November 2017 subject reports

Biology

Overall grade boundaries

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 - 26	27 - 39	40 - 51	52 - 64	65 - 75	76 - 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. These were a real pleasure to read. Nevertheless, examiners 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, 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. New material is being posted on the Programme Resource Centre, including exemplars that use these approaches. Teachers are encouraged to use these as they may clarify how these approaches would be moderated.

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 which part of the investigation the teacher was referring to.

As in previous sessions, there were several teachers who did not annotate or make comments 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, where possible, support the teacher. Where examiners were unable to support the teacher's mark, feedback was produced, which is available on IBIS.

The IB requested several exam sessions ago that samples uploaded should be completely anonymous to avoid any possibility of bias when being moderated by examiners. In addition, suitable, anonymous work is more likely to be used as exemplar material. Unfortunately, examiners were still finding candidate names, teacher's names, school names and other forms of identification on the uploaded material.

Some material was uploaded upside down. Whilst this problem can be resolved by examiners themselves, it does create further work. The IB are making less allowances for incorrect uploads by schools, therefore it is down to the teacher or Diploma Coordinator to ensure that the work uploaded is exactly what is required for moderation.

Overall, there were more schools which underwent an adjustment to the teacher's marks than in November 2016. Where this happened, personalized feedback has been provided on IBIS, which should be passed to the teacher.

Candidate performance against each criterion

The application of the assessment criteria by teachers was generally good, though often overgenerous, sometimes very generous. There are cases where teachers pointed out significant weaknesses in a criterion but then chose to award the highest grade. Therefore, more rigor is necessary when applying the final mark. Teachers were rarely considered too severe.

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

Personal engagement (PE)

Some form of personal significance was expressed in most cases. While many 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, sometimes exceptional. There were, however, too many cases of classic investigations being used with little or no attempt to modify them.

Personal input is evident in persistence to collect data, in research into the background, 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 by many candidates. For others, it seemed that 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.

A number of examiners observed that teachers seemed to be content awarding 2 marks for statement of purpose at the beginning of the report. Teachers need to look further for evidence before making a judgment on this criterion.

When assessing 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);
- Evidence of trial runs;
- 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 will almost certainly overlap with components of other criteria.

Exploration (EX)

For many submissions, the research question lacked sufficient focus. Scientific names were not always used and the range of the independent variable was not always 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 species of yeast and the sugar used. 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 have been 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 that is clearly linked to the research question. 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 candidate appreciates the other factors that may have an impact on the experiment. Uncontrolled variables, for example, room temperature, which may have a significant impact on the experiment need monitoring. One cannot just assume that carrying out the experiments in the same place is enough. Control experiments needed to be considered more frequently.

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

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

One particular technical error was encountered. Some candidates were using agar cubes (rather than gelatine cubes) to test the activity of bromelain protease in pineapple juice. Agar is a polysaccharide not a protein; bromelain is a protease so it will not digest agar. Some of these investigations were using agar impregnated with a pH indicator as in the classic surface area investigation. Unfortunately, bromelain from pineapple juice is quite acidic so it does cause a change in the indicator as it diffuses into the agar. This seems to have resulted in some confusing results for the candidates. The use of agar in this way seems to be increasing though different schools.

When assessing this 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, or further explained, in a large number of investigations. It is true that some investigations do not have any issues in these areas but there were plenty that did, yet candidates showed little or no evidence of concern. It is not sufficient to identify potential areas where safety is an issue, an indication of how the issue is to be avoided should also be seen.

There were some microbiological methods carried out by candidates that were very inappropriate for a school environment. Feedback has been provided to the schools who did not address this.

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

The use of consent forms with human volunteers is not being universally adhered to. This is an essential ethical practice.

The environmental impact and safety for fieldwork was often ignored or treated superficially.

The following guidelines should be applied:

- Only culture known, non-pathogenic strains of microbes. For example, do not culture from hands or swabs of door handles.
- Bacterial cultures should be obtained from a reputable supplier or from a safe source such as a university microbiology laboratory.
- Do not test for antibiotic resistance. There are enough antibiotic resistant strains circulating in the environment without more being selected.
- 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 plates so they can be clearly identified; 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 following local health and safety regulations.

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, however, 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.

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.

The processing of data varied between schools. Most candidates managed the basics, for example, means and standard deviations. However, there were still candidates who tried to apply a standard deviation to a sample size that was too small (n<5).

There were cases where candidates calculated mean rates by averaging the data for all the trail runs combined, then calculated the mean following this. This is inexact. The rate for each run needs to calculated individually, followed by the mean from all rates.

Candidates are still confusing R^2 with the correlation coefficient r. R^2 is the coefficient of determination. R^2 can be used as an indicator of the goodness of fit of a trend line. It can approximate to the product moment correlation coefficient (r) if the trend line is straight but it is always a positive value, unlike the correlation coefficient which can be negative.

Several candidates used 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, however, 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.

In some cases, measurement uncertainties were presented but not discussed. Candidates are expected to appreciate the limitations of their instruments and, where they have a choice, to select the most 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 other cases, the error bars were incorrectly placed or they had no bearing on what the candidate had calculated.

The interpretation of the data was often well presented after each set of data. However, it was sometimes mixed with the conclusion. The use of statistics may have been satisfactory but they were not always interpreted well. 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, interpretation was handicapped by the limited degree of data processing.

Evaluation (EV)

This was the weakest criterion for many candidates. Although is it a difficult skill for some candidates, it seemed that these were rushed in an attempt to finish off the report. Schools may want to consider further the impact of the conflicting deadlines between each chosen subject, theory of knowledge and extended essays and other requirements of the candidate.

Conclusions were not always supported by the data and some explanations were missing. Some candidates were rather overoptimistic in their conclusions. Clearly the data did not fully support the conclusion made 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. Many examiners commented that candidates were correctly interpreting statistical significance tests but they were not referring back to the research question.

The evaluation of methodology was 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 of 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. This was an area where examiners felt that teachers were often marking over-generously.

When assessing this criterion, teachers should look for the following:

- A discussion of the strengths – this might be quite general or implicit 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 – again, this is not necessary.
- Blank data tables presented at the end of the method section.
- Repetitive tables, when one representative sample would be sufficient.
- Tables split over two pages, or with a title on one page and the table or graph on the next.
- Multiple graphs drawn when these could have been combined. This not only saves space but it also improves and may aid candidates to make better comparisons.
- Squashed graphs so the distribution of the data was difficult to judge. This was often due to the candidates failing to reformat the selected font.

- Bibliography, footnotes, endnotes or in-text citation missing.
- References with an incomplete format. Often just a URL is given.
- Inefficient data table 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, for example, 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 the name should be presented in italics).

Units were occasionally missing and use of non-metric units, for example, teaspoons and cups, were noted by some examiners.

Measurement uncertainties were occasionally missing.

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

In general, the reports were of suitable length.

No automatic penalties were issued for reports that were slightly longer, as long as reports remained relevant and concise, as detailed in the Communication criteria.

