May 2017 subject reports

Biology – Timezone 1

Overall grade boundaries

To protect the integrity of the examinations, increasing use is being made of timezone variants of examination papers. By using variants of the same examination paper candidates in one part of the world will not always be taking the same examination paper as candidates in other parts of the world. A rigorous process is applied to ensure that the papers are comparable in terms of difficulty and syllabus coverage, and measures are taken to guarantee that the same grading standards are applied to candidates' scripts for the different versions of the Examinations papers. For the May 2017 session, the IB has produced timezone variants of Biology SL/HL Papers 1, 2 and 3.

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 14	15 - 24	25 - 36	37 - 51	52 - 63	64 - 77	78 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 14	15 - 25	26 - 35	36 - 47	48 - 61	62 - 73	74 - 100

Internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 3	4 - 6	7 - 10	11 - 13	14 - 16	17 - 19	20 - 24

The range and suitability of the work submitted

Many schools presented a very large range of inventive and original investigations. Like last May, many pieces of work were a real pleasure to read. Nevertheless, the moderators reported

that there appeared to be a greater reliance on classic investigations, some of which are prescribed in the core, of the program with little or no attempt to modify them.

Overall, most of the work was of a suitable standard.

Consideration of safety and ethics were frequently lacking particularly in work with microbes.

There were some trivial investigations that were not of the appropriate level for the IB biology course.

Once again, very few databases, simulations or hybrids were presented. Those involving modelling were also very rare. The situation for database work is worrying. Some candidates are simply taking published papers, copying processed data and even repeating the findings of the researchers. Not only is this an ethical problem, it is not using primary source material. New material is being posted on the OCC including some exemplars that concern these approaches. We hope that they may clarify their use and how they are marked.

The vast majority of the schools provided the appropriate material. Nevertheless, there remain problems.

Teachers who physically annotated the candidate's work before uploading, or used the Microsoft Word comments function to annotate electronically submitted work were most helpful. Examiners found it less helpful when comments were made at the beginning or the end of the work. It was not immediately obvious what the teacher was referring to.

A major problem encountered was teachers who did not annotate or comment on work at all (i.e. an unmarked, "clean" copy of the candidate's work was uploaded). This made it difficult to follow the motive behind the teacher's marks and if possible support the teacher.

The samples should now be completely anonymous. Moderators were still finding candidate names, teachers names, school names and other forms of identification on the uploaded material.

Some of the material was scanned upside down before it was uploaded. This problem can be resolved but it is irritating.

Overall more schools had their marks adjusted this time than in May 2016.

Candidate performance against each criterion

The application of the assessment criteria by teachers was generally good, though often overgenerous, sometimes very generous. Therefore, more rigor is necessary when applying the final mark. Teachers were only occasionally considered too severe.

Evaluation still was the weakest criterion for many. This criterion is difficult and it does discriminate between the candidates. For many moderators analysis was also a criterion that needed more attention. Many candidates were happy to leave the processing at the level of calculating means.

Personal engagement (PE)

Some form of personal significance was expressed in most cases. While most were clearly inspired by an observation or an issue, many were contrived (for example, “I have always been interested in…”), or there was no expression of personal significance at all.

The originality of the exploration was mostly acceptable and sometimes exceptional. There were, however, too many cases of classic investigations being used with little or no attempt to modify.

Personal input is evident in the persistence to collect data but also in the research for the background and when establishing the scientific context of the conclusion, in following through the investigation and in the choice of methods of analysis. Once again, this was clearly evidenced in many candidates. For others it seemed, after a good start with an interesting research question, they failed to follow through.

Personal input can be reflected at the simplest level by having completed the investigation, but those following classic experiments, with no sign of application, cannot expect to score highly. There must be some indication that there is a commitment to the investigation.

When marking this criterion, teachers should look out for the following:

- A statement of purpose
- The relationship with the real world
- The originality of the design of the method (choice of materials and methods)
- The difficulty of collecting data (evidence of tenacity)
- The quality of the observations made
- The care in the selection of techniques to process the data
- The reflections on the quality of the data
- The type of material referred to in the background or in the discussion of the results
- The depth of understanding of the limitations in the investigation
- The reflections on the improvement and extension of the investigation.

Marking this criterion requires a holistic approach and it will overlap with components of other criteria.

Exploration (EX)

The research question lacked sufficient focus for many. Scientific names were not always used and the range of the independent variable was not given. For example, a candidate whose question read, “How will different amounts of sugar have an effect on cell respiration in yeast used in bread making?” should have considered including the sugar used (was it sucrose, as was assumed?). The word “amount” could have been made more specific by substituting with “mass”, or “volume” or “moles”. The range of sucrose concentrations to be used should be indicated. A research question can also include how the measurements will be taken by introducing the dependent variable.

The requirements for the background are that it needs to be focused and contain relevant information. There were many cases of superficial or irrelevant material. The independent

variable needs to be justified. The dependent variable needs to be explained. The discussion of controlled variables is needed to demonstrate that the student appreciates the other factors that may impact on the experiment. Controls need to be considered more frequently.

The methods were either written in prose or recipe style. Both were acceptable. Where the method was not clear it affected both the Exploration and Communication criteria. The weaker submissions tended to be from candidates who investigated a topic in which causal relationships are difficult to confirm and a large number of controls are missing. For example, human physiology studies with limited data sets and poorly controlled variables.

The moderators frequently found the candidates' understanding of concentration to be weak. A serial dilution of a molar solution of sucrose would sometimes result in the stock solution being identified as 100% sucrose.

When marking this component of the criterion teachers should look out for the following:

- The protocol for collecting the data
- The range and intervals of the independent variable
- The selection of measuring instruments (where relevant)
- Techniques to ensure adequate control (fair testing)
- The use of control experiments
- The quantity of data collected, given the nature of the system investigated
- The type of data collected
- Provision for qualitative observations

Safety, ethics and environmental impact needed to be addressed in a large number of investigations. It is true that some investigations may not have any issues in these areas but there were plenty that did and yet the candidates showed no evidence of concern. It is not sufficient to identify potential areas where safety is an issue, there needs to be an indication of how the issue is avoided.

There were some microbiological methods being carried out that were very inappropriate for a school environment.

The following guidelines should be applied:

- Only culture strains of microbes known to be non-pathogenic. For example, students should not culture from hands or swabs of door handles.
- Do not test for antibiotic resistance. There are enough antibiotic resistant strains circulating in the environment without more being selected for.
- Apply strict rules of hygiene and aseptic techniques.
- Do not culture microbes at 37°C. Incubation should be carried out below 30°C.
- Always label cultured plates so they can be clearly identified and never open them for inspection.
- Do not tape all the way round a Petri dish, this encourages anaerobic conditions.
- Never assume that what is growing in the culture is the strain that was inoculated, even if non-pathogenic strains have been used.
- Always sterilise used cultures and dispose of the cultures using local health and safety regulations.

There were some potentially dangerous practices in investigations, for example, the use of fecal samples.

In addition to microbial hazards there seemed to be a shocking disregard for safety in some schools that can only be attributed to teacher ignorance. One example was found of a candidate employing potassium cyanide as an enzyme inhibitor.

The use of consent forms with human volunteers is not systematic. This is an essential ethical practice.

The environmental impact and safety for fieldwork was often ignored.

When assessing safety, ethics and environmental issues, teachers should look for the following:

- Evidence of a risk assessment
- An appreciation of the safe handling of chemicals or equipment (e.g. the use of protective clothing and eye protection)
- Consideration of basic hygiene
- The application of the IB animal experimentation policy
- A reasonable consumption of materials
- The use of consent forms in human physiology experimentation
- The correct disposal of waste
- Attempts to minimise the impact of the investigation on field sites.

Analysis (A)

The presentation of raw data was generally accurate but qualitative observations were missing from many submissions. Qualitative observations are expected to accompany the raw data. Their impact will depend upon the nature of the investigation, for example, fieldwork should always have a site description which could take the form of maps, sketches or photographs with annotations. A number of examiners commented on the fact that qualitative observations had frequently been ignored.

Raw data from data logging may be expressed as a graphical readout. It should be accompanied by the necessary information such as units and degrees of precision (if relevant) in the axis titles. A candidate should only present a representative sample of the raw data, for example, when large amounts of data have been collected using data logging. A representative graphical readout revealing how data is derived is acceptable. In this way the derived data becomes the raw data.

Processing the data varied. Most candidates managed the basics, for example, means and standard deviations. Nevertheless, there were still candidates who tried to apply standard deviation to a sample size that was too small ($n<5$).

Several were using significance tests from t-test to ANOVA. Although good, they need to be appropriately applied and there needs to be sufficient explanation for the processing to be followed. The use of programmes, such as Microsoft Excel, which produce a statistic, such as a p-value or a correlation coefficient, is fine but the candidate needs to know what the value actually represents.

>30 is considered a large sample,

15-30 a small sample,

5-15 a very small sample,

<5 is usually considered too small a sample to apply tests like the t-test.

Rates and proportions were not always calculated where they were appropriate.

Basic measurement uncertainties were presented but not discussed. Candidates are expected to appreciate the limitations of their instruments and, where they may have a choice, to select the appropriate one. In biology, the biggest issue for uncertainties is in the variation in the biological material (expressed as standard deviations, standard error or max-min range). Error bars showing variation were frequently used on graphs but their significance, or even what they represented, was often absent. In some cases, the error bars were incorrectly placed or they had no bearing on what had been calculated.

The interpretation of the data was sometimes well presented after each set of data. Sometimes it was mixed in with the conclusion. The use of statistics may have been satisfactory but were not always well interpreted. As with calculators, the use of a program like Excel is useful but can lead to accepting values without truly understanding them. Huge mistakes can result from this (for example, confusing the t-statistic with the p-value), leading to an erroneous conclusion. Often the interpretation was handicapped by the limited degree of data processing.

