Written Component

Section A – Criterion 3

Question 1

a) IV = temperature (1) OR change in temperature (1) OR 10°C increase in temperature (1)
DV = respiration rate (1) OR respiration rate of yeast (1).

b) Only one replicate of each treatment (1) OR two different IVs, amount of glucose & water temperature (1) OR interaction between IV and CV (amount of glucose isn't constant) (1).

c) Any two of the following (1 mark each):
- Ensure that the amount of glucose is the same in each test tube e.g. 10g or 15g
- Replicate each treatment e.g. 5 replicates for each treatment
- Add additional temperature treatments (e.g. 0°C or 50°C).

Comments

The majority of students could access this question and most gained 4 or more marks out of 5. In part a), the DV must make mention of 'rate' for the full mark. In part b) 'there is no control group' was a common answer with students not recognising that with temperature as the IV, it is not really possible to have a sensible control. If students identified as their problem that there were 2 IVs in the stated design, they needed to name them in order to get the full 1-mark allocation for this part. No answers were accepted for part c) that referenced detail which was not given in the question. Smaller temperature increments were not a valid improvement, given that the hypothesis specifically identifies 10°C increments. If 'increased sample size' was a stated improvement, only ½ mark was given if no further information was provided about how this might be achieved. Suggestions to repeat the experiment with no change to the method were not paid any marks.

Question 2

a) Possible answers include:
- Increasing the concentration of hydrogen peroxide will increase the rate of oxygen production due to the action of catalase (in potato). (3) 1 mark for IV, 1 mark or DV and 1 mark for direction of response.
- Increasing the concentration of hydrogen peroxide will increase the rate of reaction of catalase (3).
- Increasing the concentration of hydrogen peroxide will increase the rate of production of oxygen/total amount of oxygen (2) not testable as enzyme not mentioned.

IV - Needs to be concentration, only ½ mark for amount/volume of H_2O_2.
DV – Can be rate or total amount (i.e. once all H_2O_2 broken down).
Direction of response – increased production of oxygen with increased concentration.

b) Suitable control should same size potato cylinder in distilled water rather than H_2O_2 i.e. (0% H_2O_2) (1).
Expected results should be that no oxygen is given off, so measuring cylinder volume should not change (1).
Removing potato and having only H_2O_2 is not viable as the potato/catalase is not the IV – the IV is substrate concentration.

c) Any two of the following (½ mark each):

- size/weight/shape of potato cylinder
- pH of H_2O_2
- temperature at which experiment is conducted
- volume of H_2O_2 added
- more answers possible.

Light intensity was not accepted as it has no bearing on the results of the experiment.

d)
i. 1 mark for circled answer, ½ mark for mean (dashed)

	Amount of oxygen released (mL)			
Concentration of hydrogen peroxide (M)	**Replicate 1**	**Replicate 2**	**Replicate 3**	**Mean**
0.1	3.0	3.6	3.2	3.3
0.2	5.8	6.2	6.1	6.0
0.3	2.5	8.8	9.2	6.8
0.4	10.1	10.5	10.6	10.4

ii. Remove data point and recalculate mean (1). Remove outlier and discuss in report (1). No marks for suggesting repeat the experiment as the question specifically states data analysis.

e) Data appear to support hypothesis (½) as the amount of oxygen released has increased with increased concentration (½), evidence of non-linear response (½). If the response to this question related to an incorrect hypothesis in part a), the error was continued through and not penalised in this question provided the student stated it was supported or not and why.

Comments

The majority of the students found this question accessible and achieved around 6-7 marks. In part a), the enzyme was not mentioned in a lot of answers limiting full marks and there were a number of students who used ‘amount’ instead of ‘concentration’ for the IV. Part b), many students stated that a beaker of H_2O_2 was a control or just remove the H_2O_2 component without stating replacing it with water. Some students also missed stating the expected results. Part c) was answered very well, with most students achieving full marks. Part d (i) was answered correctly in most instances; however, some students did not circle an answer at all. Part d (ii) saw a lot of students just stating remove the data or repeat the experiment. Part e was answered mostly correctly; however, the marking team did see some students only answering “yes it is supported”.

Question 3

a) A and C (½ mark each)

b) There is no control in this experiment (1) as all the different discs have been soaked in a different antibiotic (½) – if there was a control, a disc soaked in distilled water/ water or blank disc without the antibiotic would have been used (½).

c) Any of the following:

- ½ mark for valid idea
- 1 mark showing how this would be administered – the method
- ½ mark for why this is needed:

Eg: Increase replication/replicas (½), have 10 plates each with the same antibiotic-soaked discs, possibly randomise position on plate (1) to see if there is continuity/consistency in the data set of replicas compared to the original data (½).

d) At least three valid answers (1 mark each) with at least one advantage and one disadvantage:

Examples of accepted answers:

- Advantages (any of the following): Easier and quicker to create a large sample size of agar plates than to find human subjects. The cost of performing an experiment in a lab with agar plates is cheaper than to find human subjects and test over a period of time. Easier and quicker to test lots of different antibiotics in the lab; doesn’t require ethics approval as human subjects are not being tested; avoids harm to human subjects; can test large range of different bacteria.
- Disadvantages (any of the following): Conditions in lab experiment are very different to human subject so that results may be misleading (both false positives and false negatives). Will require validation in human subjects anyway so slows entire process. Testing on agar plates does not represent or can be adequately applied to real life human population due to variation.

Comments

a) The majority of students incorrectly identified E and F for this question, even though the question clearly stated that “figure 2 – clear areas show where bacteria have not grown”. There appears to be a misunderstanding that the clear area around the antibiotic discs shows the inhibition zone (ZOI) which identifies the effect part.

b) This question asked students to ‘explain’ which means to provide a detailed account including reasons/causes. By simply stating that there was no control, only 1 mark could be rewarded. A significant number of students said that there was a control condition and that it was the antibiotic D, without being able to adequately explain why this was their choice which didn’t gain any marks. Several students have mixed up a control to a controlled condition/variables and did not gain any marks.

c) Many students gained 1 or 1 ½ marks for this question with identifying that a replica or sample size needed to increase to enable comparisons to be made. However, as this question asked students to ‘describe’ a method of increasing reliability of this experiment, students needed to show evidence of providing a detailed account (what, how, why) in their answer. Other accepted answers included running the experiment again (3-5 times) to see if the consistency of results were similar to the original test. Or ensuring all antibiotic was on a separate agar plate which minimises cross-contamination of the antibiotics and enables the ZOI to be accurately identified. Students who suggested having a control condition for comparison did not gain any points, as this would be linking to validity of the experiment not reliability of this experiment method.

d) This question asks students to discuss (offer a considered and balanced review that includes a range of points of view/factors). Many students simply listed adv/disadv i.e. quicker to do without detail. This would only gain ½ mark. Many students only provided 1 example of each adv/disadv yet the question asked for advantages and disadvantages (plural) so more than 1 needed. Several students only provided adv, which only generated a max of 2 marks. Several students turned the question around and looked at adv of using new antibiotics on human subjects rather than in the lab. However, the question asks about adv/disadv of using a lab experiment rather than directly testing on humans. No marks were awarded if this was done. Overall, many students gained 2 marks for this question, simply due to lack of detail.

