General comments

The paper produced a good range of marks and correct responses were seen in all parts of all questions. This paper contains the essay and this takes up most of the factual recall (AO1) marks for the paper. It follows that almost all of the rest of the paper has to test application (AO2) and How Science Works (AO3).

Students frequently scored poorly where they were expected to use information or data provided in questions. In particular, the examiners noted that in questions with a perceived How Science Works component, many students ignored the context, or even the question, and produced stock phrases and expressions that failed to gain credit. It was further evident that many students failed to read questions carefully and gave answers triggered by certain words in questions, rather than what was required.

Question 1

This question was intended to provide an accessible start to the paper, since it was almost entirely factual recall. In the event, it proved challenging for many students.

(a) Just over forty percent failed to obtain the mark. Some students failed to make reference to triplets, or three bases and made statements along the lines of ‘Many bases code for the same amino acid.’ Others got the definition the wrong way round and said that one triplet codes for more than one amino acid. Quite a few got confused between the genetic code being degenerate and non-overlapping.

(b) About thirty percent obtained both marks. Some students again failed to refer to triplets, or three bases, and some failed to say that a codon is on mRNA (we accepted DNA).

(c) (i) This question demonstrated that the majority of students think that RNA polymerase causes base pairing, rather than joining together nucleotides that have already base paired.

(c) (ii) About seventy-five percent of students correctly named the enzyme.

(d) A similar percentage obtained the mark for an explanation of what a palindromic recognition sequence is.

Question 2

(a) (i) About a third of students explained at length how tropomyosin prevents contraction, rather than explaining its role in contraction. Some of these students obtained one or both marks by going on to describe what happens during contraction.

(a) (ii) About forty percent obtained one mark for describing how the myosin head pulls actin past itself. A similar percentage went on to obtain a second mark for either describing the ratchet mechanism, or the role of ATP. The remainder tended to get confused between the roles of actin, myosin, troponin and tropomyosin.

The specification requires students to know the general properties of slow and fast muscle fibres. In general, fast fibres are used for movements that involve brief, intensive contraction (e.g. sprinting) and slow fibres are used for more protracted contraction (e.g. long-distance running). The intention was for students to bring this knowledge to bear in 2(b), when using the information in the table.
(b) (i) About half of students obtained one mark for this question, for stating that glycogen is a source of glucose for anaerobic respiration (glycolysis). Only a few went on to note that a high concentration of glycogen provides a lot of glucose, or very rapidly supplies glucose, for a rapid rate of anaerobic respiration. The mark could also be gained for noting the advantage of this rate being high, ie it overcomes the fact that anaerobic respiration provides little ATP.

(b) (ii) Many students obtained one mark for noting that many capillaries would provide a good supply, or a lot of oxygen. As in (i), few went on to link this to maintaining a high rate of aerobic respiration.

Question 3

(a) The vast majority of students obtained two or three marks for the description. Those who obtained three usually noted the growth/formation of the vacuole and the appearance and movement of starch grains. A smaller number noted the elongation of the cells. Change in size of the nucleus was treated as neutral; if the scales are used, the nucleus does not diminish in size.

(b) The question asked about the information in the diagram. Students who used the diagram scored quite well. How many marks they got depended on how many of the possible points they identified. Some students drifted into rote How Science Works answers about there being only one cell, or one study, or correlation not proving causation and did not get credit for these.

(c) This question produced some very good answers from students who used the diagram. About forty percent of students obtained one mark for noting that there was less growth on the lower side of the root (or more on the top). The twenty percent who got two marks linked this to cell elongation. The forty percent who got nought displayed a variety of misconceptions and often displayed poor logic. For example, some stated that the high concentration of IAA produced greater growth and this caused the root to grow upwards and others introduced light as a factor.

