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Human Biology HBIO4

(Specification 2405)

Unit 4: Bodies and Cells In and Out of Control

Report on the examination

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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 polygenic inheritance, the mechanism of steroid hormonal control, the nerve pathways associated with vision, the coordination of temperature regulation, and the process of meiosis in oogenesis.

Mathematical weakness was evident in the selection and manipulation of appropriate data and in the inter-conversion of units.

Candidates should be encouraged to make use of information given in the stem of a question as this is provided specifically for their guidance. Similarly, they should take care in the interpretation of information provided in the form of flow-charts, graphs, diagrams or tables of data: time would be well spent in assimilating the information provided and in making sure it is well understood *before* attempting to answer any questions based upon it.

Candidates should also be encouraged to use appropriate, subject-specific, scientific terminology wherever possible in order to avoid ambiguity in their answers. Examples in the current paper include the distinction between the terms *gene* and *allele*, and deciding whether related molecules are the *same* shape, a *similar* shape or are *complementary* in shape. Candidates also need to know what is expected when different command words feature in a question, for example, the distinction between the commands *explain*, *describe*, *suggest* and *evaluate*.

Question 1

(a) This section was generally well answered with the vast majority of candidates able to describe at least one suitable feature of the placenta. However, only half could give **two** features.

(b) Almost two-thirds of candidates knew the name of a hormone (such as progesterone or hCG) responsible for maintaining the placenta throughout pregnancy.

(c) About one-third of candidates knew that the IUD prevented successful implantation. Rather more appreciated the ethical implication of terminating the development of a human embryo.

Question 2

(a) While most candidates appreciated that the given drug must have been a similar shape to acetylcholine, some spoilt their answer by describing it as being the 'same' shape. Many considered this sufficient for it to bind to the acetylcholine receptor, but better candidates explained the complementarity of fit which enabled it to do so.

(b) Most candidates realised that the drug would block the acetylcholine receptors. Some were careless and described these receptors as being located on a neurone rather than on the muscle fibre. Many went on to explain that Na^+ ion channels would not open. Fewer made any reference to the prevention of influx of Ca^{2+} ions and thus prevention of the unblocking of the myosin binding site on actin. Hardly any referred to the non-breakdown of the drug by choline esterase and hence its persistence in the neuromuscular junction.

Question 3

(a) This question was well answered by the majority of candidates. Most had no problem in relating the changes in ion permeabilities to the changes in membrane potential shown in the graph. Some became a little confused by attempting to introduce the concept of a refractory period which was not really relevant to the portions of the graph referred to in the question. One prevalent error was the idea that K^+ ions 'entered' the neurone rather than *leaving* it to cause a lowering of the membrane potential.

(b) Most candidates linked the increased oxygen consumption to the increased energy use of the neurone during impulse transmission. Active transport of Na^+ and K^+ ions was often given as the main use of such energy, although some gained this mark for stating that re-synthesis of the neurotransmitter would consume energy. A point frequently overlooked was that *respiration* was the process that consumed the oxygen and released the energy.

Question 4

(a) Almost 90% of candidates correctly selected 161 cm as the modal value in the distribution. A similar proportion was able to explain why 161 cm was also the median. In part (iii), a majority of candidates appreciated that the bell-shaped bar graph constituted a normal distribution. However, relatively few knew that, in such a distribution, the mean = the mode = the median; despite having just answered two questions that demonstrated this relationship. A few candidates pointed out that some columns were unexpectedly high or low, but hardly any attributed these anomalies to the random variation expected with a relatively small sample size.

(b) Very few candidates were successful in this question. Some made the observation that human height was an example of continuous variation but very few linked this to it being an example of polygenic inheritance. If they did, then they did not understand that if each of a number of genes (n) had 2 alleles, then there would be 2^n possible combinations of alleles giving, potentially, a wide variety of phenotypes. There was also some confusion in the use of the terms *genes* and *alleles*.

Question 5

(a) About half the candidates knew that the *sympathetic* branch of the autonomic nervous system was involved in activation of the adrenal gland in response to stress.

(b) Just less than half the candidates knew that adrenaline *decreased* blood flow to the skin and *increased* the heart rate.

