

New
Specification



Rewarding Learning

ADVANCED
General Certificate of Education
2018

Centre Number

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Candidate Number

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Biology

StemUp Model Solution

Assessment Unit A2 1

assessing

Physiology, Coordination and
Control, and Ecosystems



[ABY11]

ABY11

THURSDAY 7 JUNE, MORNING

TIME

2 hours 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all nine** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.

Section A carries 82 marks. Section B carries 18 marks.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

You are expected to answer Section B in continuous prose.

Quality of written communication will be assessed in Section B (Question 9).



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Section A

- 1 In many plants, flowering is controlled by day length. This is known as photoperiodism.

(a) Name the light-sensitive pigment involved in photoperiodism.

Phytochrome(s)

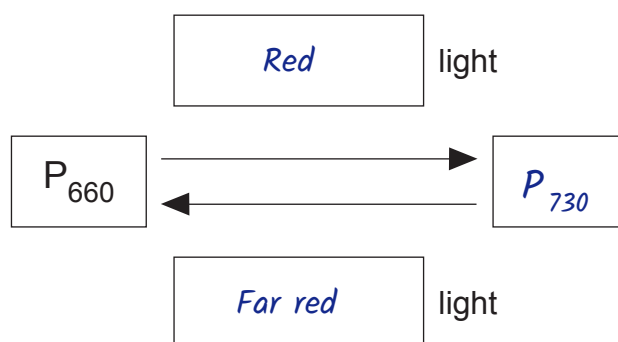
[1]

(b) State the location of this light-sensitive pigment in the plant.

In the leaves

[1]

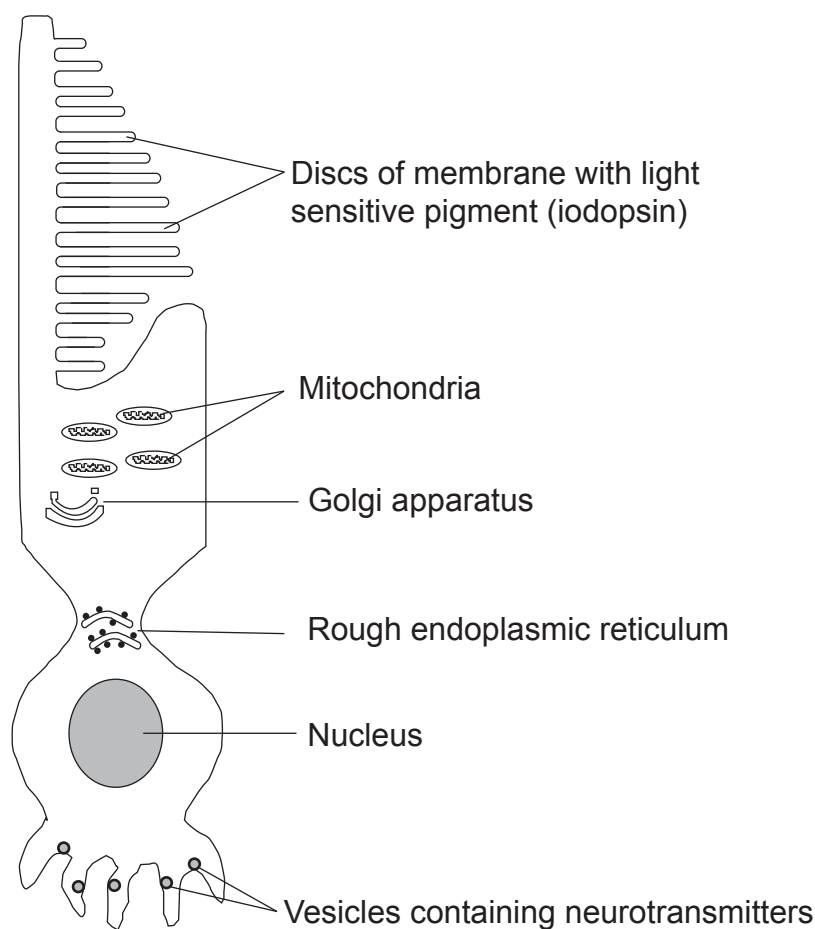
(c) Complete the diagram using the most appropriate words or terms.