Question 4

a) Green tea extract decreased the total cholesterol by about 12% (½) over 12 weeks, relative to placebo (½) and decreased LDL by about 17% (½) compared to a small increase of about 3% in the placebo (½). HDL with green tea extract increased by about 2% (½) relative to a 1% decrease for the control (½).
Students lost ½ mark if values from graph were not provided. Students must discuss LDL for full marks.

b)

i. Use of the placebo provides a control group (½) which can be used for comparison with the treatment groups (½) OR to reduce impact of psychological bias (½).

ii. E.g. tasteless/flavoured capsule containing extract, flavoured powder mixed into water, tasteless/flavoured pill, tea and coloured/flavoured tea to match. (½ mark for suitable form and ½ mark if they stated they needed to look/taste etc. identical).

c) Any of the following (1 mark):
- Randomisation of patients to control or treatment group
- Matching patient groups by sex, age, BMI
- Single/Double blind so that person providing treatment doesn't know the identity of the treatment
- Controlling/recording other aspects of diet and health to ensure no effect on cholesterol
- Ethical considerations – informed consent.

d) Any two of the following (1 mark for any of the following):

- Ethnicity of patients – study only tested on Chinese patients. Other ethnic groups might show different response.
- Sample size – only 120 people tested with active treatment = small sample size, would like to see study repeated with 1000s of subjects.
- Background cholesterol levels – study only recruited patients with high cholesterol levels, no data on what happens with subjects with average or low cholesterol
- No long-term data. Study was conducted over 12 weeks only. Would need to have longer-term study to see if lower LDL levels were maintained.
- Not enough data points – only collected levels at beginning and end of study. Doesn't account for fluctuations.
- Increased HDL levels or dropped LDL levels too far – could impact
- Dosage information not provided.

Comments

Most students were awarded at least half marks for the question. In part a) many students did not compare enough of the data or failed to use data from the graph resulting in reduced marks. Part b) i. was generally half marks as students either failed to mention control group or weren't specific in their description about a comparison with the green tea results. Some students mis-interpreted the questions for part b) ii. and discussed double blind studies here when this was actually a possible answer for the next question. Part d) was generally well responded with most getting close to full marks.

Question 5

a) 1 mark for each valid answer in each category provided in the question stem – need all five categories for full marks:

- Treatments – Statement describing number of balls per vial (½) e.g. 20 vials with 5 balls in each and statement describing how different treatments were set up (½) e.g. increasing distances from a light source.
- Control – Vial/s kept in the dark/wrapped in opaque material (1); hydrogen carbonate indicator with no algal balls (½).
- Replication – Statement describing at least two vials allocated per different light intensity (1); simply stating 'replicate twice' or 'repeat twice' (½).
- Controlled variables – At least two of the following (½ mark each): number of algal balls, amount of chlorella per ball, volume of liquid, volume of indicator added, colour/spectrum of light source, time of experiment, temperature of environment.
- Measurement methods – Comparison of colour of solution (½) against a colour chart/calibrated solutions/use of spectrophotometer (½).

b) Expected results would be that vials exposed to greater light intensity would become more purple/change to purple more quickly (1); the vials at high light levels may experience limiting factors on their photosynthetic rate (½). Control treatment vials should remain yellow/unchanged (1).

Comments

Most students could score at least 3 out of the 7 available marks. In Part a) students could easily list the controlled variables. Many did not provide enough detail in terms of the treatments of the balls under lights, and many described using more than the allotted 100 balls in their experiment. Roughly half could identify algal balls in the dark as the control. Many students confused the terms ‘control variables’ and ‘controlled variables’. Most students did not adequately describe replication in their experimental design – many simply stated that they would repeat the experiment, and many suggested that having multiple algal balls per tube was a form of replication; however, this is not true, as each ball contributes to the overall colour of the vial (only one piece of data). A small number of students mis-read the question and instead designed an experiment to test either different numbers of algal balls or the different concentrations of indicator solution, rather than light intensity.

Section B – Criterion 5

Question 6

a) (½ mark each)

Letter	Component
A	Substrate
B	Active site/site of reaction
C	Enzyme-substrate complex
D	Products

b) Need to discuss all three stages of process and to refer to the diagram explicitly for full marks.

Stage 1: Specific (½) substrate molecule encounters active site of enzyme (½), causing conformation change of active site (½).

Stage 2: Enzyme-substrate complex forms (½), holding substrate in position which reduces the activation energy required to break chemical bonds (½) by changing the shape of the substrate molecule, forming a temporary bond or changing the local environment (Induced fit theory) (½).

Stage 3: Once the chemical bonds of the substrate are broken, products are released (½) and active site changes back to original conformation (½).

c) Competitive inhibition (1).

d) In non-competitive/ allosteric inhibition (½), an inhibitory molecule will bind to a site on the enzyme distant to the active site (allosteric site) (½). This causes a conformational change (½) in the enzyme, which means that the substrate can no longer bind to the active site (½).

Comments

The majority of students answered this question well with most being able to get over half the marks.

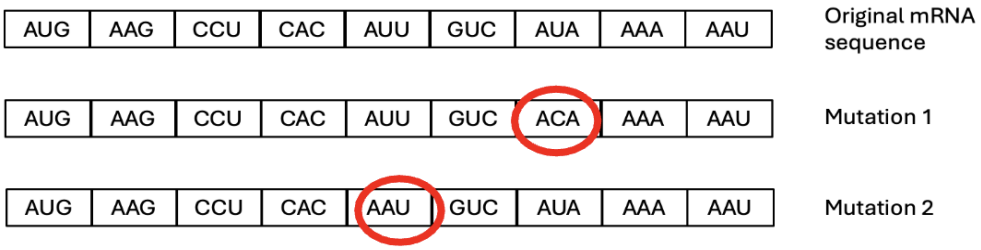
Students almost universally knew what A, B and D were but only about a quarter of the students knew the term for C ‘enzyme substrate complex’. Marks were awarded for ‘enzyme bonded to substrate’. Most of the students said it was simply the ‘enzyme’, which did not attract any marks.

