

Candidate 1 evidence

1. Read through the supplementary sheet for question 1 before attempting this question.

- (a) Mammals have both specific and non-specific defences against parasites. Antibody production is a specific immune response.

Describe how one non-specific defence protects against parasites.

1

Chemical secretion such as saliva and
mucus stops initial entry of parasite.

- (b) Refer to Figure 1.

There is a positive correlation between total blood antibody concentration before and total blood antibody concentration after measles infection.

What conclusion can be drawn about the effect of measles on the total antibody concentration in the blood?

1

~~At the total blood antibody concentration before measles infection it causes an increase in the total antibody concentration in the blood.~~

- (c) (i) Refer to Figure 2.

Give a conclusion about the effect of infection with the measles virus on antibody diversity.

1

The infection with measles causes the
antibody diversity to go below 0%. as
group Mmild and Msev were both contracted
with measles and their percentage change
in total antibody hits (%) went below 0%.

a) measles causes an increase in

b) There is no effect of measles on the total
antibody concentration in the blood.

MARKS

1. (c) (continued)

(ii) Refer to Figure 2.

The mean age of the control group and the measles infected groups was around eight years old, but the mean age of the group vaccinated against measles was less than two years old, as this is the normal age for measles vaccination.

Suggest why the antibody diversity might be expected to increase more in younger children compared to the control children.

1

As it was administered at a young age the antibodies will diversify as they grow up by becoming in contact with new antigens therefore increasing the diversity

(d) Refer to Figure 3.

(i) Calculate the percentage decrease in the proportion of antibodies still present between the medians of the control group and the severely affected measles group.

1

Space for calculation

sev - 0.6
control 0.89

difference - 0.29

32.6%

(ii) Other than the differences in the median values, use the data to compare the effect of the severity of measles infections on the proportion of antibodies still present.

2

The maximum values for each severity of measles infection differed with the control group having the highest maximum value

The mild group had the lowest minimum value of proportion of antibody types still present

(iii) Previous studies have suggested that loss of memory cells may contribute to the immune suppression observed after measles virus infection.

Explain how the data support this hypothesis.

1

loss of memory cells means that if cells were exposed to the virus again it will take longer to form a clonal population of the lymphocyte.

MARKS

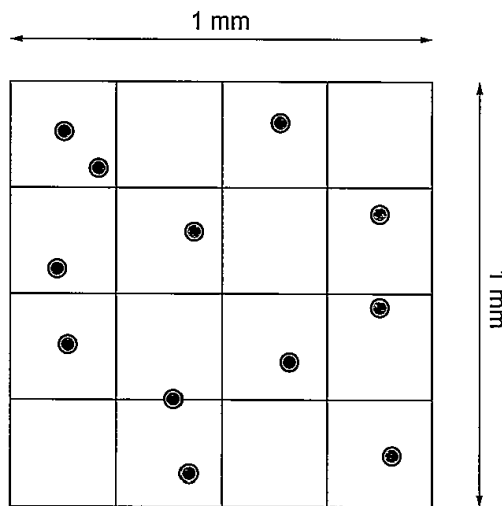
2. Many species of bacteria can be grown in liquid culture.

(a) State the importance of aseptic technique when culturing micro-organisms. 1

allow ~~the~~ unwanted microbial contaminants to be eliminated when culturing micro-organisms

(b) A haemocytometer can be used to estimate the number of bacterial cells in a liquid culture.

The figure represents bacterial cells from a culture, placed in a haemocytometer that has a depth of 0.1 mm.



Calculate the number of cells per cm³ of the liquid culture. 1

Space for calculation

12 1mm - 0.1cm

$0.1 \times 0.1 \times 0.01 = 0.0001$

$$\frac{12}{0.0001}$$

120,000 cells per cm³

MARKS

2. (continued)

- (c) An experiment was carried out to compare the effects of two novel antimicrobial substances, compounds A and B, on the growth of the bacterium *E. coli*. Cultures of *E. coli* were grown in the presence of the compounds. Cell counts were carried out following vital staining with a dye that is only retained by non-viable cells. -dead

Results from the experiment are shown in the table.