Recommendations for the teaching of future candidates

- Teachers should present the criteria as early as possible in the course and spend time discussing the requirements of each criterion with candidates. Teachers may find it helpful to adopt the use of these criteria for the assessment of the labs/investigations/experiments throughout the course, as this will help candidates understand what is expected in their investigation before carrying it out.
- Ensure that the candidate's work has some originality. It should not just be a repeat of a classic investigation.
- Examiners are looking to understand how the teacher has decided on the marks awarded. Therefore, comments to justify the awarding of marks should be made on the work (throughout, where possible, rather than either just at the beginning or the very end of the work).
- Look to apply the criteria more rigorously; access exemplars on the Programme Resource Centre for further understanding.
- 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 teacher support materials in My IB to see examples of individual investigations that are considered adequate. 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 could 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 - 20	21 - 26	27 - 31	32 - 40

General comments

A total of 2712 candidates took the examination: 1754 in English, 703 in Spanish, 254 in German and 1 in Japanese, representing a 26% increase overall, compared to November 2016. A significant increase was seen in Spanish, rising from under 200 candidates in November 2016.

The mean mark for this paper across all languages was 23. The mean was considerably lower for Spanish language candidates, at 19. It was also low for German language candidates, at 18. For the first time, there was one Japanese language candidate at HL, resulting in 25. The mean for the English language candidates was also 25, mathcing that of Japanese.

From the G2 comments received, the respondents believed there was a good range of knowledge questions and application questions where candidates wouldn't have seen them before but could apply their knowledge. They also commented that the experimental questions based on theory were good.

Of the 25 G2 comments recieved, the majority of respondents believed the difficulty of the examination was appropriate (80%), with only a few perceiving it as too difficult (20%).

Compared to last year, most respondents believed the paper was of a similar standard (40%) or a little more difficult (36%), with only some perceiving it as much more difficult (8%) or a little easier (16%).

The suitability of the paper in regards to clarity and presentation in general was good. The clarity of wording was excellent (20%), very good (36%), good (24%) and fair (12%), with some respondents perceiving it as poor (8%). The presentation of the paper was considered to be excellent (20%) very good (52%), good (20%), fair (4%) or poor (4%).

Most respondents agreed that the examination paper was suitable in terms of accessibility and cultural/religious/ethic bias/gender and ethnicity. Only one did not agree but did not give any explanation or reasons for this disagreement. There were some complaints that some questions required a lot of analysis, making the time too short. There is no evidence of this happening, as the number of blank questions has not increased towards the end of the exam.

This paper had many questions with a high discriminating index, showing that good candidates answered the questions well. The questions had a full range of difficulty indices, showing there were questions accessible for all levels.

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

Candidates did not know how a *Paramecium* maintains homeostasis through the contractile vacuole. Many candidates did not know how endonucleases cut the DNA. Questions on leaf structure and function of stomata were not attempted.

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

Candidates appeared to be well prepared in molecular structure of sugars and peptides, karyogram analysis, exchange of nutrients in tissues and seed germination.

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

Question 2

In section 1.1 of the biology guide, there is an application that suggests the investigation of functions of life in the *Paramecium*. The role of the contractile vacuole in the maintenance of homeostasis in these eukaryotic organisms is a nice example of how organisms react to changing environment. Unfortunately, distractor C attracted many good candidates, determining this question as a bad discriminator.

Question 3

Both answers B and D have been accepted, as B is a transmembrane protein and D is pointing to the sugar of a glycoprotein. The small buldge at the bottom of the membrane underneath D could be showing it is transmembrane, therefore could also be a receptor.

Question 4

Many candidates who answered this question gave the correct answer; this question discriminated well.

Question 7

This question did not discriminate well, as although it was a very easy question, some good candidates might have though it was more complicated and chose answer B instead of D.

Question 8

This was a long and demanding question that required candidates to work through all the different permutations of using either the top strand or the bottom strand, and they had to work through both transcription and translation. Most candidates answered this question correctly. There is no evidence that candidates started guessing the answers at the end of the exam showing that time has not been a real concern.

Question 9

This experiment is a skill described in the guide, so it was surprising that many candidates believed that movement of the soap bubble measured CO_2 production rather than O_2 consumption, ignoring the fact there is soda lime present in the bottom of the jar.

Question 10

In section 3.2 candidates need to compare diploid chromosome numbers of *Homo sapiens* and other organisms. It is clear in this karyogram that there are not 23 pairs of chromosomes but a very different number. There is no way that such a large change could happen through non-disjunction. Although 'disjunction' is not a common term used, candidates had to relate this term to 'non-disjunction' in order to deduce that this option is not the answer.

Question 13

Candidates did not perform well in this question. Many candidates answered there were 4 fragments formed instead of 3. This is most probably due to lack of knowledge about endonucleases.

Question 14

The total area of the forest should have read 10,000 m². Many that did not get the right answer considered the number of silver maple trees in the area that was not sampled as being zero, therefore gave answer B.

Question 16

This question discriminated well and seems to be a fair question.

Question 17

This question is a clear example of how all questions need to be read very carefully before being answered. The candidates who did not understand that chordates were being asked for did not get the right answer.

Question 18

Although this was a difficult question, it had the highest discrimination index of the whole exam, meaning that candidates who did well in the whole exam got this question right.

Question 19

Although this was quite an easy question some candidates had trouble answering it. It is important to stress the fact that in a dichotomous key, one should work through all the options starting from 1. The result shows that some candidates have poor knowledge of classification of chordates and the use of this type of key.

Question 23

Although the word "facilitate" might have confused some capable candidates, the most correct answer was type I pneumocytes.

Question 24

There have been complaints that this question was unfair as the syllabus states that the details of structure of different types of neuron are not needed. This is true, but in 6.5 they need to know about chemical synapses and in 11.2 about muscle contraction.

Question 26

This question discriminated very well although it was a difficult question.

Question 27

The question discriminated well. Candidates have studied that in replication nucleotides are added to the 3' carbon of the deoxyribose (in the 5'-3' direction), the only possible answer was B.

Question 28

Protein synthesis in eukaryotic cells is compartmentalized, with soluble proteins being synthesized on free ribosomes and secretory/integral membrane proteins on endoplasmic reticulum (ER)-bound ribosomes. Candidates should know about the structure of muscle fibres and the function of actin and myosin (11.2) therefore infer that they are synthesized in free ribosomes.

Question 31

This question had a very high discrimination index despite being a difficult question.

Questions 33 and 34

Many candidates omitted this question, showing poor knowledge of the practical skills required for plant biology (section 9.1 and 9.2).

Question 35

Many candidates mistakenly chose answer C as it was too close to the truth.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 11	12 - 15	16 - 18	19 - 22	23 - 25	26 - 30

General comments

A total of 3557 candidates took the examination: 1246 in English, 2278 in Spanish (almost double that of English), 30 in German and 3 in Japanese, representing a 13% increase overall, compared to November 2016.

The mean mark across all languages for this paper was 15. The mean mark in Spanish was 14, where the mean in English was 19. A very small number of candidates sat the the exam in Japanese, where the mean was 16. For German language candidates, the mean was 17.

Of the G2 comments received, the respondents believed there was a good range of knowledge questions and application questions where candidates wouldn't have seen it before but could apply their knowledge. They also commented that the experimental questions based on theory were good. Some teachers complained there were too many questions focused on rote learning rather than critical thinking skills.

Of the 42 respondents, the majority believed the difficulty of the examination was appropriate (83%), with only a few perceiving it as too difficult (12%) or too easy (5%). Compared to last year, most believed it was of similar standard (36%) or a little more difficult (36%), with only some perceiving it as much more difficult (2%) or a little easier (22%).

