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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 accommodation in the eye, the behaviour of chromosomes in meiosis, post-transcriptional modification of messenger RNA and how heat is lost from the *blood* in breathing, sweating and vasodilation.

Mathematical weakness was evident in the use of scales and the interconversion of units (here, millimetres and micrometres). Candidates also need to check that their calculated answers are realistic.

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 or diagrams: 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.

Question 1

The general level of response in this question was somewhat disappointing, there being much confusion about the working of the eye.

(a) Most candidates knew that *cones* were involved in colour vision but many had difficulties making it clear that three separate types of cone were responsible for detecting different ranges of wavelengths / different colours.

(b) Many were confused about whether the ciliary muscles contracted or relaxed in order to focus on a near object and whether a thick or a thin lens was needed – some even omitted any mention of the lens and thought that 'pupil size' was important. There were also various vagaries about the degree of tension required in the suspensory ligaments. Only a quarter of candidates scored full marks.

Question 2

(a) Nearly all recognised that the unlabelled line on the graph represented changes in the concentration of *progesterone* throughout the menstrual cycle. Similarly, most could work out that, in the given cycle, ovulation occurred on day 12 ($\pm$ 1 day) and could relate this to the peak in LH.

(b) Many knew that oestrogen in the contraceptive pill inhibited FSH production / release and most could explain that either ovulation or follicle development would be inhibited.

Question 3

(a) Just over three quarters of candidates got the base sequence of the mRNA correct. The most common error was to suggest that thymine, rather than uracil, was complementary to the DNA's adenine.

(b) Relatively few (around one quarter) of candidates knew that mRNA was modified by removal of introns prior to translation. Many described the process of transcription which, of course, had already taken place.

(c) Descriptions of the codon-anticodon interaction between mRNA and tRNA were often imprecise, despite the presence of a diagram which showed that the bases interacted in sets of three.

Question 4

(a) Satisfactory definitions of basal metabolic rate were given by almost two-thirds of candidates.

(b) In part (i), relatively few candidates were able to give a full explanation that the BMR data in the graph were normalised per unit surface area to take into account people being of different sizes which would otherwise render the data non-comparable. Hardly any candidates explained that the rate of heat loss would be in proportion to the body's surface area.

In part (ii), a satisfactory explanation for the decline in BMR after the age of 45 years was rarely given. Many thought it was due to a lower level of activity, which contradicted their definition of BMR in part (a).

(c) The vast majority were able to give at least one physiological function that declined with age, cardiac output and nerve conduction velocity being the most common.

Question 5

(a) There was some imprecision and confusion over where calcium ions actually went when they triggered synaptic transmission. For some, this appeared to be into the synaptic cleft rather than into the presynaptic neurone. Others thought vesicles of neurotransmitter actually left the presynaptic neurone rather than fusing with its membrane. A substantial proportion confused synaptic transmission and muscle contraction, and phrased their answers in terms of the displacement of tropomyosin from actin.

(b) Given the details shown in the diagram –clearly showing vesicles of neurotransmitter in one neurone and receptors on the other – it should have been relatively straightforward to explain why the transmission of information could only be in one direction. A substantial proportion of candidates ignored the diagram completely and constructed their answers in terms of the effect of the refractory period. Only just over half of the candidates got this right.

(c) Nearly all candidates noticed the similarity in structure between the molecules of dopamine and cocaine, as shown in the diagram. Attempts at explaining complementarity, or 'fit', between the cocaine molecule and the dopamine transporter were sometimes rather weak – some merely repeated the question by referring to

'binding' while others chose incorrect terminology, suggesting that cocaine would fit into the 'receptor' rather than into the dopamine transporter.

In part (ii), most candidates scored 2 of the 3 marks available. They often had the right idea but did not necessarily express it with sufficient precision. Some could see from the diagram that the cocaine became bound to the dopamine transporter but did not explain the consequential failure of dopamine transport back into the presynaptic neurone and hence the accumulation of dopamine in the synaptic cleft. Others wrote rather loosely about stimulation of the postsynaptic neurone by dopamine without mentioning the receptors with which it combined or explaining that impulses would continue to be transmitted along the second neurone.

Question 6

(a) Many candidates gave somewhat vague descriptions of negative feedback. Others were succinct and precise and described it as a restoration of the normal level from which some parameter had previously departed.