Antimicrobial compound in culture	Mean number of cells	
	Stained by vital stain	Not stained by vital stain
A	380	40
B	385	127

- (i) State which of the antimicrobial compounds is more effective at killing bacterial cells and use the data to explain your choice. 1

Most effective antimicrobial A

Explanation As 380 cells were stained, meaning

those were all dead and only 40 were alive at the end compared to B which still had 127 alive

- (ii) What method, other than vital staining, can be used to determine the number of viable bacterial cells in a liquid culture? 1

Microscopy

- (iii) Benzalkonium chloride is an antimicrobial compound found in products such as handwashes. It works by disrupting the interactions between the phospholipids of the cell membrane.

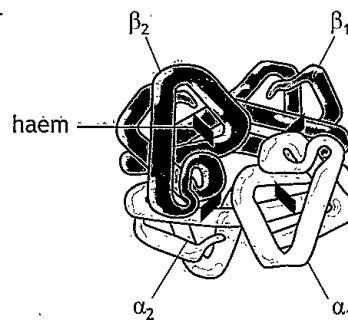
Suggest how this disruption could lead to cell death. 1

causes the interaction to be lost which

means that structures unfold, and interactions between R-groups to be lost meaning the cell will undergo apoptosis

MARKS

3. Haemoglobin, the oxygen-carrying protein in the blood of vertebrates, consists of four subunits: two alpha (α) subunits and two beta (β) subunits. The α and β subunits have similar tertiary structure. Each subunit contains a haem group, which binds to oxygen to produce oxyhaemoglobin.



haemoglobin

- (a) Within each haemoglobin subunit, a high proportion of the amino acids in the polypeptide form α -helices.

State the main force stabilising these regions.

1

peptide bonds

- (b) Explain why haem is described as a prosthetic group.

1

its a non-protein unit that is necessary for its function

- (c) Haemoglobin is affected by a number of allosteric interactions.

Allosteric interactions between the oxygen-binding sites result in co-operativity.

Explain what is meant by co-operativity in haemoglobin.

1

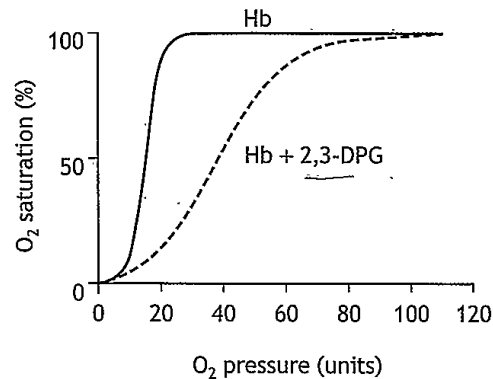
The binding at one subunit of oxygen increases the affinity for haemoglobin to oxygen in the remaining subunits. Binding at one subunit increases the affinity for the remaining subunits.

MARKS

3. (continued)

- (d) The compound 2,3-diphosphoglycerate (2,3-DPG) is an allosteric modulator that binds haemoglobin (Hb).

The graph shows the effect of 2,3-DPG on the binding of oxygen.



- (i) Explain how the data show that 2,3-DPG is acting as a negative modulator.

1

~~An increase in haemoglobin causes a decrease in the binding~~
^{binding to}
 An increase in haemoglobin causes a decrease in the binding

- (ii) The concentration of 2,3-DPG in the blood is normally 5 mmol per litre, but this rises to approximately 8 mmol per litre in individuals living at high altitude.

Explain how this increase in 2,3-DPG concentration at high altitude would help oxygen delivery to tissue.

1

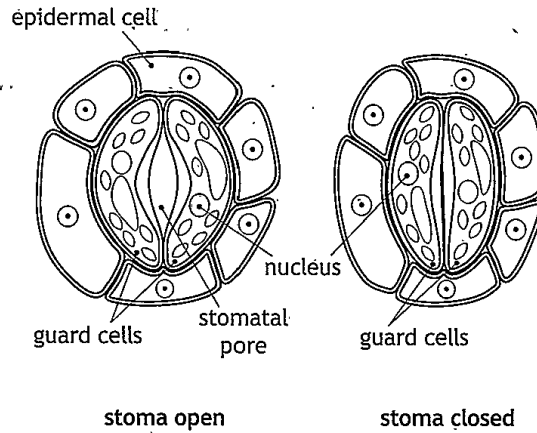
More molecules would bind to haemoglobin increasing the metabolic activity and therefore is able to transport oxygen to more cells.