The suitability of the paper in regards to clarity and presentation in general was good. The clarity of wording was excellent (12%), very good (48%), good (14%) and fair (24%), with some perceiving it as poor (2%). The presentation of the paper was considered to be excellent (31%) very good (43%), good (14%) or fair (12%).

Most respondents agreed that the examination paper was suitable in terms of accessibility and cultural/religious/ethic bias/gender and ethnicity. Only two somewhat disagreed but did not give any explanation or reasons for this disagreement. There were some complaints that some questions required a lot of analysis, making the time too short. The fact that 56 candidates did not answer the last question might be an indication that this is the case.

This paper had questions with a high discriminating index, showing that good candidates answered the questions well. The questions had a full range of difficulty indices, showing there were questions accessible for all levels.

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

Candidates did not know how a *Paramecium* maintains homeostasis through the contractile vacuole. Many candidates did not know how endonucleases cut the DNA. Questions on hormones that regulate the metabolic rate, small intestine model and on genetic code were not attempted by some candidates.

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

Candidates appeared to be well prepared in causes of coronary heart disease and homologous structures in the pentadactyl limb.

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

Questions 1, 2 and 3

In section 1.1 of the biology guide, there is an application that suggest the investigation of functions of life in the *Paramecium*. The role of the contractile vacuole in the maintenance of homeostasis in these eukaryotic organisms is a nice example of how organisms react to changing environment.

Question 5

This question discriminated well.

Question 8

Most candidates were able to see what conclusion can be drawn from the graph. A few thought that it showed the hydrogenated nature of margarine was the cause of coronary heart disease. The graph does not mention number of deaths caused by diseases, although it might have confused only a few candidates that answered D.

Question 10

This question did not discriminate well, as although it was a very easy question, some good candidates might have though it was more complicated and chose answer A instead of D.

Question 11

This was a long and demanding question that required candidates to work through all the different permutations of using either the top strand or the bottom strand, and they had to work through both transcription and translation. Most candidates answered this question correctly.

Question 12

This question discriminated very well although it was a difficult question.

Question 15

Candidates did not perform well in this question. many candidates answered there were 4 fragments formed instead of 3. This is most probably due to lack of knowledge of this topic.

Question 17

The total area of the forest should have read 10,000 m^2. Many of those who did not get the right answer considered the number of silver maple trees in the area that was not sampled as being zero, therefore gave answer B.

Question 19

This question discriminated well and seems to be a fair question.

Question 20

This question was too easy, as most candidates had it correct.

Question 22

Although this was quite an easy question some candidates had trouble answering it It is important to stress the fact that in a dichotomous key, one should work through all the options starting from 1. The result shows that some candidates have poor knowledge of classification of chordates and the use of this type of key.

Question 23

This question is a clear example of how all questions need to be read very carefully before being answered. The candidates who misunderstood that chordates were being asked for did not get the right answer.

Question 24

Maltose is hydrolysed by membrane-bound enzymes in the small intestine and the glucose is then taken in by the epithelial cells. The dialysis tube has no membrane bound enzymes, therefore answer B is not plausible. Many candidates believed the fact that starch could not pass the membrane as a limitation to the model. As a matter of fact, this is a strength of the model.

Question 26

Candidates confused antigens with antibodies.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 14	15 - 22	23 - 34	35 - 44	45 - 54	55 - 72

General comments

A total of 2712 candidates took the examination: 1754 in English, 703 in Spanish, 254 in German and 1 in Japanese, representing a 26% increase overall, compared to November 2016.

A significant increase was seen in Spanish, rising from under 200 candidates in November 2016.

Of the G2 comments received, over 90% of respondents thought that the paper was appropriate in difficulty, with the remaining perceiving it as too difficult. Most respondents thought it was of a similar standard to November 2016, with smaller numbers considering it either easier or difficult: slightly more respondents thought it was more difficult. The statistics back up respondents' impressions: the mean mark for the paper was just slightly lower than in November 2016, but the difference was less that one mark out of the possible 72.

Most respondents were happy with the clarity of wording and presentation of the paper, with more than 50% regarding it as very good or excellent for both.

The exam was effective in spreading the candidates over almost the entire mark range. The spread was not even though, with more candidates in the lower half of the mark range than the upper. As in previous seasons there were some weak scores from candidates that did not seem to be properly prepared for the challenges of the higher level course. Nonetheless, there were many excellent, high-scoring performances from candidates whose knowledge and understanding of biology was most impressive.

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

- Advantage of electron microscopes;
- ADH and osmoregulation;
- Photolysis;
- Endosymbiotic theory;
- Peptide bond formation;
- Peat formation.

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

- Hybridoma cells;
- Solvent properties of water;
- Evidence for evolution from selective breeding;
- Seed structure.

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

Section A

Question 1: Data-based question on adaptation to hypoxia

This question proved very effective as all candidates were able to make some progress with it and there were some real challenges for the most able. It was based on mammalian physiology

and candidates whose understanding of muscle contraction and nerve impulses was weak were disadvantaged in some parts of the question.

a) Stronger candidates had no difficulty in deducing the effects of hypoxia, but some others failed to realise that a slower rise in body mass, compared with the control, shows that hypoxia causes body mass to be lower.

b) Again, not all candidates realised that in an experiment such as this the effects are shown by the difference between results for the treatment and the control. The word 'endurance' was used both in this question and in the original research paper to mean the persistence of force generated by the muscle. This was greater in the rats with hypoxia, because their muscle force declined less rapidly over time than in control rats.

c) In questions such as this, careful attention to the command term is required. Candidates were expected to explain the effects of hypoxia by giving reasons for the changes, for example, more erythrocytes to transport oxygen. Many candidates just stated the changes triggered by hypoxia and the examiners did not regard this as a proper explanation.

d) (i): Answers to this question were often very convoluted, with double or even triple negatives. An example would be to state that when the nitric oxide synthase inhibitor was not present the concentration of pumps was higher. A better answer would state that the concentration of pumps is higher when nitric oxide has been produced. When analysing data from a controlled experiment it is important to keep in mind the purpose of the experiment and to draw conclusions in accordance.

   (ii): This question was one of the few on the paper that proved too hard for most candidates. They were expected to base answers on understanding gained from sub-topic 6.5 of the guide, in particular the role of sodium-potassium pumps in generating the resting potential. Instead of focussing on the re-establishment of sodium and potassium ion gradients and thus the resting potential, candidates tended to answer in terms of depolarisation and repolarisation, which are due to channel proteins rather than sodium-potassium pumps. With more pumps, resting potential can be developed faster and muscles can be stimulated at a greater rate to contract.

e) (i): Nearly all candidates knew that hypoxia reduced the force of contraction, but a mark was only awarded to those stating that this applied to both peak tetanic and twitch contraction. About half of candidates were diligent enough to specify this.

   (ii): This was probably the hardest question on the paper and few candidates made very much progress with it. Two types of answer were accepted. One was that loss of volume of diaphragm tissue would increase surface area to volume ratio. The other was that an increase in the ratio would help oxygen uptake by diaphragm muscle cells. Many candidates focussed instead on the effect of the diaphragm on SA/volume ratios in the lungs.

f) This was generally well answered, with candidates using evidence from the data of effective adaptation. In the best evaluations, candidates also gave counterarguments by including evidence that adaptation wasn't fully effective.

g) A variety of arguments was credited here, but vague and excessively generalised answers were not. This is because it is expected that biology HL candidates give better-informed answers than non-scientists. Some candidates seemed unaware that rats and humans are both mammals and that they share many features.

