to take care with molecular structure diagrams always showing correct connections.

- Practice identifying organisms by visible recognition features.

- Outline requires brief description rather than a list as in membranes question.

- Students need practice at structuring answers to compare questions. Peer editing can be used to assess whether practice questions have clear one to one mapping of points of comparison.

- Explain to students what a diuretic is to help avoid confusion over the role of ADH.

- Many candidates were thrown off by the first line of question 6 a suggesting students need to be taught the distinction between information used to make the question coherent (the stem) and information necessary to answer the question.

- An explanation requires reasons and mechanisms, not just a list as in the case of the germination question.

- Provide students with guidance about writing answers that are longer than the space allocated by the boxes. Due to the e-marking format, candidates run the risk of having parts of answers missed. Students should provide a clear indication that their answer continues on another page. The box is used to indicate the recommended length of the answer.

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Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 15	16 - 19	20 - 24	25 - 28	29 - 40

General comments

The comments on the G2 forms available at grade award indicate that 93% of respondents felt the paper was at the appropriate level of difficulty. Compared to last year's paper, 72% felt it was of a similar standard with an almost equal number indicating it was easier or more difficult. The clarity of the wording as well as the presentation of the paper was found to be suitable or good by 99% of the respondents. Teachers' comments are all considered at the grade award meeting and all teachers are encouraged to fill out the G2 form at the end of each examination session. The actual percentage of teachers who do this was better this year but is still very small.

Options and D, E and G were the most commonly chosen options. Very few chose Option F.

It was surprising to see a larger number of candidates this session incorrectly doing all options rather than the two they should have been taught. These seemed to be weaker candidates who tried every data analysis question but did not seem to know the content in any option.

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

Although many were able to successfully tackle the long response questions, a sizeable number found the longer response questions difficult and did not have sufficient depth of knowledge to answer these. Instead, these candidates wrote vague generalities that did not get awarded marks.

Definitions were poorly stated and often incomplete, even when these are clearly given in the syllabus.

Topics which proved difficult were:

- Anatomical features that define humans as primates
- Endorphins
- bioremediation
- edge effect
- example of biological control of invasive species
- oxygen dissociation curve

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Levels of knowledge, understanding and skill demonstrated

Some candidates produced very good scripts and it was obvious they had been given sufficient instruction and time to cover the options thoroughly. They were able to both analyse the data in Question 1 as well as indicate their level of subject knowledge in Questions 2 and 3. However, many scripts indicated only a superficial knowledge of the options with most points being awarded for the data analysis question.

As in the past, one area of difficulty remains interpreting the command verbs and thus knowing what precisely was required to answer accurately. When candidates were asked to "discuss" an issue, they tended to "describe" it instead. Likewise," compare" and "evaluate" presented problems with candidates writing whatever they knew and not choosing what was needed in their answer to the question.

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

Option D: Evolution

This was a popular option again this examination session and candidates tended to score fairly well on it.

Question 1

a) Almost every candidate was able to find the probabilities required from the graph.

b) Almost all obtained one mark for correctly indicating that the lowest probability of breeding was between different varieties from the same lake.

c) Many were able to get one mark for indicating that individuals were more likely to breed if they were from the same variety but few received a second mark for looking at the variation in range of values.

d) This was the most discriminating section of this data analysis question with only the abler candidates discussing the evidence for reproductive isolation indicated by the data and for looking at what type of speciation this might be. Few used the terms allopatric or sympatric speciation.

Question 2

a) Many were able to get mark for the definition of clade but others were omitting the idea of common ancestry.

b) This was fairly well done with many getting both marks. The most common example used for homologous structure was the pentadactyl limb with various examples for analogous structures such as insect and bird wings.

c) Virtually all candidates were able complete the cladogram for 2 marks.

d) Although this question asked candidates to 'describe' features, many wrote a simple list and others simply stated common features of mammals, not specifically primates.

Question 3

Many candidates were able to score four or more marks on this question on the endosymbiotic theory by describing it and looking at the supporting evidence shown by the structure of chloroplasts or mitochondria. However, even those candidates scoring well seldom 'discussed' the fact that evidence was weak for evolution of other organelles such as cilia or flagella and that the theory cannot be falsified.

Option E: Neurobiology and behaviour

This was a popular option this examination session and candidates tended to score fairly well on it.

Question 1

a) Almost all candidates were correctly able to identify 'in flight' as the activity that took up the least time of the overall time budget.

b) This was a very difficult calculation and very few successfully used both pie charts to calculate that only 4.2% of the overall time budget was spent resting on the sea surface. Most incorrectly looked at only the first pie chart and saw that 25% of time was spent on the surface of the sea. The second pie chart showed that this was divided into active (5/6 of total on sea surface time) and resting (1/6) time which was ignored. As it was worth only one mark, it did not have a detrimental overall effect on this high scoring option.

c) Most were able to get one mark for seeing that alloparenting would give chicks a greater chance of survival. Others also noted that this allowed parents to hunt for food or rest.

d) Many were able to get one mark for a possible reason the birds spent so much time at the colony such as resting, recovering energy or protecting young.

e) There were few good responses to this question asking candidates to distinguish innate behavior from learned behavior. The idea that learned behaviour requires experience or develops due to environmental context was ignored. Candidates should know that they cannot define a term by using a variation of the same word such as saying learned behavior is what a bird learns.