[3]



- 2 A typical cone cell from the retina of a mammalian eye is shown in the diagram below.



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(a) Identify the structure labelled in the diagram which:

1. synthesises protein Rough endoplasmic reticulum

2. modifies protein Golgi apparatus

[1]



- (b) With reference to the diagram, suggest and explain how the cell is adapted for its function.

The many discs of membrane give a large surface area containing iodopsin, allowing maximal light absorption.

The many mitochondria provide ATP for metabolic activity, e.g. synthesis of opsin (protein) and of neurotransmitter.

The vesicles containing neurotransmitter allow transmission of an impulse across the synapse; the branches of the cell body enable connections with bipolar neurones.

Iodopsin needs high light intensity to break down, and different cones have different iodopsins, allowing colour vision.

[3]

[Turn over



3 Within an ecosystem, certain populations are r-selected, while others are K-selected.

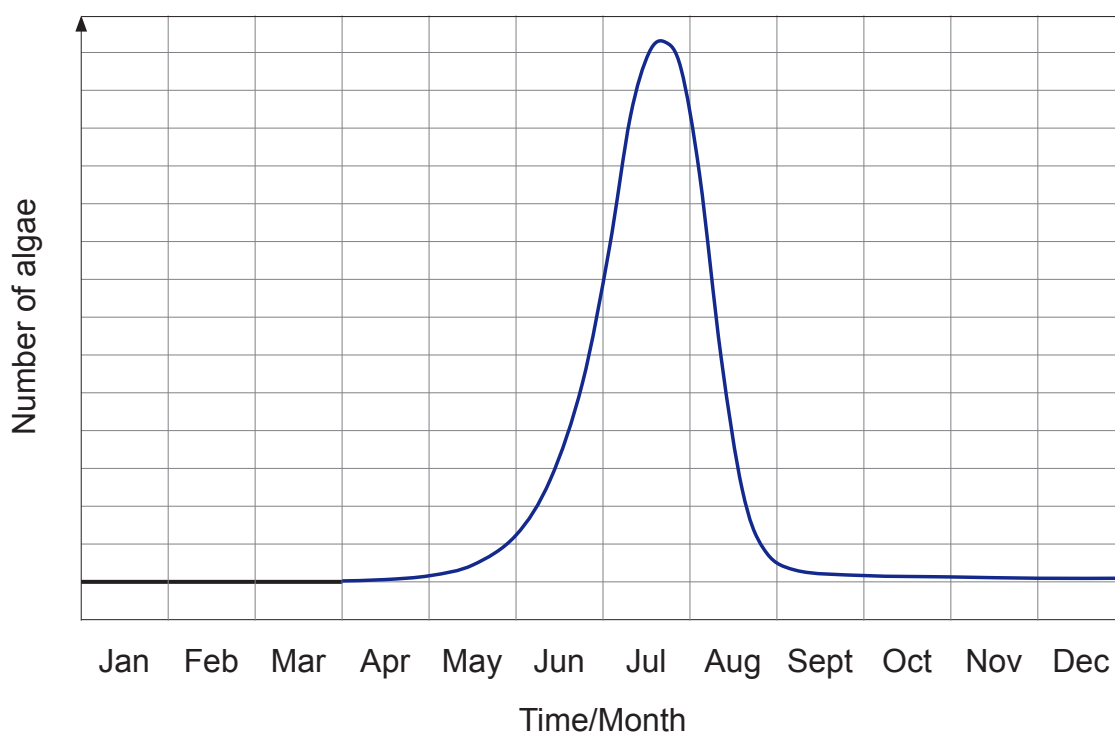
(a) Define the term population.

A group of organisms of the same species living in a particular area at the same time (able to interbreed).

[1]

An algal population in a pond is an example of an r-selected population.

(b) On the axes below, sketch an appropriate growth curve for an algal population in a pond from April to December. The population from January to March has been completed for you.



[1]



(c) List **three** characteristics of r-selected species.