Question 2: Viruses and antibodies

a) The best answers here were based on the idea that electron microscopes give higher resolution and therefore can provide greater magnifications. Candidates were also rewarded for simpler answers stating that viruses are too small to be seen with a light microscope, as long as this was clearly stated.
b) Many candidates stated that antibiotics do not work on viruses because they are not alive. This was given a mark, but it isn't a strong argument because antibiotics do not kill all living cells. The better answers focussed on the lack of metabolic apparatus in viruses and therefore the absence of targets for antibiotics.
c) Surprisingly few candidates knew that plasma cells produce antibodies.
d) (i): The method pf production of hybridoma cells was not well known, although it is a required understanding from 11.1 of the syllabus.
(ii): All that was required here was to state that hybridoma cells produce monoclonal antibodies, or give one of their uses, for example in pregnancy testing. Not surprisingly, candidates who did not know what hybridoma cells were could not give a use.

Question 3: Water and osmoregulation

a) Well prepared candidates drew clear and accurate diagrams to show hydrogen bonding between water molecules but there were also many answers showing errors of understanding. Some candidates thought that it was possible to alter the structure of water molecules by adding extra atoms and others thought that hydrogen bonds are covalent.
b) For reasons that examiners did not entirely understand, fewer candidates wrote about the solvent properties of water than about other properties. Of those who did focus on solvent properties, most stated that water has polar molecules, but it was evident that many did not really understand what this means. Ionic compounds, such as sodium chloride, were often stated to be polar and there were few convincing answers explaining how polar solutes and ionic solutes dissolve in water.
c) Answers were very variable in quality, but included some strong ones explaining clearly how ADH results in the production of small volumes of concentrated urine, so returning the blood to the set point for osmolarity.

Question 4: Ferns and photolysis

a) (i): About half of the candidates correctly identified the fern as a member of the phylum filicinophyta.
(ii): Candidates who were well prepared had no difficulty in stating two recognition features of this phylum.
b) The weakest candidates tended to confuse photolysis and photosynthesis, but most candidates could give at least a partial description. The separation of electrons and protons is of course a critical part of photolysis so it is important to distinguish H and H^+.

Question 5: Crossing over and gene linkage

a) Crossing over in meiosis is often mentioned by candidates when describing sources of variation, but a description of the process was required here, which is harder. There was confusion between homologous and non-homologous chromosomes and between sister and non-sister chromatids. Many candidates revealed a misunderstanding of how crossing over occurs and drew an incorrect diagram suggesting that it happens in the same way that we cross our legs when sitting. This diagram may be in text books, but it isn't how crossing over occurs. Instead there must be a breaking of the DNA molecule in two non-sister chromatids and subsequent re-joining with the other chromatid. This both recombines genes on the chromatids and creates the physical structure of a chiasma.
b) Only about half of candidates could explain that linked genes are on the same chromosome and are therefore usually inherited together, giving ratios different from those that Mendel discovered.

Section B

Question 6: Evolution and gametogenesis

This was the most popular of the three questions section B with more than three quarters answering it.

a) The endosymbiotic theory for the origin of eukaryotic cells was generally well known and there were some very informative answers.
b) All candidates knew something about spermatogenesis and oogenesis and in some cases impressive amounts of evidence were included. A common fault was to write about spermatogenesis and oogenesis separately, leaving it up to the examiner to piece together the similarities and differences. In a question such as this, it is far better to write about both processes together, because that makes it likelier for both sides of a comparison or contrast to be given. It also helps ensure that important principles and concepts are the focus, rather than details that don't have wider significance.
c) This was one of the questions that elicited the poorest answers. Very few candidates really explained how selective breeding provided Darwin and later biologists with powerful evidence for evolution by natural selection. The argument that was almost always missing was that if humans can cause radical changes in a species by selecting artificially which individuals to mate to produce the next generation, then natural selection can do the same. In many answers the word *species* was obviously not understood. There was often an implication that evolution has only occurred if one species changes into another. Evolution can of course occur without speciation.

Question 7: Transcription, translation and insect excretion

This was the least popular question in section B, with fewer than half of candidates attempting it. It tended to be chosen by strong candidates, as the three parts of the question all required secure knowledge and understanding.

a) Answers were mostly impressive with two amino acids accurately represented and then a dipeptide plus water.
b) As in 6 b), there was a tendency to write first about transcription and then separately

about translation, leaving the examiner to do most of the work in distinguishing between these two processes. Some candidates used a table to construct an answer. This can work well, but the most impressive answers were a series of sentences, each giving a difference between transcription and translation, typically with the word *whereas* linking the two halves of the sentence.

c) This was an opportunity for well-prepared candidates to impress with their knowledge and understanding of nitrogenous excretion by the Malpighian tubule system of insects. There was a deliberate move to include comparative physiology in the last curriculum review and this is one of the topics included as part of that initiative.

Question 8: Seed structure, water transport in plants and peat formation

This question offered candidates who appreciate the importance of plants to show their knowledge.

a) The internal structure of seeds was not well known and there were few convincing drawings. The most successful were representations of the dicotyledonous seed structure of a bean.

b) Candidates found this question relatively easy, especially water uptake by the root. In some answers, there was more attention paid to apoplastic and symplastic water transport across the root than expected, as these processes are emphasised less in the current than previous program. A common misconception is that adhesion between water and the wall of xylem vessels can cause water to move up from roots to leaves. If xylem is already filled with sap, adhesion cannot make the sap rise. Adhesion is important in keeping pores in leaf cell walls water-filled, when evaporation could cause these walls to dry out.

c) Peat formation is an important process in these times of excessive atmospheric carbon dioxide concentrations, so it was very pleasing to see widespread understanding from November 2017 candidates. Many candidates scored full marks and very few knew nothing about peat formation.

Recommendations and guidance for the teaching of future candidates

- Success in biology HL will only be achieved after diligent study of the program.
- Answers to data-based questions should be based as far as possible on biological understanding.
- In experimental biology, the effects of treatments are determined by comparing the results for treatments with control results.
- When drawing conclusions in biological research, the aims of the investigation should always be borne in mind.
- Groups of superficially similar words can cause confusion in biology, for example, antibiotic, antibody and antigen. Particular care is therefore needed in these cases.
- Answers should only be written inside boxes on the exam paper. The space is sufficient for the expected answer but if a candidate needs to continue their answer, an additional answer booklet should be used instead of continuing their answer outside the box on the same page. Examiners have been advised to read all extensions to answers but answers outside the box are easier to miss than answers in an additional booklet.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 4	5 - 9	10 - 15	16 - 21	22 - 28	29 - 34	35 - 50

General comments

A total of 3557 candidates took the examination: 1246 in English, 2278 in Spanish, 30 in German and 3 in Japanese, representing a 13% increase overall, compared to November 2016.

Of the G2 comments received, 90% thought that the paper was of an appropriate difficulty, with most of the others thinking it too easy. 63% thought that the paper was of a similar standard to November 2016, with an almost equal split of the remainder between those thinking it easier and more difficult. In reality the overall mean mark was about 3.5 lower than last year, with the English language candidates dropping 2.3 marks, and Spanish language candidates dropping by 3.6. Interestingly there were 23 G2 comments from English language schools, but only 18 from Spanish language schools, even though the Spanish candidate entry was almost twice as much.

