The Chief Examiners met with the marking team at Newstead College during the week after the exams. With a team of 15 markers the standards required for A, B and C ratings were determined for the externally assessed criteria. The Assessment Panel met early December to review the results and reassess the borderline candidates on an individual basis.

General Comments

The final examination paper was generally seen as fair and reasonable. There was a decent balance between C, B and A difficulty questions. Some of the longer response questions were more challenging but gave candidates an opportunity to show their ability. The cut-offs were fairly consistent and on the whole there was a good correlation between the internal and external criteria.

Examination Marking Scheme and Comments

Suggested answers with mark allocations for each question are given in the following section along with comments on candidate's performance in the exam. Marking examiners have provided specific comments on aspects such as how the question was assessed, where candidates gained and lost marks and where candidates misinterpreted questions. Comments on the open-ended questions may necessarily be limited to general comments rather than specific details.

The suggested answers are by no means prescriptive and most of them go into a greater detail than would be required to gain full marks. Candidates providing different but valid answers were given credit for any points that addressed the criterion and relevant to the question.

Part 1 - Criterion 4

Question 1

(a) The length of time for which each plot was kept weed free (1). Accepted presence of weeds/weediness/weight of weeds. ½ mark for just weeds.

(b) The weight (accept dry mass) of lettuce harvested from each plot (1). Accepted growth of lettuce. ½ mark for just lettuce.

(c) Plot A (½). By keeping this plot weed free throughout the experiment the candidate could compare the results of the other plots with this one (1), hence establishing the effect of the weeds growing in the other plots (½) or ½ mark for any statement that

indicated control gives a baseline for comparison or normally provides an optimum or normal growth conditions.

Comments

On this question candidates generally did well. If they did not on part A and B, it was usually because they mixed up the dependant and independent variables. Most had a good understanding of the dependant and independent variables though. Part c) of this question was generally done very well, the majority of candidates got full marks (2) or 1½ marks. The candidates that got 1½ marks was because they stated the correct plot and said a control was a comparison but did not describe the need of the comparison to get the last half mark.

Question 2

(a) Four of: (½ mark each) (other answers may be acceptable)
- temperature of ponds (average; temperature range day/night; summer/winter)
- light (intensity and length)
- run off from fertilizers and pesticides entering ponds (concentrations of nitrates, phosphates, dissolved oxygen, BOD etc)
- size of ponds (surface area/volume, water flow, aeration etc)
- presence/abundance of other plants/animals (especially algal growth)
- food of fish/tadpoles
- fish health, tadpole health
- presence of toxins.

(b) (Various answers acceptable)
- That pesticides used on the farm inhibited growth (and/or sexual maturation) of fish in the farm ponds (4).
- The tadpoles compete successfully with fish for food reducing the growth, reproductive health and life span of the fish. (4)
- Answers need to be in the form of an hypothesis, not as a question or detailed explanation (-1), should be credible and testable and include both dependent and independent variables.

Mark allocation- ½ mark for each of the correct variables, 1 mark for writing in a hypothesis format and stating it as testable, 1 mark for stating the effect of the variables and 1 mark for putting it in the correct context and giving it a credible cause. Marks were deducted if these points were not present.

Comments

Part A of this question was completed really well and most candidates got full marks and many named more than four factors. Part B was not done very well overall and most candidates only received around half of the marks. Many candidates could state two variables and write it in a hypothesis format but a lot struggled to come up with a credible underlying

cause. Some candidates did not use write use the hypothesis format, but went into a detailed explanation or stated it as a question rather than a statement.

Question 3

(a) No (½). There would be variables that could not be controlled perfectly when repeating the experiment (½).

For example: (1 mark for any example)

- individual leaves might have differing photosynthetic capacity, as a result of individual genetic variation or named specific variables such as different numbers of stomata or chloroplasts, or proportion of vascular bundles to non-vascular tissue or age or health of the leaf.
- temperature or light levels may have varied despite experimenter's endeavours 'to control all factors other than light intensity'
- precise measurement of CO_2 absorption may have been difficult and inaccurate
- any other sensible suggestion was given credit.

(b) **Set 1** consistently had the lowest rate of CO_2 absorption; there was a consistently higher rate of photosynthesis in **Set 2**, as measured by higher rates of CO_2 absorption; **Set 3** had intermediate results (1 mark).

Some candidates clearly explained that **Set** 1 had the lowest rate of CO_2 absorption or that **Set 2** had the highest rate of CO_2 absorption. Either of these observations was given the full mark, as the consistent results in each set do constitute a pattern on their own.

For the second and third mark, a distinct cause was needed, followed by a clear indication of **how** this would have to vary in order to account for the pattern described above. For example, any of:

- temperature variation (e.g. each set carried out at a different time of day or on different days)
- variation in light levels for each set (highest for **Set 2**; lowest for **Set 1**)
- variation in individual plants or leaves used for each set (e.g. more chlorophyll, chloroplasts, stomata in **Set 2**; less in **Set 1**. Or healthier, more vigorously growing plants in **Set 2**, etc).

Other variables include (followed by explanation) variation in CO_2 available for photosynthesis, water availability or light wavelengths, (despite the experimenter's efforts to control them)

- any other sensible suggestion.

(c) The rate of CO_2 absorption increases as light intensity increases *or* the rate of photosynthesis increases as light intensity increases *or* some combination of these. (1 mark)

(d) Fairly confident (half mark). For the remaining two and a half marks, any number of things could be said. Any of the following points scored a full mark:

- very strong correlation between increasing light level and rate of CO_2 absorption
- consistent results across all three sets of data
- consistent results within each of the three data sets
- experiment repeated three times
- trend unlikely to continue indefinitely at light levels outside the range studied; it would be good to check other levels
- hard to tell if sample size was adequate, as we are not told how many plants or individual leaves were used
- sensible use of the data anywhere in the answer.

The following each scored half a mark:

- no outliers in the data (could be one mark if explained well)
- although there were variations between sets it would be good to:
  - repeat experiment more
  - have a control
  - repeat with adequate sample size (if not already)
  - repeat with closer control over whatever was varying between the sets
  - control all variables (researcher only 'endeavoured' to control all factors)
- partial use of the data, in the answer
- any other halfway sensible points.

Comments

Most candidates were able to tackle most parts of the question with reasonable success. Marks were well spread across the whole mark range, with only a handful of the top candidates scoring the full 9 marks for full, clearly thought out answers.

(a) Many candidates seemed unaware of the strength of the word 'identical' in the question. Many weak answers included statements such as, 'yes, fairly identical', or 'yes, but not exactly the same'.

Some candidates misunderstood the phrase, 'endeavoured to control all factors except light intensity' and thought this meant the researcher had not controlled the light intensity. This would not make sense in view of the precise light intensities given in the table, and the responses of the leaves.

Some candidates did not understand the phrase 'at each light intensity' in the question, and said that they expected the CO_2 absorption would change as the light intensity changed, which was not relevant here.

