External Assessment Report 2009

Subject	Biology
Level	Advanced Higher

The statistics used in this report are pre-appeal.

This report provides information on the performance of candidates which it is hoped will be useful to teachers/lecturers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding. It would be helpful to read this report in conjunction with the published question papers and marking instructions for the Examination.

Comments on candidate performance

General comments

Markers reported that there were marked differences in the candidates this year in that some were very well prepared whereas others, often from the same centre, were not.

When all components are aggregated, there is evidence of a small decline in the average performance compared to last year, although the standard of the exam was similar.

The performance in Section A (multiple-choice questions) is high with an average of 18.9/25: this is half a mark down on last year but it is evidence of good performance, and one broadly expected from pretest data. The high value here is an essential part of controlling the overall demand of the course assessment by varying the difficulty across the components. Candidates can do well in this section because it relies on either problem solving, at which they are good, or the recognition of correct answers; in both of these they are not limited by their ability to express themselves accurately.

The other two components, Section B and the Investigation Report, demand extended writing. For some candidates, their ability to express scientific concepts as a piece of extended writing is a challenge.

The average score for Section B this year was (35.3/75), which is less than in 2008 (38.8), but similar to previous years. In this section, questions are contextualised so, to access the material, candidates need good reading skills combined with fast, accurate recall. When candidates attempt to write answers to these questions it becomes evident that, for many, the common combination is actually limited preparation and poor understanding, combined with weak expression.

In Section B, the mean score for the mandatory units was 46% for Unit 1 questions and 49% for Unit 2 questions, very similar to previous years. This discrepancy is consistent with the pattern that started in 2005 when the exam format was changed.

Also, there was a decrease in the standard of the candidates' responses to the extended response questions: the mean value was 6.0/15 this year compared to almost 9/15 last year; this year's was the lowest performance for several years. Q8A on *Carbohydrates* scored 6.3 and was tackled more frequently (73% of essays); Q8B on *PCR and DNA profiling* scored 5.4 (27% of essays). The poor preparation reported by markers is substantiated by evidence of this sort.

Within Section C, there were several changes in performance relative to 2008. Uptake of the *Physiology, Health and Exercise* option was about 85%, so changes in performance in this topic were likely to have a significant impact on the overall performance of the question paper. Uptake of the *Animal Behaviour* option was down to about 10% and less than 5% of candidates tackled the *Biotechnology* option

Performance in *Physiology, Health and Exercise* was down to an average of 10.1/20 from last year's 11.3. There is some evidence of weaker understanding based on item performance data (see below). Average *Animal Behaviour* performance was much the same as in the last few years (9.6). The *Biotechnology* option had an average of 7.5 (based on a small sample) compared to 9.4 last year.

The Investigation Report is the third component of the course assessment. The average score for the Report remains just over 14/25 (14.1), a standard that has been constant over the years, despite many advisory publications and regular exemplification of standards intended to improve it.

The Investigation element of Advanced Higher is a challenge for many candidates and Centres. It is meant to be a challenge - but in a positive way where the outcome is students who are engaged and excited by doing science at this level.

The Advanced Higher investigation needs a substantial investment of time from candidates and staff. Candidates need to do good background research, acquire an independent understanding of scientific method, master new lab techniques, collect results and evaluate them scientifically, all of which are required to meet the

standard for the internal assessment. Staff are encouraged to undertake one-to-one supervision, advising and supporting, reviewing and assessing regularly so that they can sign off unit Outcomes as the candidate progresses. The development of a 'daybook' is the vehicle for managing an investigation. The value of any time invested by staff at this stage cannot be over-estimated as it is one factor that underpins candidate success.

When candidates write up a Report of their investigation for external assessment; they must follow the publication guidance set out by the SQA (in the document *Advanced Higher Candidate Guidance*), just as if they were writing for publication in a journal. The Report is not intended to be a literary work; it is a factual account built from the continuous lab record. The guidance document is equivalent to an exam rubric.

Uptake of Advanced Higher Biology has increased by around 8%, to 2050 approximately.

Areas in which candidates performed well

Most candidates performed very well in Section A.