3di) An increase in the binding to the substrate cause a decrease in the binding to other substrate. 2,3-DPG causes a decrease in the rate of O₂ saturation

[Turn over

MARKS

4. Stomata are pores in the underside of the leaves of plants that allow gas exchange. Each pore (stoma) opens in response to high light intensity and humidity.



The opening mechanism begins with the active transport of positively charged hydrogen ions out of the guard cells via an ion pump.

- (a) The hydrogen ion pump is known to be an ATPase.

Describe the chemical reaction that ATPases catalyse.

1

the hydrolysis of ATP to ADP.

- (b) What name is given to ion channels that open or close in response to changes in ion concentration?

1

voltage-gated channels

MARKS

4. (continued)

- (c) (i) Explain the meaning of the term electrochemical gradient. 1

~~electrochemical gradient is the~~
~~the ion concentration and the electrochemical~~
~~difference~~

- (ii) The movement of hydrogen ions out of the guard cells causes the inside of the cell to become more negatively charged, which in turn results in the opening of potassium ion channels. The final event in the process is the movement of water molecules into the guard cells by osmosis, which results in opening of the stoma.

Explain why, after the potassium channels open, positive potassium ions move into the cell against the concentration gradient. 1

To restore the resting membrane potential
 of the cell

ci) its the gradient at which certain molecules need to overcome to reach sufficient polymerisation.

MARKS

5. Steroid hormones are a type of hydrophobic signalling molecule.

Describe how steroid hormones bring about a response in target cells.

5

Example of steroid hormones include oestrogen and testosterone. As they are hydrophobic they can diffuse directly across the phospholipid bilayer of membrane. They then bind to receptors known as transcription factors either in the cytosol or nucleus. The binding causes a conformational change which forms a hormone-receptor complex. This complex then moves towards DNA where it binds to DNA sequences known as hormone response elements. The binding at these sites influences the rate of transcription.

MARKS

6. The black mamba, *Dendroaspis polylepis*, is a large African snake whose bite is extremely venomous and usually fatal to humans. Its venom consists of a mixture of toxins that primarily affect the nervous system.

- (a) One of these toxins binds to neurotransmitter receptors at synapses, preventing their activation.

Describe the process by which neurotransmitters released into a synapse initiate an action potential in a connecting cell.

3

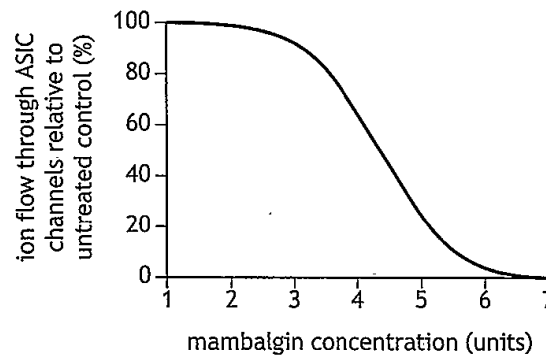
Neurotransmitters will bind to receptors known as ligand gated channels. Binding to receptors causes a conformational change causing the opening of these channels. This causes the inflow of positive sodium ions into the cell. Action potential is ~~the flow of positive ions~~ the wave of electrical excitation or ion flowing across the membrane. The inflow of positive ions causes depolarisation of the cell causing voltage gated sodium channels to open allowing more sodium ions to flow into the cell.

MARKS

6. (continued)

- (b) *Acid sensing ion channels* (ASICs) are involved in the perception of pain and are activated by small changes in the pH of the surrounding cellular environment. *Mambalgin* is another toxin found in black mamba venom, which is known to be able to bind to ASICs.

The graph shows the effect of increasing the dose of mambalgin on the activity of ASIC ion channels.



- (i) Describe the effect of mambalgin concentration on the activity of the ASIC channels.

1

As the mambalgin concentration increases the ion flow through ASIC channels relative to untreated control decreases.

- (ii) Laboratory experiments on mice show that mambalgin has a similar effect to that of a strong painkiller.

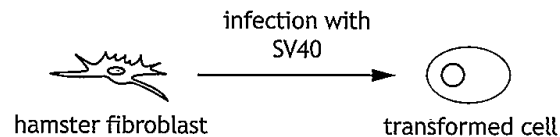
Suggest the mechanism by which mambalgin might work as a painkiller by preventing the generation of a nerve impulse.