(b) Most candidates were able to spot the obvious pattern/s. Some, however, indicated a basic lack of understanding of what a 'mean' is by offering the observation that the mean was closest to the middle set of figures, which is hardly surprising!

Some candidates commented that results for Sets 1, 2 and 3 diverged more with increasing light intensity. Again, this is unremarkable and simply reflects the fact that a small % difference between sets will involve larger numbers as the CO_2 absorption figures rise.

Some candidates reeled off lists of individual figures from the data (sometimes even almost replicating the results table) without ever identifying 'any pattern which suggests that conditions for all three sets of data were not identical'. Also many candidates had failed to notice that the units for CO_2 absorption were microlitres/minute/*unit area*, and thus comments about the overall surface area or size of the leaves were not relevant.

(c) Most candidates gained the full one mark here. Some gained only half a mark, for vague conclusions such as, 'the rate of photosynthesis is *affected by* light intensity'.

Some candidates had by now forgotten that the experimenter 'wished to determine the relationship between light intensity and the rate of photosynthesis' and became tangled up in secondary conclusions relating to the differences between results in Set 1, 2 and 3, rather than seeing the strong overall, obvious conclusion.

(d) The questions required answers to refer to the data, which the strongest candidates did well and commented very perceptively on the overall trends and wrote excellent answers. Far too many candidates fell into the trap of entirely overlooking the very strong relationship between light intensity and CO_2 absorption, and giving largely irrelevant answers about the need for controls, larger sample sizes etc. The most perceptive candidates noted that no information is given about the sample size – we do not know if one or more plants were used; how many leaves were used or if Sets 1, 2 and 3 were repeats of the experiment, using the same leaves and light source, or if different leaves and lights were used. Advice to candidates: try to visualise experiments described in Criterion 4 questions, and be absolutely clear on what we do know about the experiment, what we don't know, and what is implied but not certain.

*Note that comments did have to be, 'based on the data collected **in this investigation'**.*

Question 4

(a) The 508 patients in this trial would vary in many factors which could affect the results of the experiment, such as age, sex, ethnic background, reason for the risk of thrombosis, other health issues, other medication being taken, diet, level of fitness etc. (1). For each patient assigned to the first group, a patient who matches him/her most closely for other variables should be assigned to the second group, thus reducing the impact of other variables (1) Alternatively subjects can be allocated randomly, which avoids bias and balances out variations between groups or because the sample size is large, ensure that both groups contain as close as possible to the same spread of

variables in the patients. Credit was given for other answers that addressed the question, such as using a double blind approach in assigning patients (1).

(b) The patients receiving the placebo would be given tablets which appeared identical to the warfarin, but which contained no active medication. This group acts as the control group (½), providing data against which the data from the 'warfarin' group can be compared. (1) Patients who receive medication (real or placebo), and the time and attention of a doctor, may have a psychological response which has a physical effect causing a lowering in their risk of thrombosis (1). Thus, without a control group receiving a placebo in a double blind experiment, this trial would have no validity at all (1). The best ethical alternative to a placebo is to use the best established treatment for the problem as the control. (1)

(c) Earlier, pre-clinical tests must have suggested that warfarin had a high chance of being effective in inhibiting blood clots (1). If so, the patients receiving the placebo would have a higher risk of developing a thrombosis and be at risk of death or permanent injury (1). They are also deprived of the opportunity to take medication for the problem (½). Alternatively: there is a need to run a fully controlled experiment that can clearly establish the effectiveness of a new treatment and so serve a greater good must be weighed against the ethical responsibility of not withholding a treatment that you know would benefit those in the trial (which can still be achieved by using an established treatment as the control).

Comments

On the whole, this question was very well done, with most candidates scoring around five out of seven marks. Most responses showed a good understanding of subject selection and the use of control groups.

(a) Generally well done, although some problems were apparent, such as insisting that groups had to be made up of identical individuals, same sex, age, weight etc, instead of having balanced groupings. A surprising number majored on the fact that the numbers in each group were not identical, when there was only a difference of two and differences could be overcome by percentage comparisons.

(b) Most identified the placebo as acting as the control group and necessary for a comparison to show if the treatment had any effect. A minority included a consideration of the placebo effect and how it is better than a control with no treatment. The best answers recognised that in this situation a control using an established treatment for blood clot inhibition solved the ethical problem and the need for a control.

(c) This part offered more challenge and sorted the candidates out. Many couldn't see past a perceived deception of the subjects in the trial because they weren't told which treatment they were getting, and even suggested that this could do psychological harm. The best answers recognised that the patients with placebo were at risk and were being denied any medication through the design of the experiment.

Question 5

The results shown in the three graphs differ widely suggesting factors not discussed in the given information are affecting the results.

In the laboratory experiment:

- the number of bites at each food may not be an accurate measure of the quantity of each food type actually ingested (1).
- all three food types were offered simultaneously, probably without any of the normal camouflage found in their natural environment. The high number of bites per hour for worms may indicate that it is the preferred food of *Nesogobius* but they may be less common, or well hidden in the natural environment, and so make up less of the *Nesogobius* diet (1).

The sampling from the natural environment:

- the gut contents of fish may not accurately reflect the food eaten in the previous three hours. Worms are soft bodied animal and it is reasonable to suggest that worms would be more quickly digested than the exoskeletons of crustaceans or the shells of a molluscs. Thus worms may form a bigger part of the diet than these results indicate (1+).
- netting took place on a single day and night. The movement of some species of prey in or out of the seagrass habitat may be affected by tides, seasons or phases of the moon, weather/climatic variations varying levels of pollution, runoff etc, thus making their availability to the *Nesogobius* very variable (1 or more).
- *Nesogobius* appears to feed both day and night (small proportion of empty stomachs both day and night) but some of the prey species might be diurnal or nocturnal. The molluscs may be less active, thus less easily caught at night, or alternatively they may be better camouflaged at night (1+).
- Examining the stomach contents would normally mean killing the fish, which is going to have an undesirable impact on the population if large numbers are involved (1).

Comparisons: (1-2 marks)

- The results of the stomach content analysis are considerably different from the lab data (e.g. the stomach analysis suggests that crustaceans form the greatest proportion of the diet whereas the lab data suggests that it is worms). Since the field data took place over a much longer period (24h compared with 1h lab observation) and the field experiment involved a large sample size (313 compared with 'a number') the scientist should give more credibility to the field data.
- Comparing the lab data with the field data indicates that the fish in their natural habitat consume a significant quantity of other species besides crustaceans, molluscs and worms. This problem could be reduced by providing the other species in the lab experiment. This however only indicates there preferred foods but doesn't actually show what they depend on in their natural environment.
- The lab experiments have advantages that they have controlled environments, which are next to impossible to achieve in the fish's natural habitat, but there are problems in

that lab conditions in that they are not very representative of natural conditions, especially other factors such as competitors and relocation problems etc.