Question 2

a) Candidates were not able to give a concise definition that was complete. The definition of stimulus is given in the syllabus.

b) Outlining the functions of the two parts of the brain was done fairly well by many candidates who were able to get the two marks.

c) As noted on the G2 forms, candidates were not sure what to include in their explanations of the effects of psychoactive drugs on synaptic transmission. The more able candidates were able to bring in different ways drugs could either increase or decrease synaptic transmission.

d) This section on how endorphins act as painkillers was very poorly done by most. It seemed that endorphins had not specifically been studied.

Question 3

Many candidates were able to get 5 or 6 marks for this section on the ear. This seemed well taught.

Option F: Microbes and biotechnology

This option continues to be the least popular of the HL options but it was encouraging to see a few more schools studying this option and some doing very well. Too often, however, it was answered by candidates with little knowledge who attempted all options.

Question 1

   a) Most were able to the simple calculation required for one mark.

   b) All were able to use the data to distinguish between the soy sauces produced by the two species of mould.

   c) Although many were able to get two marks for this section few included in their evaluations the economic advantage of using a local fungus over an imported one or the possible effects of more dissolved nitrogen.

Question 2

   a) Most were able to get a mark for indicating that bacteria can be Gram-positive or Gram-negative. Many were able to obtain a second mark for indicating the different compositions of their cell walls.

   b) Candidates tended to either get the roles of both bacteria in the nitrogen cycle correct or both wrong.

   c) Many candidates were able to get one of the two marks available for defining chemoautotrophs by their energy source and their source of organic compounds.

   d) While many had a general idea of the use of bacteria in bioremediation, few were able to give an actual example.

Question 3

This proved to be one of the more difficult long response questions on this paper. Candidates scored marks for knowing that prions were a form of protein that was an infective agent but other knowledge was sketchy.

Option G: Ecology and conservation

This was a very popular option although candidates had more difficulty with the questions this session and it was a lower scoring option than D or E.

Question 1

   a) Almost all candidates correctly read the graph to find the mean terrestrial invertebrate biomass.

   b) Most candidates were able to correctly describe the trend in the aquatic invertebrate flux for two marks.

   c) The majority of candidates were able to get one mark for seeing the negative relationship between defoliation and biomass and some were able to get a second mark for suggesting why this might be.

d) Candidates struggled to suggest explanations for the pattern of movement between the aquatic environment and forest. Some were able to get a mark for suggesting adult forms moved to the forest to utilize food supplies. Almost none were able to suggest that fewer were moving into the forest as the adult forms of the invertebrates had already migrated and therefore few were left in the stream or that the fluctuations were due to different life cycles or species. In retrospect, this question did seem too difficult for candidates considering the information they were given.

e) Candidates also struggled with this section of the question. Although the word allochonthous was briefly given in the question stem, it seemed that candidates were still not able to understand enough to answer the question. A few were able to get the mark for indicating that the aquatic invertebrates that migrated to the forest would provide an alternative food source for the forest birds and others indicated that this would cause changes to the food web.

Question 2

a) Almost all correctly identified the biome as tundra. (ii) Many were able to correctly get one mark for the characteristics of vegetation.

b) Candidates struggled with this section on the consequences of the edge effect for small nature reserves. Most tended to talk about endangered species. Some were able to get a mark for an example of edge effect such as increase in cowbirds which lay their eggs in the edge or for the fact that small nature reserves have more edge effect.

c) Most candidates also struggled to give a valid example of biological control of an invasive species with several mentioning chemical or physical methods of control.

Question 3

While many candidates knew how r- and K-strategies were different, only the better ones were able to discuss the environmental conditions that favoured each. Again, candidates described each type of strategy rather than discussing the environmental conditions. They were still able to get at least 4 marks for doing so.

Option H: Further human physiology

This was a fairly popular option.

Question 1

- Most were able to correctly do the calculation required.

- Most were able to correctly state that DIDS reduces the rate of decrease of pH.

- Candidates struggled to evaluate the given hypothesis and most did not relate the support for the hypothesis to the movement of ions.

- Some candidates were able to get the mark for indicating that a possible explanation for the observation was that host cells increased transcription to make more carriers.

- Some candidates correctly predicted that pH will fall but few related this to transport of ions by SLC26A9.

Question 2

   a) The outline of how coronary thrombosis can be caused was surprisingly poorly done. Most simply gave a list of risk factors without actually stating what caused the thrombosis.

   b) This section on the oxygen dissociation curve was also poorly done. Few stated that the shift in the curve could be due to either an increase in CO_2 concentration or a decrease in pH.

   c) The full two marks for this section were often awarded as candidates seemed to know where and into what hemoglobin was broken down.