1

By blocking the receptor ligand gated receptor, mambalgin will bind to the receptor blocking neurotransmitters to bind

MARKS

7. Some viruses can deregulate cell division in cells and cause tumours. Simian virus 40 (SV40) is a virus that naturally infects some species of monkeys. SV40 infection rarely causes disease in its natural host, but it has been shown to be able to induce tumours in laboratory animals and transform rodent cells in culture by causing them to divide in an unregulated way.



- (a) (i) Cells transformed with SV40 have features of tumour cells in culture.

State one way in which tumour cell lines differ from primary cell lines in culture.

1

Tumour cell lines have a unlimited
division of cells where a primary cell lines
have a limited division

- (ii) Suggest one advantage of studying SV40 in laboratory animals rather than in cell culture.

1

Allow scientists to see if SV40 will have
an effect in whole organisms.

- (b) Large T antigen (Tag) is a protein encoded by the SV40 genome. This protein is essential for SV40's tumour-forming capabilities. Tag has been shown to bind to and inactivate the tumour suppressor p53.

- (i) Give one outcome of p53 activation in a normal cell.

1

arrest of the cell cycle

- (ii) Tag has also been shown to bind to and inactivate the retinoblastoma protein (Rb).

Explain how the interaction of Tag with Rb would disrupt the normal control of cell division.

2

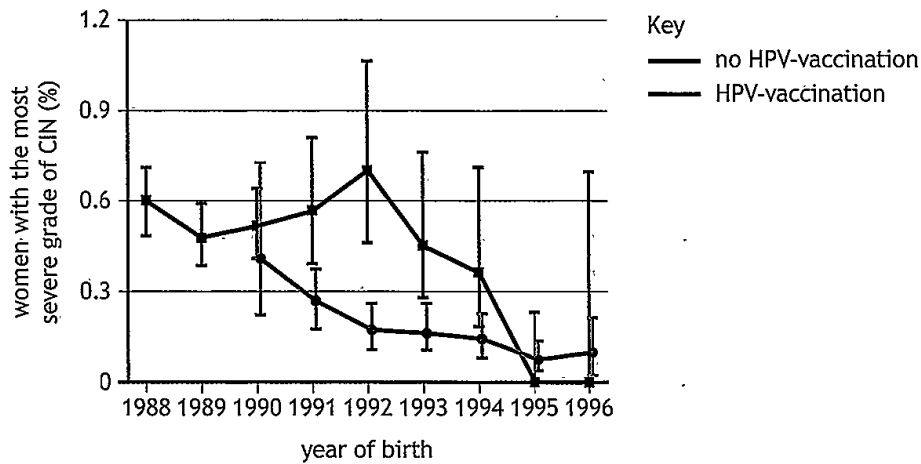
retinoblastoma is a tumour suppressor
protein, the inactivation caused the
progression through the cell cycle to
stop as the genes required for transcription
of DNA for DNA replication is not
activated. The transcription factors for DNA
replication cannot be inhibited.

MARKS

7. (continued)

- (c) Human papillomavirus (HPV) is another virus that has also been found to inhibit p53 and Rb. HPV can cause the development of cervical intraepithelial neoplasia (CIN), the abnormal growth of cells that line the cervix that can lead to the development of cervical cancer.

A recent study in Scotland assessed the impact of routine vaccination against HPV on the development of CIN in the first year of screening. The graph shows the effect of HPV-vaccination on the percentage of women found to have the most severe grade of CIN by cervical screening.



- (i) What is the effect of HPV-vaccination on the incidence of CIN? 1

It decreases the women with the most severe grades of CIN(%)

- (ii) Explain how the data support the suggestion that vaccination against HPV could lead to herd immunity. 1

As the severe grades of CIN will reach the threshold in which the population of resistant hosts will be required to ~~prevent~~ ^{prevent} an epidemic.
It more women are vaccinated against CIN then they can create a part of the population that is immune to CIN [Turn over

MARKS

8. As bananas ripen, the insoluble starch in the cells is converted to soluble sugars giving a sweet taste.

A student wanted to estimate the changes in soluble carbohydrate content of bananas using colorimetry. They crushed peeled banana segments in distilled water and centrifuged the resulting extract. The supernatant was pipetted off into vials and tested with Anthrone reagent. Anthrone turns a blue-green colour with carbohydrates. This coloured solution was then tested in a colorimeter measuring absorbance at 620 nm. Five bananas attached together in a bunch were used. One banana from the bunch was taken and tested each day for 5 days.