Many teachers commented that the questions in section B were not as straightforward as in previous years.

About 86% and 90% respectively said that the clarity and presentation were good to excellent

There were mixed comments about time, with most commenting that the time was sufficient, but others that there was too much in the paper for the time limit. Markers did not report that the candidates seemed to be rushing to answer the last questions.

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

- Knowledge of the bonds between water molecules and the solvent properties of water (topic 2: molecular biology, 2.2: water) was extremely poor for the majority of candidates.
- Few candidates could thoroughly discuss the roles of the enzymes secreted by the pancreas during digestion (topic 6: human physiology, 6.2: digestion and absorption). Few candidates could successfully outline natural cloning methods (topic 3: genetics, 3.5: genetic modification and biotechnology). There was only meagre understanding of how peat is formed (topic 4: ecology, 4.3: carbon cycling)
- Classification of the filicinophyte was poor (topic 5.3: classification).

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

Many parts of the data analysis question were answered reasonably well. Candidates generally showed good comprehension of the data, regardless of its format. Knowledge of the usefulness of an electron microscope (topic 1: cell biology, 1.2: ultrastructure of cells) was apparent as was the reason for a limited number of trophic levels in a food chain (topic 4: ecology, 4.2: energy flow). Many candidates could, at least, name the hormones that control the menstrual cycle (topic 6: human physiology, 6.6: hormones, homeostasis and reproduction). The diagram of the palisade mesophyll cell (topic 1: cell biology, 1.2: ultrastructure of cells) was often done well. All candidates had some general understanding of photosynthesis (topic 2: molecular biology, 2.9: photosynthesis).

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

Question 1: Data analysis on Chronic Obstructive Pulmonary Disease (COPD)

a) Most were able to state ‘severe’ as the correct answer.
b) Many candidates didn't see the necessity to mention the connection between low FEV and emphysema. Many of them just explained each of them and no explanation of the connection between them.
c) Surprisingly few correctly identified the ‘no disease’ group.
d) Most correctly identified the plasma desmosines as the better marker as they increase in line with severity.
e) Most gained one mark for realising that the degradation from other tissues could have influenced the result. Several teachers commented that two ‘evaluate’ questions in succession was demanding. This was noted.
f) Most were able to correctly identify the negative correlation.
g) Most were able to give at least one factor.
h) This was perhaps the least well answered part of the question. The large ranges make it very difficult to categorise a single patient at a moment in time. But by monitoring that patient over time a change in that patient can be followed.

Question 2: Microscopy, antibiotics and plasmids

a) Most realised that the resolution of the light microscope is not great enough to view viruses.
b) Most candidates writing in English were able to explain why antibiotics are useless against viruses. There was a marked difference with the candidates writing in Spanish who scored poorly.
c) Most English candidates could correctly state an application of plasmids, but the Spanish candidates could not.

Question 3: Water (common with HL)

a) Surprisingly few candidates were able to draw a second water molecule with the

oxygen facing the hydrogen of the original (or vice versa) and draw and label a dotted line as a hydrogen bond.

b) Most candidates did know something about the general properties of water and were determined to tell the examiner about SHC etc, which did not answer the question. Only the better candidates were able to explain why water is a good solvent, rather than just state the fact.

Question 4: Classification (common with HL) and trophic levels

a) Those who had been taught plant classification did well. There was some fairly freestyle spelling of Filicinophyte. If it was obvious, it was credited. Again, those who had covered the syllabus comprehensively were able to give two characteristics.
b) Most English candidates were able to cite energy losses for the limit to the number of trophic levels. Surprisingly the same was not true of the Spanish candidates.

Question 5: Biochemistry and enzymes

a) Surprisingly few were able to correctly name a disaccharide and its monomers. Examiners reported answers stating that proteins and fats were disaccharides.
b) Weaker candidates saw the word 'pancreas' and wrote about insulin. Few were able to give the three enzymes, their substrates and products.
c) Those who had covered cis and trans scored both marks. Some candidates had difficulty in expressing the difference in words and would have been better with annotated diagrams. Good candidates noted that it was a 'compare' question, giving both a similarity and a difference.

Section B

The need for clear communication should be stressed here so that the quality mark is not compromised. It was good to see more candidates writing some form of plan before starting. This should be encouraged.

Question 6: Reproduction

This was the favoured option (parts a and c in common with HL).

a) Most had heard of the endosymbiotic theory and gained at least 1 mark.
b) All but the very weakest candidates gained marks on this part, which, on the whole was very well answered. A number of weaker candidates tried to answer it with half remembered graphs. Fully annotated graphs would have been perfectly acceptable for most of the marks.
c) The word 'natural' was commonly misunderstood. Dolly the sheep and taking plant cuttings were common wrong answers. A specific plant example was looked for, such as strawberry runners.

Question 7: Plants, photosynthesis and the carbon cycle (peat formation)

a) In general, most gained at least two marks. There were some G2 comments about the

expression ‘palisade mesophyll’. This is specifically stated in section 1.2, so the candidates should be familiar with the term.

b) Most who attempted this question could explain the basics of photosynthesis very well. It should be noted that knowledge of the AHL part of the syllabus was not expected and all 8 marks could be achieved without it. However, many candidates did have some knowledge of these parts and were given some credit. Perhaps some schools over-taught this section to the detriment of other more relevant sections.

c) There was some criticism of this part in the G2 comments as being too knowledge based. Every paper is written with a balance between knowledge and application. It just so happens that the knowledge of peat formation (section 4.2) was being tested and, unfortunately, most candidates did not know it/had not been taught it.

Recommendations and guidance for the teaching of future candidates

This was the second November session under the current syllabus. It is important for teachers to make sure that candidates are aware of the differences in syllabuses when attempting past questions. For example, topics have appeared or disappeared and there is now only a choice of 1 out of 2 questions in section B. In addition, teachers should ensure that their schemes of work have been fully updated: it was obvious that some had not taught disaccharides, peat or classification.

Candidates should be reminded that answers may be amplified by the use of clear, annotated diagrams. However, poor half-remembered diagrams will not gain anything. Diagrams must also be drawn boldly in a dark pencil or pen. Papers are scanned in for marking and feint diagrams will not display.

Surprisingly, there was an increase in candidates requiring extra pages. Teachers should continue to stress that if they require additional booklets to continue their answer, they are almost certainly writing too much. If additional booklets are used, candidates must make sure that they state this at the end of their answer in the answer box. They should not attempt to continue their answer outside the boxes on the same page.

Many, mainly weaker candidates seem to fill up the first few lines by restating the stem of the question, thus restricting the number of available lines.

Some candidates do panic when they see question 1. If this happens, it could be suggested for them to start on section B, leaving sufficient time to go back to question 1 later. In section B, and in the longer answers, for example, in 1 h) or 3 b), candidates should be encouraged to think of a plan instead of starting to write straight away. For example, “what key words do I need to use?” should be uppermost in their minds. This also enables the answer to flow easily, requiring little or no rereading by the examiner, meaning that the candidate is more likely to gain the clarity mark for section B.

A point for teachers rather than candidates: there were a few comments to the effect that topic *x* was not in sufficient depth in the textbook. Teachers should realise the dangers of only using

one source of information. In addition, the whole syllabus needs to be covered and the candidates should readily have access to it.