Evaluation (EV)

This was the weakest criterion for many. It is a difficult skill but many candidates just seemed to hurriedly finish off the report. Schools may need to consider the impact of the deadlines for each subject, theory of knowledge and extended essays on the candidate's workload.

Conclusions were not always supported by the data and explanations were missing. The candidates did not always refer back to their research question at this point. Some candidates were rather overoptimistic in their conclusions. Clearly the data did not fully support it but they would aim to put a positive spin on it. A scientific context is needed for a full discussion and this was frequently superficial or absent. For weaker candidates, the conclusion was just a description of the results.

The evaluation of methodology is still a challenge to most candidates. The consideration of the strengths was frequently missed. Weaknesses were often restricted to practical details or sloppy manipulation and the level impact on the conclusion was often not discussed. Proposed improvements were sometimes unrealistic and often too vague. Extensions were often missed or illogical, not following on from the investigation.

When assessing evaluation, teachers should look for the following:

- A discussion of the strengths – this might be quite general or it might refer to specific parts that worked well or data that was consistent.
- Discussion of the reliability or the data.

- Identified weaknesses in the method and materials.
- The evaluation of the relative impact of a weakness on the conclusion.

Communication (C)

The responses to the communication criterion were generally good. Those who communicated well were candidates who had already scored highly in the other criteria.

The most common problems in the work were:

- The use of whole pages for titles. This is not necessary.
- Whole pages for a list of contents. This is not necessary at all.
- Blank data tables presented at the end of the method section (unnecessary).
- Repetitive tables, when one would do.
- Tables split over two pages or with a title on one page and the table or graph on the next.
- Multiple graphs drawn when they could have been combined, this not only saves space but it also improves comparisons.
- Squashed graphs so the distribution of the data is difficult to judge.
- Bibliography, footnotes, endnotes or in-text citation missing.
- References with an incomplete format.
- Inefficient data tables headers. The art of designing data tables needs to be taught. A hand drawn sketch of the table layout should be considered first.
- Scientific nomenclature was not always used and the formats were not always respected.

For graphs that result from data logging that are used to derive a value (e.g. a rate) one example can be presented to explain the processing then the rates derived can be organised in a table.

The format for the citations, when they were presented, was mostly correct.

Format of scientific names was sometimes incorrect (small case letter for species name and it ought to be presented in italics).

Units were occasionally missing and use of non-metric units did occur sporadically.

Measurement uncertainties were occasionally missing.

The numbers of decimal places were sometimes irregular or they did not correspond to the precision of the data.

In general, the reports were of a suitable length.

There were no automatic penalties for reports that were slightly longer, as long as the reports remained relevant and concise.

Recommendations for the teaching of future candidates

- Present the criteria to the candidates early on in the course and use them for the assessment of practical work.

- Explain the expectations of each component of each criterion.
- Ensure that the candidate's work has some original purpose. It should not be the repeat of a classic investigation.
- Teachers should add comments throughout the work (rather than at the beginning or end).
- Apply the criteria more rigorously.
- Counsel the candidates on the feasibility of the investigation, focussing research questions, safety ethics and environmental impact, use of statistical programs and the use of citations.
- Teach candidates how to design tables and draw graphs.
- Consider the global context of the candidate's entire IB workload when scheduling the individual investigation in the scheme of work.
- Teachers should visit the OCC to see examples of individual investigations that are considered adequate (teacher support material). These have been updated in the light of the material received in the first examination session.
- Graphs should not be reduced to such a size that they become uninformative, simply to stay within the page limit.
- Candidates should not add on appendices in addition to a write up of about 12 pages and should not send in excessive quantities of raw data from data loggers (although showing an example of how raw data have been processed will be needed).
- Reams of extra work should not be submitted. Teachers marking the work should annotate it if they judge the processed results to be a true reflection of the raw data from, for example, a data logger.
- Full calculations are not expected to be shown, examples will suffice and a worked example from a calculation carried out on a spreadsheet or a programmable calculator will not be expected. However screen shots should be considered.
- Teachers should ensure that the work is anonymous. The candidate name, the school name, and the session numbers must all be removed before scanning and uploading.

Higher level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 12	13 - 15	16 - 21	22 - 26	27 - 32	33 - 40

General comments

This question paper was included more questions that involved careful thinking by students than in multiple choice exams on the previous program. Assessment objective 3 is now tested in paper 1 whereas before it was not, making paper 1 more challenging overall. Grade boundaries will reflect this, so candidates are not disadvantaged. Some teachers making comments using G2 forms seem unhappy that general understanding can now be tested more

effectively in multiple choice questions and others still attack any question that requires specific knowledge. The examining team is aiming to test significant knowledge and the sort of secure understanding that can be broadly applied, so there is a mixture of styles of question on this paper and will be on papers in the future.

It is always hard to predict how challenging candidates will find a question and there were a few questions especially near the start of the exam that proved to be too difficult. However, the statistics show that this exam was effective in spreading candidate over the mark range according to their standard. In the report that follows comments will be concentrated on questions that either performed badly or were criticised by teachers. Most questions were very successful questions and proved to be appropriate both in terms of difficulty and discrimination.

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

Identification of parts of a plant cell in electron micrographs

The difference between hydrophobic and hydrophilic substances

The immune response to viruses

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

Interpretation of DNA profiles

Analysis of the outcomes of crossing over

Analysis of cladograms

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

Question 1

Only half of candidates correctly identified the lysosome as the organelle with a single membrane and many thought that it was the nucleus. The skill of drawing the ultrastructure of eukaryotic cells based on electron micrographs is included in 1.2 of the program and there is guidance that the nucleus and membrane-bound organelles in the cytoplasm should be included.

Question 2

This question proved to be too hard for many candidates. All of the four choices of answer were chosen by large numbers, which is unusual. Statement III was clearly wrong as membrane proteins are not in fixed positions. Rejection of this should have allowed answers C and D to be eliminated, so many candidates either did not understand how evidence falsifies models, or

were not familiar with the Davson-Danielli model. Candidates then had to decide whether Statement II was evidence for falsification, but the idea of non-polar amino acids causing proteins to remain in the membrane was probably too challenging and the numbers of candidates choosing answers A and B were similar.

Question 3

Candidates also found this question hard, with fewer than 30% answering it correctly. The distribution of answers shows that many candidates thought that the chloroplast was a whole cell. Many also either confused the cell wall and plasma membrane or they thought that the wall controls exchange.

Question 4

This proved an effective question. Candidates were expected to know that the mitotic spindle is assembled towards the end of G2 and in the early phases of mitosis, so the correct answer is D as it shows the levels of a cyclin that rises to a peak at that time.

Question 5

The structure and function of starch is in 2.3 of the program and guidance states that amylose and amylopectin should be included, so the examining team decided that the question was acceptable. Both forms of starch are worth viewing using molecular visualisation software, which is a required skill in 2.3. Some teachers felt that this question was testing an unimportant minor detail about starch, but most candidates had gone wrong even before choosing between amylose and amylopectin. The commonest answer was cellulose, suggesting incorrectly that it is a branched molecule. The second commonest answer was glycogen, despite the question asking for a polymer found in plants.

Question 6

This was a successful question with a high discrimination index and three quarters getting it right. The expected dependent variable was the rate of formation of product. Changing substrate concentration was arguably also correct, but it was not the best answer because ‘changing’ is vague and there is no indication of time, which ‘rate’ gives us in the accepted answer.

Question 7

Candidates found this hard and only about half got it right. There were some complaints about the wording of the answers, but with careful reading they are clear. The examining team felt that it was not unreasonable to ask about conservative replication because the term ‘semi-conservative’ only makes sense in the light of what conservative replication would be. The relatively low discrimination index suggests that this is a topic that needs to be taught carefully.

Question 9

To get the answer, the candidate must be clear that a transcribed strand has the complementary base sequence to the mRNA produced, so the other DNA strand that is not used as a template

has the same base sequence as the mRNA, apart from the U-T substitution. Given that only a little over a third of candidates answered correctly, the very high discrimination index is surprising, but it shows that the stronger candidates were successful.

Question 11

This was another question where is has been argued that there are two correct answers. The best evidence for the condition being due to an autosomal recessive allele is that two parents have a child that is affected. The observation that there is no affected person in generation 1 fits with the allele being recessive, but the first generation does not show all parents of individuals in the pedigree and a dominant allele could have been brought in to the pedigree by these individuals, for example the father of the children in the 3rd generation.

Question 13

Teachers expressed concerns about the clarity of the gels, but the only actual issue was that nearly all candidates understood the biology involved very well, with over 90% getting it right, so the discrimination index was low. On the other hand, the question indicates successful preparation for the exam and it is important that some questions are approachable for weaker candidates.

Question 15

There were complaints from some teachers that this question favoured candidates who had used one particular text book, but the diagram had been deliberately altered with the addition of a dead elephant to avoid this. Candidates really had to think to get the correct answer and only 30% were successful. Nearly all realised that arrow 3 represented photosynthesis in producers, so answers A and D could be eliminated. Answers B and C only differ in the interpretation of arrow 1, which shows carbon passing from the dead elephant to the atmosphere. Twice as many candidates incorrectly decided that this flow of carbon is due to the death of a consumer, as correctly realised that it is cell respiration in saprotrophs, hence the low percentage of correct answers. The high discrimination index shows that stronger candidates tended to choose the correct answer and there was no evidence of any benefit to candidates familiar with a carbon cycle containing a live elephant.

Question 16

This was based on the statement ‘Methane is oxidized to carbon dioxide and water in the atmosphere’ in 4.3 of the program. Only about a third of candidates knew this, but a very high discrimination index shows that stronger candidates were successful. The examining team consider detailed knowledge of the science behind climate change to be important and therefore worth testing.