(b) To answer parts (b) and (c) successfully, candidates had to be prepared to spend a little time familiarising themselves with the details in the diagram. Those who did then found part (b) quite straightforward as it was evident that a higher concentration of cholesterol in the cell would inhibit expression of the gene coding for the synthase enzyme which was required to catalyse a step in the production of mevalonate: hence less mevalonate would be produced.

(c) This part was slightly more complicated but candidates did not help themselves by trying to describe processes which were the exact opposite of those indicated by the direction of the arrows in the diagram. For example, many who stated correctly that there would be a low concentration of cholesterol in the cytoplasm went on to insist that this would reduce transport of cholesterol 'out of the cell and into the blood'. In fact, the diagram showed that a low cholesterol level would cause less inhibition of the gene for the cholesterol transporter protein. Thus, more transporter proteins would be placed in the membrane and more cholesterol would be transported out of the blood and into the cell. Only around one in seven candidates appreciated this.

Question 7

(a) This question was answered rather poorly. Very few candidates were able to relate reduced heat loss through breathing to either a reduction in the rate of evaporation from the lungs or to a reduced temperature gradient between the blood and the air when warm, water-saturated air was inhaled.

(b) Similarly, the initial fall in core temperature that occurred when a hypothermic patient was wrapped in blankets was only occasionally related to stimulation of sweating and of vasodilation, both of which would increase heat loss from the blood in the skin followed by a return of the cooled blood to the body core. In addition only a minority of candidates were able to relate a fall in core temperature with cardiac arrest due to either a fall in metabolic rate of the heart tissue or of the coordinating system in the brain.

(c) Many candidates were able to score quite well in this section by describing the key differences shown between the two curves in the graph. Extra credit was given if a candidate was able to quote precise numerical data from the graph.

Question 8

(a) Around two-thirds of candidates were able to select one haploid and one diploid cell from the 14 cells in the diagram of spermatogenesis. Descriptions of the differences between spermatogenesis and oogenesis were only given credit if they related to the actual process rather than when it occurred in the life cycle. Thus, the fact that all four cells produced in spermatogenesis became gametes, or that meiosis was completed before the release of the sperm cells, were acceptable answers.

(b) Examiners found it surprising that relatively few candidates were able to recognise two distinctive features from the photograph of chromosomes in late prophase I of meiosis, namely the association of homologous chromosomes in pairs and the occurrence of crossing over. To give even one of these points was the domain of only about half of the candidates. A similar proportion successfully nominated cell D from the diagram of spermatogenesis as the one in which this chromosome behaviour would be occurring.

(c) The quality of the evaluation of the data relating different aspects of sperm production to men's cigarette-smoking habits was highly variable. Although most were able to make at least one point successfully, less than half were able to make any advance on this.

Relatively few candidates commented on the considerable overlap of the ranges in the data, or on the apparent anomalies in the trend in two of the sets of data. Many candidates phrased their answers in rather vague terms, e.g., pointing out that there were different numbers of men in the different groups (which is quite common in any human studies) rather than stressing the particularly low – and hence potentially less representative – sample size in one particular group.

Question 9

(a) An unexpected, and invalid, answer to part (i) was the suggestion that harvesting mRNA would cause less damage to cells than taking DNA from them. Thus, many candidates appeared not to realise that the cells would have been broken to pieces in a blender in order to extract their nucleic acids.

More sensible answers related to the relative abundance in pancreatic cells of mRNA molecules coding for the production of insulin and to the absence of introns in the mRNA. However, less than one-third of candidates were able to make even one of these points.

In part (ii), over three quarters of candidates were able to name one of the two enzymes, but only about one-third recognised the role of both *reverse transcriptase* and *DNA polymerase* in catalysing the given reactions.

In (iii), it was pleasing to find that the *hydrogen bond* was almost universally known as the force involved in holding the two strands of the DNA molecule together.

(b) Around three quarters of candidates correctly stated that the short lengths of single-stranded DNA were known as *primers*. 'Sticky ends' was a common incorrect answer. Almost two-thirds knew, or could deduce from the diagram, that the purpose of cooling the reaction mixture at the given stage was to enable the primers to form hydrogen bond with the single-stranded lengths of DNA. Some answers were rather

too imprecise and could equally have been interpreted as meaning that the primers were bonding to themselves.