Most students gained some marks for part b). The better ones were very thorough. Quite a few students mentioned the ‘lock and key’ model when it was not necessary and confused their answer. Students answered questions c) and d) exceptionally well with many gaining full marks.

Question 7

a) Any of the following for (1 mark): ionizing radiation, UV light, mutagenic chemicals (e.g. cigarette smoke, benzene), viruses or bacteria.

b) ½ mark for each mutation



Comments

a) Majority of students answered this one correctly, but those who did not, tended to put temperature as an environmental factor causing DNA mutation (no marks awarded) or went down the speciation/evolution path.

b) Most students circled or shaded the correct mutations.

c) **This question was not marked. Codon chart is incorrect.**

To be fair to all the students, it was decided by the marking team to exclude this question from the marking scheme, due to the incorrect codon chart. Question 7 was reduced to 2 marks for part a) and part b) reducing Question 7 from 5 marks to 2 marks in total.

It appears that some students didn't receive the TASC announcement regarding this question during the exam, so there were many comments written on the paper – "very confusing to read", "wrong", "took longer than 3 minutes", "already completed by the time TASC said there was an error".

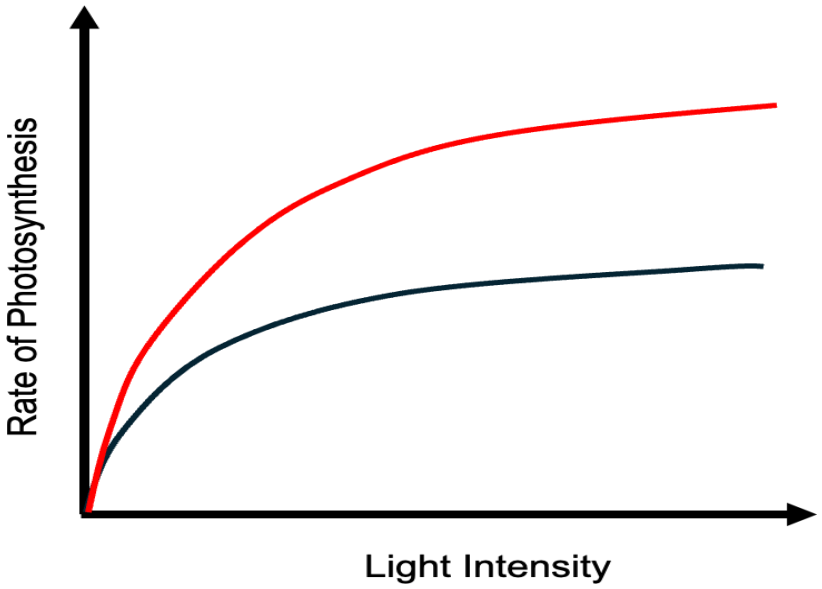
Question 8

a) A: Thylakoid (½) B: Stroma (½).

b) Thylakoid/thylakoid membrane (1).

c) Curve had to be a similar shape and high enough above the original line to show an increase of 0.02% CO_2. Marks awarded for the graph: (½) mark for drawing the line above the printed one. (½) mark for correct shape. (1) mark for correct position above the original line.

d) A limiting factor is anything that prevents photosynthesis occurring at its maximum rate (1). In photosynthesis external limiting factors include light intensity, carbon dioxide concentration and temperature (1). In addition, limiting factors such the number of chloroplasts/amount of chlorophyll/amount of rubisco & other enzymes will limit the maximum rate of photosynthesis (1). An increase in any of these factors will increase the rate of photosynthesis (1).
OR
Increase in light intensity increases rate of photosynthesis up to a certain point, when light saturation point is reached (1). Carbon dioxide becomes a limiting factor. Carbon dioxide is a reactant/substrate required by plants for photosynthesis to make glucose (1) so if carbon dioxide is constant then so will be the rate of photosynthesis as it is an enzyme driven biochemical reaction (1).



Comments

a) Majority of students were able to get this correct with variations on spelling. Those who didn't get the question correct wrote chloroplasts, chlorophyll, A (referring to the diagram).

b) Those students who answered a) correctly generally answered this question correctly too. Those that didn't, again tended to write chloroplasts, chlorophyll, etc.

c) A large portion of the students did not draw a second line on the graph indicating a second concentration of CO_2 – this suggested that the students did not see the question within the thread.

d) There were variations on the answers to this question depending on how the question was interpreted. Generally, most students had some success, but very few achieved full marks.

Question 9

a) Process A: Transcription (½).
Section 1: Exon (½).
Section 2: Intron (½).

Molecule C: Polypeptide chain/protein subunit/protein/amino acid chain (½).

b) Process C is translation (½). Each of three sequential bases of the mRNA (codon) (½) is matched to a corresponding sequence (anticodon) (½) on tRNA (½) molecules, each of which carries a specific amino acid (½). The tRNA molecules place the amino acids in order so they can then form peptide bonds/links (½) between them. Once the peptide bonds have formed the tRNA molecules are released from the ribosome and the growing polypeptide chain is produced (½).

Comments

a) Most students that attempted this question received full marks which indicated that they had a sound understanding of the steps involved in protein synthesis.

b) Very well answered by the majority of the students with most receiving 2.5 to 3 marks. Students were not required to discuss process A or process B but many did, which took up valuable space to complete what the actual question was requiring.

Question 10

a) Semi-conservative (1).

b) (½ mark for each correct enzyme).

Letter	Name of Enzyme
C	DNA Polymerase
A	Helicase
D	Ligase
B	RNA Primase

c) DNA provides the instructions to produce all of the molecules required to build cells (½) which are needed for growth, replacement and repair (½). Replication is needed to ensure that daughter cells have the identical amounts (½) and sequences of DNA (½) for these processes.

Comments

Overall, a large majority of the students scored full marks for this question showing a strong understanding of the enzymes involved in DNA replication and its importance to multicellular organisms.

Question 11

a) RNA polymerase (1). DNA polymerase (½), polymerase (½).

b) The *LacI* gene codes for the repressor protein (½), which in the absence of lactose binds to the operator (½) which prevents transcription of the structural genes (½). When lactose/allolactose is present, it binds to the repressor (acts as an inducer) (½) which changes the repressor's shape (½), causing it to be released from the operator (½). This allows RNA polymerase to bind to the promotor (½) and transcribe the structural genes of the lac operon (½).

c) When *E.coli* in the gut of animals is surrounded by glucose, its preferred energy source, it does not waste energy making enzymes/proteins involved in lactose digestion, so lac operon is switched off (1). When the gut habitat of *E.coli* changes to lactose, the lac operon enables *E. coli* to gain energy from a different source providing flexibility in its food environment (when glucose is absent) (1).