Further experimentation

To more accurately establish the organisms upon which *Nesogobius* depends for food the following steps need to be taken:

- Use laboratory experiments offering one type of prey at a time to establish the rate of digestion of each type of prey, and hence to establish any adjustments that would need to be made in interpreting gut contents as a measure of food eaten in field experiments (1).
- Field data (gut analysis) needs to be collected for more 24 hour periods, ensuring that all tidal, seasonal and moon phase are included and across a number of locations to better represent the range of *Nesogobius'* habitat (1-2).
- The field experiment indicates that the night time catches are different from the day time catches. This problem could be reduced by observing the aquarium fish during the night as well as during the day. (1)
- A controlled experiment could be carried out by having two or more seagrass habitats that were sampled to find the possible food species first and then netting off the control area to exclude the fish while allowing them access to the other area. Sampling of food species to be done at regular intervals that cover day to day changes as well as seasonal and tidal variations. (2+)
- This information could be supplemented by observations of the feeding behaviour in their natural environment using cameras etc (1).

Various answers were acceptable. Mark allocation was such that candidates needed discuss each of the following to gain full marks:

- Problems with the lab and field experiments
- Suggestions for improvements

Comments

This question proved to be a problem in a number of ways and the marks reflected this with an average mark was around 2.5 out of 6. The question was preceded by a blank page, with no indication that there was a question on the following page. This could well have been a significant factor contributing to the large number (10%) of the candidates who did not attempt to answer it. In a lot of cases these candidates had made full attempts on all the other questions in the section.

The question by its very nature was complex and involved a lot of reading. The very good candidates could cope with this and could see the major limitations of the experiments, particularly the first experiment, where the food preference approach tended to detract many from the point of the question, which was to find the food species on which *Nesogobius* depends. Also as the candidates were asked to refer to the information and data, many spent most of their time discussing the experimental results and didn't get around to looking at the main difficulties; let alone how to overcome them. The B standard answers considered the

limitations of the methods as stated and touched some of the other considerations which were not adequately covered, such as different tides, seasons and localities.

The task of overcoming the difficulties of finding the food sources that *Nesogobius* depends on is a very challenging and complex one and it would be asking too much to expect the candidates to come up a controlled experiment that overcame all the major difficulties. So, not unexpectedly very few candidates actually managed to come up with a credible and workable method and none came up with one involving a control group as such. A number tried to include the usual catch phrases like, control group and controlled conditions without saying how they would do it, as well using large numbers and repetitions. A lot of the methods were rehashes of the first experiment, with the vain hope that offering the fish the three of food types one at a time would show which species *Nesogobius* depends on. The best answers either included either a good consideration of how you could overcome the unrepresentative nature of the tests and/or proposing 'workable' investigations. Some went as far as proposing sampling an area before and after *Nesogobius* was placed in it.

Part 2 - Criterion 7

Question 6

(a) X = phosphate (1); Y = ribose sugar (1)/sugar (½)

(b) T, C, G, G, C, T (1 mark lost for each error)

(c) U, C, G, G, C, U (1 mark lost for each error)

(d) 2 (1)

Comments

Very well answered by most candidates.

Question 7

(a) (i) The active site (1)
(ii) Molecule C (½).The shape of molecule C is complementary to that of the active site (1), enabling them to fit together like a lock and key (½). The active site is specific for the substrate (½). D is the wrong shape to fit the active site (½).
(iii) The shape of molecule A is similar to molecule C (½) so it too, can enter the active site (1) preventing substrate molecules from doing so (½) (competitive inhibition).

Molecule B would inhibit the enzyme by locking into a part of the enzyme other than the active site (½), resulting in a change in shape of the enzyme and its active site (1) so that the substrate molecule could no longer fit the active site (½) (non-competitive inhibition).

(b) The graphs show that the relative energy level of the glucose molecule is higher than that of the product, indicating that this is an exergonic (exothermic/energy releasing) reaction (1). The presence of the enzyme does not change the relative energy levels of both molecules (1). The first graph shows that if sucrose is to be broken down activation energy is required (the 'hill' of the graph) (1). When the appropriate enzyme is present the amount of activation energy required is less (1) (the 'hill' is lower), thus making the reaction easier (½) as there is less energy needed for the reaction to proceed (½). Credit given for stating that the graph indicates that the enzyme does not decrease the time taken to produce the product, however credit was also given to candidates who noted that the total time indicated by the graph was shorter with enzyme than without it.

Comments

Most candidates answered Part A (i) and (ii) very well. In (iii), many did not mention the importance of the shape of the inhibitor. Many candidates thought that the semicircular cavity in the enzyme was a second active site. Some candidates labelled that cavity in the diagram with a letter and were able to refer to it in their answer. Some candidates had not read the question well enough and thought the non-competitive inhibitor was a cofactor which would increase the activity of the enzyme.

Part B was generally answered poorly. Many candidates wrote excellent, yet irrelevant information about the action of enzymes and the breakdown of glucose. To answer the question properly required the use of information obtained from the graph of the reaction.

Question 8

(a) (i) Aerobic respiration (1).
(ii) The presence of many mitochondria, the site of aerobic respiration, indicates this process is taking place (1). The many capillaries near the cells would enable rapid delivery of oxygen, which is used in aerobic respiration, and the removal of carbon dioxide, a product (1).

(b) The few mitochondria near the fast-twitch cells indicate that their main form of respiration is anaerobic (½). Fast-twitch muscles contain a large store of glycogen which would supply the glucose needed by the cell (½). Because each molecule of glucose would be only partly broken down to lactic acid, large amounts of glucose are needed and large amounts of lactic acid would accumulate (1). The lack of many capillaries near theses cells would inhibit the removal of lactic acid from the cells (1).Faster contraction time requires more rapid energy production resulting in more rapid build up of lactic acid (½).

Comments

Part a) was well answered overall although a number of candidates only mentioned one piece of information from the table instead of two.

Part b) was poorly answered with only a small number of candidates obtaining over 2 marks.

The majority of candidates did not use evidence from the table to answer the question and most of those who did only used one piece of evidence. Many answers described the anaerobic/aerobic processes or different muscle action processes. There were quite a few Sport Science type answers that again described processes without answering the actual question.

Question 9

(a) The rate of respiration rises slightly during the day (½) and drops slightly at night (½).

or The rate of respiration rises and falls slightly following the rise and fall in the rate of photosynthesis (½).

or The rate of respiration is fairly constant but with slight fluctuations upwards and downwards (½).

(b) The rate of chemical reactions, including respiration, is influenced by temperature (1). The rate of respiration would increase as the temperature rose during the day and fall as the temperature fell at night (1).

or The rate of respiration increases in response to the increased presence of the products of photosynthesis (glucose and oxygen) (1), to provide energy for translocation of glucose within the plant (1), or, because greater availability of glucose and oxygen allows slightly greater rate of respiration (½).