The student prepared a range of concentrations of glucose solutions and tested these in the same way as the banana extract solutions.

- (a) The student used information from a peer reviewed article to develop their method using Anthrone reagent.

Describe what happens during the peer review process.

1

a specialist with expertise in the relevant field

~~make a recommendation on the basis of the scientific suitability of a submitted manuscript by make recommend~~
 (b) (i) Identify a positive control for this experiment. before it is published.

Anthrone reagent.

- (ii) Suggest why it was important to use bananas originally attached in a single bunch rather than separate bananas.

1

As other bananas may be younger or older which could have a different effect on the soluble carbohydrate content.

- (c) The student used data from the known glucose concentrations to construct a standard curve.

Describe the purpose of this standard curve.

1

It allow the concentration of an unknown concentration to be determined.

MARKS

8. (continued)

- (d) Anthrone reacts with both soluble and insoluble carbohydrates.

In the pilot study, the student did not use the centrifuge.

Explain why using the centrifuge is an improvement to this experimental procedure.

1

The centrifuge allow ^{substances} ~~the carbohydrates~~ to be separated on differing density. Allowing more dense components to settle in the pellet and less dense to stay in the supernatant.

- (e) Describe a method that the student could have used when preparing the banana extract to ensure the concentration was controlled.

1

Make sure that the crushed peeled banana segments were placed in the distilled water for the same length of time.

- (f) The student did not carry out an independent replicate of this experiment.

State one feature of an independent replicate for this experiment.

1

A new bunch of bananas used.

- (g) Give one reason, other than the lack of independent replication, and the extract concentration, why any results achieved might be considered invalid.

1

The experiment went over 5 days which meant bananas used at the end would be riper than those before which could provide different results.

MARKS

9. Taxonomy is an essential tool for studies of biodiversity. It involves both the identification and classification of organisms, often based on their morphology.

- (a) (i) State one method that can be used to identify organisms in a sample during fieldwork.

1

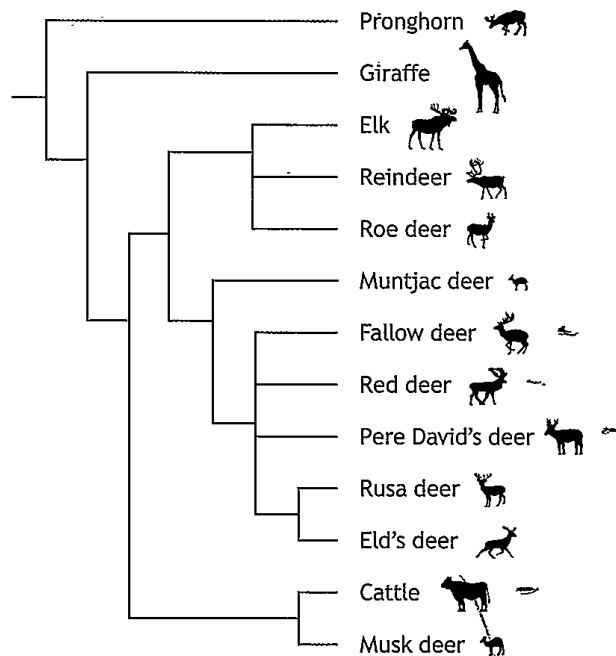
Quadrats

- (ii) What is meant by 'morphology'?

1

form or taxonomy used to identify organisms and create a phylogeny

- (b) The figure is a phylogenetic tree showing the evolutionary history and relationships of a number of mammalian species.



- (i) Other than morphology, give an example of heritable evidence that may be used to construct a phylogenetic tree.

1

DNA structure

MARKS

9. (b) (continued)

- (ii) Tick (✓) the box to indicate which of the following statements is correct from the evidence shown.

