Version : 1.0

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Human Biology 2406

HBIO4 Bodies and cells in and out of control

Report on the Examination

2010 examination - June series

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Set and published by the Assessment and Qualifications Alliance.

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General Comments

There were some excellent answers to many of the questions with candidates demonstrating a sound understanding of the material covered in this unit. However, there were some areas where many candidates appeared to have rather limited knowledge and understanding, such as protein synthesis, genetic engineering, and colour vision.

Mathematical weakness was very prevalent, with only around 10 to 12 percent of candidates being able to perform the two calculations set. In particular, understanding of the relationship between units, such as micrometres and millimetres, or milliseconds and seconds, was very poor. Candidates should be encouraged to check whether the magnitude of their answer appears to be realistic.

Candidates' misspellings occasionally caused problems, especially where similar technical terms could be confused, e.g. *glycogen* and *glucagon*, *meiosis* and *mitosis*.

Candidates should be encouraged to make use of information provided in the stem of a question as this is provided specifically for their guidance.

Candidates should also be encouraged to check that they have understood the requirements of the question. They should avoid being side-tracked into answering a related question which is, essentially, irrelevant and thus unlikely to be awarded any marks.

Although data often needs to be examined critically to assess its reliability and applicability, candidates should not be so hypercritical that they lose sight of the patterns revealed by the data; some candidates were so intent on finding potential flaws in the methodology that they totally ignored the purpose of the investigation.

Question 1

Although generally answered quite well, many candidates were rather confused about various aspects of protein synthesis.

(a) About half of the candidates knew that three bases were involved in the triplet code, although some confused these with amino acids. Many did not state that the triplet codes for one amino acid. The most extreme error encountered was that a triplet code is 'three codons coding for a protein'.

(b) Most knew that transcription involved RNA synthesis but a fair number did not specify mRNA, while others confused transcription with reverse transcription. Some suggested that DNA polymerase was the enzyme involved and many struggled to express in an unambiguous manner the concept of complementary base pairing, or using one strand of DNA as a template.

(c) Accounts of translation sometimes omitted all mention of the ribosome and some even confused translation with DNA synthesis. Many seemed to be using relevant terminology but with no clear picture of the process; thus 'codons' and 'anticodons' paired up but often had nothing to do with mRNA and tRNA molecules – e.g. 'an anticodon brings its amino acid...'; sometimes 'bases' were joined by peptide bonds. Relatively few candidates could give two appropriate details.

Question 2

(a) This question was a good discriminator. Most candidates knew that cones were found at the fovea and that they were involved in colour vision. Fewer candidates were able to explain that there were three different types of cone, each characterised by its possession of a different pigment which was sensitive to a particular range of wavelengths ('colour') of light. In many cases, candidates' weak powers of expression made it appear that any one cone possessed all three pigments.

(b) In (i), many appeared not to understand that high visual acuity is associated with individual cones each being connected to a separate neurone. Some appeared not to appreciate the difference in meaning between *acuity* and *sensitivity*.

Part (ii) was another good discriminator. Most candidates knew that other parts of the retina, outside the fovea, contained rod cells and that these were generally connected in groups to a ganglion cell or neurone. Fewer were able to go on to explain how summation could then make it more likely that the threshold for an action potential could be reached even with little individual stimulation of the rods involved.

Question 3

(a) The vast majority of candidates were able to identify one part of the diagram of oogenesis which represented cell division by mitosis and most could identify the first meiotic division. However, only 25 percent knew that the secondary oocyte was released from the ovary during ovulation rather than the mature ovum.

(b) In (i), over 90% of candidates were able to identify two genetically-identical cells from the diagram (i.e. any of those prior to the first meiotic division) but in (ii) fewer were able to explain what caused the secondary oocyte and the first polar body to be genetically different – many thought the polar body was genetically empty.

(c) Over 80% were able to give the name of an appropriate hormone that could be used to stimulate ovulation prior to IVF treatment, usually FSH or LH.

Question 4

(a) Just under half the candidates were able to name the A-band as the part of the myofibril that remained unchanged in length during muscle contraction, while less than 10% knew that both the H-zone and the I-band decreased in length.

(b) Only 10% of candidates were successful in the calculation of the number of sarcomeres in a myofibril of length 21 mm. A further 14% had the right idea but were unable to interconvert the units micrometres and millimetres. From the scale bar on the diagram it should have been evident that the sarcomere was 3 micrometres in length and hence there were 7000 of them in 21 millimetres.

(c) The role of calcium ions in muscle contraction was well known, with almost half the candidates scoring full marks. Some told the wrong story – about synaptic transmission and the mobilisation of vesicles of acetylcholine.

