# BIOLOGY TZ2

## (IB Africa, Europe & Middle East & IB Asia-Pacific)

## Overall grade boundaries

**Higher level**

| **Grade**: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Mark range**: | 0 - 15 | 16 - 28 | 29 - 42 | 43 - 54 | 55 - 67 | 68 - 79 | 80 - 100 |

**Standard level**

| **Grade**: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Mark range**: | 0 - 13 | 14 - 25 | 26 - 39 | 40 - 51 | 52 - 63 | 64 - 75 | 76 - 100 |

## Higher level and standard level internal assessment

### Component grade boundaries

### Higher level

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

### Standard level

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

## General

Most schools used appropriate investigations. Two problems persist, however. For some schools the complexity of the investigations is not up to IB standards and other schools are setting investigations for assessment that are too heavily directed.

Structured investigations often originate in collections of laboratory exercises not intended for use in assessment. Careful editing of the instructions is necessary if they are to be used for assessment. Some teachers are using these investigations without providing instruction sheets to the moderators. The moderators are quite familiar with the material that is available and can spot when it has been copied by the candidates.

In many schools the new criteria are being applied rigorously but in a number of schools the teachers seem to be ignoring the descriptors of the different aspects. In these cases the moderators were marking down. The Group 4 Project can only be used for the assessment of Personal Skills and none of the other criteria. Fortunately very few schools this session seemed to be ignoring this rule.

**Ethics**

The IB has now published a document, the Animal Experimentation Policy which is available on the OCC. This and the Ethical Practice Poster, also available on the OCC, will be applied to future Internal Assessment moderation. If necessary, teachers need to make adjustments to their Practical Scheme of Work.

The IB does not wish to inhibit investigations but it does want to stimulate a responsible attitude towards experimentation on animals. Any proposed experimentation involving animals, including humans, should result in a discussion between teacher and candidate based on ethical implications and how to refine the experiment to prevent any harm or distress to the animal, to reduce in the numbers of animals involved, or to ultimately replace the use of animals by using cells, plants or computer simulations.

Moderators continued to comment on investigations that were unsafe or unethical. Behavioural experiments or experiments on animal physiology were frequently quoted as examples. Experiments in these areas are still possible as long as they remain within the normal tolerance limits of the animal. Thus, exposing animals to conditions normally experienced in their natural environments is permissible. It is good practice to include a discussion with the candidates on the tolerance limits of the animal and how these could be established. There are plenty of sites on the web that will help here. Some inappropriate examples quoted by moderators this session include:

- Exposing woodlice to high temperatures (60-80°C) and high concentrations of NaOH.
- Using toothpaste as an example of a texture in judging the behaviour or meal worms.
- Exposing goldfish or *Daphnia* to solutions of nicotine, caffeine or ethanol.

It goes without saying that wild animals should be returned to their natural environment soon after the investigation. Animals obtained from a supplier should be kept under safe and healthy conditions.

Situations that deliberately demand the euthenising of animals are no longer appropriate. Thus, fruit fly genetics must be replaced by, for example, rapid *Brassica* plants, *Sordaria* mould, maize cobs or simulations, such as the virtual fly lab (though this would mean that as a simulation it could not be assessed using the IA criteria).

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

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

The approach to experiments on human physiology should be reconsidered by a lot of teachers. Using fellow candidates for investigations into the effect of exercise on the heart rate can be considered unsafe if the health status of the candidates is not determined first. Some schools are already expecting their candidates to use a proforma for the signed consent of the participants in experiments. This is good practice.

## Clerical procedure

Earlier versions of the 4/PSOW form were still being used by some teachers. These do not provide space for the moderator and senior moderator marks. The latest versions (available on the OCC) should be used.

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

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

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

Atypical candidates should be replaced in the sample. These would include candidates whose work is incomplete or transfer candidates where a substantial part of their work has been marked by another teacher.

When the only marks appearing on the 4PSOW form are the two marks required for the internal assessment, it causes concern for moderators. There is no indication that the candidates were marked a number of times using the criteria. One wonders how these candidates receive the necessary feedback to improve their performance.

Some moderators commented on transcription errors between the marks indicated on the work and the mark on the 4PSOW form. This should be verified before it is sent.

Some schools are sending photocopies of the candidate’s work. Usually these are of good quality. The problem is that graphs and diagrams using colour can be confusing. The originals must be sent and a photocopy kept back.

## Areas of strength

The variety of investigations, the duration and coverage of the practical programme were generally good. The use of ICT in the areas of **1** Datalogging, **2** Graph plotting software and **3** Spreadsheets is good.

## Areas of weakness

Although the vast majority of teachers are adapting to the requirements of the new criteria, there are many that are still presenting similar investigations to the previous programme. This was particularly apparent in those used to assess DCP, which has become more demanding.

Trivial, simplistic investigations that do not generate sufficient data to permit adequate assessment of data processing were sometimes used for assessment. If there is one significant area of weakness it is in the processing of data. Candidates are missing quite obvious conventional points (e.g. indicating uncertainties in their data) as well as limiting their processing to the calculation of a mean. Teachers are also missing these points and marking over generously. Sometimes teachers point out the errors to their candidates and still give full marks.

Where teachers apply the criteria rigorously and clearly the moderators make relatively small adjustments to the marks. In schools where the descriptors of the aspects are ignored the moderation can reduce the marks quite severely.

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

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

**Rules applied by the moderator**

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

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

## Candidate performance against each criterion

**Design**

Some teachers are setting general themes with little scope for different investigations. The result is that the whole class of candidates selects the same variables and investigates the same system.

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

Research questions need to be focused. A research question that lacks focus will have an impact right through the rest of the investigation. For example candidates who decide to investigate several independent variables at once, such as the effect of pH, temperature and substrate concentration on the activity of an enzyme.

The three categories of variables must be clearly identified. It is clear that candidates need to be taught what the different variables are and what their relationship is. Moderators have observed that there is sometimes confusion over what is a controlled variable and what is a control experiment.

The investigations assessed must contain quantitative data. Moderators have reported that there are schools still presenting investigations that collect only qualitative data (e.g. microscopic observations of tissues or observations on dissections). They are inappropriate for assessment.

Even if the investigations are quantitative then they are frequently too simplistic. The range of values of the independent variable may be insufficient to establish a trend; the number of repeats may be insufficient to permit statistical analysis. E.g. testing the effect of pH on an enzyme using an acidic environment, a neutral environment and a basic environment will not establish an optimal pH.

Standard protocols will, no doubt, be used by the candidates when they design their investigations. We are not expecting them to re-invent the wheel. HOWEVER these standard protocols must be significantly modified or applied to the candidate's own investigation. For example, if osmosis is being investigated and the candidate uses the method of change in mass of tissue to monitor the effect of solutions of different concentrations on the tissue, this is legitimate. If the investigation is simply to determine the isotonic solution of one tissue then it remains trivial and it repeats many textbook investigations. If the investigation is used to determine the effect of the salinity of irrigation water on different root crops, the investigation becomes more substantial.

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

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

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

**Data Collection and Presentation (DCP)**

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

Despite the clear warnings in the subject guides, teachers are still providing instructions on how to present the data and how to process the data. Their marks will be moderated down.

The classic investigations (e.g. mark and recapture, chromatography of leaf pigments, rates of photosynthesis using sunken leaf disks, rates of reaction of catalase and osmosis) often create problems. Teachers are using standard textbook protocols without modifications. A little imagination and editing could easily solve the problem.

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

- There were no quantitative data collected
- No uncertainties were given in the tables of data collected using measuring instruments.
- There were inconsistent decimal places in tables
- The decimal places did not correspond to the precision of measurements
- There were no associated qualitative observations. E.g. an ecological field investigation is incomplete without some kind of description of the site used
- Raw data were plotted in graphs that do not actually reveal anything (e.g. maxima, minima, optima or intercepts)
- Raw data were plotted when the mean should have been calculated and plotted (often the mean is actually calculated and then ignored by the candidate for graphing)
- There was no statistical treatment of the data when it was possible
- When statistical treatment is applied there is no consideration of its appropriateness
- There was no presentation of uncertainties in graphical data either by using trend lines or error bars
- The error bars, when used, were not explained.