G2 comments are encouraged as much as possible, giving impressions of the examination, regardless of if they are positive or negative. If respondents feel unqualified to compare the paper to previous years, this parts could be left blank or N/R added. Feedback is valuable and is taken seriously. It is used many times throughout the paper development process. Considering the number of Spanish language candidates, there seems to be a lack of feedback from those Spanish speaking schools.

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 - 28	29 - 34	35 - 45

General comments

A total of 2712 candidates took the examination: 1754 in English, 703 in Spanish, 254 in German and 1 in Japanese, representing a 26% increase compared to November 2016. A significant increase was seen in Spanish, rising from under 200 candidates in November 2016.

A total of 25 G2 comments forms were received (20 in English, 5 in Spanish). Of these, 96% respondents felt that the level of difficulty of this paper was appropriate, and 4% too difficult. When comparing the difficulty of the paper to that of November 2016, 8% of respondents perceived it as easier, 68% of a similar standard and 24% a little more difficult. For clarity of the wording, 16% judged it to be excellent, 44% very good, 28% good, 8% fair, 4% poor. No respondents suggested that the paper was very poor.

For presentation, 28% thought it to be excellent, 48% very good, 16% good, 8 fair. No respondents suggested that the presentation was either poor or very poor. All figures show an increase in satisfaction compared to the November 2017 paper.

All exam papers are scanned in black and white. The legibility of most answers was excellent to acceptable, but there were still a limited number of candidates whose work was difficult to read. The majority of candidates also complied with the instructions, but there were still some continuing to write outside the answer boxes, rather than using additional answer booklets. Examiners initially only see the answer boxes per question (rather than the entire page, or the space around the question).

A very negligible number of candidates omitted section A or answered more than one option in section B. The majority of candidates chose option D, followed by option C, A and a small number choosing option B. Option C was more popular with Spanish language candidates, who also option B more, whereas only responses top options C and D were seen for German language candidates.

The responses from Spanish language candidates varied more in quality, from very good to extremely poor, and showed a generally lower overall performance. Many of these candidates attempted to answer questions about which they knew little or nothing and there were also numerous candidates who left answers blank, particularly in question 3 of section A.

The worst overall performance was seen in German language candidates. The biological knowledge of those candidates showed major gaps for a candidate studying the higher level course. Sometimes answers were left blank. Candidates seemed to lack a basic understanding of ecological concepts as well as a basic knowledge of the action of hormones. Data based questions continue to pose a major hurdle for those candidates. Often all questions in one section or option were interpreted as all relating to the graphs or the initial stem, which they were not all meant to. They often inverted the conclusions based on the graphs, i.e. the cause was seen as the effect.

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

Areas of the programme

Section A seems to have been the most difficult part of this examination, in some cases indicating a lack of understanding of the practical programme. This was seen particularly in chromatography and nature of science aspects of the syllabus. This seemed even more obvious for those writing in Spanish or German. The seven practicals described in the "Applications and skills" sections of the guide must be addressed not only theoretically, but also with a hands-on approach. Candidates should also develop an understanding of basic scientific methodology.

Areas of the examination

For all candidates, the problem is precise terminology and there are many errors in knowledge and in understanding. Many candidates had difficulty answering according to the command terms, especially for questions that required more than short answers. Practical skills, such as unit conversion and identification of cells from micrographs or diagrams, were weak in many responses. There were some difficulties in expressing interpretations of graphic data and provision of a proper evaluation, candidates limiting themselves to descriptive aspects. The roles of introns/exons were not well understood. Knowledge of biopharming was very variable. Understanding of population growth curves and differences between exchanges of energy and nutrient cycling was poor. Many candidates had difficulty considering other perspectives than those required in past papers for human physiology, especially about bile pigments and altitude training.

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

The options seemed to be more uniformly covered than section A, with candidates demonstrating the normal range of knowledge, from excellent to little or absent, but without any specific, outstanding problems with the individual topics covered in this paper. The candidates

appeared well prepared for most questions simply requiring memory and reading data. They also seemed to deal better with areas common to past papers and elements that gave candidates the opportunity to display evidence of rehearsed rote-learning. Some candidates seemed well prepared for extended questions on innate and learned behaviour and high altitude training (although the latter was very variable). They seemed to be slightly more prepared to deal with questions relating to human physiology, but sometimes did not include sufficient details in their answers.

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

Section A

Question 1

a) The majority of candidates had a general knowledge of what happens in chromatography but difficulty in expressing it in the correct terms. Candidates either knew this material or they did not; many held back by poor use of language, not referring explicitly to "pigment" and "solvent" and using "extract" instead.
b) Many candidates had only a vague idea of the relevance of R_f values. Many explained R_f in terms of ratio of distances travelled by pigment and solvent front, however there were misconceptions revealed, including the suggestion of a relationship to movement and time and, in some cases, the idea that R_f was a measure of wavelength associated with pigments; weight and size were also sometimes used instead of solubility.
c) Many candidates stated two pigments, but a significant number could not; some even provided irrelevant answers.

Question 2

a) Most candidates realized that the hypothesis should not be supported and stated that there was not much difference between the two sets of data, but otherwise failed to fully comply with the command term "evaluate" by not considering the many aspects of the investigation that should have been taken into account.
b) (i): The vast majority of candidates measured the line accurately and knew they had to divide the line length by the magnification, but a very large number made errors in determining correct decimal positions from their calculation and/or the (optional) conversion between units.
(ii): Many candidates provided a correct answer, but many incorrect, such as sperm cell or Sertoli cell, or irrelevant answers, such as eukaryote, phloem, vacuole and mitochondria, were also seen.

Question 3

a) This question addressed the nature of science aspect of the syllabus and the understanding of scientific reasoning. Only a few candidates could describe steps of the experiment in such a logical and concise manner that it would lead to the scientists' conclusion. A certain number remembered some elements, but there was a wide range

of misconceptions involved, even among those who correctly identified the experiment, such as the role of the blender in the method. Although the experiment's conclusion was provided in the question, thus making the names Hershey and Chase unnecessary, few linked the question with appropriate experiment, confusing it with other DNA work, such as the use of heavy nitrogen isotopes to demonstrate semiconservative replication of DNA, or even with general genetics, such as Mendel's work. Many left blank answers.

b) Many candidates stated other correct functions of DNA not coding for proteins, but some repeated those provided in the question or provided incorrect, irrelevant or blank answers.

Section B

Option A: Neurobiology and behaviour

Question 4

a) (i): The majority correctly stated rodents, but a certain number did not read the graph correctly and stated insectivores.
(ii): Most candidates could suggest at least one valid advantage.
b) Most gave a correct role for the cerebral cortex.
c) Most candidates explained the difference using two or three valid elements.

Question 5

a) Many could not identify the cell although they knew the direction of light through the retina. Only a few candidates answered both parts correctly.
b) Most candidates had a general knowledge of local anesthetics but many limited their explanation to the reduction of pain.
c) Most had a general knowledge of red-green colour-blindness, but many answers were not very specific.

Question 6

a) Most candidates were able to state that the foraging behaviour was disrupted.
b) Most candidates generally understood the consequences but not all were able to give sufficient detail.

Question 7

a) Most candidates limited their answer to the description of what was depicted by the diagrams, and only a limited number completed their answer with detailed explanations.
b) The majority of candidates provided a valid answer.
c) (i): A certain number of candidates had the knowledge, but many were not specific enough in their answers.
(ii): A mixture of correct and incorrect answers were provided.