1. Small body size and short lived.

2. Reproduce rapidly, producing many offspring with little parental care.

3. Rapid dispersal, colonising new (unstable) habitats as pioneer species.

[3]

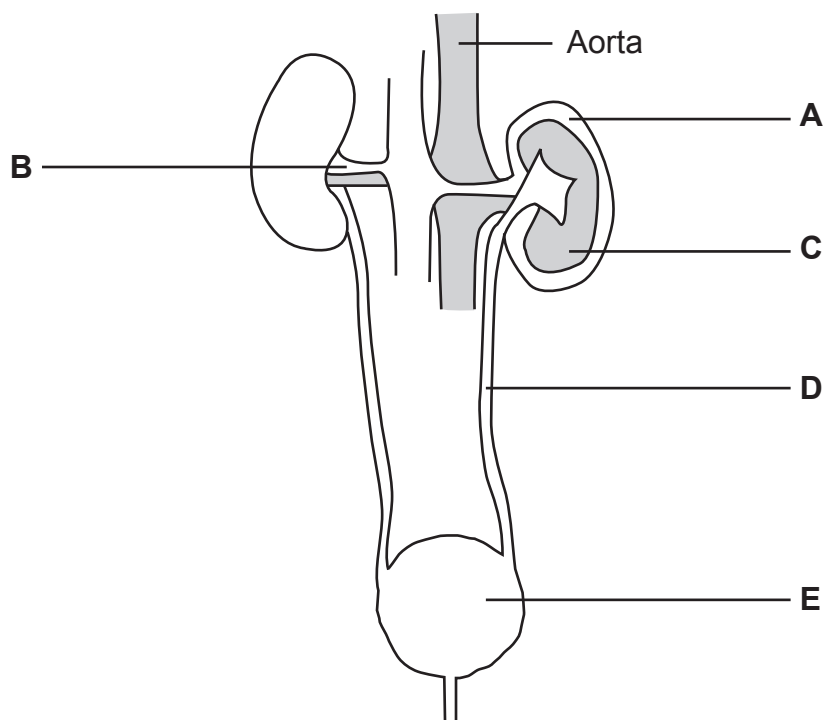


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- 4 The human urinary system is shown in the diagram below. One of the kidneys shown is dissected.



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(a) Identify A–E

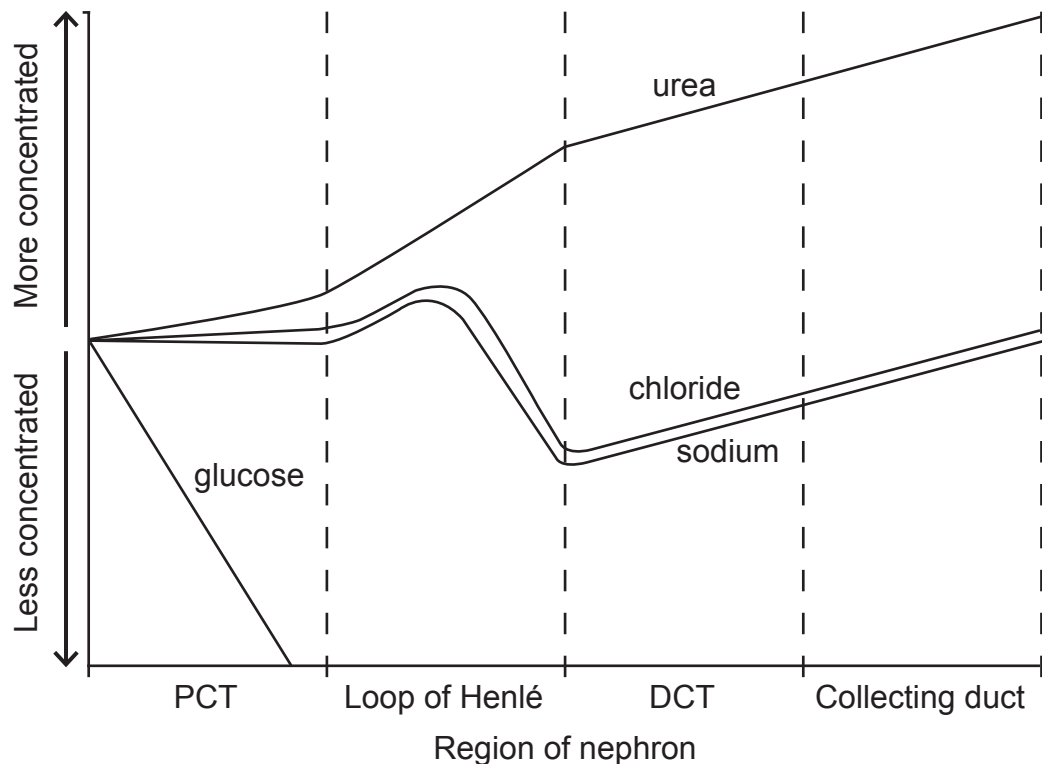
- A Cortex
- B Renal vein
- C Medulla
- D Ureter
- E Bladder