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

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

**Conclusion and Evaluation (CE)**

Investigations that lead to trivial amounts of data will lead to limited discussion of results and weak conclusions. Insufficient data will not reveal uncertainties and this has an impact on evaluation. So although each criterion is marked on its own merits there will be a knock-on effect through a poorly designed investigation that collects a limited amount of data leading to a weak conclusion and evaluation. Some teachers are using simulations instead of real biological investigations. These may be useful for training data collection and processing as they generate large amounts of data quickly. However they are not suitable for assessment, especially the assessment of this criterion. It is not possible to provide a biological explanation in these cases.

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

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

Suggested modifications were sometimes superficial and yet marked over generously.

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

**Manipulative skills**

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

**ICT coverage**

This was generally covered adequately by the majority of the schools.

Schools seem to have made an effort to equip themselves with the necessary materials to carry out data logging. However, the use of this material in investigations for internal assessment of the criteria was not always appropriate. Teachers and candidates are strongly advised to read the relevant section of the subject guide.

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

The use of spreadsheets for data processing was less apparent in the sampled investigations. When spread sheet tables are inserted into document files the conventions of presenting tabulated data were often ignored or forgotten (e.g. centering numbers, adjusting the number of decimal places, column headings).

Some schools are not fulfilling the requirement for a range of ICT applications to be used in their practical programme. It is the use of databases and computer modelling/simulation that are most often missing.

**The Group 4 Project**

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

## Recommendations for the teaching of future candidates

- Read your school's IA feedback from the previous session and act upon it.
- Consult the Online Curriculum Centre (OCC) for teacher support material (TSM)
- Apply the internal assessment criteria rigorously.
- Ensure that the open-ended theme that you set has enough scope to provide a variety of research questions.
- Give the candidates experience in identifying independent, dependent and controlled variables.
- Be sure that investigations used for assessment produce quantitative data.
- Encourage the candidates to make additional observations about their experiment.
- Ensure that the investigations have the potential to generate sufficient data for substantial processing.
- Teach the candidates that plotting graphs of raw data is often insufficient.
- Encourage the candidates to carry out research into the background literature both before starting an investigation and once the results are complete.
- Do not use simulations for assessment.
- **Do not** use the Group 4 Project for assessment of D, DCP CE or MS. Only use it for Personal Skills. Inappropriate use will be sanctioned in subsequent sessions.
- Make sure that you are using the most up-to-date version of the 4/PSOW form (available on the OCC).
- Check to be sure that all the parts of the 4PSOW form are completed correctly.

# Higher level paper one

### Component grade boundaries

| **Grade**: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Mark range**: | 0 - 10 | 11 - 15 | 16 - 23 | 24 - 27 | 28 - 31 | 32 - 35 | 36 - 40 |

## General comments

Of the 38 G2 reports received by the time of grade award, 56% thought that the paper was of a similar standard to that of last year. Of the others, some thought it was a little easier, fewer thought it was a little more difficult and fewer still that it was much easier or much more difficult. The majority view was in this case correct as the statistics showed that the paper as a whole was easier. Nearly 90% thought the level of difficulty was appropriate.

40% of G2 forms commented that the syllabus coverage was good and 47% that it was satisfactory. 13% felt that the coverage was poor, despite the wide range of topics targeted by the forty questions. 35% commented that the clarity of wording was good, 57% that is was satisfactory and 8% that it was poor. Detailed comments will be made later in the report of questions that were considered to be unclear.

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

Comments will be confined to questions where there is something to be learned for examiners who set the question or for teachers who are preparing candidates for future IB exams. There are comments on all of the questions that elicited significant numbers of comments from teachers on G2 forms.

### Question 5

This question was based on AS (Assessment Statement) 2.5.1, which requires an outline of the cell cycle including the $G_1$, S and $G_2$ phases. The percentage of candidates answering correctly was the lowest on this exam at 36.6%. Many candidates chose answer D (replication of DNA), which happens in S phase. Substantial numbers of candidates chose answer A (homologous chromosomes pair), which happens during prophase I of meiosis, not before mitosis. Candidates should have been able to answer this question by eliminating the incorrect answers even if candidates did not know that some protein synthesis occurs during G2. More candidates would probably have been able to answer this question if, instead of $G_2$, it had asked about $G_1$ as most protein synthesis occurs during that phase.

### Question 6

This was considered unfair by some teachers, as A.S. 3.1.3 requires only one role of sulfur in plants, animals and prokaryotes. About two thirds of candidates chose the correct answer, including most of the stronger candidates. Even if candidates did not know that two of the twenty amino acids in proteins contain sulfur, or that disulfide bridges form between cysteine residues in the tertiary structure of proteins so proteins must contain sulfur, they should still have been able to answer correctly by eliminating the three incorrect answers.

### Question 7

This was an unusual question as it involved data analysis, normally tested on Paper 2 and Paper 3. The question proved to be easier than expected and a poor discriminator. There were some other questions that most candidates easy and for that reason they failed to discriminate well between weaker and stronger candidates, particularly Questions 4, 8, 12, 16 and 20. Two of these involved data analysis, Questions 12 and 16, confirming that the usual practice of avoiding data analysis in Paper 1 is best.

### Question 24

This was the most controversial question on the exam and it also proved to be a very poor discriminator with statistics showing little relationship between success in answering correctly and the overall strength of the candidate. This was another question that involved data analysis but in this case the question was not excessively easy. The data was presented in a novel way that needed to be studied carefully.

The candidate first had to deduce which part of the digestive system was the small intestine and which the large, and then deduce that the greatest reduction in volume and therefore the greatest volume of water absorption was in the small intestine. Instead many candidates, including those with good knowledge, immediately looked at the possible answers and chose A because they understood that the colon was the part of the intestine responsible for water absorption. The lesson for candidates is that when data is presented it must be carefully considered before choosing an answer and the lesson for examiners is that data questions should not be constructed in such a way that candidates with knowledge are disadvantaged!

**Question 28**

This was not as well answered as expected. Nearly two thirds chose B, which was the correct answer but substantial numbers also chose D, which contained the incorrect statement that NADH is reduced in the link reaction of aerobic respiration. Candidates should be advised always to check carefully whether statements concerning oxidation or reduction are correct.

**Question 29**

This caused more difficulty to candidates than expected though the better-prepared candidates mostly answered it correctly. In AS 8.1.5 and AS 8.2.4 it is clear that chemiosmosis involves the synthesis of ATP. This is achieved using potential energy stored in the form of a proton gradient and this gradient is built up by electron transport. The correct answer was therefore A. Answer C should have been rejected because it does not include ATP synthesis and it refers to the mitochondrion only, excluding chemiosmosis in photosynthesis.

**Question 31**

This was problematical because of the use of the word *adventitious*. Many candidates were unfamiliar with it and in retrospect it should have been explained in the question. It is not IB Biology policy to expect candidates to memorize large numbers of terms; overall understanding is far more important. Candidates may also have been misled by the description of adventitious roots as fibrous, as they are typically wider and less fibrous than the branching dicotyledonous roots. However, candidates could still answer this question correctly as long as they knew that monocotyledonous flowers do not have organs in multiples of four and that they do have parallel leaf venation. Nearly 80% of candidates answered the question correctly but it was a relatively poor discriminator.

**Question 32**

This question contained an error, which a small number of G2 forms commented on. The question was intended to be based on AS 9.2.2, how mineral ions move to the root, not how they enter the root. The answer was therefore B. However the question actually asked how mineral ions move into the root. Perhaps surprisingly, this question proved to be the best discriminator on the paper. The most able candidates presumably answered it by eliminating the other answer, because they knew that mineral ions do not enter roots by osmosis, translocation or through phloem. There was some truth in the answer *mass flow of water* as mineral ions do pass through epidermis and cortex cell walls in the apoplastic flow of water, but this is certainly not expected knowledge for IB Biology candidates.