Comments

Students who had a good grasp of this topic performed exceptionally well on these questions. However, there were many students who were unsure of the function of the lac operon and in particular the function of the *LacI* gene and the repressor and so made several key errors (shown below).

a) A large percentage of students thought that Enzyme A was lactose. Lactose is a sugar/carbohydrate and not an enzyme/protein. It is important that students recognise that RNA polymerase is an enzyme that has a different function to DNA polymerase.

b) Many students did not mention the *LacI* gene in their answer even though it was specifically asked for in the thread of the question. This meant that students could not gain full marks even if they understood the process.

   Many thought the *LacI* gene bound to the 'operator' – the *LacI* gene is part of the DNA sequence which codes for the repressor which then binds to the operator, this is a very important distinction to include to gain marks.

   Many thought that the presence of lactose would prevent the *LacI* from being transcribed and so preventing the repressor protein from being produced. This is not the case. The *LacI* gene is constitutively expressed, meaning that it is always being transcribed, regardless of whether lactose is present or not.

   Many also thought that the repressor was an enzyme that had an active site and denatured when lactose/allolactose bound to it. Better language to use to describe the repressor is as a protein (allosteric) which has 'binding sites' and will change shape when lactose/allolactose binds to it. Students who did this well gained marks.

   Many thought that the repressor bound to the 'promotor' – the repressor only binds to the 'operator' and RNA polymerase binds to the 'promotor'. It is important that the students realise that the promotor and operator are DNA sequences that regulate the transcription of the structural genes and that they each have a specific function that are not interchangeable.

c) The majority of students gained 1 mark out of 2 for this question. Some students were not aware that *E.coli* live in the gut of animals and were confused about the term habitat.

Section C - Criterion 6

Question 12

a) Initially, as temperature increases, the rate of transpiration rises from zero (½). Higher temperatures lead to an increased rate of water evaporation from the stomata of the plant (½). As the temperature continues to rise, the rate of transpiration plateaus (½). This plateau occurs due to a limiting factor, such as high humidity in the greenhouse, which prevents further increases in transpiration (½).

b) When the plant experiences water stress at the roots, the guard cells lose turgor, causing the stomata to close (½). This reduces or halts water evaporation from the leaves (½). On the graph, this would appear as a decrease in the rate of transpiration OR as the plateau occurring at a lower rate (1).

Comments

Most candidates earned marks for this question, with the majority receiving 2 marks. However, many lost marks on part (a). Common errors included describing the shape of the graph without explaining it, particularly the initial increase in the rate of transpiration. Incorrect explanations for the plateau included statements such as "temperature is the limiting factor," "enzymes were denatured," or "stomata closed to conserve water." Accepted responses included explanations like "the maximum rate of transpiration occurred" or "all stomata were transpiring". It was concerning that some students incorrectly stated that the rate of transpiration decreased or stopped. In part (b), the strongest responses explained how plants maintain water homeostasis by closing stomata and predicted how the graph's shape would change accordingly.

Question 13

c) Normal upper level is c. 130mg/dl (accept 120-140) (½), normal lower level is 60/65mg/dl (½).

d) Plasma insulin levels rose to a much higher level after breakfast (40mU/ml) (½) than at lunch (20mU/ml) (½) suggesting that there was considerably large release of glucose from food at breakfast (1) – perhaps indicating larger volume (½) and/or more carbohydrates consumed (½).

e) Organ A: Pancreas, Organ B: Liver, Tissue C: Skeletal Tissues (accepted) cells, body cells, muscles), Compound B: Glucagon. (½ a mark for each of the correct responses).

f) Negative feedback is where the response to a stimulus operates in the opposite direction to that stimulus (½). In this case, if plasma glucose levels change (increase or decrease) (½), this is detected by receptors/cells in the pancreas (½). If levels are too low, a-cells in the pancreas release glucagon (½) which stimulates the liver (½) to release glucose from stored glycogen (½). Conversely if levels are too high, b-cells in the pancreas release insulin (½) which stimulates the liver to convert blood glucose into stored glycogen(½). Both of these processes reverse the stimulus and restore blood glucose to set-point levels (½).

Comments

a) Very few students answered this as expected; it was generally interpreted as range. Therefore, ½ mark was given for any number between 60 and 70 and ½ mark given for any number between 120 and 140. A good response mentioned the normal lower range as being 60-70 and the normal upper as being 120-140.

b) This was interpreted in a variety of ways by students. Some discussed the use of energy and exercise, others discussed fasting before breakfast and others mentioned food intake. Some responses discussed the literal period between breakfast and lunch and the decrease in glucose.

c) Most students had Organ A and B correct. Tissue C was not well answered, many students wrote fat but this was not considered correct due to the minimal role it plays in storing glycogen as it mostly stores minimal glycogen as it converts glucose to fat. Regarding Compound B, many students confused glycogen and glucagon. Some students wrote receptor, effector: this was not given marks.

d) Some students only displayed the definition for a negative feedback loop. Some students only provided half of the process. Quite a few students confused glycogen with glucagon.

Question 14

a) Normal human core body temperature range = 36.5-37.5°C (1) accept any range.

36-38 (1) or any individual temperature within range (½).

b) Hypothalamus/anterior hypothalamic nucleus (1).

c) Any two of the following (1 mark for full description, ½ mark for just naming response):

- Shivering – involuntary muscle contractions generate heat through cellular metabolism
- Vasoconstriction – blood flow to surface vessels is shunted to flow through deeper vessels, retaining heat deeper in body and reducing loss from body surface
- Piloerection – small muscles attached to hair follicles contract, raising hair which traps air and act as insulation
- Sweat production is decreased leading to less evaporative cooling
- Non-shivering thermogenesis – triglycerides are burned in brown adipocytes generating metabolic heat.

d) All cellular metabolic reactions in endotherms (e.g. protein synthesis, waste removal, cellular respiration) are controlled by enzymes (1) which have optimal operation within a limited temperature range (1).

Comments

This question was well answered by the students in most part – part b) contained a range of regions from “frontal lobe, CNS, brain etc” with students who answered this part well typically being quite high scoring on the rest of the question. In part d) not many students explicitly mentioned enzymes – a lot of students mentioned things such as hypo/hyperthermia in their answers.