[3]

[Turn over



- (b) The concentrations of four substances in different regions of the nephron were measured. Their concentration compared to that in the glomerular filtrate was then calculated. The results are shown in the graph below.



- (i) Describe and explain the trend shown for glucose in the proximal convoluted tubule (PCT).

The glucose concentration decreases along the PCT, falling to zero.

All the glucose is selectively reabsorbed into the blood by active transport (co-transport with sodium ions) in the PCT.

[2]



- (ii) Explain the changes in the concentrations of ions (sodium and chloride) along the loop of Henlé.

The descending limb of the loop of Henlé is permeable to water, while the ascending limb is impermeable to water.

In the descending limb the ion concentration increases because water is removed (osmotic extraction of water) and ions are absorbed.

This osmotic extraction depends on the lower water potential of the interstitial fluid of the medulla.

The low water potential is achieved by actively pumping sodium and chloride ions out of the ascending limb, so the concentration of ions in the ascending limb decreases.

[4]

Antidiuretic hormone (ADH) has a role in osmoregulation of the blood.

- (c) (i) State the precise location of osmoreceptor cells in the brain.

Hypothalamus

[1]

- (ii) State precisely where ADH is released into the bloodstream.

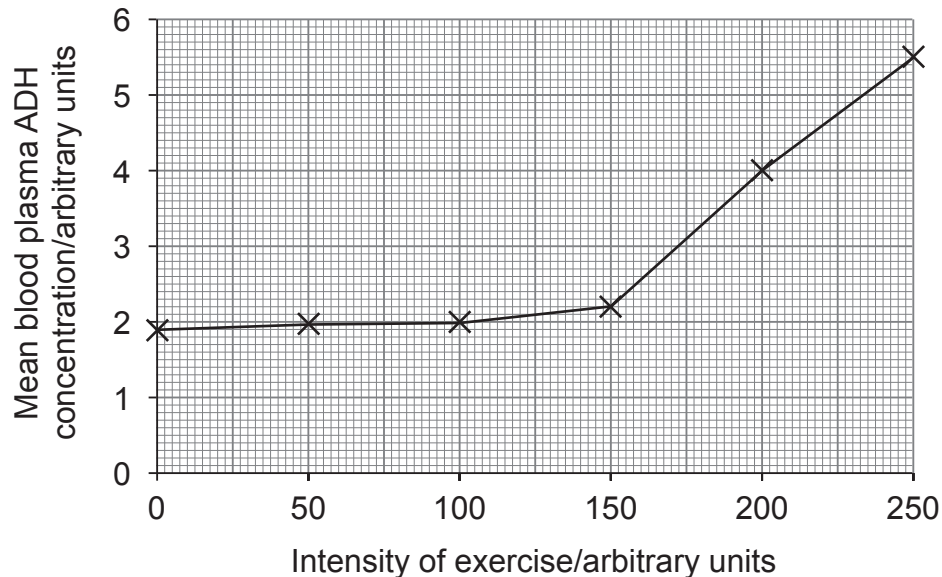
Posterior pituitary gland

[1]

[Turn over]



The effect of intensity of exercise on the concentration of ADH in blood plasma was investigated in a group of students. They carried out exercises of different intensities for the same length of time, and the ADH concentration in each student was measured one hour after the exercise. The results of the investigation are summarised in the graph below.



(d) (i) Identify one **other** controlled variable appropriate for this investigation.

All subjects the same sex (or same body mass or same fitness level).