Question 4

(a) The question asks ‘How do these data support this conclusion?’ A significant number of students appeared to re-write the question as, ‘Do these data support the conclusion?’, or ‘Evaluate the conclusion.’ In either event, they tended to launch into rote How Science Works responses about correlation not proving causation, not enough rats in the study, only one study, the spread of the data, etc. This approach did not gain credit. Many (fifty percent) did obtain one mark for noting the positive correlation between concentration of sucrose and increase in dopamine release. A third of students then obtained a second mark for linking the increase in dopamine to an increased desire to eat. Only a minority obtained the third mark for clearly stating that this was positive feedback because drinking the sucrose leads to wanting to drink more.

(b) About a third of candidates scored 0 because they could not say what the refractory period is, or what it does. Those who had some idea usually wrote about it leading to discrete nerve impulses, or being a time when no new impulse could form, and scored one mark. Under twenty percent of students were able to link this to a limit on the frequency of nerve impulses, or to a limit in information about concentration that could reach the brain.

(c) Few students failed to score on this question; about a third scored one mark and just over forty percent obtained two marks. Marking points 1 and 2 were the ones most commonly awarded. Only a minority obtained a third mark by making a reasonable suggestion about the importance of limiting eating. A high number of students thought that the stomach, or person would burst.
Question 5

(a) About two-thirds of students were able to calculate the percentage increase.

(b) Half of students obtained one mark and thirty percent obtained both marks. One mark was usually awarded for transfer of heat from the suit to the body, or the inability to lose heat by sweating. Those who obtained a second mark noted that the suit was (initially) warmer than body temperature, or referred to inability to lose heat through evaporation of sweat. Some students thought that the suit would prevent any sweating. Others wrote about what might happen after hyperthermia sets in; for example, a higher metabolic rate, with increased respiration and more heat production.

(c) Equal numbers of students got this question right and wrong. Many are still totally confused about the relationship between a P value of 0.05 and significance.

(d) This question proved quite accessible, with half of students obtaining one mark and a third obtaining two marks. Some who failed to score appeared to read ‘ventilation’ for consumption and wrote about changes in ventilation rates.

Question 6

(a) It was a little disappointing to find that twenty percent of students could not name the bases correctly. It was encouraging to note that almost no students resorted to simply using letters, instead they wrote out the full names as in the example named for them. Letters on their own were not accepted in the context of this question, where they were asked to name the bases.

(b) This question discriminated very well, with similar percentages getting 0, 1, 2, 3 and 4. There were numerous examples of students getting confused about what binds to what. For example, some wrote about siRNA being complementary, or binding to, proteins or cells. Others failed to point out that only infected cells have the HIV protein for the carrier to bind to.

(c) Many students did not read this question carefully enough. The question asks how the carrier may be able to prevent the infection of cells by HIV. It does this by binding to HIV before it can enter cells. Many students wrote about the carrier binding to the HIV protein on the surface of cells. These cells would have to be infected already.

Question 7

(a) There were many good answers and half of students obtained both marks. There were quite a number of incomplete answers; for example, writing about sodium ion channels opening but not saying that the ions move into the post-synaptic cell. Some students wrongly wrote about calcium ion and others were penalised once for writing about sodium, rather than sodium ions.

(b) There were many good answers, with students writing about serotonin always binding to its receptor and thus causing continuous depolarisation, or action potentials. Some only scored one mark, because they overlooked the continuous binding. Others strayed into accounts of how neurotransmitters are recycled at the pre-synaptic membrane.

(c) Almost all students scored at least one mark but only a fifth obtained all three marks. There were various elements here that support the conclusion. All of the groups showed the same levels of movement before MDMA was given. This was only noted by a small minority. Most noted the
increase in movement in group L. Group K was a control group that demonstrated that MDMA caused the change observed in group L, thus supporting the conclusion. Group M showed no change in movement (and had no serotonin receptors), again supporting the conclusion. The question asks ‘How do these results support this conclusion?’ Quite a large number of students treated this as ‘Evaluate this conclusion.’ and launched into rote How Science Works responses about correlation not proving causation, not enough mice in the study, only one study, the results wouldn’t apply to people, there could be other factors, etc. No credit was given for this approach.