Question 17

This question was answered very poorly. Given that guessing gives a 25% chance of answering a question correctly, it was remarkable that only 22% of candidates chose the correct answer.

Question 21

The statistics show that only a third of candidates answered this question correctly, with a large number of the weaker candidates thinking that glucose is non-polar and therefore hydrophobic, rather than the converse. Both terms are used in the program and the words hydrophobic and hydrophilic are specified both in relation to water solubility and phospholipids in membranes.

Question 24

This question asked for a hormone that both promotes thickening of the endometrium and inhibits LH. Some teachers thought that progesterone and estrogen were equally valid as answers, but whereas both hormones stimulate the repair or thickening of the uterus lining, only progesterone inhibits LH secretion.

Question 26

It is arguable whether the base sequences that were the subject of this question should be regarded as alleles of a gene, but despite this the discrimination index for the question was very high, showing that it was the stronger candidates that tended to get it right. Many candidates answered incorrectly though, either by thinking that a band on the gel could contain DNA of two different lengths or that short pieces of DNA travel slower than longer ones.

Question 34

There was some criticism that cytokinin was included in two of the four possible answers despite not being part of the current curriculum, but candidates were expected to identify the correct answer here, rather than eliminate wrong ones. Over 60% of candidates did this and the discrimination index was the highest on the paper.

Question 37

In contrast to question 34, the expectation was that this question would be answered by elimination. Three of the answers refer to aspects of the normal response of the immune system to pathogens, including viruses, so they could be eliminated. The remaining reason for the lack of a secondary immune response therefore had to be the high mutation rate of some viruses. About half of candidates answered correctly, but a rather low discrimination index shows that some of the stronger candidates mistakenly thought that viruses may fail to induce a primary immune response, or that either B cells or antibodies may not interact with viruses.

Question 39

This question had too many convolutions and though half of candidates answered it correctly, the discrimination index was rather low. Perhaps some candidates were surprised by the presence of protein in the glomerular filtrate. Although most proteins remain in the blood plasma, some small proteins are filtered out, hence the low concentration of protein shown in the data. Even given this confusion it should have been possibly for candidates to work out that the presence of the same concentration of glucose as in the plasma indicates that the filtrate must have been in the Bowman's capsule.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 24	25 - 35	36 - 45	46 - 56	57 - 72

General comments

This was a more difficult paper than in the previous year and the grade boundaries were accordingly lower. The data based question in particular proved to be very challenging and weaker candidates struggled with it. Other parts of section A and the extended response questions in section B sampled candidates' knowledge and understanding of topics in the Core and AHL. Performance varied from outstanding to very poor and depended partly on the ability of candidates but even more on how carefully they had studied the program, both over the preceding two years and in the weeks before the exam. Given that the higher level IB biology program is ambitious and wide-ranging, it is not expected that candidates will be able to answer every question faultlessly even at the upper end but over the exam as a whole there is ample opportunity for candidates to show the standard that they have reached through their studies in biology.

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

- Functions of life as exemplified by organelles in *Paramecium*
- Pasteur's falsification of spontaneous generation
- The function of immunoglobulins
- The difference between antibiotics and antibodies
- Exact definitions of terms related to genes (allele, dominant, recessive)
- Active transport in phloem

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

- Reading graphs and data analysis
- Transpiration and transport in xylem
- Muscle contraction
- Functions of membrane proteins
- Catabolism, anabolism and metabolism
- Evidence for evolution from homologous structures

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

Section A

Question 1

This was one of the most difficult data based questions of recent years and even the examining team struggled with parts of it. Five pieces of data must be a record for an HL data-based question. Interestingly, performance seemed to correlate more closely with overall performance on the paper than is the case when there are straightforward parts to the question that all candidates can answer with ease. Nevertheless, it is not the intention of examiners to bamboozle candidates and in retrospect more information should have been given about the research, to allow more informed answers. It must also be added that it was impressive how well many of this cohort of candidates coped such a difficult question and only rarely did candidates leave any parts of the question unanswered.

The first table of data was complicated as there were three independent variables: the waste product, the organ of excretion and whether the turtle was in water or not. Both parts (a) and (b) asked candidates to compare aspects of this data and unless the question was read carefully, the wrong comparisons could easily be made. Weaker candidates tended to do this.

The graph that followed showed two clear trends and (c)(i) asked what these were. This was also quite discriminating, with about a third of candidates failing to realise that the oxygen concentration of rinse water fell when the turtle's head was dipped into water and rose when it was out of water. Part (ii) was hard because candidates did not really have enough information about the way the experiment had been done. Nevertheless, some candidates realised that oxygen was being absorbed in the mouth when the head was in water and that oxygen from the air was dissolving in the water when the head was out of it, raising the concentration.

The bar chart that followed was easier to understand and most candidates were able in (d) to deduce that the action of phloretin shows that urea transporters are present in the mouth of the turtles. Only the weakest candidates failed to conclude this, but there wasn't much evidence that candidates used the conclusion to help answer remaining parts of the question.

The next data was in the form of gel electrophoresis results. Although the program does not specify this procedure with RNA, sub-topic 3.5 includes gel electrophoresis with DNA - this is similar enough for candidates to be expected to analyse the pattern of RNA bands on a gel. The phrase 'mRNA expression of a urea transporter gene' was used in the description of the data and candidates tended to repeat this in their answer to (e), suggesting that they weren't clear what it meant. The intended answers were that mRNA for the urea transporter gene was present in the roof of the mouth and the tongue, but not in the other named parts of the body which were organs of the digestive and excretory systems. From this, candidates were expected to conclude that it is in the mouth where there are urea transporters working, and nowhere else in the body. A common error was to conclude that the gene for the urea transporter is only present in the mouth. This ignores the principle that cells have all the genes in an individual's genome but only express some of them.

There then was a fifth piece of data, which showed the effects of raising the blood concentration of urea or of ammonia on the level of expression of the urea transporter gene. Most candidates answered (f)(i) successfully, with the salt solution as the control and the reason being either that the concentration was the same as in the turtle's body fluids, or that the turtle normally lives in saline water. It was in (f)(ii) where the examining team, like the candidates, failed to find any truly convincing answers. Even a careful reading of the original research paper did not help. Marks were therefore awarded for any reasonable comment. The most successful answers were based on information about urea in sub-topics 2.1 and 4.2 of the program and about excretion of nitrogenous waste in 11.3.

The final part of the question was intended to draw together conclusions from all parts of the question but again there was a problem that candidates had not been given enough information about how the experiments had been done. In particular, many candidates remained confused by the difference between turtles living in water all the time and living out of water but periodically dipping the head under water. A wide variety of answers were seen and the mark scheme was constructed so that any reasonable idea was rewarded, whether or not it was what the original researchers had concluded. To their credit, this part of the question was fully answered by nearly all candidates, who realised that it is far better to give some sort of answer than to give none.

Question 2

This question required some specific knowledge of nucleosomes, tRNA and the differences between free and bound ribosomes. About half of candidates knew the components of a nucleosome and about a third could state a chemical modification of nucleosomes that affects gene expression. Some candidates thought that the two binding sites labelled on the diagram of tRNA are for binding to the A, P or E sites on the ribosome but more knew that the site labelled I is where an amino acid is attached and II is the anticodon that binds to the codon. In the last part of this question, candidates were expected to state that free ribosomes synthesise proteins that remain in the cytoplasm but proteins synthesised by bound ribosomes pass into the endoplasmic reticulum and then mostly on for processing in the Golgi apparatus and secretion by the cell. Again, about half of candidates were able to explain this successfully.

Question 3

This question was common to the HL and SL paper. The theme was cell biology.

Part (a) tested candidates' understanding of how Pasteur's experiment with swan-necked flasks falsified convincingly the concept of spontaneous generation. Well-prepared candidates were familiar with this experiment and described it in detail but there were also candidates who appeared never to have heard of it. One common error was to suggest that Pasteur sealed his flasks to prevent entry of microorganisms. This would not have satisfied critics who claimed that life could only arise spontaneously if broth was in contact with air. That was the point of using swan-necked flasks – oxygen and other gases in the air were free to diffuse to or from the broth but microbes could not get past the swan neck. Spontaneous generation of cells did not occur in the sterile broth even though there was contact with the air outside.

In part (b) candidates were asked to state the functions of life carried out in *Paramecium* by cilia and the contractile vacuole. This was based on a statement in sub-topic 1.1. Movement is not mentioned in the program as a function of life but it was accepted here as an answer. Nutrition was also accepted because cilia in the oral groove waft particles of food to the site where they are taken in by endocytosis. More than half of candidates gave one or other of these answers but there was less success with the function of the contractile vacuole. Because its function is expulsion of excess water that has been taken in by osmosis, either homeostasis or osmoregulation were accepted as answers, but more commonly candidates stated that contractile vacuoles store water or other materials.

Part (c) was the most successfully answered in question 3. Most candidates could give at least one advantage of the use of adult stem cells and there were many clear answers that scored well.

Question 4

The inclusion of the graph at the start of question 4 was criticised by some teachers as being unnecessary, but this would have been a very dull question without it and the graph established a theme of interactions in ecosystems and also led onto part (a) on climate change. It also made (a) more discriminating because weaker candidates tended to misinterpret the graph and write that increased carbon dioxide caused soil temperatures to rise rather than increases in carbon dioxide released by respiration in soil organisms (and other sources) causing more heat retention in the atmosphere. Although not referred to in the question, there is positive feedback here as so often with processes causing climate change – release of CO_2 due to warming soils contributes to further warming.

Part (b) was one of the best answered questions on the paper and most candidates had no difficulty in outlining two of the general characteristics of ecosystems.