Question 3

There were variable responses from very poor to very good with many responses being awarded full marks.

Recommendations and guidance for the teaching of future candidates

- Sufficient time should be allotted for the teaching of the options. Teachers should choose the options according to their own strengths so that the candidates benefit by the knowledge and enthusiasm of the teacher. The options should not be left for self-study.

- Teachers should teach only two options to their candidates. Those candidates selecting from the entire range of options do poorly. Schools that prepared their candidates for only two options did much better on average.

- When assessment statements are open-ended with regard to an example, please ensure that this is covered.

- Use the command terms in homework, tests and exams to make candidates familiar with the question stems so that they understand what is required of them when they are asked to "discuss", "compare" or "evaluate". If they are asked to "outline" a process, this requires more detail than a simple "list" but less than if they were asked to "describe".

- Use past papers and mark schemes for practice of data analysis questions. The IB Store has collections of past papers and mark schemes available which are a valuable teaching tool.

- Insist that candidates look at graphs carefully and make careful measurements as required rather than give a wide range of possible answers. Candidates should use a ruler to help them read values accurately off a graph.

- Remind candidates to think about their responses before they begin to write and to ensure they address the question asked specifically and not simply write down whatever they remember on a topic. They should use the size of the box, the number of lines and marks available as a guide as to how much to write.

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Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 9	10 - 12	13 - 18	19 - 22	23 - 26	27 - 30

General comments

Of the G2 forms submitted by the time of grade award, 56% thought that the paper was of a similar standard to that of last year, while 21% thought that it was a little easier. 99% of respondents thought that the level of difficulty of the paper was appropriate. Most teachers thought that clarity of wording and presentation were satisfactory to good. There were many discriminating questions on the paper, and questions 9, 19, 25, 28 and 30 had many candidates leaving them blank.

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

Some questions performed in a predictable way and no comments need to be made about them. The comments that follow relate to questions where candidate performance was very good or very poor, or to questions that aroused comment from teachers on the G2 forms.

Question 2

This question was a poor discriminator in spite of being relatively easy, and most candidates chose option D instead of the correct response of C. In the G2 forms, some teachers comment that the addition of "by mitosis" at the end of item II could interfere with the assessment of the students' understanding of cell theory. However, it was felt that this had not been a significant problem for the candidates since a large number had chosen the correct answer.

Question 9

Although this question discriminated well, a large proportion of candidates chose option B (carbohydrate) instead of the correct response of A. It was thought that perhaps students are more used to seeing the side chains of amino acids represented by R in diagrams, rather than specific chemical groups.

Question 13

This question seemed to cause problems for many candidates, with many choosing option D rather than the correct answer C. There was a complaint in the G2 forms that asking students to identify the source of oxygen in the process of photosynthesis was beyond the scope of the SL syllabus. However, it is assessment statement 3.8.5 in the core syllabus.

Question 16

Feedback on the G2 forms suggested that there was not enough information in the question, but the majority of candidates did pick the correct answer,

Question 17

More candidates chose response C instead of A, the correct answer, so the question discriminated well. A comment on the G2 forms suggested that shape was also a property that students would be expected to know, and this was not an option in the responses. It was felt that often not all possible information is included in questions, and that it was a fair set of options.

Question 19

Although this question discriminated well, many candidates chose responses A and B instead of the correct D. It would imply that perhaps many are confusing DNA replication with DNA recombination.

Question 20

This did not discriminate very well, with quite a number of candidates choosing C (a community) instead of B (a population). It was thought that this may be language difficulty for ESL students, and also the definitions are often associated with a time factor.

Question 21

This was the easiest question on the paper and, quite rightly, the majority of candidates chose the correct answer.

Question 23

Comment on the G2 forms suggested that the wording of two of the options was difficult, but the majority of candidates picked the right answer of B, with few going for the other alternatives.

Question 27

There were some comments about this question on the G2 forms. It was suggested that protein could be confused with polypeptides, but students should know the relationship between the two. It was felt that perhaps the wording of D was not good (as viruses are non-living) and many students picked this option. However, candidates should have been able to eliminate options C and D when making their decisions.

Question 28

Some comments on the G2 forms implied that this was an unfair question. Most candidates did pick the right answer of B, although many were distracted by D, which is not an appropriate response. It was accepted that the stem of the question was not in alignment with the assessment statement, and so perhaps a little too much was asked of the candidates, but at the same time, it was felt that the question was not unfair.

Question 29

G2 comments suggested that this question was too specific. However, it was deemed to be a fair question, reflecting the assessment statement 6.5.11.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 18	19 - 24	25 - 31	32 - 37	38 - 50

General comments

One hundred and four G2 forms were returned. Nearly all respondents indicated that the paper was at the appropriate level of difficulty and most believed that it was of a similar standard to last year's paper. The majority of respondents responded that the presentation of the paper was good. Approximately equal numbers of participants responded that the clarity of wording of the paper was either satisfactory or good. Only three of the respondents believed that clarity of the wording was poor.