[1]



- (ii) Describe and explain the trend shown and the consequence of this on kidney function.

At low exercise intensity (0 to 150 units) the plasma ADH concentration remains relatively constant at about 2 units, then it increases sharply at higher intensity, to 5.5 units at 250.

At higher intensity more water is lost from the body due to sweating. This water loss lowers the water potential of the blood plasma, which is detected by osmoreceptors in the hypothalamus, so more ADH is released into the blood.

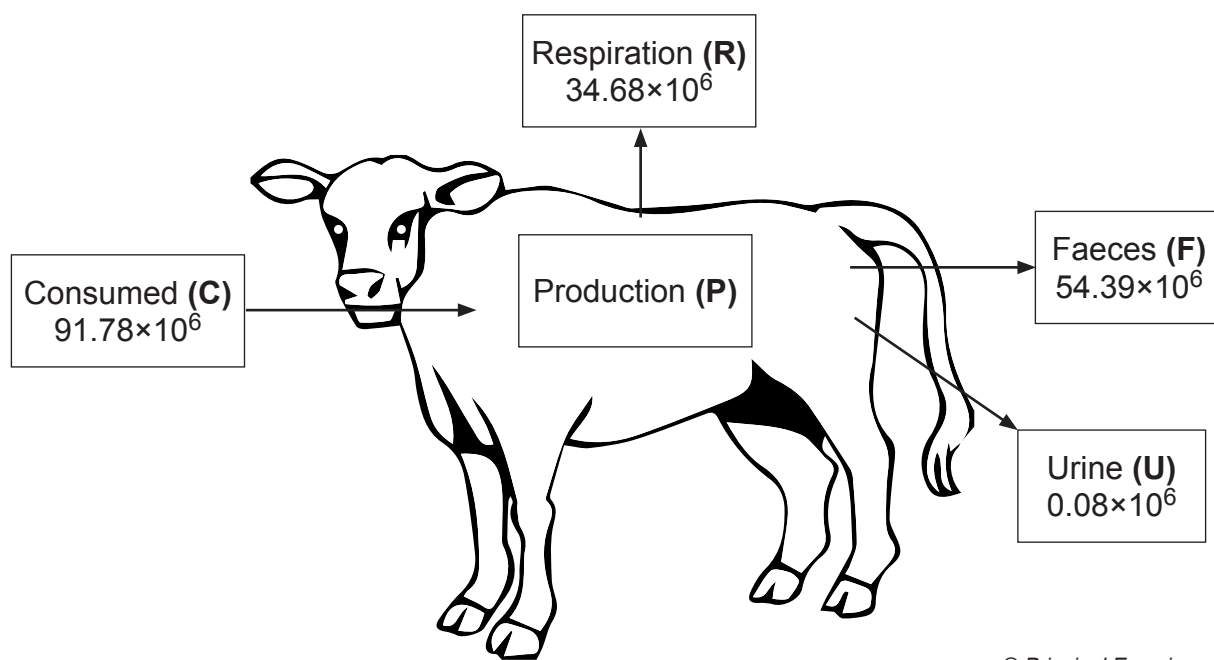
Increased ADH increases the permeability of the distal convoluted tubule and collecting duct to water, so more water is reabsorbed into the blood and a smaller volume of more concentrated urine is produced.

[4]

[Turn over]



- 5 The energy flow through a cow is summarised in the diagram below.
All values are given in kJ year^{-1} .



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- (a) (i) Using the letters shown (**C**, **F**, **R** and **U**) write a formula which will allow production (**P**) to be calculated.

$$P = C - (R + F + U) \quad [1]$$

- (ii) Calculate the value for production (**P**).

$$P = 91.78 - (34.68 + 54.39 + 0.08) \\ = 91.78 - 89.15$$

$$\underline{2.63} \times 10^6 \text{ kJ year}^{-1} \quad [1]$$



- (iii) The productivity of grass is $22\,275\text{ kJ m}^{-2}\text{ year}^{-1}$. A different cow feeding on 9500 m^2 of grassland has a production of $1.6 \times 10^6\text{ kJ year}^{-1}$.