The remaining two parts of the question turned to plant physiology. Part (i) was challenging. Weaker candidates tended to be in rather a muddle about what is done by active transport in phloem. There was confusion between xylem and phloem and also a lack of appreciation that flow of sap in phloem is passive, but energy has to be used to generate the pressure differences that drive the flow. The best candidates gave an account of loading of sucrose into phloem by proton pumping and co-transport.

Part (ii) was more familiar to most candidates and many scored well, with absorption of water in roots by osmosis often included and the importance of cohesion between water molecules in allowing movement under tension. In this question adhesion was only relevant in relation to the generation of tension in leaf cell walls. When a plant is transpiring and the xylem vessels are already full of water, the adhesion between water and cellulose in the walls cannot cause upward movement. Adhesion is only important when xylem vessels are refilling, for example in spring when deciduous trees are about to open new leaves.

Section B

Question 5 was the most popular out of the three choices and most candidates answered it. Of the other two questions, 7 was a little more popular than 6, especially among weaker candidates.

Question 5

The most challenging part of this question came first. Electron transport and chemiosmosis were well explained by strong candidates and all but the weakest could give partial explanations. Given the difficulty of the topic it is not surprising that there were few faultless explanations and in particular there were often gaps or errors in tracing the flow of energy from the arrival of reduced NAD to the final synthesis of ATP. The naming of the inner mitochondrial membrane caused particular difficulty. Some answers were far longer than they needed to be, with details of glycolysis and the Krebs cycle, and usually then too little on the actual processes specified in the question.

In part (b) candidates were asked to outline four functions of membrane proteins and most candidates got at least two or three. The main error was to confuse structure with function and include for example glycoproteins as one of the four answers, without stating what they do.

Part (c) was also generally well answered. Most candidates correctly distinguished between anabolism and catabolism. The third term in the question was metabolism. This was sometimes confused with metabolic rate or was described too narrowly. The expected answer was that metabolism is all of the enzyme-catalysed reactions in a cell or in the body, but anabolism plus catabolism was also accepted.

Question 6

Many candidates ran into difficulties in the first two parts of the question by misunderstanding the terminology. Some teachers complained that the term antibodies would have been more widely understood than immunoglobulins. The latter term is used in sub-topic 2.4 of the program in the list of proteins whose functions should be described. By asking about immunoglobulins, examiners were able to award a mark for identifying them as antibodies, but far fewer candidates knew the term than expected.

It was more surprising that so many candidates were confused about the meaning of the term antibiotics in part (b). Having failed to write anything about antibodies in (a) some candidates did so here. Antibiotics appear twice in the program – evolution of antibiotic resistance in 5.2, including the essential idea for that sub-topic and the mechanism of action of antibiotics in 6.3. Candidates who based their answer on those sub-topics had no difficulty in scoring well.

Part (c) was the long part of this question. A context of coughing by means of muscle action was given and marks were available for including some basic ideas about this, but a few candidates devoted their entire answer to it. The second sentence of the question made it clear that a general account of muscle contraction was required. There were some excellent and detailed accounts and nearly all candidates knew at least something about the structure of striated muscle and how it contracts.

Question 7

Part (a) of this question probably caused examiners as much problem as candidates because of the diversity of style of answer and the many relevant ideas included. Current policy is to use point-based mark schemes rather than subjective assessments of the quality of answers. A mark scheme was therefore constructed that rewarded each relevant idea. The best answers were those from candidates who had thought about all the genetic factors that distinguish individual members of a species and that both characterise a species and make it different from other species. Answers ranged from detailed and highly perceptive, to brief and error-strewn. Some answers were marred by imprecise use of terminology. Better answers, for example, made a distinction between genes and alleles.

The second part of the question concerned speciation. The program includes easily enough on this topic for a four-mark question and there were plenty of good answers. The commonest fault was to write about the evolution of a species over time, rather than the splitting of one species into two. Another error was to think that speciation is the classification of organisms into species. A common misconception is to think that speciation causes reproductive isolation, whereas the reverse is actually the case – reproductive isolation allows speciation to occur. The examining team had expected candidates to mention the idea that speciation can be gradual or abrupt as this is part of sub-topic 10.3, but few candidates mentioned this.

Part (c) was also well answered by many candidates. Any example of homologous structures was accepted, but most candidates unsurprisingly chose the pentadactyl limb as this is specified in 5.1. In some cases, the description of pentadactyl limbs was inaccurate and functions of different examples were sometimes lacking, such as flight in bats or swimming in whales. Candidates who chose other examples often picked something inappropriate, for example hominid features that differ little in structure and hardly at all in function. Although homologous, they do not provide strong evidence for evolution so were unsuitable in this question.

Recommendations and guidance for the teaching of future candidates

- Success in IB biology is based on two years of determined study, during which a secure understanding is established.
- A period of intense revision is needed before the final exams to ensure familiarity with all the essential ideas and detailed examples in the program. During this revision period a careful reading of the core and AHL is advised, to check whether there are any terms that are unfamiliar, in which case their meaning should be learned.
- Candidates are expected to have studied applications that are included in the programme as a way of building transferable understanding. Though questions should not focus on memorization of details of applications, some familiarity with this material is needed.
- It us better to keep trying when answering a question if it a perfect answer seems out of reach.
- Answers should only be placed inside the boxes on the exam paper. Usually the space inside the box is sufficient for the expected answer but if more space is needed this

should be on an extension sheet, not outside the box. Use of extension sheets should be clearly indicated by the candidate in every answer to ensure that examiners quickly and easily find the additional text.

Higher level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 10	11 - 16	17 - 22	23 - 27	28 - 33	34 - 45

General comments

The number of teachers who submitted a G2 for this session was down from last year. All teacher comments are considered at Grade Award meetings so teachers are encouraged to take the time to give feedback. The comments received on the G2 forms indicated that 89% of the respondents felt the difficulty level was appropriate. The clarity of the wording was considered good to excellent by 78% of respondents and the presentation was felt to be good to excellent by 84% of respondents which is higher than last year.

Last year, paper 3 changed in both format and content compared to previous years with a compulsory section A appearing for the first time. Many respondents felt what was included in section A this year was more appropriate than last May. Also last year, a major concern was that some candidates had omitted section A. The instructions were changed and this year there were very few cases of section A being omitted.

The most popular options this session were again C and D with a large number choosing A as well. Very few candidates attempted more than one option which was good to see.

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

The level of knowledge shown by candidates was highly variable, ranging from very good to extremely weak. However, there were a very large number of candidates who did not seem to be prepared for this examination and found all sections difficult. Many struggled to understand the questions; others struggled to express their answers clearly and concisely; and others lacked the expected subject-specific knowledge and vocabulary. Command terms such as ‘suggest’ or ‘evaluate’ caused problems in understanding what was required by the question. Section A presented difficulties for almost all candidates, even though many comments on the G2 forms felt the question topics were more appropriate and fair.

Topics that appeared difficult included:

- Cochlear implants

- Development of axons
- Microarrays
- Gersmehl diagrams
- *Ex situ* conservation
- Phosphorus cycle
- Cardiac muscle cells
- Emphysema

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

In most cases, candidates could read graphs and interpret trends accurately. Objective level 1 questions such as 'list' or 'state' were answered correctly by those who had done any studying at all. Questions related to topics on the previous syllabus or on recent examinations were often among the best answered.

Topics for which candidates appeared well prepared included:

- Brain structure
- Reflex arc neurons
- Continuous culture fermentation
- Emergent properties of biofilms
- BLAST
- Mutualism and parasitism
- Components needed to calculate biodiversity/Simpson's Index
- Peptide hormones
- Liver

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

Section A

As with last year's exam, section A was answered more poorly than section B in almost all cases. Many did not seem to have the background in the practical tasks, applications and skills to answer the questions.

Question 1

a) Most candidates struggled to get any marks for (i) and (ii) and this was a question that generated some comments on G2 forms. The vast majority indicated that a 'respirometer' was used although this is used for respiration rates in germinating seeds or small invertebrates (topic 2.8). A variety of correct types of apparatus were acceptable. It was obvious that some candidates had used displacement or volume balloons, pressure meters or chest belts and data-loggers, but they were not able to give any details. Even inhaling deeply before exhaling completely or having all participants in the same standing or seated position was seldom mentioned.

b) It seems that many candidates do not read the questions carefully enough. This question starts with "Using the information in the table". Therefore, simply mentioning 'increase in

pulmonary function' did not score a mark as reference to the data in the table on FVC or FEV was required.

c) Candidates were not considering controlled variables for this particular experiment but rather seemed to equate this to an exercise practical such as a timed run. A factor such as age, height or gender was expected.

Question 2

a) Very few could do the magnification calculation, which has been the case in the past as well. Some answers had ridiculously high magnifications. Students should be taught to check the reasonableness of their answers. Please note that it is expected that candidates will have basic equipment with them such as a calculator and a ruler. IBDP Coordinators should see that these items are available. It had been noted in last year's subject report for HLP3 under Recommendations and guidance for the teaching of future candidates that candidates should "Bring a ruler to the exam".

b) Unfortunately, many candidates had only a vague idea of the steps for focusing a light microscope. Some were able to get a mark for indicating that the lowest power lens was used first or for indicating the sequence of using the two focusing knobs. Descriptions (large knob and small knob) were accepted in place of correct terminology yet most candidates still could not get the points.

c) Most candidates could successful state an advantage of a light microscope over an electron microscope. However, some incorrect answers showed misconceptions by a sizeable number such as the idea that more detail could be seen under the light microscope.