(c) At point **A** the rate of photosynthesis is higher than the rate of respiration (1), thus more oxygen is being produced by photosynthesis than is being use in respiration thus resulting in a net oxygen production (1).

or The plant is both producing oxygen (by photosynthesis) and using it (in respiration) (1).

(d) The rate of photosynthesis is dependent on light intensity (1). The plant would not photosynthesise in darkness (the period after midnight) (1). Early in the morning as natural light intensity increased so too did photosynthetic rate, reaching a peak during the middle of the day, and decreasing as light intensity fell in the afternoon (1). Because the plant was indoors it would be subjected to any artificial lighting used. This would explain the plateau in the graphs at night and the abrupt stop when the lights were turned off (1). The early afternoon of the second day may have been cloudy (reduced

light intensity), resulting in a lower rate of photosynthesis than on the first day (1). Also the rate of photosynthesis will be affected by water stress later in the afternoon, due to heat and/or airflow (1).

or

- photosynthesis requires light therefore will only occur during the day
- increasing light intensity will cause the rate of photosynthesis to increase resulting in the peaks around noon
- increasing temp will cause the rate of photosynthesis to increase resulting in the peaks around noon
- slightly lower rate of photosynthesis on the second day may be due to lower light intensity, lower temperature (maximum of 3 marks).

Full mark answers recognised the effect of being indoors – i.e. lights turned of and perhaps cloudiness on second day or other factor.

Comments

(a) Many candidates attempted to explain as well as describe, but were not penalised if the description was adequate.
(b) Few candidates recognised the significance of a daytime temperature rise. Most assumed that the fluctuations were directly related to photosynthesis.
(c) Many candidates recognised that the plant would be producing oxygen due to photosynthesis but did not comment on the fact that it was also using oxygen due to respiration resulting in a net gain of oxygen.
(d) Candidates commonly missed out on marks for one or more of these reasons:
    - they did not relate their comments specifically to the graph
    - they commented only on the second 24-hour period rather than the whole 48 hours.
    - they assumed (and so did not comment on) obvious changes such as the cessation of photosynthesis when no light is present, or even the link between photosynthesis and light intensity, and just commented on aberrations such as the night-time plateaus and the 'bump' in the graph on the second afternoon.

Quite a few candidates wrongly attributed the evening continuation of photosynthesis to the continuation of the 'dark reactions' when light had gone.

Part 3 - Criterion 8

Question 10

(a) Cell C is prokaryotic (½) because it
    - Lacks a nucleus (½).
    - Lacks mitochondria (½),

- Is much smaller (½) than a typical Eukaryotic cell.

Other acceptable answers included
- Lack of other membrane organelles such as endoplasmic reticulum (½)
- Lacks membrane bound organelles (1)

(b) Cell B is the plant cell (½), because it
- Has a cell wall (½)
- Has chloroplasts (½),
- Has a large central vacuole (½)

Other acceptable answers included
- Larger than the other cells (½)
- Has plastids (½)

(c) Ribosomes (1). Or Cell membranes (1)

Comments

This question was well answered and most candidates achieved 4 – 5 marks. Few candidates noticed the actual sizes of the cells and hence this was rarely included in the answer. In some cases, organelles that were not visible were incorrectly included in their answer. Approximately half of the candidates incorrectly answered C.

Question 11

Cell A

(a) Palisade, (photosynthetic cell accepted) (1)

(b) Function – main photosynthetic cell of the leaf (1)

Plus 3 explained points clearly linking structure with the function of the cell (1 mark each)
- Columnar (oblong) shape and packed in closely to allow the maximum area exposed to the light
- Thin cell wall to allow maximum light penetration
- Large number of chloroplasts for maximum light absorption
- Found near the top of the leaf where generally the greatest amount of light is to maximise light absorption
- Chloroplasts can migrate to maximise light absorption for photosynthesis
- Large central vacuole to help maintain turgidity.

Cell B

(a) Sieve tube (1)

(b) Function – 2 way transport of sugar rich nutrients (products of photosynthesis) (1)

Plus 3 explained points clearly linking structure with the function of the cell (1 mark each)

- Form long continuous column of living cells running through the plant, joined end to end to enable transport of fluid
- Sieve plate between end walls of sieve tubes, has holes which allows sugars to pass from one cell to the next
- Cells are linked by cytoplasm strands that pass through the sieve plate and allow transport of sugars from one cell to the next
- No nuclei and reduced organelles to maximise room for transport of sugars
- Companion cells close by with a nucleus to control active transport and direction of flow of sugars.

Cell C

(a) Guard cell (1)

(b) Function – controls movement of gases in and out of cell, and loss of water (1)

Plus 3 explained points clearly linking structure with the function of the cell (1 mark each)

- Kidney shaped cell working with another guard cell, create an opening (stomata) or pore in the surface of the leaf
- In pairs and joined at the end to create a pore that opens and closes, allowing for control of exchange of gases
- Cell walls are thicker on the side next to the stomata and this allows them to stretch and expand outwards as they become turgid, which causes the stomata to open
- As the guard cells lose water (become flaccid), their shape changes and they close the stomata, this reduces water loss from the plant and also prevents gaseous exchange for photosynthesis
- Generally positioned under the leaf so as not to lose excessive amounts of water through evaporation, whilst open to allow for gaseous exchange.

Comments

Palisade Cell

Candidates that chose this cell generally achieved good marks on part b. Many labelled the cell type as Mesophyll and only received ½ mark for part a), as Mesophyll is a tissue, not a cell type.

Sieve tube

Many candidates incorrectly labelled this as phloem (which is a tissue) and only received ½ mark in part a). Part b) was often not fully answered in terms of the relationship between the structure and the function.

Guard cell

Many candidates named stomata as the cell type in part a), and hence only received ½ mark. Therefore many candidates in part b did not demonstrate much understanding of the guard cells and how their structure and function were related. Full marks could not be achieved in part b if only transpiration and not the function of gaseous exchange was mentioned. A common mistake was to suggest that when guard cells are turgid, they shut the stomatal pore.

Question 12

(a) (i) Active Transport (½). For each of the ions the concentration of ion inside the root hair cell is higher than it is in the solution surrounding the root (½) indicating that the cells are moving the ions against a concentration gradient, or from low to high concentration.(1).

(ii) Active transport requires energy (½) in the form of ATP (½), or active transport requires energy (1) which is provided by aerobic respiration (½) which requires oxygen (½).

(b) (i) As the volume of a cell increases so does its surface area, but not at the same rate (1) so the larger a cell the smaller its surface area to volume ratio (1).The smaller the SA/V (and the larger the cell) the less efficiently a cell can exchange materials with its environment (1).

or

The larger the cell, the smaller it's SA/V (1½). The smaller the SA/V (and the larger the cell) the less efficiently a cell can exchange materials with its environment (1½). (½ mark extra for additional relevant information).

(ii) Mitosis results in one cell dividing into two (½). Each daughter has a smaller volume than the parent cell (½) and thus a larger SA/V (½) resulting in an improved ability to exchange gases with the environment (½). (1 mark given to those candidates that mentioned an increase in cell size prior to division, therefore resulting in decreased SA/V).