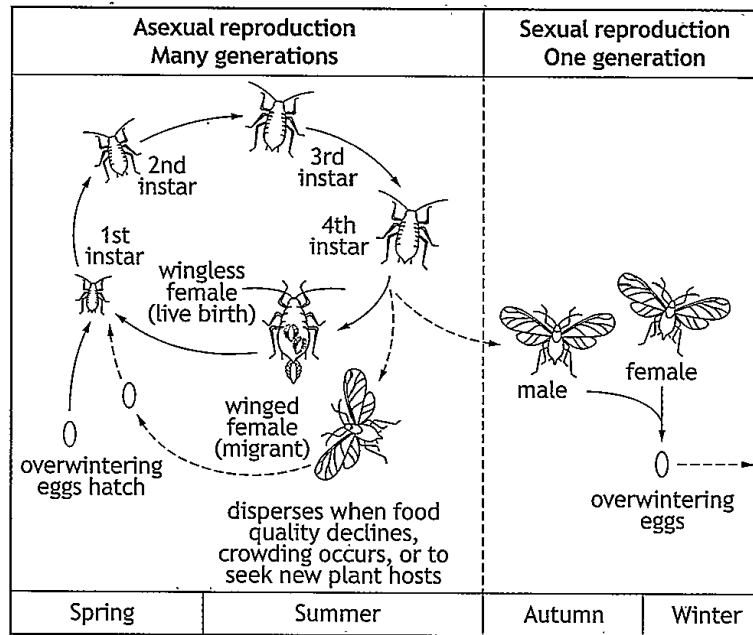
1

Red deer are more closely related to reindeer than elk	<input checked="" type="checkbox"/>
Cattle are closer relatives of fallow deer than giraffes	<input type="checkbox"/>
Pere David's deer and red deer have evolved at the same rate	<input type="checkbox"/>

MARKS

10. Aphids are small insects adapted to feed on plants by piercing and sucking sap from them. Many crop species are hosts of aphid species and the rapid reproduction rate of aphids represents a significant challenge to food crop production.

Aphids have complex life cycles as shown in the figure.



(a) The form of asexual reproduction carried out by aphids is called parthenogenesis.

State the meaning of the term parthenogenesis.

1

The reproduction from a female gamete without fertilisation.

(b) Many invertebrates act as vectors for plant viruses.

Use the figure to explain how aphids may act as vectors for plant viruses.

1

the aphids ^{were} actively involved in the transmission of the parasite as they can reproduce asexually to spread the parasite to eggs. developed wings which allowed to try to new hosts.

MARKS

10. (continued)

The importance of aphids in food security has prompted research into how they are affected by climate change.

- (c) In a study of 55 aphid species, it was found that over a period of many years all produced winged forms earlier in the year. Most species showed an increased duration of the flight season. These aphid flight trends follow trends in climate change associated with rising global temperatures.

- (i) Predict with justification the effect of these trends on crop production. 1

The crop production would ~~decrease~~ ^{increase} as the aphid ^{parasites} prefer cooler climates

- (ii) Suggest one evolutionary benefit to aphid populations from increased sexual reproduction made possible by climate change. 1

Allow there to be more genetic variation in the offspring.

MARKS

11. Several hypotheses regarding the adaptive significance of zebra stripes have been proposed. One study investigated the effect that stripes might have on biting insects. Biting flies are serious pests of many animals, affecting behaviour and productivity.

In this study, an experiment was carried out that involved painting striped patterns on Japanese Black cows. Changes in fly-repelling behaviours and the number of biting flies landing on the cows were observed.

Three cows were each subjected to three different treatments:

- Treatment 1 (BW) — painted stripes using white lacquer (4–5 cm wide)
- Treatment 2 (BB) — painted stripes using black lacquer (4–5 cm wide)
- Treatment 3 (CONT) — no painted stripes (control)

The figure shows a Japanese Black cow with white painted stripes (BW).



The researchers used a grid called a Latin Square to organise the treatments given to each cow. Each experiment lasted for 9 days and was made up of three periods, each lasting for 3 days.

Each cow experienced all three treatments over the course of the three periods. Only one cow was assigned to each treatment in one period.

(a) Use the codes BW/BB/CONT to complete the grid to show one way in which the treatments could have been organised as a Latin Square.

1

	Period 1	Period 2	Period 3
Cow 1	BW	CONT	BB
Cow 2	BB	BW	CONT
Cow 3	CONT	BB	BW

BW ~~BB~~ CONT BB
 BB BW CONT
 CONT BB BW

MARKS

11. (continued)

- (b) Explain how the experimental design contributed to minimising any ethical concerns about the study.