Question 3

a) Many stated the trend of the graph rather than offering a hypothesis for the decline over the years. However, one mark was often awarded for indicating a factor that could be responsible such as pollution or change in water temperatures or for indicating that there was a decrease in plant, algae or phytoplankton numbers.

b) Candidates generally knew what a mesocosm experiment was but few were able to get more than 1 mark, usually for either controlling conditions or not mimicking natural environmental conditions accurately. Many tried unsuccessfully to relate this to chlorophyll levels in the Bay itself. Setting up a sealed mesocosm is prescribed practical (5).

Section B

Option A: Neurobiology and behaviour

About 25% of candidates chose to do this option and they scored a wide range of marks.

Question 4

a) Most were able to state that there was a positive correlation between the volume of white and grey matter.

b) The development of axons was very poorly understood with few marks awarded except to the most knowledgeable candidates. Some candidates wrote about synapse development, neural pruning and other related topics that did not answer the question.

c) This was one of the better answered questions in this topic with many able to get 2 or 3 marks. However, there were also a number of errors in the answers. Candidates achieved marks for knowing that there was specialization in the regions of the brain, but the answers were often lists (with mistakes) of functions in the different lobes. Also, candidates need to be clear that a greater surface area is not the same as a greater surface area to volume ratio.

d) Candidates also found this question very difficult and few could give a reason for the large energy requirement of the brain. Just “there are many cells” is not the answer.

e) Almost all those of grade 3 and above could state an activity of the medulla oblongata.

Question 5

a) Very few could successful answer this question on the use of cochlear implants. Many confused these with hearing aids.

b) Surprisingly few candidates named the semi-circular canals.

c) This question showed a wide range of results with those achieving the higher grades doing well. Most candidates seemed to know something about the process of light reception by rods and cones but marks were lost because they didn’t directly answer the question about the bipolar cells.

Question 6

Most candidates could achieve marks on the sub-sections of this question, perhaps as they were not significantly different from the old syllabus.

a) Most could read the graph and get one mark and many were able to get both.

b) This question also provided an easy 2 marks as many knew the different types of neurons in a reflex arc.

c) Conditioning in rats seemed to have been covered in schools but there were many imprecise answers. The markscheme for the question on learning did allow for some fairly general answers.

d) There are so many types of innate behaviour that the possible correct answers were very wide ranging. This resulted in several unusual examples, some of which were not clear whether the behaviour was truly innate.

Question 7

There were a wide range of responses to this question with the occasional one being very good, but many were very disorganized and confusing to read. Some could not distinguish

between excitatory and inhibitory psychoactive drugs or incorrectly mentioned cocaine or heroin. Those that had the correct examples were rarely able to explain the neurological effects.

Option B: Biotechnology and bioinformatics

Once again, this option was selected by very few candidates which is unfortunate as it is quite interesting and topical.

Question 8

a)(i) For those who were able to answer this question, most received a mark for mentioning methanogens

a)(ii) All candidates struggled with this section of the data-based question on biogas and did not score many marks.

b) Most candidates could score 1 or 2 points on continuous culture and some scored the full 3 marks.

c) As this was a 'distinguish' question, some comparative word was required, not simply a description of Gram-positive and Gram-negative bacteria. Only better candidates were able to do this clearly.

Question 9

a) Many got a mark for this question on open reading frames by stating that they were between a start and stop codon but seldom was a second marking point seen.

b) What the branching off point of the cladogram represented was poorly explained by most candidates.

c) Many struggled with this question on introducing DNA into protoplasts. Those who did get marks understood what protoplasts were and could outline one technique, usually a physical method such as microinjection or biolistics.

Question 10

This question was well answered with most candidates able to give one example of an environment in which biofilms could be found for (i). The second part was quite discriminating with most being able to get one mark and more knowledgeable candidates able to get full marks on emergent properties of biofilms.

Question 11

a) There was some confusion amongst the candidates between genetic markers and marker genes. Due to a lack of clarity in the syllabus, the mark scheme allowed for answers that referred to either.

b) This question was poorly done for two reasons. Candidates were confused as to what they had to do to 'evaluate' (give strengths and limitations). Many also wrote about the use of viral vectors in genetic engineering rather than gene therapy.

c) There were very few good, clear answers to this question on microarrays.

Question 12

In general candidates had a better understanding of BLAST and its applications than other sections of the option B syllabus. Many candidates scored well here, however, clear, well-worded answers were seldom seen.

Option C: Ecology and conservation

This was a very popular option but many of the candidates selecting this option seemed poorly prepared and good, clear concise answers were seldom seen. question 13 was generally well answered while parts of the other questions proved very difficult for the candidates.

Question 13

a) Describe "body length frequency" was a bit confusing for some candidates as they described the range rather than frequency. However many were able to achieve a mark here.

b) This sub-question was generally well answered. There were several comments on the G2 forms about the difficulty of placing parasites in a trophic level and thus the suitability of this question, but candidates did not seem worried about this.

c) Quite a lot was required for the 2 marks but many candidates answered this correctly, although there were some vague examples given.

Question 14

a) This question on nutrient flow using a Gersmehl diagram was rarely answered correctly and even when a mark was awarded, there was usually a lot of additional writing by the students that didn't directly address the question. It was almost as if the mark was reached randomly by guessing. Candidates tend to link all environmental problems together without distinguishing between effects of ozone depletion, global warming, acid rain and other issues.

b) About half of the candidates knew what an indicator species is. This is a "Define" question so there was no mark for an example. There are a wide range of definitions but one is included in the syllabus. Some students were thrown off by this simple question appearing under the taiga question above as they tried to link the two together which was not required.

c) Many candidates were able to get 2 out of 3 marks on this question on biomagnification. One was often awarded for an example, commonly DDT or mercury. Some tried unsuccessfully to relate this to indicator species in the question above it.

d) Many could correctly answer this question on alien species.

e) Better candidates could relate this to flow of matter but most seemed unclear as to what closed or open ecosystems were.

Question 15

a) Most candidates struggled with the data provided on elephant breeding as well as the command term 'evaluate'. Most simply calculated or stated a number. As there did appear to be some incongruity in the data provided, what was being looked for was an idea of being successful or not.

b) Many did not know what *ex situ* meant and did not relate their answer to conservation. Many vague responses were seen.

c) This question asks about calculating biodiversity so the answer expected two things that were numerical. This was done well by many as candidates seemed to know the Simpsons Index. However, the vague word "amount" was often seen and was not very helpful and often confusing in this case.

Question 16

a) This question was very poorly done. Many did not understand the graph and seemed to misunderstand the questions. For example, many students described the trend in the graph but did not discuss the implications of future phosphorus depletion. A noteworthy number of candidates felt that the graph implied that the scientists had it wrong since they thought the graph "showed there was more phosphorus every year". Only some seemed to know anything about phosphorous and its use in fertilizers and agriculture.

b) Few know the phosphorous cycle so did not score marks here. Saying how it was different from the nitrogen cycle required knowledge of both. This was again an example of candidates not understanding command terms as most students did not realise what they had to do to answer this question.

c) There was some understanding of conversions of nitrates in the nitrogen cycle. Many candidates could achieve 1 or 2 marks here despite very vague and poorly worded answers.

Question 17

Many candidates did not answer the question asked on factors affecting the exponential phase of population growth. Thus, it was surprisingly poorly answered by some with many rambling accounts of human population growth, carrying capacity, natural disasters and irrelevant examples. Stronger candidates focused on natality, mortality and lack of limiting factors and were able to score full marks.

Option D: Human physiology

This was also a very popular option and it was a good discriminator between candidates. In Option D, students could effectively identify the trends in the graphs.

Question 18

a)(i) There was a comment on the G2 forms about the use of 'quartile' in the data of this question as it is not on the list of mathematical requirements. Candidates did not seem confused by this and in fact, many are seen to use such graphs in their internal assessment work. What candidates generally did not realize is that a trend cannot be determined from simply seizures/no seizures. Despite this, most were able to get the one mark even if the answer was imprecise.

a)(ii) Candidates carelessly lost the mark as they did not relate the reason to 'these infants' who were all breastfed.

b) Many knew that vitamin D production by humans occurs in the skin when exposed to UV light but others carelessly said that a person 'gets vitamin D from the sun".

c) Almost all got the mark on essential amino acids.

d) There were many cases of candidates not reading the question carefully and thus losing an easy mark. This question did not ask for characteristics of villi but the cells that line the villi.

Question 19

a) The graph threw students off and many focused on the mean values as opposed to the distribution, thus not earning any mark.

b) Many candidates confused this with cardiac cycle or the heart overall rather than structure of cardiac muscle cells linked to transmission of impulses. Most had difficulty in saying how the structure linked to the function. Only the stronger candidates received more than 1 mark.

c) Although candidates had probably learned the cardiac cycle, explanations of the reasons for the delay in contraction between atria and ventricles were poor. Candidates were unsure if the question wanted the mechanism by which the delay was achieved in the heart or if they should write about the end result of that delay. Other candidates ignored the question asked and described the cardiac cycle. Seldom were 2 marks awarded.

Question 20

a) Most students could achieve one mark for seeing that more milk intake led to higher iodine levels but only some were able to see another valid point. Many seemed unclear how being asked to "deduce" was different from being asked to "describe".

b) Examiners were surprised by how many did not know this simple question on the use of iodine. Many students clearly identified the link between iodine intake and the thyroid gland, while only a few could say what the link between the two was. Some weaker candidates seemed to think its function was related to urine production due to the question being asked after the graph on urinary iodine levels.

c) This was an easy 3 marks for those who studied at all since questions on peptide and steroid hormones have been asked regularly in the past. However, a fair number of students focused on growth hormones.