Comments

(a) (i) Answered well by candidates, with most acknowledging that the process involved was active transport, and were then able to explain the graph and the movement of ions against the concentration gradient.

(ii) Less well answered, with a lot candidates, including many who did well in (a) i) failing to note that the process required energy through aerobic respiration, thereby the need for oxygen to be supplied.

(b) (i) Well answered with many candidates gaining 2½ - 3 marks for their understanding of SA/V.

(ii) Although nearly all candidates that attempted this question had an understanding of what Mitosis was, thereby gaining ½ - 1 mark, fewer were able to relate the process to the maintenance of a high SA/V.

Question 13

(a) (i) (½ each)
Juvenile = 8
Eggs = 4
Sperm = 4
Nymphs = 8

(ii) Either one of Adult female →eggs (1) or Adult male → sperm (1).

(b) Asexual reproduction of the juveniles from the adult female is a result of the cell division called mitosis (1). Mitosis results in two daughter cells being produced which are identical to the parent cell (1) hence all the cells in the juveniles contain a complete set of identical genes to that of the adult female and so are genetically identical(1). Credit (up to 1 mark) was given to other relevant points – e.g. without fertilisation there is no mixing of parental genes; asexual reproduction ensures that any favourable characteristics are passed on to the offspring, enabling the aphids to quickly and successfully colonise the bean plants.

Comments

This question was very well done, with most candidates scoring at least 4 marks. However, many candidates did not indicate where meiosis was occurring, or identified the point of fertilisation rather than where egg/sperm were being produced. In part (b), many candidates didn't name the process of cell division occurring (mitosis), but if they provided a good description of the process then they could still gain 2 ½ marks for this section. Overall, candidates had an excellent understanding of how asexual reproduction produces genetically identical offspring.

Question 14

(Candidates must address each of the three dot points to gain full marks).

The pond water in which the *Amoeba* or *Paramecium* finds itself on the bench is hypotonic to the cell contents (½). This results in a net water gain by the cell (½) due to osmosis as water moves from a weak solution (the pond water) to a stronger one (the cytosol) through a semipermeable membrane (½). The cell must constantly remove water as rapidly as it enters the cell (½) by the action of its contractile vacuole (½) in order to maintain osmotic balance (and prevent the cell from swelling and bursting). *Credit was given to other relevant points, up to a maximum total of 2½ marks for addressing this dot point.*

As the water in the drop evaporates the solution increases in concentration (½). This lessens the concentration gradient between the water droplet and the cytosol (½) resulting in less water entering the cell (½). The rate of contraction of the contractile vacuole would slow down (½). Briefly the cell would be in and isotonic solution where, there would be no net water movement (½). At this point the contractile vacuole would stop removing water (½). As water continued to evaporate the cell would be in a hypertonic solution (½). The solution would now be a stronger solution than the cytosol (½), resulting in a net movement of water out of the cell by osmosis (½). *Credit was given to other relevant points, up to a maximum total of 3 marks for addressing this dot point.*

Due to the action of its contractile vacuole, the cells mentioned are able to survive in a hypotonic solution indefinitely (½), and because there is no water gain or loss, they can survive in an isotonic solution (½) but once sufficient water has evaporated to make the solution hypertonic the cells have no way of preventing water loss, and they will shrink (½), becoming progressively dehydrated resulting in their death **before** the water has all evaporated (½) or the salt concentration reaches toxic levels (½). *Credit was given to other relevant points, up to a maximum total of 1½ marks for addressing this dot point.*

Comments

This question was a very good test of candidates' understanding of osmosis and osmoregulation. Most candidates were able to describe accurately what was occurring initially in the pond water, with good descriptions of the process of osmosis and the action of the contractile vacuole. Good answers then proceeded to describe how osmosis changes as the water became progressively more concentration. However, very few recognised that at some point an isotonic situation will exist, instead concentrating on the fact that the pond water eventually becomes hypertonic to the cells. As this part of the question required consideration of how the 'osmoregulatory response changes over time', it was necessary for answers to describe and explain how the action of the contractile vacuole altered in response to the changing conditions. Very few candidates addressed this aspect.

Most candidates didn't comment on the survival chances of the *Amoeba* in the original pond water or in the isotonic situation. However, good descriptions and explanations of the effect

of the hypertonic solution on survival were able to gain the maximum of 1½ marks for this part of the question.

Whilst it is always preferable to use correct biological terms where appropriate, it was clear that many candidates would have been better advised not to use the terms hypertonic and hypotonic unless they were very clear of their meaning. Some otherwise excellent answers lost marks because they confused these terms. It is quite acceptable to talk about water moving from the weak/dilute solution to the strong/more concentrated solution.

Relatively few candidates recognised that *Amoeba* has no way of preventing water loss in a hypertonic environment, believing that they are able to actively absorb water either by active transport, reversing the action of the contractile vacuole, or by using a form of pinocytosis.

Part 4 - Criterion 9

Question 15

(a) (i) carbon dioxide (½), oxygen (½).
(ii) diffusion (1).
(iii) **Two of:** large surface area; thin membrane; moist surface; rich blood supply/network of capillaries (1 each).

(b) (i) The foetal blood entering the right side of the heart would be oxygenated, but that of the newborn would be deoxygenated (1). The foetus' blood is oxygenated in the placenta/by the mother (½), while the newborn's blood is oxygenated in the lungs (½) or has just given up its oxygen to the body tissues (½).
(ii) The two bypasses result in most of the blood by-passing the lungs and not being oxygenated (1). Oxygenated and deoxygenated blood mix, allowing deoxygenated blood to be sent to the body (1). Low levels of oxygen would reduce the levels of aerobic respiration that could take place in cells (1). Anaerobic respiration would occur (½), building up lactic acid to dangerous levels (½). Carbon dioxide would not be removed (½) changing the pH of the blood (½) or building up and becoming toxic (½). The baby would have low energy levels (½)/appear blue due to lack of oxygen (½)/be unable to sustain activity (or exercise) (½)/would be unlikely to survive without assistance (½). The blood bypasses the liver (½) meaning that toxic substances could not be removed (½)/glucose levels could not be regulated (½). The baby would remain dependent on its mother for oxygen and liver functions (½). The placenta would no longer function so blood sent there would be wasted (½). The baby would lose blood via the umbilical cord (½). The two bypasses result in most of the blood by-passing the lungs (1). In a new-born this would result in very little of the blood passing through the lungs and being oxygenated (1). The disadvantages of this would be that the new-born would not have sufficient oxygen reaching

tissues, so aerobic respiration would be reduced inhibiting function and possibly damaging tissues (1).

Comments

Most candidates answered a (i) and (ii) correctly with a few adding nitrogen to the list, for which no marks were deducted because it is a reasonable answer. A significant number of candidates answered respiration or cellular respiration for (ii), among the few who gave other answers, almost every conceivable process was suggested (thankfully with the exception of mitosis/meiosis and protein synthesis).