**Question 35**

This also contained an error as the linked genes had not been shown using the notation that is specified in AS 10.2.5 and AS 10.2.6. Nevertheless, it was possible for candidates to do some working and convert the information into that form. The question then had one clearly correct answer. Perhaps because of the unfamiliar notation, this proved to be the second most difficult on the exam, but it discriminated relatively well.

**Question 39**

Was another relatively difficult question that discriminated well. The term *tubule lumen* was unfamiliar to candidates and is an unusual way to refer to the space inside the Bowman's capsule, but even so, the more able candidates were able to reject answers A, B and C and choose D correctly.

**Question 40**

This was criticized on some G2 forms for unclear wording but three quarters of candidates answered it correctly and it discriminated well between the stronger and weaker candidates. Well-prepared candidates were able to answer it without needing to look at the second column of the table, although the advice is still to always look at all the information provided in a question before choosing an answer.

# Higher level paper two

## Component grade boundaries

| **Grade**: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Mark range**: | 0 - 8 | 9 - 16 | 17 - 25 | 26 - 35 | 36 - 44 | 45 - 54 | 55 - 72 |

## General comments

Nearly two thirds of teachers who commented using G2 forms felt that this paper was of a similar standard to that of 2009. Of the remaining teachers, most felt that the paper was a little more difficult. Over 90% thought that the level of difficulty was appropriate. Reactions to the syllabus coverage, clarity of wording and presentation of the paper were varied.

A quarter of teachers felt that the syllabus coverage was poor, despite the wide range of topics tested in questions 2, 3 and 4. It is difficult to produce an exam with wide syllabus coverage that tests in-depth knowledge and understanding and the examiners felt that this paper was acceptable in this respect.

Nearly half of teachers felt that syllabus coverage was satisfactory. 8% of teachers felt that the clarity of wording was poor, probably because of a small number of questions where the phraseology was slightly unusual. The examiners are well aware of the need for clarity of wording, especially because some candidates were working in their second or third language. 60% of teachers commented that the clarity was satisfactory and 33% that it was good. All teachers who commented felt that the presentation of the paper was either satisfactory or good, with the majority commenting that it was good.

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

Calculations of percentage and magnification proved difficult for many candidates. The distinctions between some of the command terms used in questions were not well known, particularly between *Describe* and *Explain* and between *Compare* and *Evaluate.* In some centres there was poor understanding of genetic modification and stem cells. There was

much confusion over the mechanisms involved in the greenhouse effect and confusion between this and the problem of ozone depletion in the upper atmosphere.

Many candidates did not know an evidence-based example of evolution in response to environmental change. Instead they gave answers that were little more than casual narration. Because of the scepticism about evolution in the non-scientific community, it is particularly important to base assertions strictly on available evidence, of which there is plenty. Understanding of the precautionary principal was also poor.

## The levels of knowledge, understanding and skill demonstrated

The structure of the ribosome, the role of auxin in phototropism, the control of blood glucose concentration and ultrafiltration and selective reabsorption in the nephron were understood well by many candidates. Drawing skills were notably better than in some previous years. Most candidates showed the ability to analyse data in the form of tables and graphs.

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

**Question 1**

Part (a) was intended to be an easy start to the question and almost all candidates answered it correctly.

The percentage calculation in (b) was only answered by about half of candidates, perhaps because of the wording of the question, which did not make it clear whether the difference should be calculated as a percentage of that at Site 1 or at Site 2. Candidates were expected to calculate the difference between the two masses by subtraction and then divide either by the mass at Site I or at Site 2. Candidates performed many other calculations, but as only one mark was available, no credit was given for these.

The best answers in (c) made it clear whether the mass changes were increases or decreases, but many answers were vaguer, referring only to mass changes. There was some confusion between mass and mass change, with some some candidates implying that a negative mass change was a low mass. In some cases answers to this question consisted only of figures quoted from the bar chart, rather than a genuine comparison and so did not score any marks.

In (d) candidates were asked to evaluate data. The command term *evaluate* is defined as assessment of the implications and limitations. In this case it was the limitations of the data that were relevant. Candidates were expected to use the size of error bars and the sample sizes to assess the reliability of the data. Many candidates wrote instead about the differences between the data for the hermit thrush and American robin, without any actual evaluation.

Part (e) of question 1 tested a different skill in data analysis. Candidates were expected to pick out the most significant features of the data and as in (c), answers that merely quoted numerical figures from the bar chart mostly scored few marks. The points that the stronger candidates were made were that the triglycerides level at Site 1 was higher than that at Site 2 in all bird species and that the hermit thrush had the highest levels at both sites, whereas the Magnolia warbler was lowest at Site 1 and the American robin was lowest at Site 2.

1(f) was another part of the question where it was important to pay attention to the command term. The term *explain* indicates that causes, reasons or mechanisms are required. In this case the causes of triglycerides levels being higher at Site 1 and of butyrate levels being higher at Site 2 were expected. The stem of the question had given the explanations that should have been given –fat deposition or fat utilisation.

Part (f) involved another evaluation, in this case of a hypothesis. Candidates were expected to conclude that the data supported the hypothesis. No mark was given this and instead marks were awarded for evidence.

Most candidates only considered the butyrate and triglycerides levels and so scored a maximum of one mark. The second mark was only awarded if candidates gave a broader answer by referring back to differences given earlier in the question for mean mass or mass change between Site 1 and Site 2.

The last part of the question involved suggesting and advantage and a disadvantage of blood sampling. A huge variety of answers were given but few candidates gave both an advantage and a disadvantage that the examiners considered acceptable. The disadvantage was the easier of the two and many candidates wrote about the stress of the procedure for wild birds or harm that the loss of blood might cause. The advantage that was most often given was the opportunity to obtain precise measurements for many different nutrients in blood, compared to the rather blunt assessment of food quality that weighing gives. There was some confusion about the meanings of terms such as precision and accuracy. Birds can of course be weighed accurately with great precision, whereas some candidates implied that blood tests were inherently more accurate and precise.

**Question 2**

In order to ensure adequate syllabus coverage, this question tested knowledge of disparate parts of the programme. Although it made for a rather inelegant question, without any over-arching theme, candidates did not seem to be disadvantaged.

a) In part (a), only about half of candidates calculated the magnification of the electron micrograph correctly. This involved measuring the length of the scale bar in millimetres and multiplying by 1000, to convert the length to micrometres. Candidates then needed to know that magnification is calculated by dividing the size of the image, in this case the actual length of the scale bar, by the size of the specimen, in this case the length indicated on the scale bar.

   Some answers could not possibly have been correct and candidates should be encouraged to test whether their answer is sensible. This could have been done by using the answer to calculate the actual size of the nuclear pores on the micrograph, which were about five millimetres across or 5000 micrometres on the micrograph.

   (ii) This task was much easier as the nuclear pore labelled X was half of the diameter of the scale bar, so all that was necessary was to divide its length by two.

b) A variety of answers was accepted here and many candidates gave two of these. Frequent answers that were not accepted were repair of cells, antibody production, production of gametes and production of zygotes. Although some of these processes involve mitosis, it was necessary to specify how.

c) The wording of this question was unusual and as a result answers were very varied. Marks were awarded for correct statements about the undifferentiated state of stem cells, their capacity to differentiate in different ways and their role in repair of tissues.

Some candidates stated that stem cells could be used to treat leukemia or Parkinson's disease, but some details were required for a mark to be awarded.

d) This was based on AS 11.4.10 and AS 11.4.12. Many candidates used their understanding of the hormonal control of pregnancy to predict the changes in the levels of estrogen and progesterone correctly.

(ii) About two thirds of candidates gave two roles of testosterone that examiners accepted. Where a limited number of answers is allowed, candidates should be advised to give the answers which they think are most significant. If candidates gave two secondary sexual characteristics, such as axillary hair and pubic hair, the mark was not awarded as other more important roles had been omitted.