Question 15

a) Kidney (1) Nephron/collecting tubules (½).

b) Posterior pituitary (½) releases more ADH (½). ADH stimulates kidneys to reabsorb more water (½) by increasing permeability of collecting tubules (½) as well as person drinking more (½). Person will produce small quantities of concentrated urine (½).

Comments

There were a wide array of answers to this question. When the question asked for “effectors” it was clear students didn’t read the question sufficiently. In part b) quite a few students confused ADH with inducing dieresis – however, they answered the remaining part of the question well by describing the increased permeability of collecting tubules and small quantities of concentrated urine.

Question 16

a)

i. Threshold/threshold voltage.

ii. The threshold voltage (½) of 55mV is required to initiate depolarisation (½), trigger an action potential (½), initiate opening of the voltage gated sodium channels (½), this ensures that only large enough stimuli trigger an action potential (½).

b) Period B is hyperpolarisation/the refractory period (½ mark was given to either, but a max of ½ mark given for naming). This is caused by the K+ ion channels closing slowly and an excess of K+ leaving the axon (½). An additional action potential cannot be initiated until the cell returns to resting potential (½). During this period the sodium potassium pump (½) sends Na+ ions to the outside of the cell (½) and K+ ions to the inside of the cell (½) to restore the resting state.

c) Accepted 2ms, 4ms or 5ms. ½ marks given for correct value but minutes given for units.

d) Depolarisation is triggered when the axon reaches the threshold voltage (½). During depolarisation the Na+ voltage gated channels are opened (½) and Na+ ions (½) enter the axon (½). K+ ion channels are closed (½). During repolarisation the Na+ channels close (½) and the K+ channels open (½). K+ ions (½) flow out (½) of the axon into the extracellular space. Excess K+ ions leaving leads to hyperpolarisation (½). All Na+ channel and ion movement information must be included for full marks.

Comments

Many students answered part a) correctly, many of those who could not remember the name of the threshold showed good understanding of its purpose. Marks were not given for calling A a graded potential, as a graded potential does not result in an action potential being fired.

Most students were able to identify hyperpolarisation/the refractory period, but many struggled to explain what was occurring and instead just gave a description of what was occurring in the diagram i.e. ‘after the falling phase the charge drops too far and has to return to resting potential’. It was necessary to refer specifically to the transport machinery and/or ion movement for full marks.

As a wide range of answers were deemed correct many students were able to answer this correctly even if they struggled with the surrounding questions. A common correct answer was 6 or 7ms where students had clearly just copied the maximum values from the time axis.

Students showed a good understanding of depolarisation but were more likely to stumble when describing repolarisation, with K+ ions moving the wrong direction or resting potential processes being described instead. A common omission was the closing of the Na+ channel between depolarisation and repolarisation, which was required for full marks.

Question 17

a) Any of: serotonin, dopamine, glutamate, acetylcholine, GABA, norepinephrine (1).

b) (½ mark each).

Number	Name	Function
1	Mitochondrion	Provide energy by cellular respiration.
2	Synaptic vesicle	Holds neurotransmitters.
3	Neurotransmitter	Travel across synaptic gap and bind to receptors.
4	Neurotransmitter receptor OR Chemically gated sodium channels	Bind to neurotransmitter which opens ion channels OR to allow continuation of the action potential as sodium will rush into the post synaptic membrane and depolarize it.
5	Voltage-gated calcium channel	Open when depolarized to allow Ca2+ ions into neuron.
6	Neurotransmitter reuptake pump	Removes neurotransmitter from synaptic gap and terminates signal.

Comments

Students were limited in answering part a) of this question due to many interpretations of the depth required. Leniency was given to reasonable answers.

Students were able to interpret the diagram and obtain most marks of the table of functions, some wording did slip up students such as electrical signal for neurotransmitter and Ca2+ pumps releasing Calcium.

Marks were not appointed for “Powerhouse of the Cell” as students needed to identify either energy or ATP production for Mitochondrial function.

Section D - Criterion 7

Question 18

a) Similarities: both are not considered to be living because they can't exist independently without accessing cellular machinery (1); considerably smaller than cell (<300nm) (require some measure of size for full mark, 1); infectious agents that can cause pathology (1).
Differences: prion only exists as a protein (no nucleic acids) (½), viruses contain nucleic acid (RNA or DNA) and proteins (½); prions considerably smaller than virus (½) <15nm cf 20-200nm (½); prions cause disease by inducing conformation change in other proteins (½), viruses co-opt cellular machinery to make new copies of virus (½); known prions cause neurodegenerative diseases (½), viruses cause wide variety of pathology (½).
Only ½ mark given if answer was of the form "prions are x, viruses are not" or vice versa. No marks for saying prions only affect brain – need to include known prions, viruses affect lungs/other organs.

b) Flu viruses will bind to the surface of a cell in the lungs (½) and release their RNA into the cytosol of the cell (½). This RNA is transcribed by the cellular machinery (½) to create new virus particles which are released from the cell (½). These virus particles are small enough (½) to be suspended in the air or on surface of water droplets (½) which are exhaled by the infected person (½) and are then inhaled by a new host (½) completing the transmission cycle.
Answer needed to discuss specific mechanisms of influenza transmission and refer to processes shown in Fig. 20 for full marks. No marks for discussion of B/T cell-mediated immunity.

Comments

a) Majority of answers correctly identified similarities but many struggled to correctly identify differences or only identified one half of the answer. A number of candidates incorrectly identified prions as living organisms.

b) Large majority of candidates received partial marks, commonly 1-2. Many answers were not specific about the particular mode(s) of transmission of the influenza virus and provided general information about pathogen transmission only. Similarly, a considerable number of candidates did not discuss the process of viral infection, replication and release in the lung epithelial cells shown in Fig. 20.

Question 19

a) (½) for each valid example, (½) for each valid mode of action

Type of Defence	Example	Mode of Action
Physical	Any of the following: • Skin, mucous membrane, cilia, earwax, sweat, tears, saliva, urine, coughing, sneezing, vomiting	Any valid explanation aligning with example given, such as: • Stops penetration/entry of pathogens into internal organs/tissues • Traps pathogens before they can enter body • Removes pathogens from the body.
Chemical	Any of the following: • Acidic environment of stomach/skin/sweat (sebum)/urine • Enzymes (lysozyme) in sweat/saliva/tears/mucous.	Any valid explanation aligning with example given, such as: • Acid/enzymes kill pathogens through damage to cell wall/cell membranes • Low pH environment is inhospitable to pathogens.
Microbiological	Either gut microbiome or skin flora.	Compete with pathogens for space/resources OR Secrete antimicrobial chemicals to kill pathogens.

b) Any of the following:

- Entry through a wound or break in the skin (1)
- Pathogen has a protective outer surface enabling it to overcome first line defences (e.g. in a dormant cyst) (1)
- Via a vector organism (e.g. a mosquito) (½) that can directly transport pathogen into blood/tissues (½)
- Pilli on bacteria (½) can prevent their mechanical removal once embedded in mucous membranes (½).

c) Any two of the following for (1) each:

- Innate immune response is the same (non-specific) to all/most pathogens, while the adaptive immune response differs (specific) depending on the particular pathogen or antigen encountered.
- Innate immune response involves cells such as macrophages, dendritic cells, natural killer cells and mast cells, whereas the adaptive immune system involves T-cells, B-cells and antibodies.