Throughout the various components of the assessment, most candidates showed good computational skills in numerical questions (Section B:Q1(b)(i); Q5(b)(iii); Q7(a) particularly) and sound analysis in other problem-solving categories, for example the data components of Section B Q1 on trophic cascade, foraging in *Animal Behaviour* Section C Q1 and several questions in *Physiology, Health and Exercise*.

Although the average score has not changed in Investigations, there were many more examples of excellent science in 2009. Teacher intervention is important for moving students up from the level they achieved in lower level courses; without it, the investigations are simple recipe following. Sound input shows up in key areas of the Report where the mark elements are asking for high-level understanding of the process of science. Good candidates have seen the importance of replication and sampling at the design stage of the work and again, later, have been shown how to evaluate their conclusions critically by analysing variance in results and considering the response of controls.

There were many excellent answers to all questions; some where the majority did well are noted below (where sample size for item responses has been substantial enough to judge):

- the idea that coral bleaching arises from fossil fuel use
- effects of exotic species and monoculture
- parasite transmission
- steroid structure
- levels of protein structure.

Many students have benefited from being taught well; their answers were well constructed, knowledgeable and accurately expressed.

Areas which candidates found demanding

Some questions in Section B are set to have different levels of difficulty. This is achieved in different ways:

- contexts can be demanding but questions are mainly straightforward
  (Section B Q1(a)–(d); Section B Q6; *Biotechnology* Q1; *Animal Behaviour* Q2; *Physiology, Health and Exercise* Q 4)
- links can be unusual and require different parts of a unit to be brought together
  (Section B Q1(f); Section B Q3; Section B Question6; *Animal Behaviour* Q1; *Physiology, Health and Exercise* Q1)
- questions can require thoughtful, well-constructed answers
  (section B Q1(e)(f); Section B Q2(iv); Section B Q4(c); Section B Q7(b); *Biotechnology* Q4(d); *Physiology, Health and Exercise* Q 3)
- questions are extended responses, which require considerable knowledge and organisation to complete

(Section B Q8 A and B; Section B Q3; *Biotechnology* Q3; *Animal Behaviour* Q 4; *Physiology, Health and Exercise* Q 2).

The exam does expose weaknesses in understanding. Some of the key misconceptions from this year are highlighted below.

Section B
B1(a) Heterotrophs consume organic molecules; the question is about what characterises the category. Parasites, decomposers, predators, grazers all have different relationships to the organisms forming the source of the organic molecules.

B1(c) 'Age structure' was not well understood. Many candidates thought the data represented percentage germination in different decades rather than the present day age distribution of survivors.

B1(e) Candidates who had difficulty with the concept of *trophic cascade* as the impact of changes in predator populations had difficulty when considering the effect of tourism. They commonly thought that tourists were trampling the young trees, or that tourists were feeding picnic scraps to the deer, which were thriving as a result and these were trampling the saplings.

B1(f ii) Intensity of grazing affects diversity. Most errors arose from not considering grazing *intensity*, ie. high, low and moderate. There were good answers about grazing in general; interestingly the responses contained reference to plants and herbivores and did not contain reference to herbivores as predators as they had in answers to 4(a ii). This point has been discussed in a previous External Assessment Report.

B2(a i) Benefit of dormancy in seeds. Commonly *seed dormancy* was wrongly taken to be a delay in germination till conditions are optimum for germination or to protect against poor weather conditions.

Almost all plant species produce seeds that are dormant: the embryo plant stops developing while still attached to the parent plant and remains in this state of suspended activity. It is obvious that parent plants produce seeds at times when conditions for germination and growth are good, yet the seeds don't germinate; some mechanism is limiting embryo development. Normally seeds require one or more specific stimuli to activate them but the outcome is that they avoid adverse conditions that are a feature of the habitat.
(For an interesting overview, see Begon, M, et al (1999) *Ecology: 3rd Edition*, Blackwell Science, Oxford, pp195-199.)

B2(iv) Most candidates recognised that a two year seed dormancy in the pest species was an issue but many felt it made eradication impossible. More able candidates spotted that the job could be done over a couple of years if the seeds were allowed to germinate and the new plants were removed/killed before flowering.