(c) Most candidates knew that pathway **A** on the diagram would produce physiological changes more quickly, as it involved nervous impulses which travelled rapidly while pathway **B** used hormones which travelled more slowly in the blood. However, very few could explain that adrenaline (pathway **A**) might activate an enzyme quite quickly whereas steroid hormones (pathway **B**) would require gene expression which would take longer.

Question 6

(a) In part (i), poor expression quite often made it difficult to interpret candidates' responses, in particular with control **Group 1** which showed the healthy or non-diabetic response. There was often more success in explaining that control **Group 3** showed that **Group 2**'s response was due to the drug exenatide, or was not just due to the salt solution, or that **Group 3** showed any placebo effect.

In part (ii), two-thirds of candidates appreciated that the amount of insulin produced might vary in people of different sizes and, thus, it was necessary to express the results per unit body mass, in order to allow comparisons to be made.

(b) The vast majority of candidates correctly interpreted the data in terms of the drug exenatide increasing insulin secretion in type 2 diabetics. Many went on to explain how this increase in insulin could help in the control of blood glucose levels. A few indicated that this was due to increased stimulation of cells to take up glucose. Similarly, some indicated that this would mean the diabetic could have a much less restricted diet. Very few gave a full account and hardly any suggested that the drug might possibly increase the sensitivity of pancreas cells to glucose.

Question 7

(a) Many candidates simply referred to region **R** as the 'blind spot', but around two-thirds explained that no image could be detected here because there were no receptors present.

(b) There was some confusion between rods and cones in this section and there were some inappropriate references to colour vision and to acuity. However, most knew that rods were more common towards the periphery of the retina and that only cones were present at the fovea. Better candidates were able to attribute higher sensitivity in the rods to the possession of rhodopsin or to the convergence of the rods in groups, leading to summation. Converse points were also often made for cones at the fovea.

(c) The first two parts were answered rather poorly. Only about a quarter of candidates knew the term *optic chiasma* in (i) and hardly any could name the *lateral geniculate nucleus* in (ii). In part (iii), many knew that the image of an object in the left visual field would be perceived by the *right* visual cortex. However, explanations of why this was so were very weak, with less than one-fifth of candidates gaining any credit for their answers. This was because they failed to use the information in the diagram showing that an image formed on the right side of each retina would result in impulses being sent via neurones passing from here to the right visual cortex.

Question 8

(a) While most candidates could make at least one valid point from the data relating skin temperature and internal temperature, less than half were able to give two points unambiguously. This was frequently due to carelessness in reading the data or due to lack of detail. For the first 10 minutes after drinking the iced water, the data showed that the internal temperature decreased while the skin temperature increased. After this, the converse occurred.

(b) This question was answered very poorly. Many candidates gave a description rather than an explanation – the fact that this merely repeated the answer to part (a) should have indicated to candidates that more was required. Those attempting an explanation hardly ever made use of the data in the final column of the table which showed that the rate of sweat evaporation decreased as the skin temperature rose

and then increased as the skin temperature lowered – hence, the point that evaporation causes cooling was rarely given. Less than 10% of candidates made any headway at all with this question.

(c) Around one-third of candidates understood that iced water in the stomach would cool the blood here and that this cooled blood would then flow to the brain. However, few mentioned the role of the *hypothalamus* and an even smaller proportion realised that fewer impulses would be sent to the sweat glands. Many gained a mark for suggesting that vasoconstriction or erection of hairs might occur in the skin.

(d) Many candidates did not understand which figure to select from the table in order to perform the calculation. Among those whodid, many did not interconvert seconds and minutes.

Question 9

(a) Just over half of the candidates were able to suggest at least one feature of a suitable control, usually omission of the cadmium ions. Very few stressed that all other conditions should remain the same as in the cadmium-treated group.

(b) In part (i), over three-quarters of the candidates understood that expressing the results as percentages of the control values allowed valid comparisons to be made, or enabled a measure of the effect of the cadmium.

In part (ii), three-quarters were able to give an adequate description of the effect shown in the graph. Some were confused as the vertical axis showed the percentage of DNA that was unmethylated rather than the percentage methylated.