Question 21

a) Answers to question a)(i) on emphysema were very poorly worded and often relied on general knowledge rather than on the changes in the lungs such as the rupture of alveoli and the decrease in surface area of the lungs. While this question did overlap with material form the Core of the syllabus, it is expected knowledge to understand a treatment for emphysema which is in the option and was asked in a)(ii).

b)(i) Unfortunately, a text box was included although the question asks that a curve be drawn on the graph. Imprecise drawing on the graph lost several candidates the mark.

b)(ii) There was some confusion in the answers about the release of oxygen following the Bohr shift, even though the graph had been drawn correctly to the right in b)(i). However, stronger candidates were often able to get full marks for Question 21.

Question 22

This was the most consistently high scoring question on the paper and even weak candidates could score fairly well. This has been such a common, standard question which schools have practiced from past papers. Thus, sometimes candidates did not focus on what the question asked. Irrelevant material such as detoxification and the role of the liver in control of nutrients was often included.

Recommendations and guidance for the teaching of future candidates

Preparation of candidates is essential. Many of these recommendations have been made in the past but teachers do not seem to be heeding them.

1. Command terms (see page 166-167 in the biology guide)

- All examiners comment on the fact that lack of understanding of what is required by a question hinders candidate performance.
- As in the past, but possibly even more so due to changes in how the subject guide is presented, teachers must spend more time on these command terms or verbs.
- Teach and practise command terms in class and on homework, tests and exams to ensure candidates are familiar with what is expected by each verb.
- The objective level 3 words are particularly important as candidates often do not seem to know what is expected from words such as ‘evaluate’ or ‘suggest.
- Practise the differences between Outline, List, Describe, Explain, Compare and contrast, Evaluate, Discuss. Use the same context to practice these terms.

2. Course details

- Teach the details of the option and do not leave complex topics to candidates to cover

on their own.
- When dealing with ‘named’ examples these should be specific illustrations of concepts in the syllabus.
- Look up details to topics which may not be familiar to you as there are new topics in the syllabus.
- Teach all “Understandings” in the syllabus to objective level 3.
- Some candidates still seem to have been taught content from the old specifications. Ensure teaching notes do not contain any material from the previous syllabus.

3. Practical work, skills and applications

- Candidates need to pay more attention to the required skills and practical work and the methodology of the labs.
- During practical sessions, teach students to be precise in the recording of their practical work and in their explanations of what they have done.
- Review these prior to the examination session.

4. Biological language

- Students should be taught to write scientifically and to be scientifically literate.
- Teach the vocabulary of biology as candidates need to use subject-specific vocabulary in their answers. They must have access to a strong vocabulary of subject-specific words and concepts.
- Build up a glossary of terms used in the programme, particularly those that could be confusing, e.g. testes and testa.
- Candidates use terms such as 'cell', 'tissue' and 'body' as if they were synonymous, and they equate 'species, 'population', 'organism' and sometimes 'animal'.
- If candidates are at a loss for words they will be unable to express their ideas with clarity.
- Candidates’ answers were often too superficial for HL biology. This is true irrespective of whether candidates were learners of English as an additional language or not.
- The word 'amount' should never be used in any quantitative answer.

5. Use of graphs

- Students should be taught to interpret data in different forms using a variety of graphic presentations.
- Practise Section A type questions.

6. Use of past papers

- Past paper practice is an effective way to help students prepare for the exams. However, there seems to be an overdependence on material from the previous syllabus.
- Give students experience of deconstructing past questions. This should teach skills of analysis.

7. Examination techniques

- Examination techniques need to be taught and practised from the beginning of the programme.
- Read the instructions carefully before beginning the exam.

- Read questions carefully, command terms in particular. Too often, candidates are writing responses that contain correct biological information, but unfortunately that information does not address the question being asked.
- Coach candidates on how to structure longer response questions. They should take time to consider what is relevant to the answer of the question and leave out what is irrelevant.
- Encourage candidates to highlight or underline the key words in the question and plan their answers.
- Do not repeat the question or stem in the answer box. This is not awarded any marks and uses up space needed to answer the question.
- Do not write outside the answer box as this will not be visible to examiners. Use continuation booklets instead. However, few candidates gained extra marks by writing on additional pages as most of the additional page material simply repeated what had already been stated. The best students gave a sufficient number of points in the space provided.
- Use the command terms and the number of marks available as a guide as to how much detail is required. A one-word answer is not enough for 2 marks or for an 'outline' question.
- Be specific and use correct terminology. General answers do not receive any marks.
- Diagrams often help, especially in the longer response question at the end of each option.
- Write legibly as examiners can only mark what they can read.
- Bring a ruler to the exam and use it to read graphs more accurately or to measure if necessary.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 9	10 - 11	12 - 14	15 - 18	19 - 21	22 - 30

General comments

As with the higher level paper, there were more questions in this exam that required careful thinking and fewer that could be answered by simple factual recall than in previous years. This is because assessment objective 3 is now tested in Paper 1, whereas before it was not. It is to be expected that candidates' mean scores will be lower, but grade boundaries will reflect this, so candidates are not disadvantaged.

In the report that follows comments will be concentrated on questions that either performed badly or were criticised by teachers. Most questions were very successful questions and proved to be appropriate both in terms of difficulty and discrimination. There were however a small

number of questions that proved to be too difficult and also some that teachers criticised on G2 forms. All of these will be discussed in this report.

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

Absorption and re-emission of radiation in the atmosphere is the cause of the greenhouse effect

Identification of parts of a plant cell in electron micrographs

Random rather than directed mutations as the basis for natural selection

Functions of lysosomes

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

Correspondence between base sequences and amino acids in the genetic code

Location of collagen in the human body

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

Question 1

Common question with HLP1

Question 2

Common question with HLP1

Question 3

Proved to be too difficult for most students. It was based on the structure of eukaryotic cells. The candidate had to work out that plants have DNA in three organelles, including the mitochondrion and chloroplast. If they knew that ferns are plants, or that none of the other three organisms in the possible answers are plants, they could then select the correct answer. Only 30% of candidates managed this.

Question 6

Common question with HLP1

Question 7

Common question with HLP1

Question 8

Common question with HLP1

Question 10

This was another question that many candidates found hard and only 28% got it right – scarcely more than the percentage expected with guessing. Some teachers commented that two answers seemed to be partially correct. The most popular reason with candidates for the rate of reaction scarcely rising at high substrate concentrations was that an optimum rate has been reached. This was not accepted by the examining team because there is no optimum rate for an enzyme-catalysed reaction. We might identify optimum pH or temperature conditions at which the rate is maximal, but we would still not refer to this as the optimum rate.

The expected reason was that the active site is saturated. This is not entirely true as theoretically the curve on a graph continues to rise at high substrate concentrations, and though the rises are smaller and smaller, there is never total saturation. Despite this, saturation was the best answer and the only one that was accepted

Question 14

Only 45% of candidates placed the phases of meiosis II in the correct sequence. The commonest error was to put metaphase before prophase. The image of metaphase showed the chromosomes on the equator, whereas in prophase they were distributed through the nucleus. A very high discrimination index showed that stronger candidates were successful in this question.

Question 15

This question did not discriminate very well between the candidates, probably because the ideas involved in were too difficult. The statistics suggest that some of the weaker candidates guessed correctly and some of the stronger rejected the idea that a gene could code for more than one protein and instead decided that the proteome could contain a larger number of proteins than genes because some proteins are made of more than one polypeptide. This would of course result in fewer proteins than genes in the proteome, rather than more.

Question 16

Some teachers expressed concerns about this question. While the wording ‘is affected by’ is rather loose, the correct answer was undoubtedly that non-disjunction happens in anaphase and that in meiosis I it is chromosomes that are failing to separate, not chromatids.

Question 18

Common question with HLP1

Question 19

The low discrimination index for this question shows that some of the stronger candidates answered it incorrectly. The answer that they mostly chose was that water acts as a greenhouse gas because it absorbs UV radiation but does not then re-emit it. This is perhaps a sign of confusion in candidates' minds between the greenhouse effect and the absorption of UV light by the ozone layer.

Question 20

This question also exposed another error of understanding in many candidates' minds (and also in the minds of some teachers commenting using G2 forms). Two thirds of candidates thought that use of antibiotics causes bacteria to respond by mutating to become resistant to the antibiotic. There is of course no mechanism for this, other than epigenesist, which we should not regard as a type of mutation. As ever, candidates do not all have a firm grasp of evolution by natural selection and often do slip into Lamarckian explanations such as this.

Question 22

This was not a successful question. Fewer than 20% of candidates answered it correctly and the discrimination index was low. In retrospect, it was not reasonable to expect candidates to know that both eukaryotes and archaeans have histone or histone-like proteins, especially as the program states specifically that it is eukaryotes that have them. For this reason, two answers were accepted so that candidates would get the mark as long as they knew that eukaryotes have histones.

Question 27

Common question with HLP1

Question 29

This was another question where few candidates were successful, but a high discrimination index shows that stronger candidates tended to choose the correct answer and weaker candidates one of the incorrect answers. The question asked what keeps blood flowing away from the heart in an artery. Most candidates chose valves as their answer, but these only prevent blood from flowing in the wrong direction. The correct answer was that elastic fibres keep blood flowing.

Question 30

Only a third of candidates answered this question correctly. A common error was to think that lysosomes are involved in the secretion of digestive enzymes from a pancreatic cell. Some candidates also thought that free ribosomes rather than rough endoplasmic reticulum were involved.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 16	17 - 23	24 - 30	31 - 37	38 - 50

General comments

Of 132 teachers who completed the G2 questionnaire 83% found the difficulty of the paper to be appropriate and 16% suggested that it was too difficult. Most thought that the exam was of similar standard to last year (49%) with 38% suggesting that it was more difficult.

Presentation and clarity of the paper was described as good, very good and excellent by 95% of teachers who reported. The specific comments of teachers are included with specific questions in the next sections of this report. Thank you to all the teachers who responded to the G2.