**Question 3**

a) Almost all candidates knew something about the bonding between nucleotides but in some cases the answers were not precise enough to be awarded marks. A common fault was to describe bonding within nucleotides rather than between nucleotides.

b) Many candidates knew that hydrogen bonds form between water molecules, but often the remainder of the answer was weak. A common misunderstanding was revealed by candidates who stating that hydrogen bonds are strong and therefore take large amounts of energy to break. It should be stressed that individual hydrogen bonds are in fact weak, but because water molecules are small, large numbers of hydrogen bonds are formed within water so collectively they have significant effects. Another area of misunderstanding was the difference between the energy needed to heat up water (heat capacity) and the energy needed to evaporate water. Sweating and transpiration have cooling effects because of the energy needed for evaporation, not raising the temperature of water.

c) Less than half of candidates were able to give an equation for anaerobic cell respiration in humans. Many included oxygen, carbon dioxide or water in their equation and so were not awarded the mark. Others gave an equation for yeast rather than humans. In some cases the answer was not given in the form of an equation but as long as the substrate and product was correct, the mark was awarded. Both pyruvate and glucose were accepted as the substrate, though glucose was preferable.

**Question 4**

a) There was a significant challenge here in explaining why carriers of sex-linked genes must be heterozygous. The inclusion of sex-linkage in this question was something of a "red herring" to use an English idiom, as the answer to the question would have been the same for a gene that was not sex linked. It was not possible to explain the answer effectively without referring to recessive and dominant alleles.

Some candidates referred to genes rather than alleles, but as long as the meaning of the answer was clear, marks were awarded. Understandably some candidates took more notice of sex-linkage than was necessary and in some cases did little more than explain gender determination.

b) (i) Approximately equal numbers of candidates scored two, one and no marks here. Many could recognise the bacterial cell (I) and the plasmid within it (II) but fewer were able to give acceptable names for the gene transferred from the eukaryotic cell or the genetically modified bacterium.

(ii) This generally well answered with most candidates naming two enzymes involved in gene transfer. Restriction enzymes and DNA ligase were the most obvious ones but reverse transcriptase was also accepted as it is used to produce DNA copies of genes from mRNA. DNA polymerase and RNA polymerase were the commonest answers that were not accepted.

**Section B**

Questions 6 and 7 were the most popular, followed by Question 8. Question 5 was the least popular. Question 8 tended to be chosen by weaker candidates.

**Question 5**

Part (a) was generally well answered with many candidates scoring marks by including annotated drawings of ribosomes. Part (b) was also answered well in many cases with most giving acceptable examples of globular and fibrous proteins and their roles. There were some doubtful statements about levels of protein structure. Although tertiary structure is more significant in globular than in fibrous proteins, it is not true to say that fibrous proteins have secondary structure and globular proteins have tertiary and quaternary structure. Most globular proteins have regions of secondary structure. Collagen, perhaps the best example of a fibrous protein, has neither α-helices nor β-pleated sheets within its structure and as it has three polypeptides wound together collagen has quaternary structure. There was an error in (c) for which the examiners apologise: auxin is of course not a protein and is instead indole ethanoic acid in its naturally occurring form. Unfortunately this mistake was propagated in many candidates' answers. Knowledge of the physiology of phototropism was good. The best answers included details of how auxin is moved between cells and its effects on cell walls and growth of cells.

**Question 6**

This question was answered by large numbers of candidates. The better-prepared ones had little difficulty in scoring highly in both parts (a) and (b). As in part (a) of Question 5, it was possible to score marks in 6(a) with a clearly annotated drawing, in this case a flow diagram of glycolysis. The only caveat is that one of the quality marks for Section B questions depends on at least two of the three parts being written in continuous prose. In weaker answers there was confusion about what was being oxidized and what reduced. Teachers should stress that oxidation in respiration is achieved by removal of hydrogen from respiratory substrates, because each removed hydrogen has an electron. Oxidation is loss of electrons.

In part (b) a familiar problem was in the spelling of glucagon and glycogen. This is one place where terms do need to be spelt correctly to avoid confusion. Two other common errors were the implication that insulin and glucagon catalyze interconversions between glucose and glycogen directly and the suggestion that the hypothalamus controls hormone secretion by the pancreas.

Part (c) was often well answered, with candidates write detailed accounts of cause and effect, linking the high blood glucose levels that characterize diabetes with the presence of glucose in urine.

**Question 7**

In part (a) the sperm drawings were mostly neat but few candidates scored full marks. Five structures shown realistically and correctly labelled were needed. The nucleus was often shown insufficiently large. Fibres and microtubules were missing from the tail.

Centrioles were missing from many drawings and the plasma membrane, head and mid-piece of the sperm were often not labelled. Many candidates also lost marks in part (b) by giving insufficient detail or by including errors in their answers. Candidates were expected to use the terms *meiosis*, *homologous chromosomes* and *non-sister chromatids*. A frequent error was to suggest that the tight linkage between sister chromatids that exists when crossing over takes place is broken prior to crossing over, and that regions of non-sister chromatids become linked instead. This would of course not result in the chiasmata that remain clearly visible throughout metaphase I of meiosis.

Candidates should be taught that crossing over occurs by breakage of non-sister chromatids and their connection to each other, forming a knot-like chiasma. Chiasmata serve the essential function of preventing non-disjunction by holding homologous chromosomes together when the tight pairing or synapsis has ended. Answers to part (c) were good in most cases. Diagrams were often included, candidates need to label them fully if they are to help answer the question. Some included more details of the normal process of meiosis than was expected and also symptoms of Down syndrome that were not really relevant.

**Question 8**

Answers to part (a) were varied but mostly were rather weak, with confusion about long wave and short wave radiation and between the greenhouse effect and ozone depletion. Most answers explained the greenhouse effect in general terms and only a few really described the relationship between the rise in atmospheric carbon dioxide and the enhanced greenhouse effect. The best answers explained that the greenhouse effect is a natural phenomenon but that there was been an anthropogenic increase in carbon dioxide concentrations that is positively correlated with global warming. Although not proven, almost all climate scientists accept that there is a causal link. Part (b) was also poorly answered on the whole, with much evidence of guesswork rather than secure understanding. The term *precautionary principle* has been used in different ways and a teacher's note was therefore inserted in the current IB Biology programme, to make clear what is expected in answers to IB Biology questions. Teachers are encouraged to follow the guidance in that note. Part (c) of this question was also poorly answered. Fewer than half of candidates gave an acceptable example of evolution in response to environmental change. Candidates were expected to give a real and well-documented example, with the species named and the precise environmental change explained. Resistance to a named pesticide in a named pest species was acceptable for example, but not accounts of how resistance might develop in general. Giraffes were not accepted as an example, as their evolution cannot be tied in to any proven and specific environmental change. The human examples that were seen in candidates' answers were also not accepted.

Many candidates' answers were vague and confused and in some cases were based on guesswork, in the hope that examiners might not realise. It is of course unacceptable to fabricate examples and evidence in science, whether in an exam or any other situation. Particularly with evolution, any assertion that we make should be based on reliable evidence. Despite these negative comments about the quality of answers, some were excellent with a clear explanation of how the characteristics of a species can change by natural selection when the environment of a species has changed.

## Recommendations and guidance for the teaching of future candidates

Some centres had clearly helped candidates to prepare very thoroughly for their exams, but in others there were centre-specific gaps in knowledge or understanding that need to be addressed. Both assessment statements and teacher's notes should be consulted carefully to find what is expected. Topics that were new in the current programme were often the least well understood, suggesting that some centres had not yet updated their teaching, although this is the second year of exams on the new programme.

In some centres there needs to be more focus on fitting the style of an answer to the command verb that has been used in the question. Data analysis skills should be developed throughout two years of preparation; suitable practice questions are widely available and are often popular with candidates. Candidates should be encouraged to take a ruler and a calculator into their exam.