Calculate the percentage of the energy in the grass that is used in production in this cow.
(Show your working.)

$$\text{energy in grass} = 22\,275 \times 9500 = 211\,612\,500\text{ kJ year}^{-1}$$

$$\begin{aligned}\% &= (1.6 \times 10^6 \div 211\,612\,500) \times 100 \\ &= 0.756\%\end{aligned}$$

$$\underline{0.76}\% \text{ [2]}$$



- (b) In an investigation, the same type of crop was grown in two adjoining fields, **A** and **B**. Each field was subdivided into six plots of one hectare (ha) each. A different mass of fertiliser was added to each plot.

After six weeks, samples of crop plants from each plot were collected and their mass in kilograms (kg) was measured. The results are shown in the table below.

Plot	Mass of fertiliser added to plot/kg ha ⁻¹	Mass of crop/kg m ⁻²	
		Field A	Field B
1	0	14.2	6.2
2	10	16.6	9.7
3	20	17.3	13.1
4	30	17.5	16.2
5	40	17.5	17.1
6	50	17.5	17.1

- (i) Explain the change in the mass of crop produced in field **B** when the mass of fertiliser added increased from 0 to 20 kg ha⁻¹.

More nitrate is available in the soil for uptake by the crop plants,

so more nitrogen is available for protein (amino acid) synthesis and

growth, increasing the mass of crop.

[2]



- (ii) During the previous year, field **A** had been used for grazing cattle. Field **B** had been used to grow the same type of crop in each year. The table shows that when no fertiliser was added, the mass of crop from field **A** was higher than from field **B**. Suggest an explanation for this difference.

Field A has more nutrients (nitrate) in the soil than field B.

In field A nutrients were replaced by decomposition of the cattle

faeces and urine, whereas in field B the crop was harvested each

year, removing the nutrients.

[2]

- (iii) State **one** advantage and **one** disadvantage of using artificial (inorganic) fertiliser on a field.

Advantage: *It is soluble, so the ions are available immediately without needing to decompose.*

Disadvantage: *It is easily leached into waterways, causing eutrophication.*

[2]

[Turn over]



6 MRSA is a strain of the bacterium *Staphylococcus aureus* and is resistant to the antibiotic methicillin.

(a) (i) State the kingdom to which bacteria belong.

Prokaryotae

[1]

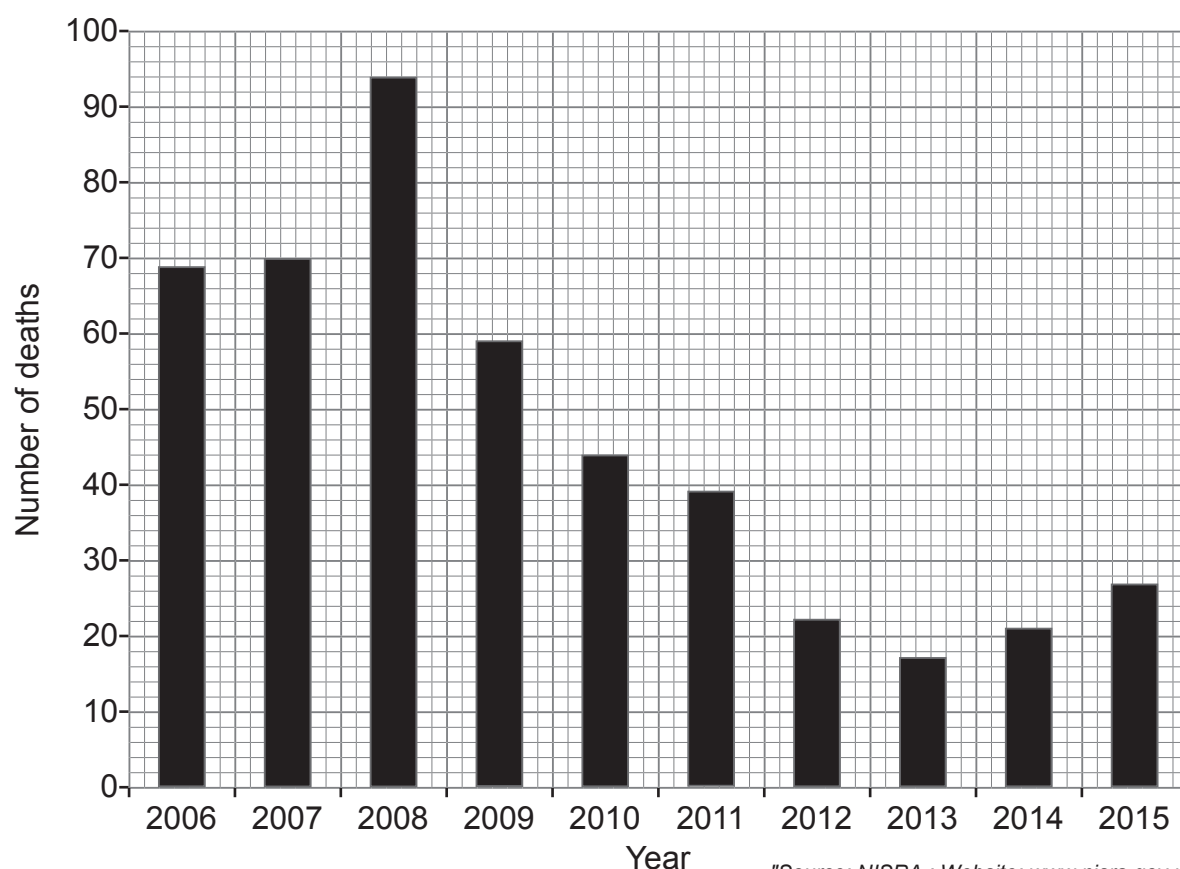
(ii) Genes for antibiotic resistance are commonly found within structures outside the main bacterial chromosome. Name these structures.