Scores for 2017 were very similar to the scores for 2016 showing that teachers and candidates are working with the new syllabus constructively. The scores are comparable to those of 2015 which tested the old syllabus.

On this paper, an interesting phenomenon was evident. Students seemed familiar with global warming, stem cell research and GMOs. Unfortunately each of these topics is also widely reported in the media in unscientific contexts and these kinds of comments made their way into student answers repeatedly. Candidates tended to respond reflexively to ideas commonly in the media without bringing their scientific thinking to bear and this was a downfall on a number of answers in this exam.

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

Reading questions and finding out exactly what is being asked

In section B. the students had to put together a sequence of events to answer the questions. Most had difficulty with this format. They had difficulty developing an argument.

Analysing and interpreting data was not done well. There was lots of repetition of one idea without teasing out the significant meanings.

Life functions of *Paramecium*

Details of Pasteur's experiments and/or falsification of spontaneous generation of life

Molecular biology especially translation and base pairing

Basic understanding of hormones and of leptin in particular

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

Data base question was managed on superficial levels with some success.

Stem cells

Genetic modification and biotechnology

Decomposers

Digestion

Fatty acid structure

Cladograms

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

Question 1

Teachers commented that the data based question (question 1) relied heavily on an understanding of chemistry that biology students do not necessarily have, nor are they expected to have. The markscheme was generous in this regard to compensate. It should be noted, that some candidates did well on this question only.

a): Easy for most.

b): Both marks often awarded.

c): Some forgot units, or the superscript 2 (^{2}) after mm; more than one correctly calculated 40% smaller.

d)(i): Significant factor usually identified correctly; many earned both marks.

d)(ii): Candidates usually answered that thinner/smaller/weaker oyster shells lead to more attack by gastropods. This question was challenging because of the two sets of conditions given in the data i.e. how the oysters were raised and how they were presented to gastropods. In spite of this challenge, many excellent answers were seen.

d)(iii): Some confused shell and radula of gastropod; similar numbers drilled regardless of conditions was often overlooked.

e): Candidates did not get the marking point about limitations even though limitations are expected in response to the command term “evaluate”. Candidates usually provided a review of the results; no student considered how exaggerated the CO_2 concentration was. The data was often not referenced in answers.

Question 2

Several teachers commented that question 2 seemed disconnected, however, it may be noted that 2a, b, c all come from topic 1. Some felt that contractile vacuole of *Paramecium* was not on the syllabus. However topic 1.1 specifically expects the life functions to be taught through the vehicle of *Paramecia* and homeostasis is specifically a function of contractile vacuoles. The current syllabus need not list every term to be used in assessment. The case in point, the term decomposer is not given in the syllabus, but most candidates scored marks for 2d as they had learned about decomposers as part of either the carbon cycle and/or as part of energy transfer in ecosystems.

a): It was evident that many of the candidates did not understand the question or had not studied spontaneous generation and Pasteur’s experiments. Wide latitude was allowed in the markscheme so that average candidates scored some marks. There were some really spectacular answers especially among the stronger candidates.

b)(i): Many got the function of cilia.

b(ii): Contractile vacuole had the fewest correct answers; the question did not discriminate well among candidates. Few candidates seemed to know about the expulsion of water or homeostasis; many wrote about nutrient or water storage, also some vague references to metabolism were made; generally poor answers.

c): Very well answered by many. However, some candidates were not able to distinguish between adult and embryonic stem cells so lost marks for confusing the two.

d): Very well answered. Candidates understood the action of decomposers and the nutrient recycling. Unfortunately, several wrote about recycling energy. Energy is not recycled within ecosystems.

Question 3

a): Often two marks were awarded for X = short-wavelength and Y = long wavelength; unfortunately, some reversed the wavelengths and lost both marks, some knew that X could be both short- and long-wavelength since it is solar radiation; X = UV and Y = IR were also accepted answers.

b): Most understood the greenhouse gas argument but use of incorrect terms such as reflect, refract or diffract caused confusion in the answers. There were many generalized answers with no mention of greenhouse gases and confusion about heat. Some understanding about this topic is likely presented inaccurately as heat is not a form of radiant energy. Candidates still confuse greenhouse gases with the ozone lay*er.*

c): Too often candidates assumed that flooding the island would be enough of an answer whereas the impact upon the birds needed to be included to answer the question.

Some candidates confused global warming with acidification of ocean water and destruction of coral. Ocean acidification is not an effect of global warming.

Question 4

a)(i): Most candidates answered correctly; this was a non-discriminating question

a)(ii): many recognized the problem of extinction, a few mentioned lack of fossils

b)(i) and b)(ii) were well-attempted, but many candidates did not get points because they did not use precise enough language. For example, "DNA" was not enough since the command term was 'describe' which requires more detail such as “DNA base sequences”

c): This question was obscure, but more than the expected number of candidates managed to get 2 marks.

Question 5

a): This question was poorly answered as candidates outlined base pairing in the context of transcription rather than translation. Better performing candidates answered this question fully.

b): Often well answered and well understood. Some candidates described DNA replication mechanism in detail rather than Taq PCR replication mechanism. Inability to sequence the process was evident in many answers.

c): Considerable knowledge was shown by many candidates with regard to benefits and risks of GMO crops. Weaker candidates failed to link points in their arguments and only gave a partial answer, so lost marks. Many candidates based answers on unscientific misconceptions. Weaker candidates based their answers on chemicals being used on crops misunderstanding the basic premise of GMO production. They wrote about chemicals damaging the soil and run-off from fields causing damage to wildlife. Herbicides and pesticides were confused. The classic misunderstandings that GMO plants, through being engineered, inherently contain toxins and "chemicals" that are directly harmful to humans, or contain cancer-causing "chemicals" was common.

Question 6

a): Understanding here was mixed with many excellent answers. Weaker answers tended to make generalized statements about the role of the small intestine with not enough accurate detailed information given. Some answers did not mention an enzyme or its action, where the digested products went and neither was there much mention of the lacteal/lymphatic system.

b): Some very clear answers but some got muddled with the double bonds and the type of fats as well as confusing the structure of *cis* and *trans* fatty acids.

c): Responses demonstrated shallow understanding. The notion that leptin levels are a response to a single meal was common, Answers often said that leptin is produced by the hypothalamus/secreted in brain. Many answers stated the function as controlling appetite rather than suppress or inhibit it. Many thought that leptin was released after a meal and thus lost marks as it is a long-term hormone.

Recommendations and guidance for the teaching of future candidates

Continue to incorporate real data based questions consistently. Interpreting data is a life skill and highly valued. This part of the curriculum is invaluable and unique. So, regularly confront students with the task of interpreting research results that, collectively, show data presented in a variety of ways. This could be done with the whole class, in small groups, or even individually. Previous IB data analysis questions could be a ready resource for such an activity as could complex data collected by students during the practical programme.

No part of the guide can be overlooked. 'Applications' and 'skills' sections are meant to amplify the 'understandings' sections through specific examples. The sections depend on each other.

When dealing with questions in class or on exams, students must focus answers on what is asked. When reading questions, have the students underline key terms and phrases in the question that ensures that they focus answers on the specific question, and thus avoid irrelevant answers. Answers on controversial topics should be based on evidence not unsubstantiated claims that may have come up in class or elsewhere. Substantial checking and cross-checking of reliable sources is expected.

When scientific curricula are more specific than popular media presentations candidates sometimes get these confused and blur them together. This should consistently be discussed with students. For example: (1) UV radiation coming through thinner ozone is not the same thing as greenhouse effect, even though both involve radiation. (2) Acidification of ocean is not the same thing as global warming, although both are influenced by rising CO_2 levels. (3) Adult stem cells have different limitations, different efficacy and different ethical considerations than embryonic stem cells, even though both are "stem cells."

Pupils are clearly exposed to a lot of false claims in the media about GMOs, I think teachers have a responsibility to share the facts and help pupils to come to informed opinions. There were a lot of answers stating they cause cancer, birth defects etc. Train students to discriminate in TOK and science classes between media presentations of science content and "real science." This is often blurry in student responses and weakens their summative exam performance.

The requirements for the command terms *evaluate, discuss,* and *explain* need to be made clear. When having a class recitation on content, be aware that a “discussion” may not be an accurate way to label the class activity.

Teachers need to emphasize in class to the students that the command terms are critical to being able to answer the questions correctly in both class activities to develop critical thinking

skills and on exams to achieve full marks. A useful activity is to teach the development of an idea through three objective levels. For example, take a topic and answer as ‘state’ or ‘list’ then ‘outline’ or ‘describe’ then ‘explain’ or ‘evaluate’. Have students recognize how much more is required as the answer is pushed from objective 1 through objective 3 levels of thought.

Use of scientific language/terms must be encouraged. It is an expectation of this course that the candidates will develop a full vocabulary of terms beyond the words used in the subject guide. Having students develop flashcards and vocabulary lists to edit, share and study could be very helpful.

Create a list of historical experiments to be studied. Find or develop data analysis questions like question 1 using the historic findings. Have students research the findings and develop such questions.

In reviewing mock exams, point out exam-taking strategies to enhance success. For example, look at the number of marks awarded and try to provide at least that many components to the answer.

Please encourage students to work on their penmanship. Many papers were extremely difficult to read and took twice as much time to mark in comparison with previous years. Students need to learn how to write legibly and fluently. Papers written in pen produced better scans.

Further comments

Overall, it was a paper of an appropriate level of difficulty.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 3	4 - 7	8 - 11	12 - 15	16 - 20	21 - 24	25 - 35

General comments

Candidates appeared to be well prepared for the nature of the paper, with only a very few omitting section A. A few weaker candidates answered from more than one option. Most made an attempt to answer all questions within the required sections. Most candidates answered within the boxes but many used extra pages, with those with large handwriting in particular finding it hard to keep to the spaces provided. Section A scored poorly in general. Option D was most often answered followed by C then A. Very few candidates answered option B.