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

In both sections, candidates often provided only half of an idea rather than complete thoughts. In various questions, there was an inability to use correct scientific terminology.

Section A

- Deducing allele frequencies from given information;

- stating relationships in non-linear graphs;

- correlating enzymes with correct source, optimal pH requirement, substrate and product (A.S. 6.1.3);

- drawing and labeling the interconnections between the gall bladder, pancreas and small intestine (A.S. 6.1.4);

- recalling the term "gel electrophoresis" (A.S. 4.4.3);

- outlining a therapeutic use of stem cells (A.S. 2.1.10).

Section B

- Drawing and labeling diagram of the carbon cycle (A.S. 5.2.1);

- giving an example of a food chain where organisms are named at the species or genus level (A.S. 5.1.4);

- explaining the causes of sickle-cell anemia (A.S. 4.1.4).

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

Section A

- Analyzing pie charts;

- predicting effects of global warming using cod fish data;

- analyzing the results of DNA profiling (A.S. 4.4.5);

Section B

- Deducing trophic levels of organisms in a food chain (A.S. 5.1.7);

- outlining *in vitro* fertilization (A.S. 6.6.5);

- explaining X-linked traits (A.S. 4.3.6-4.3.10);

- explaining the consequences of sickle-cell anemia (A.S. 4.1.4);

- outlining the functions of structures in *E. coli* (A.S. 2.2.1-2.2.2);

- moderate success in comparing energy storage in carbohydrates and lipids (A.S. 3.2.7) and the use of pyruvate in human cells when oxygen is available and not available (A.S. 3.7.3 and 3.7.4)

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

Section A

Question 1

a) (i) Almost everyone started successfully by correctly stating populations 1 and 2.

(ii) Much success was seen because alternative answers were accepted. A mark was given for population 11 or population 7 or populations 11 and 7.

b) The expression "allele frequency" raised a concern since it is not included in the core. Despite that, many candidates were able to reason through the question to a correct answer. Acceptable answers came in a variety of forms such as decimal values, ratios, percentages and fractions. Those who got it wrong either rounded off answers, or gave only one answer, or gave both correct answers without mentioning the alleles. A common incorrect answer was "half PanI^A allele and half Pan I^B allele."

c) The great majority of candidates interpreted the graph by simply stating that it showed an inverse correlation or that allele frequency decreased as latitude increased. Though the allele frequency did decline from lowest to highest latitude, the relationship was not a straight line correlation. The steep drop between 58 to 60° north latitude was usually not acknowledged. Overall negative or inverse correlation was accepted if it was qualified with some additional reference to the stepwise nature of the graph. "Slight negative correlation" was unacceptable.

(ii) Again, candidates erred by simply stating that a positive or direct correlation existed. Some additional reference to the stepwise nature of the graph was expected for a mark.

On c (i) and c (ii), those who got marks tended to get it on c (i) and not c (ii); some mistakenly said the graph in c (ii) spiked.

d) A problem here was that candidates described the allele as though it was the cod fish. For example, "In June the sea is warm and since alleles know this….." There was a disconnect between the graph that described the *Pan*l allele frequencies and the cod fish that contained the alleles. Successful candidates incorporated the concept of adaptation by citing that cod fish with *Pan*l^A are adapted to warm water and those with *Pan*l^B favor cold water. Other candidates stressed that cod fish adapted to a particular water temperature would survive and pass their alleles on to offspring. Some candidates mixed up altitude and latitude. Others wrote about environment or climate instead of water.

e) It was pleasing so see many candidates correctly apply the knowledge gained earlier in the question to the unique water circumstances near Iceland. Frequently, candidates explained that cod with *Pan*l^A would be found in the warm surface water and those with *Pan*l^B would be found in the colder water below. Those who did poorly did not relate the cod with specific alleles to the different areas and simply stated that both type of cod would be found near Iceland. In those cases, candidate thinking was incomplete.

f) Again, many candidates were able to apply their knowledge to make an accurate prediction for full marks. Most common was the prediction that cod with *Pan*l^A allele would increase in number as global warming raised water temperatures in the northern latitudes and that cod with *Pan*l^B would decrease in number to extinction. Candidates lost marks by simply referring to *Pan*l^A or *Pan*l^B without even mentioning allele.