Plasmids

[1]



The number of deaths involving MRSA in Northern Ireland during the period 2006 to 2015 is shown in the graph below.



"Source: NISRA : Website: www.nisra.gov.uk"
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(b) Describe and suggest reasons for the trends shown from 2008 to 2015.

There is a general decrease in deaths from a peak of about 94 in 2008 to a minimum of about 17 in 2013, followed by an increase to about 27 in 2015.

The decrease is due to better hygiene in hospitals, e.g. hand washing and screening patients, and to more effective treatments.

The increase from 2014 may be due to new resistant strains of MRSA evolving.

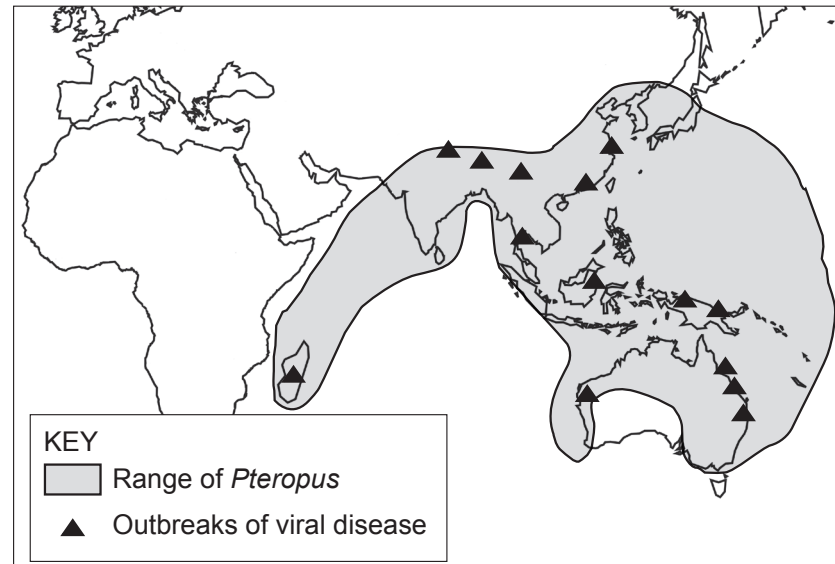
[3]

[Turn over



- (c) Some human diseases are caused by viruses that were originally found in other mammals, e.g. bats. These mammals can be referred to as 'reservoirs' for the virus concerned.

The map below shows both the locations of recent outbreaks of human diseases known to be caused by a number of these viruses and the distribution range of bats of the genus *Pteropus*.