# Higher level paper three

### Component grade boundaries

| **Grade**: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Mark range**: | 0 - 4 | 5 - 9 | 10 - 15 | 16 - 20 | 21 - 26 | 27 - 31 | 32 - 40 |

## General comments

The comments on the G2 forms indicated that almost one half of the teachers felt the paper to be of a similar standard to last year's paper, while about one-third thought it slightly more difficult. As to the paper's suitability, 70% found it to be of an appropriate level of difficulty while 27% found it too difficult. Most considered the syllabus coverage to be either good or satisfactory, although 15% indicated it to be poor, an inevitable problem due to the limited number of questions covering the specific content of each option.

Over 90% of the respondents stated that the wording and presentation of the paper was good or satisfactory. As always, teachers' comments on each particular question were carefully considered at grade awards.

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

Some candidates had difficulty in the data analysis questions, especially in response to the command terms of objective 3, such as "explain", discuss", "analyse", "evaluate" and "suggest", giving very simplistic answers which did not satisfy the criteria. This also applies to other questions, in particular for the extended response questions.

Particular areas which caused problems were:

- Option D: biolochemical arguments based on DNA and protein structure
- Option E: contralateral processing of visual stimuli, nervous control of blood flow to the gut
- Option F: diversity of microscopic eukaryotes

- Option G: biogeographical features of a nature reserve that promote the conservation of diversity
- Option H: identification of micrographic structures of an exocrine gland, the Bohr shift

## Levels of knowledge, understanding and skill demonstrated

The majority of the candidates attempted to answer all parts of all questions. Many demonstrated well developed skills in interpreting the graphs and data in a variety of formats. Most candidates could extract values from data and make simple comparisons although there were significant numbers who had difficulties in even the more basic skills.

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

**Option D: Evolution**

**Question 1**

The graph was an unusual one but most candidates were able to answer both parts of (a) on the general trends although some omitted the details of levelling off or decreasing in the last period of years. Fewer understood the estimation of the increase in diversity in (b) that required contrasting the diameter of the first circle representing the initial viral population with the last. Few candidates received 2 marks for (c), many giving very vague answers on diversity and divergence. The more common answers here mentioned greater variability in the viruses and some natural selection of the most successful forms. A number of answers concentrated on the difficulties in trying to develop new vaccines. The concept of natural selection seemed to elude some.

**Question 2**

Some candidates obtained full marks for (a) although some mistakenly discussed Oparin's experiments or discussed the conditions on prebiotic earth instead of the processes. Most candidates demonstrated knowledge of the gradualism and punctuated equilibrium although some were not sufficiently detailed to gain the full marks, particularly for punctuated equilibrium.

Many candidates had no problem with (c) although many could not define a clade in (i). Most candidates gained at least some marks in (c) (ii), although many interpreted it as a dendrogram (morphological resemblances) without mentioning the ancestral grouping over time. There were some candidates who were very confused, apparently seeing a cladogram for the first time.

**Question 3**

a) There were some excellent answers here, showing full knowledge of the topic. Many candidates were fairly knowledgeable about the general structure of the DNA code and protein, but didn't link them to the evolutionary evidence of common ancestry.

**Option E: Neurobiology and behaviour**

**Question 1**

Most candidates answered the first two parts correctly although some had difficulties calculating the actual number of homozygotes in (b). There was considerable discrimination in (c) between the candidates who showed good ability to evaluate the data as to the risk factors, and those who thought the use of drugs and alcohol *cause*s mutations. Some lost marks by not contrasting the different groups with the control group. Again (d) discriminated between those who thought the use caused mutations and those who fully understood the information given in the stem of the question.

**Question 2**

a) In (a) (i) many candidates could not identify the bipolar neuron, giving rods, cones or ganglion cells as their answers. A great number gave a description of the inversion of images in the retina in (ii) instead of contralateral inversion and some even described colour vision. Few mentioned that there are left and right visual fields in both eyes.

b) In (b) there were many good answers, many giving that of the blackcap migrating to Spain or the UK from Germany. Some missed the second mark by not describing the natural selection pressure that caused the resulting animal response. Some candidates made up examples that were not verifiable.

c) In (c) there were again many good answers, involving reproductive behaviour, dirual/nocturnal behaviour or migration of different named species. Some did not fully describe the adaptive value of the described behaviour, thus missing the second mark. A considerable number of candidates surprisingly described Pavlov's studies here

**Question 3**

Many candidates gave general descriptions of the parasympathetic and sympathetic nervous systems but had it backwards in regards to the blood flow of the gut. However, they were still able to gain up to 4 marks with a full, correct discussion of the roles of the two systems.

**Option F: Microbes and biotechnology**

**Question 1**

a) (i) and (ii) were well answered by most, showing good data reading skills. Many were not able to give the name of a nitrifying bacterium in (b), a simple recall of content.

b) Was more discriminating, with few candidates obtaining the full 3 marks. The most common correct answers were of the destruction of lower vegetation and the destruction of the nitrifying bacteria. Very few demonstrated full knowledge of the nitrogen cycle and the requirements for ammonification as related to the data.

**Question 2**

a) Some candidates gave very precise names of microscopic eukaryotes in (i), but many were guessing, such as naming red blood cells, sperm, bacteria, yeast, etc. There were few complete answers in (ii), few showing knowledge of the diversity of structures in microscopic eukaryotes.

b) There were many complete answers here, showing good knowledge of the use of microbes in food production, most mentioning the cases of beer, wine and yogurt. Some lost marks by not clearly naming the organism by its generic name.

c) Some candidates gave a very precise example with a full description of the action of the named bacteria to remove the contaminant, but others gave only one part of the answer, either the name of the organism or the action without the name, thus losing the second mark.

**Question 3**

This question caused no problem for many candidates who were able to get most marks, although some candidates very vaguely discussed a named disease without even identifying either the cause or the associated epidemiological measures. Even those who named a disease that is not considered a pandemic by WHO, such as cholera, were able to gain up to 4 marks for simply discussing the disease fully and correctly, its cause, transmission, etc. Many of the answers were very poorly organized.

**Option G: Ecology and conservation**

**Question 1**

a) Most candidates correctly identified the freshwater ecosystem in (i) although some gave marine, obviously misreading the key. Most answered (ii) correctly.

b) Surprisingly, many candidates were unable to suggest a reason. The most common correct answer was that most plants and fungi were best adapted to territorial habitats or that the terrestrial ecosystems provide better habitats.

c) Most candidates were able to fully described the *cons* of the effects of alien species, but many forgot that a *discuss* answer also must include *pros*.

**Question 2**

a) Some candidates had no problem with this question, although many did not fully distinguish between the two types of niches or simply invented answers.

b) Some candidates appeared to have misread the question, or to have read only the first phrase, and simply described natural selection, instead of referring to changes in diversity and production during primary succession. However, there were also excellent answers, showing full comprehension.

c) Many candidates obtained no marks for this question, simply giving a vague description of a national park. Some even described zoos and botanical gardens. There were only a limited number who had good knowledge of the biogeographical features that promote the conservation of diversity.

**Question 3**

There were some good answers here, as was expected, although there were many very vague discussions of different measures to conserve fish, some only discussing the problems of pollution of the sea.

**Option H: Further human physiology**

**Question 1**

a) Most candidates answered this well, but some were not able to read the correct values in one or both parts.

b) Most recognized the positive relationship although not all understood the interpretation of the lines. Most mentioned the very scattered values.

c) The answers were very varied here, although many did get the two marks. The most commonly mentioned answers were the positive correlation and the wide range of data and the impossibility of establishing a causal relationship.

**Question 2**

a) There were some very clear, correct answers, but other candidates confused the two types of hormones while some discussed the general effects of steroids on the body or simply left it blank.

b) Many candidates mistook the micrograph for cell structure, naming mitochondria and nuclei as the indicated parts in spite of the specific identification as an exocrine gland.

c) There were many good answers here, showing full knowledge of the topic, although some focussed on pepsinogen and its role without mentioning the nervous and hormonal controls.