B3 There were many errors in understanding how fossil fuels could affect coral. The question is about global warming not about dumped oil turning water brown, as some candidates thought. There was misunderstanding throughout this question, as outlined below:

i about which of the greenhouse gases are produced by combustion – methane and CFCs are not;
ii that the greenhouse effect is vital but *enhancement* of it causes problems;
iii about how global warming arises; there is too much confusion with CFC, ozone, UV phenomena
iv zooxanthellae are not zooplankton, the algae live in the coral polyps, the relationship benefits both and it happens to be temperature sensitive
v coral polyps expel the algae under temperature stress; the algae are not dead.

B4 The concept of *competition* was problematic. Candidates need to be able to define terms in the exam then explore the subtleties of the concepts; they also need to know what is not correct. For example, competition is not 'fighting' it is an *interaction.* Interaction is a necessarily open term that allows for effects to be indirect, eg. plants compete for light; if one absorbs more, there is less for another and they did not fight about it.

The key point, missing in many answers to 4(a) was that the interaction is detrimental to **both** organisms/species: both are disadvantaged if the other is also using a common resource because each will get less; the impact will show up in lower survival of both.

Question 4(b) explores the idea of *niche*. A fundamental niche is the set of resources a species is capable of using *in the absence of competition (and predation)*. It is not 'in the absence of all other species' as some candidates described since this would exclude all food species. Some candidates quoted niche as an '*n*-dimensional hypervolume' but missed the point that this is an idealisation derived by excluding competition. As soon as there is competition, the interaction reduces resources for both so that the niche is what the species can 'realise'. (There are very accessible discussions in Townsend, CR, et al (2008) *Essentials of Ecology 3rd Edition*, Oxford.)

The final misconception in Q4 relates to the outcome of interspecific competition. Many candidates implied in their answers that some negotiation takes place between species and they agree who should get what and who should live where. For example, pupils wrote that the arrangement "allows these species to co-exist but on different islands" [sic] so it "stops them from having to engage in competition with one another" and "it is better for them to live apart". The anthropomorphic slant causes confusion and it hides the harsh reality of the forces that drive evolution.

If two species are in the same place at the same time and they need the same resources, they are automatically in competition. If they can survive as a population with the other species present, then they each have a *realised niche* that is relatively distinct or differentiated, and the resources are effectively 'partitioned'. More efficient exploiters however, the 'superior competitors', will use resources to the point that another species with a similar niche cannot survive and breed in its presence. The less efficient species dies out. In the cuckoo dove example, the two species occupy different islands: since both species have similar niches they could both potentially occupy any of the islands. In the event of competition on each island the weaker competitor has died out - it hasn't moved out. This is competitive exclusion.

The major issues arising in the Cell and Molecular unit were to be found in the essays. Many candidates had poor knowledge or were inaccurate in representing their knowledge.

Q8A *Carbohydrates*
This essay has been used in largely the same form in previous years, so it was expected to perform well. However, the average mark was 6/15.

Many candidates spent time illustrating and discussing the D and L isotopes of glucose in its linear form. The Arrangements do not require this level of knowledge. The emphasis should be on the cyclic form, it being more common than the linear form in solution, and its importance as the monomer for larger molecules should be developed.

Accuracy is needed with molecular diagrams or descriptions, and key features need to be mentioned – carbon atom numbers and the alternative positions of the C1 OH with respect to the plane of the molecule. The ring part of the monomer is not made up of six carbons, and it is not a benzene ring. Polysaccharide structure arises from the condensation reaction between OH groups, principally between C1 and C4; alpha and beta arrangements need to be explicit for each polysaccharide. Other structural and functional details follow on from this. Functions need to be very clearly described.

Q8B *PCR and DNA profiling*
This essay was very poorly done with the average mark being 5.4/15. As with 8A, part of it had been used before in a previous question paper, in 2002.

Some markers reported that they saw work of excellent quality, some candidates provided responses which were more up to date than the arrangements. However, most markers reported that attempts were largely guesswork or confused or that candidates had started without reading what the second part of the essay was about.

There was confusion between *DNA profiling* and *DNA sequencing*. In the Arrangements (p19), profiling features in the section on forensic applications where there is considerable detail about the principles. Sequencing (p18) determines the order of nucleotides in a section of DNA. Candidates need to be clear that the PCR and electrophoresis procedures are used in both contexts.