Question 8

(a) To answer this question, students had to appreciate that a person has two copies of each gene but in a carrier of a condition, the alleles are different. Many students appeared not to have grasped this concept. Just over one-third of students obtained one mark. The commonest mark awarded was for noting that the parents’ DNA bound (about) half the amount of DNA probe that bound to the DNA of the person not carrying the mutation. Many went on to say that the parents were heterozygous (or described this). Relatively few stated that the DNA probe binds to the non-mutant form/allele of the gene. There were a lot of vague responses about less probe binding and fewer genes, or less DNA binding to probe in the parents.

(b) Many students obtained one mark for noting that introns are spliced out of pre-mRNA to form mRNA. Others obtained a mark for stating that only exons code for amino acids. Some obtained marks for noting that only mutations of exons would affect amino acid sequences, or affect the protein produced. In general, few students gave the whole story. Some students wrote about exons producing amino acids and this was not given credit. Others strayed into (often long and inaccurate) accounts of introns and genetic fingerprinting.

(c) This question produced a lot of partial accounts of how to sequence DNA.

Question 9

As a whole, this question tested students’ understanding of the relationship between photosynthesis and the growth of plants. The questions were marked on outcome; this is to say that the examiners expected answers of A-level standard.

(a) Many students failed to read the y axis carefully enough. All of the samples of plants increased in dry mass after 3 days, they all grew but some less than others. GB had no effect at 25°C, compared with plants without GB. Few students noted this and quite a number stated that GB produced more growth at all temperatures. Relatively few students made reference to the protection given to growth by GB up to 35°C. However, quite a few noted that growth was reduced less above 35°C with GB.

(b) (i) There was only one mark available for this question and, with this in mind, students were required to refer to the standard error bars not overlapping, or to state that there was a significant difference between plants producing GB and those that weren’t.

(b) (ii) Over a third of students obtained one mark, usually for linking a reduction in photosynthesis to a reduction in glucose (simple sugar) production. Some were also given credit for suggesting that the reduction could be linked to reduced enzyme activity. This was as far as most students went. Indeed, quite a large number wrote about reduced photosynthesis producing ‘less food for the plant’. This was disappointing at A-level. For most students, their statement about reduced glucose production was simply followed by ‘therefore growth falls’. There were very good answers
that linked reduced glucose production to less respiratory substrate and thus less ATP/energy for growth. Others displayed understanding that sugars from photosynthesis form the basis for production of other organic substances and that these add to dry mass.

(c) This was another question where some students failed to read the question carefully. A large majority correctly suggested that when the enzyme attaches to the thylakoid, this changes the shape of the enzyme, and/or its active site. They then went on to link this to a failure to bind to its substrate. Those who did not read carefully suggested that the enzyme was changed before binding to the thylakoid. This did not preclude them from scoring marks but made it less likely.

(d) It was pleasing to see that the chain of evidence and logic was seen by most students. The number of marks they obtained tended to be a question of how much of the story they gave.

(e) Many students ignored the statement in the stem that the hypothesis was developed on the basis of previous research. Instead, they reiterated the evidence from the study in the question. Good answers included the idea that research might have shown that crops in hot climates naturally produce GB.

**Question 10**

Large numbers of good and excellent essays were seen. The essay titles appeared to be about equally popular. The examiners’ opinion was that the better essays were usually produced in response to title (a) about membranes. The other essay often contained a lot of material that was of GCSE standard and of limited breadth.

The vast majority of students appeared to understand that this is a synoptic exercise, where they have to draw on a wide range of examples to obtain a high mark. Some students only dealt with one or two topics but in great detail and depth. Unfortunately, this severely limited the mark they could obtain.

Essays with a narrow scope were more common with title (b) about relationships and interactions. Many of these just went on endlessly about food chains and webs. Attempts at extension material were common. However, the use of examples that any member of the public might use did not gain any extra credit; for example, vague accounts of the plight of polar bears as ice caps melt. Extension material has to be at least of A-level standard and accurately described using appropriate scientific terminology.