- The innate immune system has no memory of previous encounters with a pathogen so response is the same each time, while the adaptive immune system produces memory cells to enable stronger/faster responses upon subsequent encounters.
- The innate immune response mechanisms are present from birth, whereas the adaptive responses are built up over time and with exposure to pathogens.
- The innate immune responses occur immediately/quickly after a pathogen is detected, while the adaptive immune response has a lag period, particularly upon first exposure.
- The adaptive immune system is present in vertebrates, whereas invertebrates rely almost entirely on innate responses.

d) Any of the following for (1) mark:

- Macrophage
- Neutrophil
- dendritic cell
- monocyte
- granulocyte
- mast cell
- B-cell.

e)

Stage 1: Receptors on the surface of the phagocyte bind to the bacterium (½), initiating endocytosis (½). The bacterium is engulfed by the phagocyte (½) via movement of the cell membrane/pseudopods (½).

Stage 2: Lysosomes merge with the phagosome (½), releasing the enzyme lysozyme (½) which destroys the bacterium (½).

Stage 3: Fragments of the bacterium are eliminated from the cell (½) via exocytosis (½), which involves the merging of the phagolysosome with the cell membrane (½).

Comments

Question 19 was very accessible and enabled many students to accumulate marks for a wide variety of answers.

a) This part was generally well attempted. Marks were commonly lost for insufficient explanations for the modes of action. Students who chose to discuss enzymatic means of chemical defense often failed to specifically mention enzymes in either their example or their mode of action. Many students were also unable to provide a microbiological example from the first line of defense.

b) This part was answered very well. Responses with a degree of ambiguity, such as “injuries”, “bites”, “large number of pathogens”, or “mutations/adaptations” required further detail to be given full credit. Ingestion and inhalation were not given credit without further explanation, as many of the first line defenses outlined in part (a) would still need to be overcome after initial entry of the pathogen.

c) This part was also well attempted. Many students failed to sufficiently describe the chosen differences, instead simply stating or listing their comparisons between the innate and adaptive responses. Students who copied information directly from the Information Sheet but didn’t make explicit comparisons were awarded no more than (½) a mark.

d) This part was very well answered. The majority of students correctly answered “macrophage” or “neutrophil”. B-cell and B-lymphocyte were accepted, but naive B-cells and memory B-cells were not. Answers such as “phagocyte”, “white blood cell” or “T-cell” were not given credit.

e) For full marks in this part students were required to make explicit references to the processes occurring at the cell membrane in Stages 1 and 3, as well as the enzymes involved in bacterium destruction in Stage 2. The description of each stage was worth (1) mark in total, but students were given credit when important details were mentioned in a later stage. Some students copied directly from the Information Sheet without clearly applying that information to the appropriate stages in the diagram. The presentation of antigen fragments on MHC proteins was not part of the diagram and was not given credit.

Question 20

a) Intermediate host (1) OR secondary host (1) OR vector (½).

b) Any two of the following (½ for state, ½ for describe why or how).

- Medication for infected humans
- Control of snails in freshwater through chemical or biological control
- Provide toilets and other methods to ensure that human excreta does not enter waterways
- Discourage people from entering freshwater bodies
- Ensure that all water is boiled or filtered
- Use of vaccine.

c) If an infected individual (½) from a country with schistosomiasis (½) arrived in Australia and excreted in a freshwater body (½), the parasite could become established in local snails (½).

OR

If a snail already infected with parasites (1) is introduced to a waterbody in Australia (½) that is frequented by humans (½) the life cycle of *S. mansoni* could be completed in Australia.

Comments

Most students were able to gain at least 2 marks out of 5 for this question. Full marks were uncommon as most students didn’t use the terms intermediate host or secondary host. A common error was not describing how the two methods stated would reduce the impact of *S. mansoni* in part b). Another place students commonly lost marks was in part c) not identifying that both snails and humans were required for *S. mansoni* to complete its life cycle.

Question 21

a) (½ mark for each answer)

Immune Cell 1: Antigen-presenting cell	Immune Cell 4: B-lymphocyte/Plasma cell
Immune Cell 2: T-lymphocyte	Immune Cell 5: B-lymphocyte/Plasma cell
Immune Cell 3: Cytotoxic (killer) T-cell	Immune Cell 6: Memory B-cell

b) Any two of the following (1 mark each):

- Antibodies produced are specific to the antigen and so will bind and flag them for macrophages to phagocytose.
- Agglutination – antibodies bind to antigens and each other leading to clumping of pathogen.
- Neutralisation of microbes and toxins through binding to antigens on surface of pathogen.
- Antibody-dependent cellular cytotoxicity – antibodies on surface of NK cell bind to pathogen which then destroy pathogen.
- Complement activation induced by antibodies leading to inflammation and phagocytosis.
- Opsonisation – phagocytes attach to antibodies bound to surface antigens Tagging of pathogens for destruction by other cells (IgA).
- Precipitation reaction where antibody binding can cause soluble pathogens to become insoluble within the tissue fluid making antigens clump together and fall out of solution.
- Binding to mast cells and basal cells – activates allergic reaction.

c) Once the body has recovered from the pathogen the levels of circulating T- lymphocytes, B-lymphocytes, plasma cells and cytotoxic T-cells (½) will decline to zero (½). Small numbers of memory B-cells and T-cells remain (½) in blood, lymph nodes and spleen (½). Suppressor T cells de-activate helper T cells, Citotoxic T cells and B cells (½).

d) When the body is exposed to a previously encountered pathogen, memory T- cells will recognise the antigen (½) on the pathogen surface and rapidly (within a few hours) (½) start to divide and produce large numbers of cytotoxic T-cells (½). Similarly, memory B cells will rapidly proliferate (½) and produce very large numbers of plasma cells and antibodies within 2-4 days (½). Both the speed and size of the response will be greater than for the initial infection (1). Memory B cells also undergo affinity maturation (½) whereby their antibodies acquire increased specificity and affinity (½).