In profiling, PCR is used to amplify or increase the number of copies of the DNA sample, which is then digested into fragments that will be unique to each individual because of VNTRs. Fragments are separated by electrophoresis and the gel is blotted and probed to reveal the profile.

The sequencing process also uses PCR. As the unknown DNA base sequence is copied, the chain terminates randomly as a modified nucleotide (dideoxynucleotide triphosphate, ddATP etc) is attached to the growing chain. After lots of cycles in the PCR machine, there should be large numbers of every fragment size, each terminated with the modified, dyed base. Electrophoresis is again used to separate the DNA chains by size order, but this time the base sequence is of interest and is read off from the colour sequence.

The final misconception in the essay answers was that ligase is needed in PCR. The PCR process is not identical to DNA replication; there is no replication fork and no lagging strand fragments to be joined. DNA is melted to give two independent strands that are both copied from the primers in the correct direction.

Section C: Option topics

Biotechnology

The performance here divided distinctly into those who understood the work and those who did not. Even for the more able candidates, the 'scaling up' extended response question proved challenging.

The performance in Q4 was poor, commonly because candidates did not read the question introduction. Preserving nutritional quality is flagged up at the start as the main goal of ensilage and a key marker is preserved protein content. Protein breakdown results in the formation of free amino acids, so in 4(d) the *significantly* lower amino acid content from using starter culture is a good thing. Overlapping error bars in the lactic acid content graph suggest that pH is not significantly different between the treatment and control.

Animal Behaviour

There was a broad range of performance in this option and in each of the questions there were one or two ideas that proved more challenging than expected, notably Q1 *extended phenotype*, Q2 the *selfish gene* concept and Q3 *vigilance*.

Question 4 highlighted some conceptual concerns: candidates were clear on examples of appeasement behaviour and about when it arises in social groups. But many were unclear that *agonistic* was a general term encompassing behaviour related to fighting. In the context of social groups, it covers ways of avoiding real fights, so it includes aggression and submission - where gestures, display or ritualised behaviour have evolved to reduce the possibility of injury and to conserve energy.

Physiology, Health and Exercise

Questions 1 and 2 were answered very well. There were a couple of issues in relation to measuring percentage body fat using the BIA method (Q1). A common response was for fat tissues to be cited as 'electrical insulators that don't absorb current'; the logic then continued with 'the faster the current goes, the greater the fat mass because less current is absorbed'. This erroneous way of picturing the BIA principle obviously leads to the wrong conclusion.

The BIA apparatus sends out a small current of a frequency selected to pass through the water compartments of the body. Fat-free tissues offer little impedance (resistance) because of their high water content whereas fat tissues, having less water, offer some resistance. The greater the overall resistance the greater the fat proportion must be. The method is estimating total body water and this value is used in empirical equations to determine fat mass within the known body mass.

Q4 touched on an area of the arrangements that had not previously been assessed. Total energy expenditure is the sum of three components – BMR, physical activity and the thermic effect of food. Few candidates were able to state clearly how direct and indirect calorimetry differ. Measuring heat output (in a calorimeter) is direct whereas measuring oxygen consumption (and calculating the energy equivalent) is indirect.

Q3 was intended to be challenging. The Arrangements state that 'Maximal oxygen uptake (VO_{2max}) is a measure of the maximum amount of oxygen that a person can use, which is used to measure fitness'. Common responses included "VO_{2max} increased with exercise" or "oxygen uptake from the lungs" is limiting athletic

performance, ie. determining fitness. The first response does not make sense unless 'exercise' is replaced by 'training', which is a different concept. The second response is physiologically incorrect.

Although VO_{2max} is a measurement of oxygen uptake (which is possibly the source of confusion), it is in reality a measure of utilisation by muscles. In a normal individual, when the heart is pumping maximally, lungs are at only 60% of maximum efficiency (Guyton, AC et al, 2006), so uptake is not limiting oxygen transport. The maximum oxygen saturation of a red blood cell can occur in as little time as 0.25s in a lung capillary of a normal person doing severe exercise. (West, JB, 2005) The heart rate would have to be over 240 bpm before alveolar gas exchange was limiting oxygen transport; this is not possible.