Question 2

a) Generally poorly answered here. For amylase, the common substrate was carbohydrate and the substrate was often a monosaccharide. For lipase, the source ranged from liver to stomach lining. Many pH values were outside the 7-9 range.

b) Although the need for enzymes in digestion is a straight forward concept, many candidates seemed challenged to go beyond general answers such as breaking down large food particles. Such a mechanical process was not relevant since enzymes perform at the molecular level. In order to gain marks, it was necessary to mention that enzymes break down large (nutrient) molecules and that enzymes enable this to occur, quickly, at body temperature. Furthermore, the resulting small molecules are soluble allowing for absorption into the blood stream. Pat definitions of enzymes as catalysts were incomplete. Some students confused absorption with assimilation, an entirely different process.

c) Extremely poor diagrams were seen in this question on the interconnections between the gall bladder, pancreas and small intestine. Many attempted whole diagrams of the digestive tract, yet major organs were unclear with no connections and no visible ducts. A few others drew an inset box in an attempt to show the detail, yet ducts remained obscure. Accurate connections rarely existed. Ideally, proportional sizes, reasonable shapes, and proper juxtaposition would have been seen. Some diagrams were totally bizarre such as a Venn diagram or lines resembling an evolutionary tree or separate structures in a flow diagram. The most frequently awarded mark was for a sac-like structure with a duct labeled as the gall bladder. Commentary on the function of the structures was not expected.

Question 3

a) Gel electrophoresis was the preferred name for the technique, but electrophoresis was also accepted. Electrophoresis was often misspelled. A common mistaken term was karyotyping. Other unacceptable terms were PCR, electrolysis, gene therapy, or DNA profiling.

b) Many candidates struggled when referring to the bands. Most said DNA or DNA fragments which were accepted. Alleles, genes and chromosomes were not accepted. Whether or not track C was declared as the likely father, a mark was awarded if the candidate supported their conclusion with some analysis of the diagram. Most candidates thought that C was the father because of the many bands in common between B and C. Almost no one mentioned that A was unlikely to be the mother.

Question 4

a) (i) Many identified the stage as interphase and gave correct reasoning. In other cases, the stage was correctly identified but wrong reasons were given so the potential mark was lost. However, there were confused candidates who thought the cell was in mitosis and gave faulty reasoning in support.

(ii) Many candidates were correct with DNA synthesis/replication and with cell growth or increasing numbers of organelles. Mistakes such as "protein synthesis" and usage of only G1/G2 and S-phase were frequent.

b) Many candidates knew that stem cells are undifferentiated and that they can differentiate into many cell types. Sometimes, vague responses were given such as stem cells can perform any job or repair themselves.

c) Often candidates could name a therapeutic use for stem cells. However, since this is a fast moving field, the difference between standard, trial, and theoretical treatments is blurred. For example, stem cells are being used to treat burn victims and those with Parkinson's but not yet Alzheimer's. Candidates who scored the maximum usually mentioned leukemia as the condition and specifically mentioned bone marrow as the stem cell source and described how the patient's bone marrow cells are killed and then replaced by the stem cells.

Section B

Question 5

This question was relatively popular with results that tended to be very good or very poor.

a) The quality of the carbon cycles varied dramatically from only a few marks to an easy 9 marks. Some candidates did not seem to realize that the carbon cycle involves CO_2 Often names of processes were lacking on arrow or arrows did not have arrow heads to show direction. Full labels should be attached to diagrams. Sometimes only pictures were shown. A factory smokestack representing the combustion of fossil fuels was inadequate. Diagrams with a lettered key were not welcome. Also, some answers included supporting paragraphs which were not relevant based on the command term.

b) Here there was a problem as most candidates provided food chains with only generic references to organisms within the chain. Specificity to the species/genus level was required for a mark. Many candidates could explain the feeding hierarchy in their

food chain so two or three marks were gained. At the producer level, there was a failure to mention the capture of energy through photosynthesis or that producers do not need to eat other organisms.

c) The method most commonly cited to measure the rate of photosynthesis involved O_2. Candidates knew that its production could be measured and that it represented a by-product of photosynthesis. Those who wrote about observing bubble release from aquatic plants neglected to mention counting them for a rate. Measuring biomass was usually discussed by those who had already explained O_2 production or CO_2 uptake.

Question 6

This question was also relatively popular. Many candidates achieved high marks.

a) Collectively, candidates were awarded all available marking points for the process of *in vitro* fertilization. Sometimes, however, answers were incomplete. For example, injected hormones (FSH or HCG) were identified but not their role or vice versa. Fertilized eggs were not distinguished from embryos as in the mistake of writing that fertilized eggs were placed in the uterus instead of embryos. Some candidates confused IVF with artificial insemination or cloning. A few candidates wrote extensively on the ethics of IVF which was irrelevant to the question.

b) Candidates often achieved full marks on this question but the way answers were developed varied greatly. Punnett squares were often used to illustrate a point. Weaker candidates never mentioned dominant and recessive alleles. When describing genes and alleles in the population, some candidates misused the words dominant and predominate. Others thought that a condition such as hemophilia was an autosomal disorder or used sickle-cell anemia as a sex-linked disease. A few even mixed up the location of X and Y chromosomes in males and females .

c) Here candidates usually gained the obvious marks by noting that in sickle-cell anemia the red blood cells become sickle-shaped with a lessened capacity to carry O_2. Sometimes however, the type of blood cell was described as white or not mentioned at all. Though many candidates realized that sickle-cell anemia is cause by a mutation (CTC to CAC or GAG to GTG), almost no one added that it was a mutation of the gene for hemoglobin. Many thought it involved a transcription error. If malaria resistance was included, a mark was awarded only if the heterozygote condition was mentioned. This was rare.