The majority of candidates also earned 2 points with their answer for (iii) because the question asked candidates to **list** two characteristics. Many candidates did not realize that the question required 2 characteristics that were common to lungs and gills, and described one characteristic in relation to lungs and a different one in relation to gills. As these were almost invariably common characteristics anyway, for which other had received full marks without a description, this variation in interpretation of the question wasn't penalized.

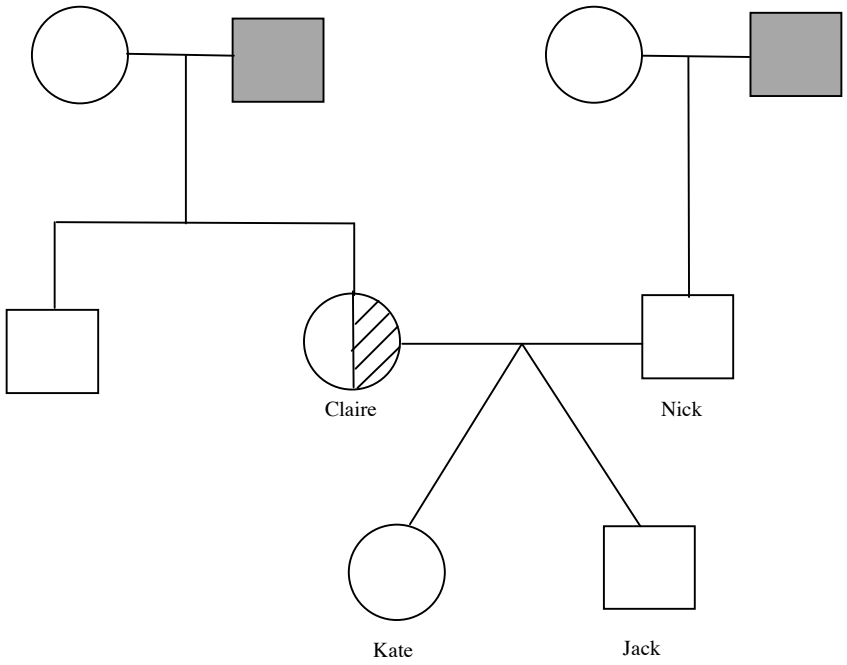
Question (b) (ii) was well answered by most candidates, but a significant number interpreted it as requiring a description of the *way in which the process of 'blood entering'* would differ in the foetus and in the new born, rather than the *composition of the blood that is entering*. Up to one mark was therefore given for answers that described the differences in blood flow into the right side of both hearts in a meaningful way. Some of these were very good answers.

Disturbingly, it was clear that a good half of the candidates thought that the foetus shares its blood with the mother, and the mother's heart pumps this blood around. In a large proportion of other answers it was unclear whether the candidates thought this or not.

Question (b) (iii) discriminated well, with the good candidates showing the ability to apply knowledge of blood circulation, aerobic respiration and liver function to this situation. A wide range of relevant answers were given and accepted. Quite a number of candidates took the question to mean that the placenta would remain attached to the baby as well but few of these seemed to realize that the placenta deteriorates, leading to some intriguing answers about the inconvenience of having ones infant still attached by its umbilical cord after birth.

Question 16

(a) (2)



(b) X^C denotes gene for normal vision; X^c denotes gene for normal vision; Y denotes Y chromosome.

Nick must be X^CY (½). Because he has normal vision his only X chromosome must carry the gene for normal vision (½).

Claire must be a carrier X^C X^c (½). Claire has normal vision, so at least one of her X chromosomes must carry the gene for normal vision (½). One of her X chromosomes comes from her father, and, because he is colour blind, his X chromosomes will all carry the colour blind gene (1).

(c) (1)

		Nick	
		X^C	Y
Claire	X^C	X^C X^C	X^CY
	X^c	X^C X^c	X^cY
		(Kate)	(Jack)

The Punnet square shown above shows that Kate ($X^C X^C$ or $X^C X^c$) has no chance of being colour blind, although she does have a 50% chance of being a carrier (1). Jack would have a 50% chance of being colour blind (X^cY) (1)

Comments

(a) The majority of candidates obtained full marks for this part. Marks were deducted if
(i) the pedigree diagram was incomplete;
(ii) the shading was assigned to the wrong individuals or
(iii) the lines were drawn connecting the wrong individuals.

(b) Candidates lost marks for Part (b) if they did not fully explain why Nick must be $X^C Y$ and why Claire must be a carrier $X^C X^c$. Several candidates made the mistake of stating that Claire must be either a carrier or homozygous dominant for the trait. Other candidates lost marks for assigning one of the alleles to the Y chromosome.

(c) Candidates usually received zero marks if they tried to work out probabilities based on the trait being autosomal. Some candidates lost marks because they were referencing Nick and Claire instead of Kate and Jack. One mark was deducted if a Punnet Square (or something similar) was not used to demonstrate how the probabilities could be predicted as the question asked the candidates to 'show' how the probabilities can be predicted.

Approximately 16% of candidates did not obtain marks for Parts (b) or (c) because they did not read the information given and wrongly assumed that the trait was linked to an autosomal chromosome.

Question 17

(a) Up to about 80 days after hatching nitrogenous wastes are predominately excreted in the form of ammonia (½), very little being excreted as urea (½). Over the next 10-15 days there is a rapid change and after about 90 days most nitrogen is excreted as urea (½) and very little as ammonia (½).

(b) Ammonia is a very toxic form of nitrogenous waste (1). Because tadpoles live in fresh water, they have a copious supply of water with which to dilute and excrete the ammonia, keeping its concentration below toxic levels (1). Adult, land-dwelling frogs, which have less access to water, expend some energy converting most of the ammonia to urea (1), because it is less toxic and requires less water to excrete (1).

Comments

(a) Most candidates did not obtain full marks for this part of the question as they did not give a complete description of the information presented to them in the graph. The

marks allocated to candidates reflected the depth to which they described the information given in the graph.

(b) Most candidates answered this part reasonably well and marks were generally deducted for incomplete answers, which usually meant that the candidate forgot to state the importance of conservation of water by frogs during the terrestrial stage of their life cycle. Some candidates gave the answer they should have written for part (a) of the question by merely describing in more detail the information already given to candidates in the graph.

Question 18

(a) Sea lions are endothermic/homeothermic or warm-blooded (½ mark) and can maintain a constant body temperature (½ mark). Iguanas are ectothermic/poikilothermic or cold-blooded (½ mark) and their body core temperature is influenced by the temperature of the environment (½ mark).