The stem of the question did not use the term VO_{2max} but the conditions for measuring it were given (exercising to exhaustion on a treadmill) and the table of results show *Maximum oxygen uptake* and a corresponding *Fitness* value that takes account of body mass, ie. in the units of VO_{2max}. Many candidates did not pick up on the information provided and consequently did not achieve marks.

The utilisation of oxygen by the working muscles determines fitness, and the two limits to this are cardiac output and skeletal muscle efficiency (anatomical and biochemical), which improves with training. It is the rate of aerobic respiration in exercising muscles that makes the demand for oxygen and it is the rate of oxygen delivery that determines if the muscles can work harder without lactic acid fatigue.

Guyton, AC et al (2006) *Textbook of Medical Physiology 11th Edition*, Elsevier Saunders, Philadelphia.
West, JB (2005) *Respiratory Physiology 7th Edition*, Lippincott Williams and Wilkins, Baltimore.

Advice to centres for preparation of future candidates

Candidates should be encouraged to discuss and refine concepts with centre staff to develop a sound understanding of course content.

Approximately one third of the marks in Section B involve extended writing, a skill which candidates should be given the opportunity to develop by practising writing extended responses. Quality feedback from centre staff is advised to ensure that candidates are demonstrating their understanding of concepts through extended responses.

Centres are advised to ensure that they use the current documentation for the course, which can be found on the SQA website (www.sqa.org.uk). Published Marking instructions and External Assessment reports should be shared with colleagues and candidates to clarify concepts.

Centres have been advised of minor changes to the assessment of the Investigation Report; these changes are set out in the updated Candidate Guide and Teacher Guide, which are available to download from the SQA website. The Teacher Guide includes a list of relevant publications relating to standards. The instructions to markers for grading Investigation Reports are also published on the SQA site.

Candidates should be encouraged to discuss their investigations with their supervisor. Candidates should be encouraged to use the information contained within the Advice to Candidate document and the Marking Instructions when preparing their report, which will help candidates achieve their potential mark.

Centres are reminded of their responsible for Health and Safety in the investigations. Some markers reported Health and Safety concerns with Investigations, many relating to working with micro-organisms.

Centres are reminded that general advice about Investigations was published in the External Assessment report in 2008.

Biology: Biology Advanced Higher
Statistical information: update on Courses

Number of resulted entries in 2008	1955

Number of resulted entries in 2009	2095

Statistical information: Performance of candidates

Distribution of Course awards including grade boundaries

Distribution of Course awards	%	Cum. %	Number of candidates	Lowest mark
Maximum Mark - 125				
A	19.3%	19.3%	404	83
B	25.3%	44.6%	530	70
C	27.1%	71.6%	567	58
D	11.7%	83.3%	245	52
No award	16.7%	100.0%	349	-

General commentary on grade boundaries

- While SQA aims to set examinations and create marking instructions which will allow a competent candidate to score a minimum of 50% of the available marks (the notional C boundary) and a well prepared, very competent candidate to score at least 70% of the available marks (the notional A boundary), it is very challenging to get the standard on target every year, in every subject at every level.
- Each year SQA therefore holds a grade boundary meeting for each subject at each level where it brings together all the information available (statistical and judgemental). The Principal Assessor and SQA Qualifications Manager meet with the relevant SQA Business Manager and Statistician to discuss the evidence and make decisions. The meetings are chaired by members of the management team at SQA.
- The grade boundaries can be adjusted downwards if there is evidence that the exam is more challenging than usual, allowing the pass rate to be unaffected by this circumstance.
- The grade boundaries can be adjusted upwards if there is evidence that the exam is less challenging than usual, allowing the pass rate to be unaffected by this circumstance.
- Where standards are comparable to previous years, similar grade boundaries are maintained.
- An exam paper at a particular level in a subject in one year tends to have a marginally different set of grade boundaries from exam papers in that subject at that level in other years. This is because the particular questions, and the mix of questions are different. This is also the case for exams set in centres. If SQA has already altered a boundary in a particular year in say Higher Chemistry this does not mean that centres should necessarily alter boundaries in their prelim exam in Higher Chemistry. The two are not that closely related as they do not contain identical questions.
- SQA's main aim is to be fair to candidates across all subjects and all levels and maintain comparable standards across the years, even as arrangements evolve and change.