Question 7

This question was avoided by many candidates.

a) Elaborate drawings of an *E. coli* cell showing their internal structures often preceded the outline of structure functions. Based on the command term, the drawings were unnecessary to gain maximum credit. The structures and functions most often mentioned were the cell wall, plasma membrane, pili, flagella, ribosomes and naked DNA. For cell wall and for plasma membrane there were two marking points available for each. A number of candidates were limited to a maximum of 8 marks because they included eukaryotic organelles, most notably mitochondria.

b) Easy marks, secured by most candidates, were that carbohydrates and lipids are both sources of energy and that carbohydrates are for short-term storage and lipids for long-term storage. When comparing carbohydrates to lipids for the amount of energy storage, it was essential to compare them based on the same given mass.

To write that lipids store more than twice as much energy as carbohydrates was incomplete. Finally, few candidates wrote that carbohydrates are easier to transport than lipids.

c) Most candidates knew the difference between aerobic and anaerobic cell respiration and many knew that pyruvate enters the mitochondrion for aerobic respiration. Though candidates often knew that, under anaerobic conditions, pyruvate is converted to lactate they mistakenly thought that a small amount of ATP is also produced. A few candidates forgot that the question was about human cells and described pyruvate metabolism under anaerobic conditions in yeast.

Recommendations and guidance for the teaching of future candidates

- Teachers should work with students on the interpretation of different types of graphs.

- Avoid seizing on simplistic correlations.

- The SL syllabus has a limited number assessment statements that begin with the command term of draw or label. Teachers should expect that their students will encounter such questions in various places on the exam. These can be studied and practised *in advance*. High standards should be set in terms of accuracy and completeness. Realistic shape, relative proportion and juxtaposition of structures should always be expected. Drawings or diagrams should be big with clear and complete labeling. Annotate all cycles. Do not rely on picture drawing to infer an idea. Include direction arrows, particularly in energy flow diagrams.

- Using former IB exam questions, teachers should get their students to practise writing responses to different command terms and writing responses that directly answer the question. Relevant accurate detailed information will always win marks. In Section B essays, all parts (a, b, and c) of one question must be answered. Students are not allowed to choose different parts from different questions. Attention should always be paid to the number of marks available in any question. It usually means that at least that number of distinct thoughts must be provided if high achievement is to be reached. However, if a question is worth 1 mark, a page of explanation is not necessary.

- Students should learn real world examples for key processes (e.g. stem cell therapy, food chains) to avoid broad generalizations. Names of organisms should be as specific as the level of genus or species.

- In genetics, make sure students know how to describe Punnett square data in words, and that they clearly understand the meaning of recessive, dominant, genotype and phenotype.

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Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 10	11 - 13	14 - 18	19 - 22	23 - 27	28 - 36

General comments

Of the G2 forms submitted, 65% thought that the paper was of a similar standard to that of last year, and 96% of respondents thought that the level of difficulty of the paper was appropriate.

Suitability of the question paper in terms of clarity of wording was judged to be good by 60% and satisfactory by 40%. In the overall presentation of the paper 70% thought that it was good, while 30% thought that it was satisfactory.

There were no clear differences in the degree of difficulty presented by the different options. As in previous years, options A and D seemed to be the most popular, closely followed by E and G. This year options B and C were answered by more candidates, whilst again option F was by far the least popular option in terms of the number of candidates who answered it.

The standard of performance showed a wide spread, but generally candidates showed reasonable achievement, and there were also some very good answers seen. It seems that in centres where all the candidates attempt the same options, the standard of responses tend to be slightly better than when the candidates have more flexibility of choice. Pleasingly, the majority of candidates followed the rubric of the paper and only attempted the required two options.

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

- The final part of the data response questions in each option required higher cognitive skills such as evaluation of data, and this proved to be challenging for many candidates, especially in options A, D and G. It did, however, allow the stronger candidates to demonstrate their ability.

- The parts of questions which required a drawing were generally poorly done, with a lot of structural inaccuracy, especially in options B3 a and E2 b.

- Mathematical calculations proved to be difficult for many students, in particular those involving percentage increases. Appropriate units were often omitted from the answers, and the use of significant figures is also a weak area.

- The commonest problem, which resulted in lack of credit for answers, was the inability of candidates to *explain* their statements, which is typically required in *discuss* and *explain* type questions. The majority of candidates listed things or processes without any further justification of the point being made.

- A number of examiners expressed concern about the lack of basic knowledge of core aspects of the syllabus, suggesting poor preparation of students for the examination. Options B and C produced some of the weakest responses in this respect, with many candidates leaving blank spaces for fairly simple answers.