Comments

a) Students answered this question well. Most students demonstrated full understanding of the cells' interaction/dependence process. Most students were awarded with full marks or 2 marks.

b) A good proportion of students misunderstood the question. Several students referred to the product/function of immune cell 1 referring to either cytokines or the MHCII instead of the Product of immune cell 1. No marks awarded.

c) Most students described the levels of circulating cells as declining but didn't specify which cells would decline preventing full marks. Most students elaborated on memory cells as present, but not many elaborated on the level as small amounts of memory cells. Few students mention the role of suppressor T cells. Some students misunderstood the question in regards to "the body has recovered" and answered the question in terms of still recovering. Overall students achieve some marks, not many full marks.

d) Most students elaborated on the importance of memory T and B cells to promote a faster and stronger secondary response. Some students extended the answer to explain the production of cytotoxic T cells and plasma cells. Not many students explained memory B cells undergoing affinity maturation to increase specificity.

Question 22

a) Active (½) Acquired (½).

b) Mother has had to have encountered the pathogen previously and have available antibodies that can be passed on the baby in two ways (1): through the colostrum and breastmilk (½) after birth or through the placenta during the third trimester (½).

c) In a naïve population with no vaccination, infected individuals will pass on the infectious disease and many/most of the population will be infected (top image) (1). If only a small proportion of the population is vaccinated, there are still a lot of susceptible individuals and again many individuals will get infected (middle image) (1). However, if a large proportion of the population is vaccinated, most individuals that an infected individual encounters will be protected and therefore the pathogen will not spread (image) = herd immunity (1).

Comments

Part (a) was answered well by the majority of students. In part (b) few students were able to recognise that in order for antibodies to be passed on to the developing baby in utero, the mother would have to be exposed to the antigen. Students who achieved full marks in part (c) were able to explain each panel of the image in order to explain what herd immunity is. Many students who did not achieve full marks either did not make reference to the image, explain the image or simply stated that herd immunity only occurred during the COVID-19 pandemic.

Section E - Criterion 8

Question 23

d) ½ mark for each answer:
- Anaphase: D or 3
- Cytokinesis: F or 5
- Interphase: A and/or B 1 or 1&2
- Metaphase: C or 3 Prophase: B or 2
- Telophase: E or 4.

e) Metaphase ensures chromosomes line up on the equator of the cell so they can be pulled apart evenly(½) spindle fibres attach to centromere/ chromatids, (½)so each daughter cell receives a copy of each chromosome and so are genetically identical (½). Allows correct division of DNA in meiosis/mitosis (½).

OR

In meiosis during metaphase 1 chromosomes line up across equator which allows crossing over/ independent assortment/ separation of homologous pairs (½), leading to diversity/ variation in cells produced (½).

f) Interphase consists of three phases -G1, S, G2 (½). During G1 the cell grows physically and increases the volume of protein & organelles (½). Normal metabolic functions occur (1/2). During S phase, the cell copies its DNA (DNA synthesis/ DNA replication) to produce two sister chromatids (½) produces 2 copies of its DNA(½). In G2 the cell grows further, replicates organelles and cytoplasm (½) and organises cell contents for mitosis(½). Protein synthesis occurs (½).

g) In meiosis during prophase 1, crossing over and independent assortment occur (½), where chromatids from homologous chromosomes exchange portions mixing genetic material/ alleles/ corresponding genes (½) from maternal & paternal chromosomes – this does not happen in mitosis (½). Independent assortment: where separation of maternal and paternal chromosomes is random leading to different arrangements of chromosomes in gametes (½) – does not happen in mitosis (½). Mutations in meiosis or mitosis can lead to variation in final cells produced (½). Mitosis leads to 2 x 2n/diploid cells, as PMAT occurs once, meiosis leads to 4 x n / haploid cells as PMAT occurs twice (1).

Comments

a) Well answered by most students.

b) Most students stated what happened during metaphase but not its importance – i.e. that daughter cells received 2 exact copies of chromosomes.

c) It appeared that many students were not aware of what occurred during interphase with many discussing crossing over and independent assortment. Interphase should be discussed to give context to normal metabolic functions i.e. protein synthesis, organelle replication, cellular respiration, DNA synthesis and growth.

d) Many students stated there was diversity without explaining the differences. An explanation was essential to score marks for this question. Many students discussed fertilisation and sexual reproduction leading to variation but the question only asked for mitosis and meiosis, so marks could not be awarded.

Question 24

a) Wrinkled (½) and green (½).

b) 9 round yellow (½): 3 round green (½): 3 wrinkled yellow (½): 1 wrinkled green (½). Can give marks for Punnett square if provided.

c) Need to conduct a test-cross/back-cross with recessive phenotype(s) (½). If all the offspring of this cross show a dominant phenotype, the individual was homozygous dominant (1), if 1:1 ratio of dominant: recessive, individual was homozygous (1).

d) In the ABO blood system, A and B and co-dominant (½), while O is recessive to both (½). As each individual only has two alleles (½), there are a total of 6 genotypes (I^AI^B, I^AI^A, I^Ai, I^BI^B, I^Bi, ii) (½) and 4 phenotypes (AB, A, B, O) (½).

Comments

a) Was well done with most candidates receiving full marks. Clear responses with most using terms wrinkled. Some students chose other letters. Some letters that were unclear could only gain half marks.

b) Most students gained 1 mark out of 2. Some students created a Punnett square and were given 1 mark if the gametes for the di-hybrid cross were correct. 1 mark was awarded for correct phenotypes.

c) Most students gained 1.5 marks out of 2. Only some students mentioned the term test-cross/back-cross. Majority of students said, ‘cross with homozygous recessive’, which gained marks.

d) Most students gained 1.5 marks out of 2. A small percentage of students mentioned all the genotype correctly. Some students used Punnett squares to show the genotypes for A, B, AB and ii and were awarded full marks.

Question 25

a)

White-eyed female: XrXr (½)

White-eyed male: XrY (½).

Comments

Question a) was generally well done with most candidates receiving full marks. Clear responses used the letters R and r. Students can use any letters but if they were unclear only half marks could be gained.

Marks were not awarded for alleles with no X or Y (e.g. rr).