The marking annotation of the essay was changed for this series, but the principles of marking remained the same. Where an AS or A2 topic was included, a vertical line should appear in the right margin. If a paragraph (or substantial piece of text) was irrelevant, a vertical line should appear in the left margin. Any notable errors should be underlined. The vertical lines do not give any information about the quality of the content. That was assessed by the examiner as they read the essay.

This report will mainly consider the topics identified on the mark scheme as relevant to the title and which were frequently used by students.
(a) The membranes of different types of cells are involved in many different functions.

Most students started with a description of membrane structure. Many did no more than that and did not relate this to *function*; for example, selective permeability to lipid-soluble substances. There were quite frequent references to incorrect Biology; such as ‘the fluid-mosaic membrane usually found in animal cells' and ‘the cellulose membrane in plant cells’. Transport mechanisms were often named but less frequently described in any correct detail. Credit was available for descriptions and explanations of facilitated diffusion and active transport. There was considerable confusion between the two processes and between channel and carrier proteins. Co-transport was a popular topic and most students identified as their example glucose transport with sodium ions by epithelial cells of the small intestine. There were some really good descriptions of the active transport of sodium ions to generate/maintain a concentration gradient for facilitated diffusion of glucose and sodium ions. It was not uncommon for students to get rather confused about what was transported, where and by which process.

The role of thylakoid membranes in photosynthesis was quite frequently described. The best examples gave these as the location of photosynthetic pigments and the electron transport chains, as well as describing the role of the membrane in the chemiosmotic synthesis of ATP and the production of reduced NADP. Poor responses often started by saying that thylakoids are important in photosynthesis, with no further detail of how. They then often moved on to irrelevant detail of all the other stages of photosynthesis. A similar picture was seen with the role of cristae in respiration, except that most students seemed to have a somewhat better grasp of this than the role of thylakoids.

The roles of membranes involved in protein synthesis and secretion were rarely seen. The nearest that many came was to write about nuclear pores and the passage of mRNA for protein synthesis. There were many good descriptions of the roles of membrane-bound receptors, antigens and antibodies in the immune response. These often included the fusion of lysosomes with phagocytic vesicles/vacuoles. Some students did get rather confused about which cells displayed receptors, antigens and antibodies on their surface. A few students strayed into details of vaccines, secondary responses, memory cells and antibody action with no reference to membrane function. Horizontal transmission of genetic material between bacteria was quite often seen. Some students did not make clear the function of the membrane in this and wrote mainly about plasmids and antibiotic resistance.

The Pacinian corpuscle was a popular choice. There were many good accounts of stretch-mediated sodium ion channels in membranes and the production of action potentials. Students often obtained credit here for the role of the membrane in the production of an action potential. Most students wrote about axons as a separate topic, sometimes going on to Pacinian corpuscles as an extension of the same paragraph. There were many good descriptions of how proteins in membranes are involved in maintaining resting potentials and producing action potentials. Some got the ion flows the wrong way round, or at the wrong times. A few wrote about the wrong ions, such as calcium.

Most students wrote about synaptic transmission and most focused on the functions of membrane. The best accounts wrote about calcium ion channels, fusion of vesicles with the pre-synaptic membrane, receptors being only on the post-synaptic membrane and the opening of sodium ion channels. This was a topic area where good extension material was often seen. One example seen in a number of essays was the role of GABA in opening chloride ion channels and the inhibitory effect on action potential formation. Those who wrote about synapses quite often went on to write about muscle contraction. There were good accounts of the role of the muscle membrane
at the neuromuscular junction and the roles of T tubules and sarcoplasmic reticulum in calcium ion movements. Some weaker accounts just said that membranes are involved and then wrote about actin, myosin and contraction.