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

- Most candidates were able to read and analyse basic trends from graphical data, and more were answering *compare* questions by addressing trends in all sets of data given. Weaker candidates still persist in answering from only one perspective, but this seems to be improving on previous years.

- Questions which ask students to state, define, outline or describe continue to produce more accurate and appropriate responses.

- The level of subject knowledge was good for many centres, and it appeared that candidates had been well prepared in options A and G.

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

Option A: Human nutrition and health

Question 1

a) Most candidates gave the correct answer, but many omitted the units, and a few simply gave the title of the horizontal axis.

b) There were a lot of incorrect answers of 500%. As mentioned earlier, calculation of percentage change continues to present difficulties for many.

c) The majority of students managed to gain 2 marks, but again, weaker responses did not give comparative statements about the two vitamin C supplements.

d) Few candidates could offer a sensible reason such as size/weight of individuals, genetic variability or differences in vitamin C requirements/metabolism.

e) It seems that many students did not understand the question, as many were writing about the importance of vitamin C in the fight against scurvy, with no reference to the data provided.

Question 2

a) (i) Quite a large number of candidates could not calculate the correct BMI, and many with the correct figure omitted the units – perhaps because in many sources the BMI is quoted without its associated units.

(ii) Most could extract the correct status of the individual from the given table.

b) There were some good answers by the majority of students, with many gaining three marks. Interestingly, few suggested a malfunction of the hunger centre, which was an acceptable alternative.

Question 3

a) The majority of candidates gained two marks, although there were some vague answers such as "mother's milk is healthier and natural". A specific mention of antibodies in breast milk was required for one of the marks, rather than a general reference to immunity.

b) This question was well answered on the whole, and most knew the symptoms of type II diabetes. It was noted that weaker candidates tended to write about blood *sugar* or *sugar* in urine rather than the more accurate term of *glucose*.

c) Most answers listed dietary advice without any justification, and since this was an *explain* question, many gained no marks. There were few accurate descriptions of foods with low glycemic index, a term with which students were expected to be familiar, purely from general knowledge.

Option B: Physiology of exercise

Question 1

a) Most candidates were able to do the calculation correctly, the majority giving the right units to the answer.

b) Many gained the mark by saying that muscles were working harder on weight-bearing machines.

c) This caused few problems for the stronger candidates, but for the weaker candidates it was more difficult to gain both marks.

d) Many candidates simply listed the advantages and disadvantages of the Body Trec rather than discuss them, and there were some who appeared to be unable to interpret the data given in the table, their answers containing no reference to the data at all.

Question 2

a) Only the better candidates gained two marks here. Many appeared to not understand the question, and many did not refer to changes after a training programme.

b) Most could outline how an oxygen debt is repaid.

c) The majority understood the ideas behind warming-up exercises.

Question 3

a) The diagram of a sarcomere was very poorly done on the whole, with many bearing little resemblance to what was required. Those who did attempt a diagram often managed to gain a mark for showing Z lines, but little else. Quite a large number of candidates left this part of the option blank.

b) This was also not well done. It is a challenging topic, and proved to be a good discriminator for the more able candidates. It is obviously an area which students find difficult to understand.

Option C: Cells and energy

Question 1

a) This was mainly answered correctly, and again, units were required.

b) The majority gave correct answers within the required range of 32-37%.

c) This question required candidates to refer to the data given in the graph, but many answered in general terms without any referral to the pHs shown in the data. Consequently, answers tended to be too vague to gain marks.

d) Most gained a mark for "use of hydrogen carbonate ions", but few gave the idea of carbon dioxide from respiration being used.

e) Many students could identify a limiting factor correctly, but did not then explain how it could affect photosynthesis.

Question 2

a) This was answered well by many students, and they could give suitable named examples.

b) Many stronger candidates had no difficulty in comparing fibrous and globular proteins, but the weaker students gave vague, often muddled responses.

c) The understanding of many candidates was insufficient to answer this question, and it proved to be a good discriminator. Often students were writing about proteins rather than amino acids.

Question 3

a) The standard of drawing was fairly good, but common errors included cristae which were too wide, inner and outer membranes too far apart, and often three outer membranes instead of two. Labelling was fairly good on the whole.

b) As the question asked candidates to *explain* the relationship of structure to function, students were expected to link a specific function to a particular mitochondrial structure, which many failed to do.

Option D: Evolution

Question 1

a) Most candidates answered this correctly.

b) The majority of candidates identified the correct breeding combination.

c) A good proportion of candidates gained two marks, showing their ability to correctly analyse the data given.

d) This was a good discriminator as it allowed the better students to connect the data with their knowledge of speciation, although very few mentioned allopatric speciation, and few gained all three marks. Many weaker candidates appear to have little understanding of the process of speciation however, and answers were often difficult to interpret.