Question 8

Many candidates outlined innate and learned behaviour very clearly, demonstrating very good understanding of the topic. Others did not give enough details while a few were confused between the two.

Option B: Biotechnology and bioinformatics

Question 9

a) Most had a clear idea of the data, but many had difficulties in expressing a clear answer. Some analyzed the data within each of the two groups instead of between them.
b) Most gave a correct answer, relating to the assimilation of the gene or an increase in growth hormone production.
c) Most candidates were able to give at least one use of marker genes, but some tried to explain the whole process of inserting them, as used in bacteria, instead of describing their use in transgenic organisms.
d) Most candidates answered with outgrowing other species but few went on to consider other impacts.

Question 10

a) Virtually all candidates correctly identified *S. unisporus*.
b) Many stated the correct answer of BLASTn.
c) Some candidates suggested clear reasons, but many gave only the simplest reasons, that is, yeast is small, fast generation time, etc., but nothing more.
d) Many were able to outline a correct medical application.

Question 11

a) Most had a fairly good understanding of biofilms although some outlines were too minimal.
b) Many could state a positive application.
c) Many candidates were able to suggest two problems. Some did not read with care that the problems had to be related to water systems.

Question 12

a) Most candidates understood the use of a continuous fermenter, and gave complete answers. Others seemed to be focused on *A. niger* and on the production of alpha-galactosidase rather than on the type of fermenter.
b) Most were able to list two other variables, but some seemed not to notice that it related to deep-tank batch fermentation.

Question 13

Although some very good answers were seen, many candidates had difficulty giving an extended discussion on biopharming. Some had no idea at all while others gave superficial answers although they showed a general understanding.

Option C: Ecology and conservation

Question 14

a) (i): Most candidates easily identified the pattern but a few made the comparison between mammals and either only birds or reptiles instead of both.
(ii) Most were able to describe at least one impact, some not attempting to go beyond this.
(iii): Most suggested a method without problems, although some gave unfeasible answers such as introducing a predator of *F. silvestris*.
b) (i): Some candidates were unable to state the role of an indicator species, but most expressed sufficient knowledge.
(ii): The majority of candidates identified two approaches, although some remained focused on giving considerable detail on only one approach, such as *in situ.*

Question 15

a) (i): Many candidates were unable to state the correct range of the years with exponential growth. The majority did not realise that exponential growth starts slowly with the lag phase.
(ii): A certain number of candidates could suggest factors that would account for the population growth curve, but also many had difficulty with this question.
b) Most candidates had identified the appropriate concept, but many missed elements in the method. A surprising number did not distinguish between determining populations of living animals and plants, giving answers such as the use of quadrats.
c) Many candidates referred to a predicted decline in population, but few considered other elements such as the impact on the food web, niche, etc.

Question 16

a) Many candidates answered this question correctly, but a large number also showed a lack of understanding of the graph and the conditions of the different ecosystems. Many identified a desert instead of a prairie/grassland/savanna, and some answers were as far off as giving tropical rainforest as the answer.
b) Many candidates had difficulty with this question. They either focused exclusively on energy **or** nutrients but without comparing and contrasting. A noticeable number even tried to uncritically answer it in terms of a question from a previous paper, drawing Gersmehl diagrams with no explanatory notes that had no relation to the question.
c) Most candidates were able to outline at least two issues, but many had difficulty outlining a third one, repeating one that they already provided or giving insufficient detail.

Question 17

a) Many candidates had difficult giving a clear definition of a fundamental niche. Those same candidates usually also had difficulties answering the second part.
b) Many candidates gave a good description of the relationship, but others were too vague or simply incorrect.

Question 18

This question was probably the best answered for this option. There were many very clear, correct answers, but there were also some candidates who confused eutrophication with general contamination of water resources. Some answers seemed well-rehearsed, but lacked logic in the chronology of events. Some also focused too much on describing the nitrogen and phosphorous cycles, ignoring the discussion of eutrophication itself.

Option D: Human physiology

Question 19

a) Well answered by most candidates.
b) Most candidates outlined correct treatments, but some without sufficient detail.
c) Many candidates correctly stated *H. pylori* as the primary cause, but a certain number stated secondary factors.

Question 20

a) (i): Most candidates stated a correct function of thyroxin.
(ii): This question was about the action of steroid hormones, which is covered by this option, and not about the action of thyroxin, which is part of the core. The majority of candidates properly read the question and described the action of steroid hormones correctly, obviously having rehearsed a previous mark scheme since some even compared it to protein hormones, which was not required this time. There were some who nevertheless described the role of thyroxin or the general action of steroid hormones on the body rather than in the cells.
b) Most candidates had at least a vague idea of the role of iodine but few were able to outline a complete answer.

Question 21

a) (i): The majority of candidates could correctly state bilirubin.
(ii): Most candidates seemed to have rehearsed a past question about the breakdown of erythrocytes leading to the normal production of bile pigments and could explain that part, but had more difficulty going further in explaining the changes that occur in the development of jaundice.
b) Some candidates distinguished very well between the capillaries.

Question 22

a) Although a large number of candidates recognized an intercalated disc, there were many incorrect and even irrelevant answers.
b) Either candidates understood this topic and could address it adequately, or they could not.
c) Most candidates provided a correct answer, although some had not idea about early inventions.

Question 23

There were many good answers on high altitude training for athletes, although some mixed in information of people living permanently at high altitude. Many candidates nevertheless drifted off into rehearsed digressions about hemoglobin and the Bohr shift, often erroneous, and failed to address the matter of this assessment item. Few really engaged with the command term "discuss", and among those who did, benefits were more reported than risks.

Recommendations and guidance for the teaching of future candidates

Preparing for the examination

- As usually recommended, the use of past papers and mark schemes is a valuable tool to prepare candidates for the examination.
- Candidates should nevertheless be warned that it is counterproductive to rehearse or memorize answers from past papers and/or manuals. Each examination paper is different in coverage and perspective. Past mark schemes are useful for familiarization to the paper format, question style, expected vocabulary and depth and variety of elements to include in answers.

Syllabus coverage

- The syllabus must be covered completely, including understandings, applications and skills, with links to TOK and NOS.
- Practical skills and understandings from the core and the AHL are necessary for Section A in paper 3 and should therefore not be approached as different compartments. Teaching should aim for a comprehensive knowledge of the subject and application of concepts and principles in a wide variety of contexts.
- A variety of practical examples, data and graphic presentations should be incorporated to the teaching of various topics.
- It is important to undertake the required practicals. It appeared, based on their specific answers to questions relating to chromatography, that some of the candidates had not in fact undertaken these in class. Approaches to practical work should go further than a series of procedures and include the reasons and the background of steps that are taken.
- Teaching of all understandings should be at objective level 3, when applicable.
- Teachers and candidates are encouraged to use multiple sources of reference.

Reading and writing skills

- Many candidates could have reached a better performance in this examination paper by reading into the questions more carefully. A school approach to reading into details, using specific vocabulary, could perhaps improve the situation.
- Candidates should be aware that command terms have a specific meaning and should familiarize themselves with them during their course. Teachers should use them throughout the course for their exercises and internal tests.
- Teach the vocabulary of biology as candidates need to use subject-specific vocabulary in their answers. Teachers may choose to build up a glossary of terms used in the programme.