**Question 3**

There were some excellent answers here, showing full understanding of the Bohr shift in respiring heart muscle, although some discussed the role of myoglobin. Unfortunately a large number of candidates drew the structure of the heart with its chambers and valves and described the circulation of the blood, showing no knowledge of the Bohr shift.

## Recommendations and guidance for the teaching of future candidates

- Candidates should be encouraged to use subject-specific vocabulary in their answers.
- Candidates need more practice with data analysis using previous exams, paying attention to accuracy of reading data. Units should always be given with an answer to a calculation or when quoting data from a graph. More practice is needed in manipulating data and in calculating percentage changes, in particular. A wide variety of graphic representations should be used during the two years, including less commonly used ones such as stacked bar graphs as they require practice to master their interpretation. It is important to incorporate evidence given by the data itself when discussing, explaining or evaluating results or hypothesis.
- There are still some candidates who do not *distinguish between* the two parts of a question, rather listing statements separately.
- Candidates need guidance in how to consider the depth of their answer and the mark allocations. The command term must be considered carefully, as well as the number of marks for the question. If a question is worth six marks, at least six specific statements must be made.

The sequence of the statements should be carefully considered, as well as using examples to illustrate an idea. Throughout the two year programme candidates should have plenty of opportunity for writing extended response answers, striving for the quality marks for an organized, complete answer.

- Candidates should have studied the whole syllabus of two options and attempt to answer only those two. It is apparent that some candidates are answering ones simply because the data analysis looks easier, but they gain no marks on the content portion of the option.
- It is important that teachers allot sufficient time to cover all AS in the chosen options as the nature of the exam means syllabus coverage is not complete due to the limited number of questions on specific content. Teachers are advised to read the teachers' notes for guidance on the expected depth and breadth of each topic, to give examples when specified. The vocabulary utilized in the AS and teachers' notes is normally utilized in the specific content questions.
- When candidates use continuation sheets for sections of a question they should indicate that an answer is to be continued elsewhere.

# Standard level paper one

## Component grade boundaries

| **Grade**: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Mark range**: | 0 - 7 | 8 - 11 | 12 - 17 | 18 - 20 | 21 - 23 | 24 - 26 | 27 - 30 |

## General comments

Of the 35 G2 reports received by the time of grade award, 71% thought that the paper was of a similar standard to that of last year and 11% though it was a little more difficult. However, more than 90% of teachers thought that the level of difficulty was appropriate. Most teachers thought that the syllabus coverage, clarity of wording and presentation were satisfactory to good. There were many discriminating questions on this paper and a small number of questions that performed less well. In question 25, two answers were accepted as correct.

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

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

### Question 2

Although many candidates realized that a greater surface are to volume ratio increased the rate at which heat was lost, many candidates wrongly believed it slowed down the rate of exchange of waste materials. Some teachers complained that the distracters were ambiguous, but it was believed at the grade award that this was not the case.

**Question 3**

Some teachers commented that answer D was not quite specific and could confuse the candidates. This was the least chosen option. Most candidates went for the correct answer, making this question quite an easy one for most and a very good discriminator.

**Question 4**

A teacher complained in the G2s that a nucleolus is not in the syllabus, therefore an inappropriate distracter. It would be possible to only use terms present in the syllabus, but this is very limiting and sometimes it is not sensible to do so. Very few candidates went for that option. This turned out to be an easy question and a good discriminator.

**Question 5**

There were many comments on this question respecting the presence of 70S ribosomes in mitochondria and chloroplasts. Although this is true, B was still the best answer of the available choices, as all others were present only in eukaryotes.

**Question 6**

Some teachers complained that in some books the synthesis of proteins is in G2 not G1. In all sources checked, the synthesis of proteins is shown in G1. There is synthesis of spindle proteins and histones in G2, but this is not the main activity occurring in this gap stage. This question turned out to be a bad discriminator and was the most difficult question on the paper. There was a spread of choices amongst the four options. It is obvious that this topic was not known well, although it is present in the syllabus.

**Question 7**

This question turned out to be an excellent discriminator where most good candidates mentioned that sulfur is used in the synthesis of proteins and many of the weak candidates believed it took part in the transmission of nerve impulses.

**Question 8**

This question was a very good discriminator and was not a difficult question for most candidates. Most candidates knew the correct answer. Some weak candidates went for the answer with ribose as the sugar present in DNA.

**Question 9**

There were many complaints about this question, and as a matter of fact it turned out to be the second question in difficulty and not that good at discriminating between good and weak candidates. Many candidates believed helicase is in charge of elongation of DNA, the syllabus clearly states that helicase only unwinds DNA for DNA polymerase to act. It was agreed that this question was more appropriate for HL than for SL, but it could still be answered with the knowledge acquired in SL.

**Question 12**

This question turned out to be an easy question. According to the teacher comments, this was due to the fact that candidates were able to rule all the incorrect answers out. There is however, a lot of interesting data in this question.

The $T_M$ is extremely important in PCR and it is interesting to see that at a given temperature the DNA strands all of a sudden tend to separate. This is also a good question to use with candidates to explain the breaking of H bonds between complementary bases.

**Question 13**

This question turned out to be a good discriminator. Some teachers complained in the G2s that there was too much detail expected in this question. This exact statement is present however in the teacher notes of the guide.

**Questions 19 and 20**

These were second and third easiest question of the exam. This means they were not good discriminators, as almost every candidate had the correct answer. In response to the G2 comments, obviously the candidates had no trouble with the food web.

**Question 21**

This turned out to be a very good discriminator. Some candidates believed nitrogen was a greenhouse gas.

**Question 22**

This was the easiest question in the entire exam. Almost every candidate answered it correctly. In response to the G2 comments, the guide states to outline how population size is affected by natality, immigration, mortality and emigration. An excellent way to explain this is using population statistics.

**Question 23**

Although most good candidates had the correct answer, many candidates believed the plant shown was a conifer. It is possible that more structures needed to be shown to ensure the candidates can clearly see the differences in phyla.

**Question 24**

This was a very easy question, where most candidates chose the villi as the structures in the small intestines increasing surface area for absorption.

**Question 25**

Thanks to all the G2 comments received, it was realized that tricuspid and bicuspid valves were not always taught as such, but often, simply as the atrioventricular valves. This would mean that candidates who knew the structure of the heart and the pathway through it would not be able to answer the question. In order to solve this problem, although answer D was not correct, it was also accepted (as well as C) as a correct answer, giving these candidates the benefit of the doubt. Most of the good candidates still went for C as the correct answer.

**Question 27**

It has been suggested that the question should have mentioned that the alveoli have a wall of single layer of cells, it was felt that this would have only complicated the question.

**Question 28**

Most candidates mentioned the reduction in the number of lymphocytes as a cause of HIV, but many believed that it was the reduction in the production of antigens. Probably the confusion was with the words antibodies and antigens.

**Question 30**

Most candidates answered this question correctly, thus turning out into an easy question. Many candidates did not realize that testosterone is involved in pre natal development of male genitalia, although this is a function specifically mentioned in the guide.

# Standard level paper two

## Component grade boundaries

| **Grade**: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Mark range**: | 0 - 3 | 4 - 6 | 7 - 12 | 13 - 19 | 20 - 26 | 27 - 33 | 34 - 50 |

## General comments

In section B the overall quality of responses and diagrams in particular appeared to be of a similar standard than in May 2009. Diagrams appeared improved with more appropriate subject content this year.

G2 forms were received from 53 teachers, which was a decrease from the previous year. Forty percent of respondents found the paper to be of a similar standard to the previous year, with 50% believing it to be more difficult. This was in fact the case and the grade boundaries determined this year were much lower than previous years. Thirty seven percent of teachers regarded coverage as good. Forty one percent found the clarity of wording to be good. Sixty-seven of the respondents rated the preparation of the paper as good. G2 forms are always read and considered at the beginning of the Grade Award process, so detailed completion of them is most helpful in the process of awarding grades. This was especially the case this year with the paper being found to be unusually difficult for candidates. Please complete a G2 form for every examination your candidates are involved in.