Question 2

a) This was well answered by some candidates, but often answers referred to *organisms* rather than *molecules*.

b) Most answers just listed the possible locations for the synthesis of organic compounds without giving an appropriate reason, and some were writing about the spontaneous origin of life rather than the question asked.

c) This was either well answered or poorly done, with the weaker candidates thinking that oxygen came from carbon dioxide rather than water. Few gave the idea of more photosynthesis than respiration helping to build up the amount of oxygen in the atmosphere

Question 3

a) There were some vague answers to this question, but most students had the idea of the half-life of isotopes.

b) Generally answered correctly by the majority of candidates, although some misread the graph.

c) Most students could describe the trends accurately thus gaining the two marks. There was little mention of reduction of the sagittal crest, which was a possible correct answer.

Option E: Neurobiology and behaviour

Question 1

a) The correct answer of "in flight" was given by most students.

b) This was probably the most challenging calculation question on the paper, and many candidates found the information in the pie charts difficult to interpret. However, a few strong candidates were able to answer correctly.

c) The majority realised that the birds spent about the same time in flight, diving *and* resting in the water, but spent more time active on the water, so gained two marks for this question.

d) Most candidates could give two correct reasons for birds spending more time at the colony.

Question 2

a) Many could not give a full correct definition of a reflex, often omitting the fact that it is a *rapid* response.

b) Many candidates did not attempt to draw a diagram, and those that were drawn were of very poor quality, gaining no marks. There were often no distinct neurons shown, and the division of the spinal cord into white and grey matter was generally inaccurate. Some diagrams were unrecognisable as a reflex arc.

c) There were some good, clearly explained descriptions of Pavlov's experiments, and most candidates gained the two marks.

Question 3

a) This question was generally not well answered, with many candidates describing specific drugs rather than giving general effects on the synapse.

b) There were few good responses to this question, and candidates seem to have little first-hand experience of such experimental work. It was often unclear whether the answer referred to a taxis or kinesis, and many non-invertebrate examples were suggested (including humans!).

Option F: Microbes and biotechnology

This was not a popular option, attempted by so few candidates that it is difficult to give more than brief comments about the various sections. Those who did attempt it often left several parts blank.

Question 1

a) The correct percentage increase was generally given.

b) Those students who answered this gained the two marks.

c) This proved to be slightly more difficult for most, with only one or two marks being gained.

Question 2

All parts of this question seemed to prove difficult. In part (b), few could list all four shapes of Eubacteria, and in (c), the role of bacteria in the treatment of sewage was poorly understood.

Question 3

a) The function of reverse transcriptase was generally known.

b) The use of the enzyme was not known by those who did attempt this part.

c) Although this was a *discuss* section, few candidates could make more than one or two correct points about the risks of gene therapy.

Option G: Ecology and conservation

Question 1

This was a difficult question, requiring a lot of interpretation on the part of the candidates, but the majority did reasonably well on the three parts.

a) Most answered correctly within the range of 162-168 mg m^{-2}.

b) This part of the question required some reference to the months of the year given in the graph, and many answers simply mentioned seasons, ie spring, summer etc, and so did not gain any marks.

c) The majority answered correctly.

d) It seems that many students did not fully understand the question, and so were unable to suggest any explanation for the movement of aquatic invertebrates. Perhaps this is due to a lack of knowledge of invertebrate life cycles,which would help to interpret the data.

Question 2

a) Few could give accurate definitions of the two niches.

b) This proved to be another weak area, as not many candidates could link the decrease in numbers to the loss of energy between trophic levels in an ecosystem.

c) Most candidates did not seem to understand that the term biomagnification refers to the passing of chemicals along the food chain, or that the chemicals are stored in the bodies of the organisms that consume them. Consequently, there were few good answers to this question.

Question 3

a) The problem of alien species has been in the paper in the past, normally asking about accidental releases. This time the question was about deliberate releases, and so many answers were not stating the correct type of example. Also the impact of the release was required in order to gain the two marks.

b) The stronger candidates could outline the problem of CFCs very clearly. However, some of the weaker students tended to write about global warming, which was not relevant in this instance.

Recommendations and guidance for the teaching of future candidates

- Candidates should be taught the mathematical skills necessary to manipulate data, such as percentage change calculations, not just using past papers but also through the practical programme so that they become familiar with using the techniques on their own data collected during experiments. This may encourage the understanding of the use of units in charts and graphs.

- Teachers can support candidates by raising their awareness of the command terms (action verbs) and their associated requirements when answering questions, so that students make an effort to justify statements in *explain* or *discuss* questions.

- Teachers should draw candidates' attention to the key definitions relevant to their option, and encourage familiarity with them in preparation for the examination.

- Teachers should remind candidates to read the data response questions very carefully and thoroughly, as they often contain important information that can help them with their answers. Candidates should be made aware that whilst their own knowledge and understanding is often asked for, sometimes key points may be found within the text provided.

- Teachers should emphasise the need for good quality drawings (with labels) of those structures outlined in the syllabus, and provide students with the opportunities to practise this skill whenever possible.

- Candidates should be encouraged to familiarize themselves with the syllabus, so that they are aware of the coverage of topics in preparation for sitting the examination papers.