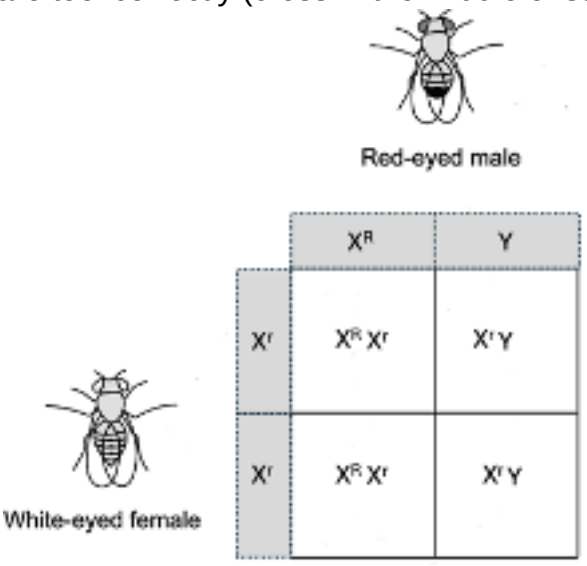
Marks were not awarded for just X and Y with no alleles shown (e.g. XX, XY).

b)

(½) for correct red-eyed male genotype.

(½) for correct white-eyed female genotype.

(1) for using Punnet square tool correctly (cross in the middle of square).



Phenotypic ratio 2 red-eyed female: 2 white-eyed male (1).

Genotypic ratio 2 XrY : 2 XRXr (1).

Comments

Question b) was generally answered well with many students clearly understanding how to use the Punnett square tool effectively and how to write the notation for sex-linked traits. Generally, if students understood this, they gained full or almost full marks.

Some students had the correct notation for sex-linked traits in part a) then reverted to the notation for autosomal traits in part b).

Full marks were awarded if two different letters were used to indicate red and white eyes (e.g. X^wX^w, X^RY) as long as upper and lower case was clear. (this should be discouraged as more commonly associated with co-dominant inheritance but was not penalised).

Marks awarded for using any of the following to show understanding of the proportions of offspring: ratio (2:2), reduced ratio (1:1), percentage (50%: 50%), fraction (2/4: 2/4) as these all show understanding of the science and use of Punnet square tool.

Students could gain marks for showing some understanding of how to use the Punnet square tool and analysis of the offspring proportions even if errors were carried forward from part a).

Full marks were awarded if students flipped the phenotype and genotype order. This was not penalised as listing the genotype first and then using this to deduce phenotype is a common way that most genetic questions with Punnett squares are set out.

Question 26

a) Affected male: I-1 II-3 II-9 or III-16 (½). Non-affected female: I-2 II-4 II-6 II-8 III- 13 or III-15 (½).

b) Marfan syndrome is an example of autosomal dominant inheritance (1). It cannot be X-linked dominant as father I–1 is affected so all his daughters would receive his dominant allele on his X chromosome and so would be affected. However, II-8 is not affected (1). It can't be X-linked recessive as II-9 and II-10 are both affected, which means they would only have recessive alleles on their X chromosomes. However, they have a son III-17 who is affected (1). It must be dominant as a non-affected individual III-17 can only appear from affected parents II-9 and II-10 if both are heterozygous for the condition (1).

c) Both Punnett squares and pedigrees show the inheritance of genetic traits (½). Pedigrees are used to determine the type of inheritance (½) and show why a certain individual has a particular trait (½) and looks back into generations of a family (½). Punnett squares are used to predict (½) the occurrence of traits in a large sample of offspring (½), therefore is a prediction of probability (½).

Comments

a) Part a) was answered well with most candidates receiving full marks.

b) Part b) was generally answered well with many students presenting an understanding of how to read the pedigree chart. Full marks were awarded if students answered autosomal dominant with at least two pieces of evidence and references to the pedigree chart.

- If the students answered, 'autosomal recessive' and could justify (with reference to the pedigree chart) why it's at least 'autosomal' they were awarded 2 marks out of 3.
- If the students answered 'X-linked dominant' and could justify (with reference to the pedigree chart) why it's at least a dominant trait, they were awarded 2 marks out of 3.
- A lot of students used the term 'infected' instead of 'affected'. Genetic conditions are not contagious.

c) Overall part c) was answered well.

Question 27

a) A mutation in a bacterium might arise through exposure to a mutagen (radiation, chemical, UV) (1) / a random copying error during cell division (1) OR sharing of plasmids from mutant bacteria (1) OR random genetic mutation (1/2) OR random mutation (1/2) OR sunlight (1/2).

b) Mutations create variety OR changes in DNA (1), which makes them more or less fit for their environment (1/2), which they then pass onto their offspring (1/2).

c) Natural/random mutations arise in populations (making them resistant to antibiotics) (½). When antibiotics (selective pressure) is applied (½), susceptible/non-resistant individuals will die, leaving only resistant bacteria, which then reproduce to pass on this resistant allele (1). This increases the frequency of resistant alleles in the population (½) This allows survival of the species as mutation drives Natural Selection (½).

Comments

a) A significant number of students listed antibiotics as a source of mutation, misunderstanding the mutation was already present. Others listed sexual reproduction or just wrote “mutation”, neither were awarded any marks.

b) Most students gained 1.5 marks out of 2, with the most common mistake being they did not recognise that the genes need to be passed onto offspring for evolution to occur. A common misconception was that bacteria use sexual reproduction rather than binary fission. Several students discussed antibiotic resistance as an outcome of antibiotic misuse, which while topical, didn’t address the question or gain any marks.

c) Students who didn’t have the specific language required (selective pressure, random mutations, etc.) were not awarded full marks.

Question 28

a) Genetic drift (1) OR Genetic bottleneck (1) OR allopatric speciation (1) OR founder effect (1) OR microevolution (½).

b) The two daughter populations contain different frequencies of alleles (1). Different alleles code for different character traits (½). Over time genetic drift may occur adding to the differences (½) and a less diverse population which could lead to populations faring poorly (½). Speciation may occur due to behavioural OR physical barriers developing (½), or different environmental factors/selection pressures (½).

Comments

a) Microevolution was only given half a mark as it is not a specific form of evolution. Many students put speciation or macroevolution. These terms didn’t gain a mark as it is not clear from the diagram that the daughter populations were two distinct species.

b) Students jumped straight into speciation (the two species will change over time, eventually not being able to produce fertile offspring – gaining them ½ a mark), rather than discussing the context of the daughter populations and microevolutionary changes that need to occur for speciation to occur. Marks were not awarded for describing what speciation is in detail.

   Quite a few students are making judgements about the gene pool remaining and directing evolution for them, rather than discussing the consequences of small gene pools. Students made assumptions that the alleles would be undesirable and that the populations would go extinct without explaining why that might happen. Providing an explanation of why the trait was desirable/undesirable paid them ½ mark. However, many students didn’t explain.