In Section A, though all parts of the data analysis question were often answered well by the candidates as a group, overall success by any particular candidate usually fell well short of the maximum number of marks available. Candidates needed to scrutinize the data (primarily graphical analyses) more precisely and make better use of the background information that was presented. Also, especially in the data analysis questions, candidates often failed to match their responses to the leadoff action verb of the question.

In Section B, similar numbers of candidates chose each question. Achievement in this section was not as high as in previous years.

Candidates and their teachers should be aware that this exam was eMarked. This means that the scripts were scanned in black and white and delivered to the examiner electronically. Such processing means that candidates must follow the guidelines for writing their responses carefully, ensuring that they respond legibly in blue or black ink. They should not use coloured pens or pencils in their responses. Responses using highlighting will not scan and the examiner will not see answers completed in this way.

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

**Section A**

This year analysis of the data proved to be a challenge to many candidates, with candidates having most difficulty comparing and evaluating data. In the question 2, many candidates were unable to explain the role of water in photosynthesis.

In question 3, many did not know the steps involved in gene transfer and in question 4, a surprising number of candidates were unable to describe the need for a ventilation system.

Many candidates left spaces blank rather than attempt questions. Candidates should attempt every question.

**Section B**

As in the past, candidates found the longest parts of these questions (worth 8 marks each) the most difficult. They should carefully consider these parts before attempting the question. Most who chose question 6 were strong on parts (a) and/or (b), but weak in (c). Linking of relevant ideas to form a fluid flow of ideas *within* at least 2 parts of a question still remained a challenge to many.

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

**Section A**

Most were able to identify that the human genome project is useful in terms of the development of medical technology to assist in the diagnosis and treatment of genetic conditions. Most also were able to describe the concept of optimal pH in enzyme catalysed reactions. Many could recall the ecology definitions and were able to explain the concept of an energy pyramid.

**Section B**

There were many excellent diagrams drawn for part (a) of each question. Most candidates appeared to understand the command term in the question and what the answer required. The answers to question 5 were especially well done, with candidates displaying a good knowledge of the structure of blood vessels and the process of ventilation.

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

**Question 1**

a) Many candidates answered NaCl instead of Na when asked to identify the dissolved element

b) Many candidates were unable to discuss correctly the relationship between sampling visits (V) and pudding time (T) in experiments 1 2 and 3.

c) Many candidates were unable to see the relationship between the NaCl concentration, the sampling visits (V) and the pudding time (T).

d) In part (ii), the majority of the candidates did not compare the gain and loss of each ion between moths which drank from laboratory solutions and moths which drank from natural puddles.

e) I the case of many candidates, no discussion or analysis was included, only description

f) Only a few of candidates mentioned the need for Na in male moths.

**Question 2**

a) This question was well answered with the best responses clearly indicating the location of both hydrogen and covalent bonds. Almost all candidates discussed hydrogen bonding, but many did not discuss the use of covalent bonds.

b) Again, this was generally well answered with the best responses indicating that the breaking of hydrogen bonds occurs when water evaporates and removes a great deal of energy.

c) Many candidates answered this well, demonstrating a good knowledge of the movement of water across membranes

d) Many candidates did not appear to be aware that water played a role in the reaction of photosynthesis. Better answers used the term photolysis and explained it appropriately.

**Question 3**

a) Most candidates could recall a definition of an allele.

b) Many candidates did not use appropriate notation and did not score a mark. The Biology subject guide is very clear that candidates must use the $I^A$, $I^B$, i notation for the relevant alleles.

c) Many candidates could not identify the respective steps in the diagram showing the process of gene transfer. Quite a number did not answer the question at all.

d) Candidates either knew the enzymes involved in gene transfer or did not, leaving the space blank or naming enzymes involved in other genetic processes (e.g. polymerase or helicase).

**Question 4**

a) This question was well answered by most candidates, though a number did not understand the difference between aerobic and anaerobic respiration.

b) Many candidates found this question difficult and were unable to describe gas exchange or the high concentration gradient that results from a ventilation system.

c) Candidates generally found it difficult to sketch the changes in hormone levels in the second half of the menstrual cycle. Strictly speaking, candidates are required to annotate a graph rather than draw one. Examiners gave candidates a fair leeway in their responses to ensure that candidates who had a roughly appropriate graph drawn were not disadvantaged.

**Section B**

There was a fairly even distribution of responses across this section, indicating that the questions were of equal difficulty. They were found to be more challenging than the previous year.

**Question 5**

a) Candidates generally understood the process of hydrolysis but had difficulty applying it to the relationship between monosaccharides, disaccharides and polysaccharides.

b) The production of lactose free milk was well understood by many candidates, but most left out basic points such as the fact that lactose is found in milk and that lactase is the enzyme that breaks it down. Sometime these fundamental points, which are worth marks, are skipped. Candidates should fully explain their answers and not take any response for granted as 'too obvious for a mark'.

c) This section was generally well done with candidates demonstrating a good understanding of enzyme function in the context of the human digestive tract. The best responses named specific enzymes, the location of release and the substrate and products of the reaction catalysed. As in 5 (b), many candidates did not indicate that enzymes are biological catalysts and that they increase the rate of digestion. Candidates should fully explain their answers and not take any response for granted as 'too obvious for a mark'.

**Question 6**

a) Candidates demonstrated a good understanding of the movement of both energy and nutrients in ecosystems. The best responses were illustrated with energy pyramids or nutrient diagrams.

b) The role of sexual reproduction in evolution was well answered in general. The best answered laid out a step-wise sequence of events that explained how sexual reproduction leads to evolution with real life examples such as Galapagos Island Finches.

c) Few candidates could recall any detail of the characteristics of the plant phyla bryophyta and angiospermophyta. Many did use a table to distinguish between the two phyla, which was an appropriate way to approach the answer, however the lack of detail let most candidates down.

**Question 7**

a) On the whole candidates appeared to understand the differences between simple and facilitated diffusion. However, whenever a question asks for a comparison, candidates must make a direct comparison or draw a table to make the comparison explicit. Lists of characteristics of both transport mechanism are not acceptable on their own. This is a case where many candidates were let down by lack of understanding of the implications of not understanding the implication of the command term beginning the question.

b) This question was generally well answered. Many good answers used annotated diagrams to illustrate the process of endocytosis.

c) Many candidates wrote about the movement of impulses from neurone to neurone (across a synapse) rather than answer the question to explain how the impulse passes along a neuron. Some very good responses used annotated diagrams to indicate the flow of ions as the action potential passes along the neurone.

## Recommendations and guidance for the teaching of future candidates

- Be aware that your script will be scanned and that a black and white scan will be read by the examiner. Responses that use light or coloured pencil or highlighters will not scan well and may be missed by the examiner and therefore not receive marks.
- Read and use ALL information provided in the question. If you can, re-read it quickly and try to apply it in responses.
- Teachers should try to familiarize candidates with the meaning of the command terms in the subject guide. Incorporate these wherever possible in school assessment.
- Candidates should be succinct in their answers, writing their answers in the spaces provided or asking for extra paper if they do not have enough space in the examination booklet.
- Teachers could train their candidates more, or at length, on aspects of quality response to questions in section B. Many candidates miss out on the quality marks on offer since many just waffle.
- When calculating data, measure figures as accurately as possible and always show working.
- Use a dark pencil for drawing and a ruler for labelling lines in diagrams.
- Candidates should consider their section B choices carefully and respond to the question to which they can confidently attempt *all* sections.
- Teachers could also spend some more time on the section of the syllabus dealing with genetic engineering and natural selection. It appears these are usually rushed through without due regard to in-depth understanding by the candidates.
- All candidates should be given a copy of the current Biology Guide (first exams 2009) so they realize the content that will be examined.
- Candidates should be taught how to write answers that reflect the direction of the “Command Terms” on pages 11 and 12 of the Biology subject guide.
- Teachers should integrate the analysis of data in tables and graphs and calculations with units wherever possible throughout the SL course. Percentage calculations must be included.
- Candidates must practise drawing the diagrams given in the subject guide. Attention should be given to accurate labelling, juxtaposition of structures, relative size, and continuity (as in a continuous tube for the digestive system).
- A good review programme, including use of past papers from 2009 and onwards is essential to good preparation of candidates for the exam.
- Candidates should be aware that they are expected to write at least as many facts/clearly stated ideas as the mark value of the question, shown in brackets at the end of the question.