Question 5

The usefulness of herbicide resistance in crop plants and the ways in which this resistance might spread to other plant species was well understood, with around two-thirds of candidates scoring full marks in each of the three sections of the question.

(a) There were some rather vague references to herbicide-resistant crops not being 'affected' by the herbicide and sometimes the herbicide appeared too universal in its application – as a means of killing insects and 'pests' in general. Better answers considered the effect on the crop of reduced competition from the weeds and hence potentially improved crop yields.

(b) Most knew that cross-pollination could sometimes occur between some crops and related weed species and that mutation might result in resistance appearing even in the absence of a herbicide-resistant crop. Some invoked natural selection without including the means by which variation arose in order to be selected. Others had some very odd ideas about herbicide residues left in the soil being taken up by weed species, and thus inducing resistance in them.

Question 6

(a) Almost 90% of candidates correctly cited the fact that healthy parents could produce a child with cystic fibrosis as evidence that cystic fibrosis was caused by a recessive allele. More than half of these were also able to explain this in terms of two heterozygous (or 'carrier') parents each contributing a copy of the recessive allele to the affected child's genotype.

(b) This question discriminated well across the whole range of marks. Almost half the candidates scored at least 3 of the 4 marks available for the completion of the genetic diagram. The two points most commonly made were the genotypes and phenotypes of the offspring. Many failed to obtain the mark for the gametes by writing them in pairs so closely together that they were indistinguishable from a diploid genotype. Most gave an incorrect probability for the offspring being a girl with cystic fibrosis: '0.25' rather than the correct 0.125. Many gave over-complicated genetic diagrams which included the X and Y chromosomes – these candidates frequently made mistakes. More sensible candidates simply multiplied their 0.25 probability by ½ in order to obtain the correct answer.

Question 7

(a) Just over half the candidates knew that oxytocin caused uterine contractions which could thus account for the pressure increase shown in the graph. However, some were so determined to parade their knowledge about positive feedback that they became side-tracked and forgot to relate their answer to the direct cause of the observed pressure increase.

(b) Upon reading the instruction to 'Evaluate this conclusion,' many candidates decided they had a mandate to find as much wrong with the investigation as they possibly could, often at the expense of analysing any pattern in the data. However, the instruction to 'evaluate' should imply that both sides of the argument need to be given consideration and that their relative merits need to be weighed up.

(c) This question was a good discriminator. Most candidates knew that the baby's suckling acted as a stimulus for milk release via impulses sent to the brain. Better candidates knew that the hypothalamus was involved in coordination of a response via the release of oxytocin and / or prolactin from the pituitary which caused contraction of the milk ducts or milk production, respectively.

Question 8

(a) Over 90% of candidates were able to give at least one effect of the decrease in oestrogen production at the menopause. Those who chose to describe effects on other hormones were often confused about whether levels of FSH, LH or progesterone would rise or fall.

(b) The data showed a marked increase in the rate of cell division in pre-cancerous cells from breast tissue when oestrogen was applied and a noticeable reduction of this effect when the drug Ebselen was included. In (i), many candidates interpreted the rise with oestrogen as an indication that oestrogen might increase the risk of breast cancer. They often forgot to point out that cancer involves uncontrolled cell division or that the increased rate of division might also increase the rate of mutation. Others were more concerned with the nature of this *in vitro* investigation and its applicability to conditions in the body. In (ii), the vast majority appreciated that the drug Ebselen might be suitable for treating some women with breast cancer as it markedly reduced the rate of cell division. In part (iii), the most common sensible suggestion was that HRT merely replaced oestrogen that had previously been present and so might not be expected to have any adverse effect, or that pre-cancerous cells may not be present in most women and so oestrogen would not be expected to have the effect observed in the investigation, or that other environmental conditions (such as tobacco smoking) might be necessary to cause mutations that might subsequently lead to cancer.

(c) The vast majority of answers here were disappointing as candidates largely ignored the information they were given in the stem of the question about the effect of Ebselen on peroxides. Hence, only a few candidates scored both of the available marks by suggesting that oestrogen might be involved in peroxide formation, or peroxide release, with consequential damage to the DNA – and very few suggested that this damage might have been in proto-oncogenes or tumour-suppressor genes and hence be related to the incidence of cancer.

Question 9

(a) Just over two-thirds of candidates recognised that the type of enzyme involved in cutting the DNA was a *restriction enzyme*.

(b) In (i), it was rather disappointing that only about half of the candidates were able to use information from the diagram to write out the base sequence of one of the sticky ends produced by the restriction enzyme. In (ii), rather more were successful in explaining the usefulness of sticky ends in genetic engineering as a means of rejoining two pieces of DNA, or for inserting a 'gene' into a 'plasmid'. Relatively few emphasised that complementary base pairing was involved in the process. Some attempted to describe the use of probes in PCR, forgetting that only the 'end' of a double-stranded DNA molecule was the subject of the question.