In part (iii), around two-thirds of candidates were able to suggest that the rise in methyltransferase enzyme activity was the probable cause of increased methylation of the DNA.

(c) Some candidates explained that the RNA-polymerase might not be able to bind to the methylated promoter of the p16 tumour suppressor gene. Others explained that the mRNA for p16 would not be made. It was somewhat rare (about one-eighth of candidates) to find *both* of these aspects in an answer.

(d) Poor quality of written expression marred many answers to this question. Candidates would refer to a 'lack of suppressor gene' as opposed to a lack of the *suppressor protein*. They would write that the gene did not 'divide', or the gene was not 'formed' or 'produced'. Similarly, they wrote that the suppressor gene helped to 'regulate' cell division rather than *inhibiting* it.

Candidates were required to synthesise an argument based on the data given in the three graphs. Many were able to relate an increase in tumour formation to a preceding fall in the production of the tumour suppressor protein. Some related this to methylation of the suppressor gene (or its promoter) due to an increase in methyltransferase enzyme, which was due to the progressive effect of exposure to cadmium ions. The question differentiated well across the ability range.

Question 10

(a) The vast majority of candidates stated, correctly, that the data indicated a higher success rate for IVF in the larger clinic. Many went on to state that there was less difference / no difference for the older women. A few candidates made reference to the absence of any statistical data which might have shown the differences were not

significant. Hardly any realised that only two clinics were being compared which would have made a generalisation impossible. This question differentiated well across the ability range.

(b) The instruction here was to evaluate the given conclusion using evidence from the graph. Points should, therefore, have been considered both for and against the conclusion and comments should have been made on the reliability of the evidence in the light of the methods used. Nearly all candidates were able to make at least one valid point and, as in part (a), the question differentiated well across the entire ability range. The most common observations were that the use of young / donated eggs gave a fairly constant and high success rate across the age range of women recipients whereas success declined when women used their own (hence older) eggs. Various other details were included by some candidates and a fair number commented on the lack of statistics, there being no information about the sample sizes and the fact that the donated eggs were all of a similar age.

(c) In part (i), most candidates successfully deduced the sequence of bases in the transcribed mRNA and the sequence of amino acids for which this coded. In (ii), a similarly large number were able to deduce that Val (the amino acid valine) would have replaced Glu (glutamic acid) in the sickle-cell mutant amino acid sequence. In part (iii), the concept of degeneracy of the DNA code was generally well understood and quite a large number of candidates also appreciated that a mutation in an intron, or a mutation resulting in a frame shift or in a chain termination triplet, would have consequences different from a single amino acid change.

(d) Nearly all candidates made some headway with the genetics cross but careless omissions deprived many candidates of one or two marks. The most common omission was a failure to state the genotypes, $\mathbf{H^AH^S}$, of each of the two parents. Another was a failure to identify the genotype $\mathbf{H^SH^S}$ in the offspring as the one that would suffer from sickle cell anaemia.

(e) A major problem in this section was that hardly any candidates attempted to answer the actual question which was to *explain the different combinations of alleles in* ***Figure 10***. Many diagrams produced by candidates were just rough sketches and were generally superfluous to the actual question, such as '2n → n → n'. The main marks awarded were for general points relating to independent assortment of chromosomes in meiosis I and of chromatids in meiosis II. Some mentioned, or drew, bivalents but many drawings were impossible to interpret. Although more than half the candidates scored one mark, very few scored more than this.

(f) In part (i), the majority of candidates appreciated that analysis of the DNA in the polar bodies left the eggs unharmed. In part (ii), most candidates knew that a DNA probe was a radioactively-labelled, or fluorescent, piece of DNA. Many went on to state that the probe would bind to the target DNA (the $\mathbf{H^S}$ allele) and some stated it would need to be complementary to (part of) the $\mathbf{H^S}$ allele. Relatively few pointed out that, in order to do this, the probe would need to be a *single-stranded* length of DNA. This question differentiated across the ability range. In part (iii), only about one-quarter of candidates gained both marks, being able to deduce from **Figure 10** which alleles must have been present in the polar bodies attached to eggs that carried only the $\mathbf{H^A}$ allele.

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