There were 190 G2 responses. The majority of teachers considered the paper to be of an appropriate standard, with sufficient clarity and accessibility, although some felt that it was more

difficult than the previous year. Most critical comments referred to the statistical questions in Section A. The mathematical requirements for Biology are listed on page 23 of the guide, which include the calculation and analysis of standard deviation. Other information relating to the scientific method can be found in "The understanding of science" on page 8 of the guide. It is also assumed that students will be familiar with experimental variables and analysis of data through their experience in the 7 compulsory practicals and the implementation of their IA.

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

The majority of candidates struggled with questions relating to practical technique and data processing in Section A and these were good discriminators. Concise terminology was rarely used and questions involving calculations and graphs were poorly answered in this section and also in the options. Command terms were poorly understood, with candidates often giving detailed answers for an outline and outlining or describing when an evaluation was asked for.

Specific areas of weak knowledge:

Section A

- Significance of standard deviation
- How to deal with outliers
- Relating exercise to increased rate of respiration

Section B

Option A

- Neuronal migration
- Energy requirement of the brain
- Function of semicircular canals
- Role of ganglion cells in the eye

Option B

- Fermentation by continuous culture
- Degradation of benzene by *Marinobacter*
- Environmental risks of GMOs

Option C

- Symbiotic relationship between *Zooxanthellae* and reef-building coral reef species
- Predicting the effect of global warming on nutrient flow (from Gersmehl diagrams)
- Analysis of biodiversity using Simpson's reciprocal index of diversity
- Advantages and disadvantages of *in situ* conservation methods

Option D

- Significance of blood supply from pancreas passing directly to the liver
- Mapping of the cardiac cycle to an ECG trace
- PKU

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

Section A

- Effect of temperature on enzyme activity
- Effect of temperature on the rate of photosynthesis

Section B

Option A

- Neural pruning
- Functional organisation of cerebral cortex
- Labelling of the cochlea

Option B

- Examples of environmental problems caused by biofilms

Option C

- Alien species

Option D

- *H. pylori* as a cause of stomach ulcers
- Use of artificial pacemakers to regulate the heart rate

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

Section A

This was generally answered poorly, with very few marks over 10/15.

Question 1

Candidates who had undertaken Practical 3 – "Experimental investigation of a factor affecting enzyme activity" would be expected to score higher marks in this question.

a): Many candidates understood that standard deviation refers to variation but very few could discuss reliability for the second mark.

b): Although some teachers remarked that the term "outlier" was unfamiliar to students, most understood this in the context of the question. However the majority would delete the outlier as it skewed the data. Many gained a mark for repeating the trial.

c): Many students correctly saw that increased temperature increased activity (although wording was sometimes awkward). The optimum temperature was often recognized but many saw rate decreasing at 700C rather than after 600C. Some students gave an explanation in terms of kinetic energy and denaturation, instead of an outline.

d): The word "amount" predominated rather than concentration or volume. Candidates appear unfamiliar with the meaning of controlled variables, viewing them rather as independent or dependent variables, thus temperature, time and pH were common answers.

Question 2

a): Most candidates did not understand the question and simply described the graph shown, with no evident comparison or contrast. This question discriminated well at the higher grades.

b): Most answered well but some answers referred to growth, which was not in the remit of the given experiment.

c): The majority of answers used a decrease in carbon dioxide. Biomass was also mentioned, but for a mark answers had to include the direction of change.

Question 3

a): Candidates did not understand that ventilation means breathing so most answers calculated the difference in volume.

b): Full marks could be obtained here with a short answer; however the confusion with ventilation continued and the need for more oxygen rather than air was often not made clear. Candidates did, however, score well across all ability levels.

Section B, option A: Neurobiology and behaviour

Question 4

a): This was a challenging question and many candidates did not attempt it. Even with inaccurate measurement it was possible to gain 2 marks if the calculations were done correctly. Some candidates calculated the rate every hour so had 5 answers.

b): Candidates had difficulty expressing themselves here so marks were hard to award.

c): While many described removal of neurons rather than synapses, marks could still be gained here.

Question 5

a): The majority of candidates answered correctly.

b): More answers were directed only at cerebral cortex functions, providing a list of areas and functions, with a possible 2 out of 3 marks.

c): Very few connected energy with respiration or resting potential, rather writing that the brain has to “work hard” or similar.

Question 6

a): Nearly all correctly identified the left side of the brain, some giving reasons as well.

b): Many knew the function of Broca’s area and scored at least 1 mark.

Question 7

a): The cochlea was nearly always labeled correctly.

b): Many candidates saw the role of semi-circular canals as balance or hearing. Those who recognized the function scored high marks.

c): Many candidates knew that ganglion cells transferred information to the brain and others that they form synapses with bipolar cells.

Option B

Very few candidates answered this option with even fewer demonstrating that the content had been learned.

Question 8

a): Biogas production appears to be poorly understood but some candidates recognized that conditions should be anaerobic or named another factor. Specific bacteria were rarely mentioned.

b): Candidates often chose answers that did not relate to the graph in general, or did not include specific years. The maximum mark was usually 1.

Question 9

a): Most gained 2 marks here, but some did not emphasise the lack of significant difference in transfection.

(b) Few gave a correct answer, with many wild guesses.

Question 10

a): While candidates might correctly describe the greater growth of bacteria with ginger root, they did not read the stem thoroughly so did not relate this to les biofilm forming. There was little evidence that the command term evaluation was noted.

b): Many recognized that microbes should not be in pipes; additional answers were less common.

Question 11

a): The majority answered this correctly.

b): Hardly any candidates knew the (genus) name of this bacterium.

Question 12

Teachers commented on a similar question in SLP2.

Answers were generally vague and related to the effects of any crop on the environment. Most credited answers referred to GM crops becoming invasive or the gene escaping. None mentioned antibiotic genes and there were very few quoted examples.

Option C

This was the second most popular option.

Question 13

Some teachers criticized the diagram as inaccurately drawn.

a): Many answered mutualism; some symbiosis.

b): Instead of naming materials, candidates described how the coral provides shelter. Most top answers named the gases provided via respiration and photosynthesis. It is apparent from this question and part c, that some students do not know that *Zooxanthellae* are photosynthetic.

c): Again some answers referred to shelter.

Question 14

a): While students may recognise a Gersmehl diagram, they are perhaps unaware that taiga has a low temperature therefore global warming would generally increase nutrient flow. Most marks awarded were for increased run-off and very few scored 2 marks.

Question 15

a): The majority of candidates scored full marks.

b): Few knew that cane toads originated in S/Central America. Teachers commented that this had not been mentioned to students and was an obscure detail.

c): Many candidates compared the baited traps to others, with a numerical comparison. Others mentioned environmental problems. Some saw the fact that tadpoles were not killed as a benefit.

Question 16

a): This was a long calculation but clearly those students who scored full marks had practiced this. Others inserted the wrong numbers, so demonstrated that they did not understand what N and n referred to.

b): Even with an incorrect calculation, many students recognized the evenness of A and/or the preponderance of one species in B.

c): A sizeable number of candidates confused *in situ* with *ex situ* conservation. Answers tended to be vague but the better candidates scored full marks here, with clearly delineated advantages and disadvantages.

Option D

This was the most frequently answered option and many of the higher marks were obtained here.

Question 17

a)(i): Nearly all answered correctly.

a)(ii): “Lack of vitamin D” on its own was the usual answer but more detail was required for the mark.

b): Many students write that vitamin D can be “synthesized by the sun”, which did not score a mark.

c): Most students recognise that essential amino acids cannot be synthesised by humans.

Question 18

a): The most common answer was acid action against pathogens and food breakdown. The acid is not for providing an optimum pH as some candidates suggest. Fewer candidates described activation of enzymes.

b): Despite the information provided and a clear graph, few candidates scored full marks here. Many recognized the need for neutralization of acid but few commented on the increase and decrease of pancreatic juice over time as shown on the graph.

c): *H. pylori* was the usual correct answer. Overuse of named drugs was not seen and many answers involved acid, lack of mucus or stress.

Question 19

Only the highest-scoring candidates scored any marks in this question by recognizing the liver as the major target organ for pancreatic hormones. Other answers referred to enzymatic digestion by pancreatic secretions or other roles of the liver such as detoxification.

Question 20

a): Over half of candidates could identify QRS on the ECG trace.

b): Often specific systolic actions were mentioned rather than the whole cycle.

c): Most candidates knew that a pacemaker regulated the heartbeat and a large number could name the SAN.

Question 21

Candidates who understood the term phenylketonuria scored high marks in this question, although by focusing on diagnosis rather than treatment might have lost one mark. Many

students guessed its meaning, with a reference to cardiac problems being common, as if the question were related to the previous one.

Recommendations and guidance for the teaching of future candidates

- Ensure that students have hands-on experience of the seven practicals identified in the syllabus. This should include planning an experiment and identifying the variables. Data recording and appropriate analysis should be taught during these practicals as well as for the IA. In this way, standard deviation and error bars will be understood, as well as other possible data processing methods.
- Provide students with opportunities to do calculations, especially those required in the options. Provide graphs for students to analyse trends using suitable terminology.
- Continue to explain the command terms and provide practice in answering questions. In particular “compare and contrast”, “evaluation” and “outline” need to be made clear.
- Encourage students to give concise and clear answers that do not include the stem. Given sufficient consideration, they should be able to answer within the spaces provided. In longer questions they should spend more time planning coherent answers rather than trying to fill the space with irrelevant information.
- Ensure that the necessary detail in the options is taught and tested. Help students to recognise when a question is asking them to apply their knowledge.