In part (iii), around three quarters of candidates knew that the primers would mark the sections of DNA to be replicated in the PCR. Very few explained successfully that they also served as starting material onto which new nucleotides could be attached.

Finally, in part (iv), just under two-thirds of candidates successfully calculated that one DNA molecule would have produced 32 molecules after 5 cycles of PCR.

Question 10

(a) Most candidates measured band X (the A-band in an electronmicrograph of a myofibril) correctly. Many did not then understand that they had to divide this by the stated magnification. Among those who did, many had problems interconverting millimetres and micrometres and were often several orders of magnitude out. Only one quarter of candidates were entirely successful.

In part (ii), most candidates knew the correct distribution of actin and myosin filaments in the two distinct bands of the myofibril. One unusual, and erroneous, concept expressed by a number of candidates was that one part of the myofibril was contracted at the same time as the other part was relaxed.

(b) Many candidates gave a full and clear account of the process of muscle contraction, including the roles of ATP, calcium ions, tropomyosin, the attachment of the myosin head to actin and its movement causing the actin filament to slide along the myosin. Weaker candidates just described how the appearance of the various bands changed when the myofibril contracted rather than offering the required explanation. Almost one-third of candidates scored full marks.

(c) Using information from the pedigree diagram showing the inheritance of Duchenne muscular dystrophy (DMD) over three generations, almost two-thirds of candidates cited the production of a child with muscular dystrophy by unaffected parents as evidence for the condition being caused by a recessive allele. However, less than half the candidates were able to identify two carriers from the diagram.

In completion of the genetic diagram, common errors included switching the genders of the two parents, giving the male parent a genotype that would have resulted in him having muscular dystrophy, incomplete assignment of phenotypes to the offspring genotypes (both gender and having / not having DMD were important) and, having shown that 25% of the offspring would be expected to be male with DMD, to then halve this figure to 12.5 %. Additional, incorrect, answers on the probability line, e.g., '25% or 1 : 4', failed to gain the mark. Despite this, almost one-third of candidates scored full marks in this section.

(d) Just over half the candidates answered part (i) correctly, realising that the complete absence of one of the gene fragments indicated that the person would suffer from DMD. In part (ii), these candidates realised it was the single copy of the other gene fragment (compared with two copies in each of his sisters) that indicated the person concerned was male as he had just one X-chromosome while his sisters had two. Only about one-fifth of candidates were able to tell the complete story, although some two-thirds got half-way.

Part (iii) differentiated very well between candidates who gave varying degrees of appropriate detail in their answers. The most able noticed that one of the girls had two copies of one of the gene fragments while her sister, having but a single copy of this fragment, must have been the carrier as she would have had one normal X-chromosome (hence being healthy herself) and one carrying the mutation responsible for DMD. Approximately one quarter scored full marks, although nearly two-thirds were able to make at least two of the three points required.

(e) Far too many candidates failed to use appropriate terminology in part (i). There were no marks available for stating that the 'immune system' (given in the question) 'fought against' / 'attacked' the implanted cells. Terms such as *rejection*, *antibody* and *antigen* were required. Less than half the candidates used such terms.

Similarly, in part (ii), there was no mark available for merely stating that the injection with salt solution served as a 'control'. The purpose of the control was required, e.g., so that the effect of the cells injected into the other leg became apparent, or to show it was not just the salt solution that had caused the effect in the other leg. Approximately half the candidates gave the appropriate detail.

In part (iii), there was plenty of scope for candidates to explain the limitations of the given investigation and to suggest appropriate further work that could be done. Candidates made general points about the limited sample size (i.e., just *one* individual), the short time period allowed to assess the effect of the treatment, or they made specific points relating to the given size of the response, the fact that success had so far been achieved only for this particular mutation, that only a measure of the *presence* of the appropriate type of muscle cells had been performed with no information about their ability to function, etc. The question differentiated very well amongst candidates who took varying amounts of care in selecting information, in assessing the reliability of the data and in applying their knowledge and understanding of how an investigation should be carried out in order to obtain reliable results and to draw valid conclusions. Although almost 90% of candidates were able to make at least one valid point, only 3% scored all 4 marks.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results statistics page of the AQA Website.