- Candidates should be shown how to write a plan/rough draft for a well-constructed answer, as an approach to writing organized answers. This is especially important for questions that start with discuss or explain. It is important for candidates to practise linking information in their answers. There is no need to repeat the question, since this takes up time and space.
- It is recommended that teachers emphasize the importance of legible handwriting. If a candidate's answer is correct but unreadable, the candidate may lose marks if deciphering the handwriting is impossible and the examiner misinterprets the script. This is especially the case now that scripts are scanned for marking

# Standard level paper three

## Component grade boundaries

| **Grade**: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Mark range**: | 0 - 4 | 5 - 9 | 10 - 13 | 14 - 18 | 19 - 22 | 23 - 27 | 28 - 36 |

## General comments

Of the 21 G2 forms submitted, 71% thought that the paper was of a similar standard to that of last year, while 14% though it was a little more difficult and 9% thought it was a little easier. Of the respondents, 77% thought that the level of difficulty of the paper was appropriate while 18% thought it was too difficult. Only 5% thought it was easy compared to last year's exam.

Syllabus coverage was judged to be good by 43% and satisfactory by 38%. 19% of teachers felt that the syllabus coverage was poor. Clarity of wording was thought to be good by 57% and satisfactory by 43%. About 71% thought the presentation of the paper was good and 29% thought it was satisfactory.

There were differences in the degree of difficulty presented by the different options. The data in D was much harder to understand for most candidates.

Options A and E seemed to be the most popular. Option F was by far the least popular option in terms of the number of candidates who answered it.

The standard of performance showed a wide spread, but generally candidates showed reasonable achievement, and there were also some very good answers seen. Surprisingly, some candidates attempted more than the required two options, and some questions were still left unanswered.

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

Answering questions calling for analysis, explanations, and calculations seemed to be the areas which proved more difficult to all candidates. Also, writing good definitions and knowing the difference between discussion and list or outline was an area of difficulty for many candidates. Few candidates were able to write concise answers. Candidates do not always read the question correctly and this can mean they get no marks for that question.

Options D and F seemed to provide the greatest challenge with some very weak answers in Option E also. The data in D proved difficult for many candidates.

Some candidates are still not responding to the command terms “explain” or “discuss” appropriately. The former needs explanations (A1(d) being a prime example where many candidates received 0 marks because they gave correct advice but without any reasons). “Discuss” needs a balance of arguments. Almost no candidate scored well on D1(c), F1(c) or F3(a). Calculating % changes is still clearly a challenge for many candidates.

## The levels of knowledge, understanding and skill demonstrated

Although there has been some progress, many candidates still have trouble reading graphs and using that information to make a calculation or to explain the results and its probable meaning. The drawing (there was only one required) was very poor.

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

**Option A: Human nutrition and health**

The X axis on this graph did not show linearity, which could have confused candidates. A1(c) indicating on the graph was difficult for many. A1 (d) a large number lost all marks because they did not explain the reasons for the advice and only listed some. In A2 (b) marks were given if candidates mentioned a source of carbohydrates in regions or countries, even if they did not mention the ethnic group. A3 (b) surprising how many thought that the sun provided Vitamin D directly and not that the skin is stimulated by sunlight to synthesize it. The rest of A was answered reasonably well. There were 2 'explain' questions in this option, but the second one, A2(c) did not cause as many problems.

**Option B: Physiology of exercise**

B1 there were some problems with the calculations here and a lot of trouble with (d) the evaluation of the limitations of the study. The rest of the questions were answered satisfactorily but only a few got the 4th mark for 3(b) because they didn't include a 'pro'.

**Option C: Cells and energy**

In C1 the graph and questions were quite straight forward and only (c) caused problems. In question C2 (a) the drawing was very poor, and (b) proved to be difficult for quite a large number. C3 (a) here some candidates did not read the entire question and only listed the functions without a named example. C3 (b) seemed to be very difficult and very few got this question right. Some candidates did mention the polarity and hydrophobicity of the amino acids, but did not mention the significance of them to membranes. This is clearly an area that needs reinforcing.

**Option D: Evolution**

This seemed to be one of the hardest on the test. The information was presented in a graphic form not seen before and so produced a great deal of confusion in its interpretation. Although an interesting graph, many candidates were not able to distinguish between divergence and diversity.

D1 (b) proved to be difficult and (c) using the data was very hard for most of the candidates. They were not able to relate what they should know about evolution and natural selection to viruses. D2 (a) Adaptive radiation was very poorly answered and in D2 (b) quite a few candidates got the two definitions right, but not the discussion part. D3 (a) was difficult and a lot of examples were of the teeth and jaw.

**Option E: Neurobiology and behaviour**

In E1 the graph seemed easy to read, but (c) evaluation of the evidence and (d) were poorly answered. There was some trouble in the interpretation of the key, as some candidates failed to notice that the difference was in problem users (Group 2) and ordinary users of drugs and alcohol (Groups 3 and 4). Many candidates failed to see that the homozygous condition was only a risk factor in drug users, but not alcohol users.

They also failed to see that in problem users of drugs or alcohol the homozygous condition also seemed to be a risk factor. E2 (b) the candidates found difficulty again with explanation of process. Many candidates were just regurgitating from some text about peripheral vision and not answering the question. Few scored rods/cones converting light to nerve impulses. Many candidates were wrongly stating that light passes through the nerves. E3 (b) connecting the learning to survival seemed difficult for some. It seemed that everyone knew about the hedgehogs crossing the roads,

**Option F: Microbes and biotechnology**

F1 (a) (ii) many candidates failed to score marks as they forgot to write the unit of net nitrogen. F1 (c) candidates had a great deal of trouble explaining this. F2 (b) was another difficult explanation question, although many candidates knew that the great diversity in prokaryotes prompted the new classification. In F3 (a) candidates had some trouble distinguishing between the two types of therapies.

**Option G: Ecology and conservation**

This seemed to be the easiest option this time. The graphs were straight forward, but there was some trouble with (d) the discuss question. There were many rambling answers. The rest of the option didn't cause any great trouble. In G2 (a) most candidates listed the abiotic factors affecting the distribution of plant species and were able to score full marks, making it easy to score 4 marks in this option. G3 (b) seemed to be answered very easily and many candidates scored all five marks. Most candidates mentioned the rainforest in their answer.

## Recommendations and guidance for the teaching of future candidates

- The importance of the command terms cannot be overemphasized. Comparisons require comparatives (more, greater, fewer than….etc) or a clear table to distinguish differences (or similarities if relevant). Similarly “evaluate” a hypothesis requires information that supports or refutes it and the candidate must state as such, not just regurgitate data from the question.
- More practice at answering questions that require the candidate to discuss or explain should be done. Invariably suitable examples are required in these questions - specific examples the candidates don't seem to have.
- Many candidates run out of space for their answers – it is not a requirement to write full sentences nor is it necessary (or wise) to rewrite the stem of the question. Pertinent phrases that make the point are often better. Try to get candidates to avoid restating the words in the question because they will gain no marks. E.g. B3 (b)…e.g. EPO benefits athletes since it increases their performance – gets no mark…it needs some greater depth e.g. EPO can increase flow of oxygen to muscles (1 mark) thereby allowing sprint runners to increase their speed and get faster times (1 mark).

- Biological mathematical skills appear to be weak. To avoid (–1 mark) for lack of units stress that candidates should always write units, even if not really required e.g. Calculate the % difference = 4%
- Similarly explain to candidates why occasionally arbitrary units are used in expressing data.