Examination techniques

- Candidates have a five-minute period before being able to start writing when they are handed paper 3. They should be aware of this and use this period to carefully read the questions and start mentally planning their answers.
- Many answers could contain more elements and more details. Developing the habit of taking a little time to lay down and organize an answer's core elements would improve answers and prevent omitting important ideas. Coach candidates on how to structure answers: they should take time to consider what is relevant to the answer, leave out what is irrelevant and avoid repeating the same ideas. Encourage candidates to highlight or underline the keywords in the question and plan their answers accordingly.
- It is unnecessary to repeat the question or stem in the answer box; this uses up time and space needed to answer. As can be seen from available mark schemes, marking is based on accuracy rather than on style.
- The number of marks indicated in the right margin of the question paper is often an indication of the expected details and number elements for a complete answer. Any "outline" question should never be answered by one word. "Discuss" or "evaluate" questions, including data based questions, usually require different perspectives to be taken into account.
- Bring a ruler to the exam. This could help measure values on graphs with the required precision.
- For diagrams, respecting proportions makes a difference. In all cases, all drawings should be well annotated and labelled carefully. Use of colour should be avoided as responses are scanned in black and white.
- Most candidates make sensible use of continuation answer booklets. The best answers fit in the space provided and very few gain additional marks from answers which extend into a continuation booklet. An indication that an answer is continued should always be made in the main booklet whenever a continuation booklet is used.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 16	17 - 20	21 - 23	24 - 27	28 - 35

General comments

A total of 3557 candidates took the examination: 1246 in English, 2278 in Spanish, 30 in German and 3 in Japanese, representing a 13% increase overall, compared to November 2016.

Of the teachers who made G2 comments, when comparing the difficulty of the paper to November 2017, most thought it was of a similar standard. For clarity of wording and presentation, most judged it to be at least good. All figures showed an increase in satisfaction compared to November 2017.

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

Section A was the most difficult for candidates, probably due to insufficient lab work performed at the school or not completing the required practicals. Very few performed well in the question on chromatography despite the guide stating ‘Separation of photosynthetic pigments by chromatography (practical 4)’ as a requirement. It was particularly disappointing to see candidates who scored high marks on all other questions having their total mark reduced due to unfamiliarity with a required practical.

Overall, there was no part of the paper that posed great difficulty to the better prepared candidates.

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

G2 comments indicate that respondents were satisfied with the examination content, difficulty, syllabus coverage and use of language. The questions were clear and focused more on common knowledge which allowed most candidates to show ability in some questions while still discriminating between the average and top candidates. Interpretation of data and identification of structures were generally well done. Options C and D were most popular followed by option A. Very few candidates attempted option B.

Candidates were able to extract raw data from tables and graphs but found processing the extracted information more difficult.

Candidates seemed to understand the experimental questions quite well, with the exception of the chromatography.

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

Section A

Question 1

This question described an experiment where water cooling in plastic cups provided a model of the body cooling with sweat. Parts a), b) and c) were fairly well answered though some candidates did not calculate the difference in temperature, instead just writing the initial and final values.

In part d) many candidates became confused between specific and latent heat so only the best candidates scored 3 marks but many candidates scored 2 marks for relating the loss of heat from the cups with heat loss due to sweating.

Question 2

It appeared obvious that many schools were unfamiliar with the separation of pigments by chromatography. Few could name a suitable solvent and even fewer could explain how the pigments are identified. The most common answer was ‘by their colour’.

Question 3

Most candidates were able to identify the correct structure and provide the distinguishing characteristics on the micrograph. The most common answers were thickness of wall and size of lumen.

Option A

Question 4

This question was about the eye. It was generally well answered with the better candidates scoring high marks. Most common errors were in a) not including a reason for identifying *x*, in b) not mentioning the nerve and in d) having the arrow in the wrong direction.

Question 5

There were no major difficulties in this question concerning the human brain.

Question 6

There were mixed responses to this question on the ear with good candidates scoring well. There were some vague answers to b) explaining the function of the cochlea with many candidates failing to mention the movement of the hair cells.

Question 7

Most candidates could score 2 marks explaining the processes in the diagram of synapse density in the cerebral cortex. Most common correct answers were describing the increase in synapse density and neural pruning. Only the best candidates went beyond this to score full marks.

Option B

Very few candidates attempted this option. Of the candidate that chose this option, question 8 was answered well, showing knowledge of fermenters. Question 9 was answered less well generally, showing candidates did not know how the vaccine for hepatitis was produced in TMV. Better candidates scored well on the questions on biofilms and bioremediation.

Option C

Question 12

The question showed energy flow in a lake. The calculation in a) proved fairly difficult with about half the candidates getting the correct answer. Also in b) around half the candidates gave good reasons for measuring energy flow over a year. In part c) there were some good answers for explaining biomagnification in the lake.

Question 13

This question concerned feeding relationships in rocks at the edge of the sea. It was well answered by most candidates, overall. Some dropped marks in b) by drawing the arrows in the wrong direction. In c) most candidates could define keystone species but many could not provide evidence from the data.

Question 14

The question concerned conservation and biodiversity of species. Candidates in the middle grade range and above scored well here. Part d) discriminated well with better candidates explaining the impact of plastic waste on albatrosses and weaker candidates simply saying they eat it and die.

Question 15

The question asked for explanations for the differences in the realised and fundamental niche of an organism. Only the better candidates achieved full marks. Reasonable candidates could define the terms and mentioned competition but did not develop their answers further.

Option D

Question 16

The question referred to a phonocardiogram. In part b) there were many mixed responses in explaining the heart sound with only the better candidates mentioning the AV valve or

contraction of the ventricle. Many mentioned the semi-lunar valves. Part c) also provided mixed responses with candidates able to say that the pacemaker controlled abnormal heart rhythms but few mentioning electrical impulses or the SA node.

Question 17

In part a) many candidates described the relationship between gastrointestinal damage and gastric acidity as directly proportional so were only awarded the mark if they went on to say as acidity increases, GI damage increases. In b) candidates were familiar with PPI but there were few candidates who answered fully. Many discussed antacids as healing the ulcer rather than providing the conditions for them to heal.

Question 18

A few candidates did not correctly identify the hepatic portal vein in a) leading to incorrect answers in b). Reasonable candidates knew the blood vessel carried blood from intestine to liver and contained nutrients but only the better candidates gave more detailed answers. In part c) the most popular difference was the size of sinusoids and capillaries.

Question 19

Most candidates scored some marks for explaining the health risks of being overweight by identifying cardiovascular problems. Answers tended to be long and repetitive, almost never achieving full marks. Good candidates scored full marks by explaining additional risks such as type II diabetes.

Recommendations and guidance for the teaching of future candidates

Candidates should practise answering previous exam questions, recognizing the command verbs. They should understand that if a reason is requested, then it must be provided for the mark to be awarded.

The required practicals must be addressed in class. The reasoning behind the proper procedure should be discussed and potential exam questions explored. Teachers should include section A type questions on their class exams.

Candidates must do more practical work at school and be provided with opportunities to relate key biological principles (theory) to everyday situations and recognise them in new unfamiliar contexts. Spanish candidates tend to write long answers with little scientific background. Their in-depth knowledge of the subject is often weak; this is evidenced in the low results of many candidates.