1

reduced the number of animals used only 3 cows

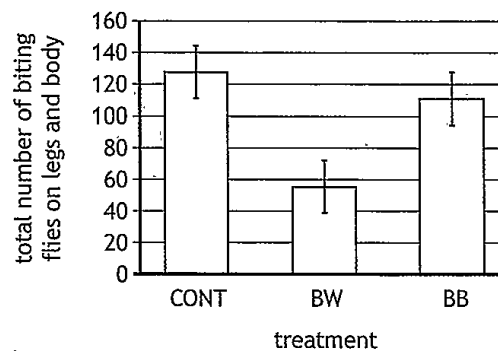
- (c) Each cow was observed twice a day (am/pm) for 30 minutes. Photo images were used to count the number of biting flies on the body and legs.

- (i) Suggest one confounding variable, other than those mentioned, that would need to be controlled in this experiment.

1

The temperature

Results from the experiment are shown in the graph.



- (ii) Give one conclusion about the effects of the treatments.

1

The control group had the most highest number of biting flies on legs and body.

- (d) Assuming that colonies of biting flies can be safely maintained in a laboratory, briefly describe a simple experiment (not using live cows) that could be carried out to check the findings of this research.

2

Have similar images of live cows with the different stripes and monitor which biting flies will move towards the images.

MARKS

12. *Batillaria cumingi* is a mudsnail species abundant in saltmarshes and mudflats in north-east Asia. This snail is frequently infected with trematode (flatworm) parasites such as *Cercaria batillariae*. A study was carried out to see the effect of these parasites on the growth and behaviour of the snail hosts.



Batillaria cumingi

At the principal study sites infected snails were 20–30% longer than uninfected snails, and their reproductive ability was either blocked or ended.

- (a) Suggest one benefit to the parasites of the changes induced in the snails.

1

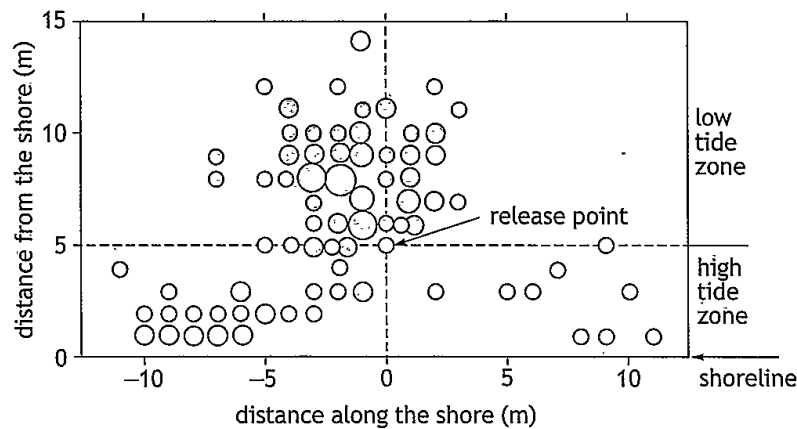
By snails being longer means that they can be more visible to predators increasing the parasites rate of transmission.

MARKS

12. (continued)

A transplant experiment was carried out in which 200 snails, collected from both the upper and lower shores, were moved to the boundary between the upper and lower tidal zones and released. After two weeks the vertical and horizontal distances from the release point were recorded for the snails that were recaptured. All snails were examined for parasites.

Results are shown in the figure.



Key

○ uninfected snails

○ snails infected by *C. batillariae*

The area of each circle is proportional to the number of snails found at each location

- (b) Use the figure to describe the effect of parasite infection on the snails' behaviour. 1

Snails who are infected preferred the low tide zone than the high tide zone

- (c) Suggest how a new ecological niche for these snails may be created by the changes in their growth and behaviour caused by this parasite. 1

ecological niche - the multidimensional summary of tolerances and requirements.
 changes caused by parasites may cause them to require new substance or tolerate new substances that are in new niches

MARKS

12. (continued)

- (d) The mark and recapture technique was involved in some stages of this research.