(b) By sitting on the black rocks the iguanas are able to raise their body core temperature (1 mark). If they get too hot they can reduce their body temperature by returning to sea OR when they are feeding their body temperature will drop to 21ºC (1 mark). In this way they are able to regulate their body core temperature (1 mark) and achieve some degree of homeostasis by behavioural means (1 mark). It is an example of negative feedback (1 mark). At a higher temperature their rate of respiration is higher and they have more energy for movement (1 mark) OR the iguanas enzymes work more efficiently at a temperature higher than water temperature, possibly about 26ºC (1 mark). They can also carry out other body functions such as digestion at a faster rate, at the higher temperature (1 mark). With a higher body core temperature they are able to feed more efficiently, or for longer or escape from predators (1 mark).

(c) The sea lion has a temperature of 38ºC (1 mark). As the temperature decreases below 30ºC the amount of oxygen required increases (1 mark). This extra oxygen is used when the rate of aerobic respiration increases (1 mark) such that more heat is generated or energy used in muscle movement (1 mark) to maintain the body core temperature (1 mark). This is an example of homeostasis or negative feedback (1 mark). The greater the difference between the water temperature and the seal's body core temperature, the greater the heat loss and so the greater the amount of oxygen required (1 mark).

Whilst there were more than four marks to be allocated they could only gain full marks if they made the link between oxygen intake and respiration.

It was possible to get full marks without mentioning the body core temperature of 38ºC but most candidates who gained full marks mentioned it anyway. It was not possible to get full marks, however, without discussing the trend in graph 2 i.e. oxygen intake increases as temperature decreases. It was easier to discuss this point from this angle rather than in the reverse.

No marks were given for considering the iguanas in this part of the question, nor what happens outside the range of the 10ºC to 30ºC.

Comments

(a) This section was reasonably well done with most candidates being able to give one of the definitions. Some candidates thought that it was a surface are to volume ratio question. Many candidates thought it was to do with osmosis and most of these incorrect answers involved the terms osmoregulator and osmoconformer. The fact that most candidates could get some marks in this section meant that overall most candidates had at least a few marks of those available for the whole question.

(b) The candidates did this quite well. There was quite a spread of marks with most candidates getting at least a mark. Only one candidate mentioned that iguanas ate seaweed, most thought that they were predators.

(c) The candidates found this question easier than the previous one and made a well-reasoned argument as to why the oxygen intake increased i.e. to increase the respiratory rate, to generate more heat or for muscle movement to raise the body core temperature etc. Many candidates were concerned about the case of the sea lions overheating and mentioned that they reduced their oxygen consumption so as not to overheat. They even mentioned the mechanisms by which sea lions cool down, like panting. Given that the body core temperature is 38ºC and the amount of oxygen is constant from 30ºC external temperature, this was not considered to be a valid answer.

Quite a number of candidates answered this as a homeostasis question giving a stimulus, effector and a response. This was generally done poorly and earned them few marks, if any.

Part 5 - Criterion 10

Question 19

(a) (i) Fox B would be the Artic fox (1), because its small ears would reduce heat loss to the cold environment (1) Also accept that the Arctic fox has thicker fur for better insulation (1).

(ii) The smaller an animal the greater its surface is to volume ratio (1) and hence the greater its potential heat loss per kilogram to the environment (1). Thus, because it lives in and environment where keeping cool is paramount, the adult Fennec fox would be the smaller of the two (1). Answer could be phrased in terms of smaller surface area to volume ratio of the Arctic fox that would mean that there is relatively more tissue to produce heat than surface area to lose it (1)

(b) (i) **Plant C** Environment: Floating on water (½).

Justification: Any stomata on the lower surface of a floating leaf would not be able to exchange gases with the air, so such a plant would have all its stomata in the upper epidermis. The relatively large number of stomata suggests it lives in a humid environment (1½). (Other suggestions acceptable, - as long as justification adequately explained the lack of stomata on the lower epidermis)

(ii) **Plant D** Environment:
I) A very dry/desert environment (½) or
II) totally submerged underwater (½).

Justification: I) Plants lose water via evaporation through the stomata, so plants growing in very dry environments usually have significantly reduced numbers of stomata, which this pant has on both leaf surfaces as an adaptation to dry environments, the lower epidermis has slightly more stomata to minimize exposure to the drying effects of the sun. (1½).

II) No stomata or very few are needed as gas exchange can happen across the epidermis (1½).

Comments

(a) (i) Most candidates answered this question very well. Some lost marks when they didn't give reasons for their choice.
(ii) Candidates found this more difficult with many not picking up on increased surface area to volume ratio giving improved cooling ability to the Fennec fox in the desert environment. Many imaginative reasons were given (large ears providing shade from the hot sun) which provided amusing reading.

(b) Candidates found this question difficult. Many who had scored well on part (a) gained no marks here. There was confusion about what the question was asking and quite a few answers commented on the presence or absence of an epidermis rather than stomata on the epidermis. Several candidates missed the point altogether and wrote general comments about plant size, shape or energy requirements rather than transpiration. Far too many answers stated that plants gain water, nutrients and light only through their stomata, which was a concern.

(i) A large number of those attempting this question had no idea. Those answers that were correct were beautifully done suggesting that the candidates had been taught about floating aquatic plants. Others were floundering and gave answers about rainforest plants where light was coming from above only and therefore the plants needed lots of stomata on top to get enough light. Some credit was given to answers that didn't mention a pond if they included that the plant lived in a wet environment where water loss was not an issue.
(ii) This question was better done with more candidates getting some marks.

A common misconception was that the plant was growing in a dark environment or was a very small plant and therefore almost no photosynthesis or gas exchange gas was going on so there would be few stomata present.

Question 20

There are two species represented (½). Members of the same species can interbreed to produce fertile offspring (½). Thus A and B would be classified as one species while C would be a separate species (1).

Comments

The majority of candidates gained full marks for this question with very good answers. A high proportion of the rest scored zero. This was a question where they seemed to know what was going on really well or had no idea; there wasn't much middle ground.

Question 21

(a)

- There are more plants growing at C than at A to produce leaf litter etc, which constitutes the humus (1).
- Much of the dead plant material at A would be blown/washed away because the location is much more exposed (1).
- Less bacteria at A therefore breakdown of dead plant material is much slower (1).
- Sandy soil is less fertile and so less vegetation grows (1).
- Salt inhibits soil microbes so less fertile soil so less vegetation. (1).

Credit can be given for suggesting that there is a sand dune succession taking places where the older dunes have had longer to build up the soil etc (1)

(b)

- Soil nitrates are produced by nitrifying bacteria which act on organic matter in the soil (humus) (1).
- Location C is higher in the humus required, and soil bacteria, some of which would be nitrifying bacteria (1).
- Also nitrates are usually built up during a succession over time as there are progressively more wastes and remains that are broken down (1)
- More plants so more animals for more nitrogenous wastes from urine or death/dung decay (1).
- More plants so more likely to be some nitrogen fixers to improve the nitrogen concentration (1).