(c) Just over one-third of candidates identified band P in the electrophoresis pattern as being the largest. In part (ii), only about a tenth of the candidates could work out that a length of DNA would have to be cut three times in order to produce four fragments. In (iii), however, over a fifth were able to predict that there would be one less fragment following the mutation but very few of these could predict that this, being larger, would be nearer to the origin.

Question 10

(a) There were many bizarre calculations of the time taken for an action potential to be completed. Given that the frequency was 160 per second then, logically, each should have taken 1/160 second which, when converted to milliseconds, gave an answer of 6.25 ms. Only about a tenth of candidates got this far, although as many more ended up with these digits but with the decimal point in the wrong position. The most improbable answer was in excess of 6 hours.

(b) Over two-thirds of candidates made at least some headway with this question. Many knew the term refractory period and / or appreciated that greater stimulation was required to overcome the threshold if the axon were hyperpolarised. However, very few were able to give correct details regarding the closure or opening of Na^+ and K^+ channels in the axon membrane. Many candidates were side-tracked into extolling the benefits of the refractory period in terms of it preventing impulse transmission in the wrong direction which was irrelevant and scored no marks.

Question 11

This question presented candidates with data in a variety of formats and invited them to be both analytical and critical in their interpretation of it, thus applying their knowledge and understanding of How Science Works.

(a) In (i), nearly all candidates appreciated at least some aspect of the nature of the specificity shown by the membrane-bound insulin receptor protein. In (ii), most recognised that substance **A** was *glycogen*, although spelling proved a problem for some if they were unable to convince the examiners of the difference between this and 'glucagon'. In (iii), many candidates seemed to have a very vague understanding of the problems involved in the transport of glucose through the cell membrane: some thought glucose was so big it needed to be digested; others thought it was 'insoluble'. The facts that glucose is insoluble in lipid but soluble in water escaped most candidates and none seemed to understand that the glucose-transporter protein shown in the diagram provided a water-filled channel through the membrane. Most of the marks gained in part (iii) related to the specificity of the glucose-transporter protein.

(b) Most candidates performed well in this section. They understood the types of factors for which different groups of people would need to be matched in an investigation, they could detect patterns in tabulated data and most understood at least some aspect of why the use of a mean and standard deviation was more informative than just knowing the range of the data.

(c) The vast majority of candidates were able to state a satisfactory null hypothesis for the investigation. However, only about half were able to interpret the meaning of the stated

probability of 0.01. Many would have fared better had they considered the data that had produced this value, from which the difference was obvious, rather than merely trying to remember what the figure for the probability represented.

(d) Approximately two-thirds of candidates were able to explain how the data presented in the two graphs each showed a *negative correlation*. One very prevalent, and anticipated, error was the misunderstanding that 'negative' meant 'none'.

(e) This question had the clear instruction to consider data from figures **6**, **7** and **8** and omission of any one of these inevitably forfeited one-third of the marks. Less than half the candidates scored all 3 marks, although the vast majority were able to make at least two valid points. Candidates were at liberty to agree or disagree with the scientists' hypothesis, or even to submit the verdict 'not proven', provided they could cite evidence to support their argument. Two negative aspects, often argued successfully, related to the vast spread of the data and the dictum that a correlation does not prove a causal link.

(f) This was the most challenging section of this question as it required candidates to reconsider all the data previously presented to them and to produce a novel hypothesis to explain a phenomenon with which they were already familiar. Some fell at the first hurdle as they completely ignored the information given in the stem of the question about adiponectin levels and glucose-transporter proteins. Many were the victims of their own presuppositions about the nature of insulin receptors and they gave scant regard to the information provided. Very few *used* the information in the stem in order to explain that there would be fewer glucose transporter proteins *in the cell membranes* of cells that normally removed glucose from the blood, although better candidates did at least appreciate that less glucose would be removed from the blood, hence resulting in elevated blood glucose levels. Very few candidates related an increased blood glucose concentration to increased stimulation of the pancreas to release more insulin and hence the rise in blood insulin concentration (most concentrated on the insulin 'not being used up' due to faulty insulin receptors – which had nothing to do with the given information about adiponectin levels).

(g) This question was another good discriminator. About a fifth of candidates scored full marks. Approximately three-quarters of the candidates were able to use information from the graph to make at least two valid observations about the use of the two forms of modified human insulin for treating type 1 diabetics. The points made related to the speed and intensity of action, the longevity and stability of action, and the possible usefulness with respect to meals taken.