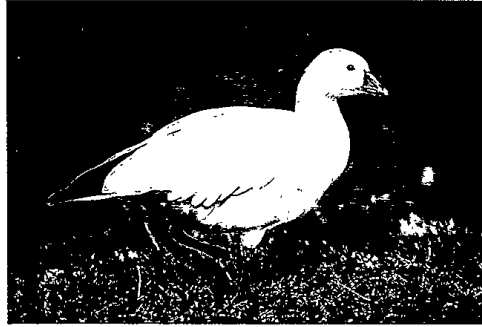
Describe how the mark and recapture technique could be used to estimate the size of a population.

3

It allows an estimated number of the population to be obtained. The formula is $N = \frac{MC}{R}$, M being the total number of animals in the first capture, marked and released. C being the total number of the second capture, and R being the number of marked in the second capture. This allows the number of animals in a population to be estimated. It ~~now~~ predicts that all the organisms will mix with the whole population after released from the first capture. There is no emmigration or immigration. All have the same chances ~~as~~

MARKS

13. Cooke and Ryder (1971) studied the genetics of Ross's goose (*Anser rossii*). As goslings (baby geese), they have either yellow or grey feathers. Once the geese mature to adulthood, they all become white.



adult Ross's goose

In a population of geese, observers counted 274 yellow goslings and 423 grey goslings.

- (a) (i) Grey is dominant (G) and yellow is recessive (g).

Use the Hardy-Weinberg principle to calculate the frequency of the homozygous dominant genotype to 2 decimal places.

1

Space for calculation

p^2

$$p^2 + 2pq + q^2 = 1$$

$2pq$

$$p + q = 1$$

$$423 + 274 = 1$$

179000

- (ii) Not all goslings survive to adulthood. The Arctic skua preys upon yellow goslings more than grey goslings. It was observed that 312 grey goslings survived to adulthood, but only 121 yellow goslings survived.

An absolute fitness value of 0.8 was calculated for yellow goslings.

What does this value indicate about the frequency of this genotype?

1

~~It has a high value~~ The frequency of the genotype is high

MARKS

13. (continued)

- (b) Ross's geese form a symbiotic relationship with a nematode parasite, *Amidostomum spatulatum*.

What is meant by a symbiotic relationship?

1

Both the geese and parasite gain from
the relationship. Co-evolutionary relationship
between parasite and geese.

- (c) For many nematode parasites, definitive hosts are infected through direct uptake of eggs or larvae passed from faeces of infected definitive hosts.

What is meant by a definitive host?

1

The host in which sexual reproduction
occurs.

	MARKS
14. Attempt either A or B. Write your answer in the space below and on page 34.	
A Discuss animal reproduction strategies under the following headings:	
(i) mating systems in animals	3
(ii) courtship and female choice.	6
OR	
B Discuss changes in allele frequency under the following headings:	
(i) natural selection	4
(ii) genetic drift.	5
<p>14 Ai) Mating systems are based on how many individuals mates an individual has during one breeding season. Examples include monogamy and polygamy.</p> <p>Monogamy - the mating of a pair of animals with the exclusion of all others</p> <p>polygamy - individual of one sex has more than one mate.</p> <p>polygyny - one male mates exclusively with a group of females.</p> <p>polyandry - one female mates with a number of males in the same breeding season.</p> <p>ii) Some species exhibit mate-selection courtship rituals. Successful courtship in birds and fish can be a result of species-specific sign stimuli or fixed action pattern responses.</p> <p>Female selection involves</p> <p>Female choice - assessing of honest signals of fitness of males.</p>	

ADDITIONAL SPACE FOR ANSWER to question 14

Sexual selection selects for characteristics that have little survival benefit on the individual but increase the chance of mating and producing offspring. Many species exhibit sexual dimorphism.

Females are generally inconspicuous with males containing more conspicuous markings, structures and behaviours. In some species reversed sexual dimorphism can occur.

In lekking species males gather to display at a lek and during the display female choice occurs.

Dominant males occupy the centre of the lek with subordinates and juveniles at the fringes as 'satellite' males.

Male-male rivalry increases access to females for mating.

Male-male rivalry ~~often~~ involves fighting for dominance and access to females often using 'elaborate' weapons such as tusks, antlers, horns.

Honest signals are favourable alleles that increase the chance of survival of offspring (fitness) or a low parasite burden suggesting a healthy individual.

Male-male rivalry can be real or ritualized.