Hormones were frequently written about. The best accounts focused on the involvement of membranes. Many wrote about the lipid nature of oestrogen and how this allowed it to enter through the phospholipid bilayer of cells. Others wrote about insulin but details of its effects on transport of glucose across membranes were relatively rare. Glucagon and adrenaline were also commonly used as examples and frequently involved good outlines of the second messenger concept.

Large numbers of students wrote in one way or another about osmosis. Plant roots were a common setting for these accounts. There were some good accounts of active transport of mineral ions by root hairs, leading to lowering of water potential inside the cell and entry of water by osmosis. Accounts of the same sort of sequence involving endodermal cells were rare. Many students appeared to be totally confused between apoplast and symplast. This was a topic area where quite a few drifted into accounts of water movements in the xylem and through leaves which contained no references to membranes.

(b) There are many different types of relationships and interactions between organisms.

There were some good accounts of the interactions between pathogen and host. These usually focused on the reaction of the immune system to a pathogen. Some looked more at how a pathogen may harm the host. This was a topic area where extension material was quite often included, usually relating to detailed accounts of the effects of a pathogen not named in the specification. Cholera was used as a specific example by many, together with varying amounts of detail on how it interacts with the host. Tuberculosis was quite often cited but relevant detail appeared to be rare.

Only the best essays tended to contain detailed and relevant accounts of taxonomy, classification and evolution. These included accounts of principles of phylogenetic classification, DNA hybridisation and immunological comparisons of proteins. These essays often contained good accounts of evolution of populations and speciation. Weaker essays often contained rambling accounts of competition and evolution of new species but used little or no correct terminology and often confused populations and species.

Behaviour was a very popular topic. There were good accounts of its importance during reproduction to identify individuals of the same species, in order to produce fertile offspring. Some accounts went on to explain its role in identifying individuals in breeding state, or even its role in promoting gamete production or release. There were a lot of vague descriptions of behaviour showing who was ready to mate, with no A-level content.

Many essays had very long and rambling accounts of relationships within ecosystems. Some consisted of little else. There were some very good accounts of the concepts of food chains and food webs and the inter-dependence of populations of different species within a community. These often went on to consider energy transfers within ecosystems, between different trophic levels. Weak accounts were at GCSE level or below, with references to plants making their own food, or energy, and this being passed on to all the animals. The predator-prey relationship was often described but infrequently with references to populations, inter and intra-specific competition or time lags.
Succession was another frequently seen topic. The best accounts wrote about pioneer species and communities, resultant changes in abiotic and biotic factors and the ensuing competition from other species that (may) out-compete the pioneers. They also wrote about communities and biodiversity changing over time until a climax community was established. Many accounts contained little or no scientific terminology or concepts.

Human impacts on the environment were as commonly written about as relationships within ecosystems. Unfortunately, many accounts were at or below GCSE standard and were often at the level of humans causing global warming which was bad for polar bears. There were good accounts that used, for example, deforestation as an example and contained references to habitat destruction, loss of niches, loss of diversity and the reasons for this. Others wrote about farming and the simplification of food webs, loss of diversity, use of pesticides and selective breeding. Nutrient cycles were written about by most students. The specification rather limits what they can be expected to know about the carbon cycle but some failed to include any relevant detail. The nitrogen cycle was well done by some but there were common misconceptions about what happens in the root nodules of leguminous plants. Many thought that \textit{Rhizobium} converts nitrogen to nitrates for the plants. There was also considerable confusion between nitrifying and denitrifying bacteria. Many students went on to write about eutrophication and it was pleasing to see many correct accounts of the process.

Gene technology in various forms was a popular topic. Most wrote about genetically engineering microorganisms to produce useful substances such as insulin. Others wrote about genetically engineered crop plants with herbicide resistance, or that produced an insecticidal protein. The quality of the accounts varied a great deal. Many who wrote about this also wrote about evolution of antibiotic resistance in bacteria. Good accounts included horizontal transmission of genes for resistance between species of bacteria, involving plasmids. Relatively few students made any mention of antibiotics as a selection pressure, or random mutations as the source of resistance.

**Mark Ranges and Award of Grades**

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