(c)

- Sites A and B are relatively low in soil nitrates (½), which might restrict the growth of most plants (½).
- Legumes have nodules on their roots which contain nitrifying bacteria (½),
  - which enables them to grow in soils with low nitrate levels (½).
  - This gives them a competitive advantage in these low nitrogen conditions (½)
- Legumes are better suited to A than non-legumes because of their ability to fix nitrogen (1).
- Nitrogen is a vital mineral for plant growth (½)
- Fewer nitrifying bacteria at A so legumes will do better than non legumes (½)

Comments

(a) Some candidates misinterpreted the diagram and assumed that the water was a river or lake.

Many candidates didn't look for two reasons for the higher percentage of humus at C. It is important to look for 2 distinct reasons, even if they are related, e.g. the bacteria levels and the vegetation levels are both related to each other and they are also reasons why there is more humus at C.

(b) For two marks candidates needed to expand on a single reason or give two. The simplest answer to get two marks is 'higher humus levels and higher soil microbe levels will cause more rapid breakdown of proteins in the dead plant material to produce nitrates in the soil.'

It is not enough to **list** 'higher humus levels and higher microbe levels' when the question asks to **explain.**

(c) Many candidates did not know what a legume was. These candidates tried to answer for the point of view that it was just a hardy plant able to tolerate low nitrogen, sandy soil with high salt content and wind/waves blowing/washing them away.

Other candidates who did know what a legume was or found it in their dictionary, simply described what legumes do without relating this information to the actual question.

Question 22

Biomass

There is a significant drop in biomass as you move from the shrub (maximum 50 000 units) to the hare (maximum 950 units) to the predator (maximum 0.95 units) populations (1). The shrubs are the producers for the ecosystem and they use the Sun's energy to produce the initial biomass for the system. Biomass decreases with increasing trophic level because

energy/biomass is lost as heat through respiration, for example as the hare uses energy for movement and to maintain body temperature (1), and converted to wastes, bones, fur etc, making it unavailable to subsequent trophic levels for biomass production(1).

Population Patterns

The plentiful supply of food over the first five years and the low numbers of predators would have enabled the hare population to rise (1). The increasing hare population from years 0 – 5 would have had an increasing impact on the shrubs, resulting in an eventual drop in the shrub population (½), but at the same time increasing the food supply of the predators enabling the predator population to increase (½). Once the shrub population had dropped, the reduced food supply for the hares along with the increased pressure from the predators caused the hare population to crash (½) which resulted in less food for the predators and a drop in their numbers (½).

Other Accepted Answers:

Biomass:

There was a significant drop in relative biomass between trophic levels (½)

Energy/biomass is used up (½)

Biomass is lost as waste (½)

Shrub biomass decreased due to a change in growing conditions, e.g. less available water (1).

Population Patterns:

All components of the food chin show a similar shape of graph. Initially there are optimal conditions for growth and the populations grow rapidly (1). Then environmental resistance sets in (lack of food/shelter more predators/disease) and this reduces the populations (1). The peaks in each component occur at different times (shrubs years 1-5, hares year 5 and predators years 5-6) because there is a time lag due to slower reproductive responses of the consumers (1).

Comments

Very few candidates managed to attain full marks for this question. A number of candidates discussed only biomass or population trends exclusively and as a result could not gain full marks. Several candidates merely described the trends without accounting for the differences. Other candidates did not use examples or figures from the graphs, which also resulted in them receiving less than full marks.

Common Mistakes:

- Misreading the scale – a number of candidates thought that the data was collected over 10 months and that the decrease in shrub biomass could be attributed to winter reducing biomass production.
- A number of candidates did not compare the relative biomasses between the populations and talked about biomass and population size as if they were the same entity.
- Many candidates described how biomass decreased with increasing trophic level but failed to provide reasons for the trend.

Question 23

(a) (i) The organochlorine pesticides were non-biodegradable (1). They would not accumulate in the muscle tissue if they were biodegradable (1)

(ii) Much of the pesticides would have accumulated in the waterways via run-off from land use. Low levels of pesticide would have initially been absorbed by the water plants (1). First order consumers (invertebrates, tiny fish) would eat the plats and store the pesticides within their tissues (1). Larger fish would consume many times their own body mass of the first order consumers and the herons would consume many of larger fish, resulting in the biomagnification of the pesticides and the high levels of organochlorine in the herons (1).

Other Accepted Answers:

(a) (i) The organochlorine pesticides were non-biodegradable (1), because they built up as you move up the food chain (1)

The organochlorine pesticides were non-biodegradable (1). They would not accumulate if they were biodegradable (1)

(ii) Pesticides would make their way into the waterways via run-off and be absorbed by the plants (1). The pesticides present in the plants would accumulate in the bodies of the first order consumers as they ate the plant tissue (1). All the pesticide ingested in food at each trophic level becomes concentrated in a smaller biomass at each successive level. So as the larger fish ate lots of the first order consumers and the herons ate the larger fish the organochlorine levels increased in the heron (1).

(b)

- The graph shows that at the time of the introduction of the insecticide the insects varied in their natural resistance to the insecticide (1).
- Variation in the population is due to mutation and/or meiosis (1).
- The particular variation (insecticide resistance) was already in the population before the insecticide was first used. (1).
- The insecticide acts as an artificial selection agent, selecting those insects with the 'fittest phenotype' (1).
- When the insecticide was first used more of the least resistant insects would have been killed (1),
  - leaving more of those with greater resistance to produce the next generation (1).

- Resistance to the insecticide must have been genetically determined, so the more resistant insects passed on their resistance to their offspring, resulting in an increase in the frequency of the genes for resistance (1).
- In each generation there would still be variation in resistance, but with an overall increase while the pesticide was being used (1).
- Any new mutation or meiotic combination which produces more resistance will be favoured if the spraying continues. (1).
- This must have occurred because the maximum resistance (amount of pesticide needed to kill the hardiest members of the population has increased. (1)

Comments

(a) (i) This part of the question was generally answered well. The majority of candidates suggested that the organochlorine pesticides were non-biodegradable, but many candidates then suggested that the reason was that the pesticides appeared in all animals.

(ii) Many candidates were able to explain how the pesticides collected in the waterways but failed to explain adequately how they entered the food chain. For full marks it was not sufficient just to describe the food chain, candidates needed to mention that the pesticides were stored in the tissues of the organisms and not excreted and how the pesticide was biomagnified by organisms at each trophic level eating large amounts of biomass at lower trophic levels.

(b) Many candidates (over 14%) gained no marks for this question. Insects **do not** get used to insecticide after prolonged exposure and then pass the insecticide onto their offspring which makes them immune. Many candidates have obviously missed the point completely on this topic of Evolution/Natural Selection.

Many candidates have used the dictionary to explain what natural selection is but have not applied it to this particular situation, not even once mentioning the fact that agent of selection is an insecticide and there are insects involved. Candidates need to make sure that they address the question and not just copy out information- they must apply it.

A number of candidates did not understand what the graph was showing them and seemed to think that the X axis was time.

Quite a pleasing number of candidates appeared to understand the ideas of natural selection very well, with almost 25% of the candidates gaining very high marks. It was important to mention the variation in the original population, though.

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