Nipah Virus Distribution Map © Centers for Disease Control and Prevention

- (i) Using the map, suggest why *Pteropus* bats may have been identified as reservoirs for these viruses.

All the disease outbreaks are located within the boundaries of the range of the Pteropus bats.

[1]

- (ii) Suggest **two** reasons why viruses which are carried by bats may pass relatively easily to human populations.

- Bats are mammals with a similar physiology to humans.*
- Bats fly, giving them a large range, and humans encroach on their habitat, so contact is more likely.*

[2]



Once a virus is transmitted to humans, it may mutate so that it can spread more easily to other humans. This could potentially cause a pandemic.

(d) (i) Define the term 'pandemic'.

*A disease that affects very many (many thousands of) people,
across several countries or continents (a large geographical range) at
the same time.*

[2]

(ii) The viruses referred to in part (c) are retroviruses. State the type of genetic material contained within retroviruses and explain the significance of the enzyme reverse transcriptase in retroviruses.

Genetic material *RNA*

[1]

Significance of enzyme *Reverse transcriptase converts the
single-stranded viral RNA into double-stranded DNA,
allowing the viral DNA to be incorporated into the host cell genome.*

[2]

(iii) State how an inhibitor of reverse transcriptase might help to prevent a pandemic.

*It would stop (reduce the rate of) production of new viral particles,
reducing the spread of the virus.*

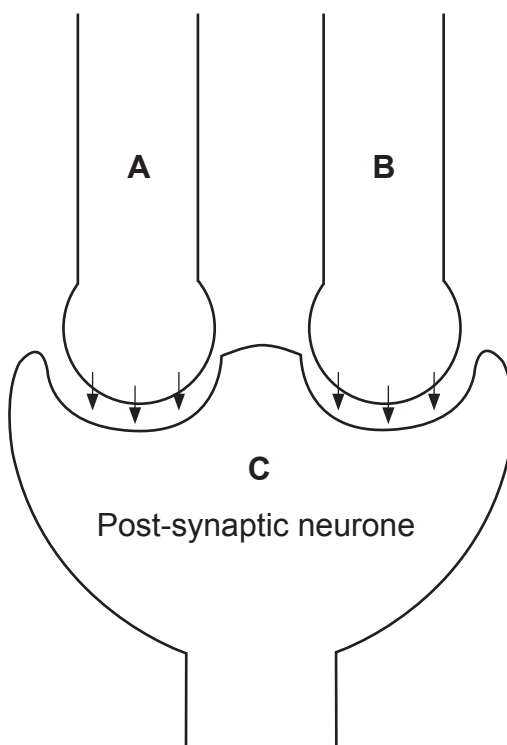
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- 7 Synapses allow coordination and integration in the nervous system. The diagram below shows how two neurones, **A** and **B**, synapse with a third neurone, **C**.

Neurone **A** releases the neurotransmitter acetylcholine and is excitatory. Neurone **B** releases a different neurotransmitter called GABA (gamma-aminobutyric acid) and is inhibitory. Neurone **C** is the post-synaptic neurone. Binding of GABA results in the movement of negative ions into the post-synaptic neurone.



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- (a) (i) Explain how the release of acetylcholine from neurone **A** causes an excitatory post-synaptic potential (EPSP) in the post-synaptic neurone **C**.

Acetylcholine binds to receptors on the post-synaptic membrane of neurone C, resulting in greater permeability to positive ions as sodium ion channels open.

There is a rapid influx of positive (sodium) ions, depolarising the membrane.

[2]



- (ii) Suggest why the arrival of an impulse in neurone **B** reduces the possibility of an EPSP forming in the post-synaptic neurone.

GABA causes negative (chloride) ions to enter, so the inside of the neurone becomes more negative (hyperpolarised), consequently depolarisation becomes more difficult, as more positive ions are needed to reach threshold.

[2]

- (iii) The enzyme acetylcholinesterase acts in the synaptic cleft. Explain the role of this enzyme.

Acetylcholinesterase hydrolyses acetylcholine, resulting in its release from the receptors on the post-synaptic membrane. This prevents the neurone from remaining in the excited state, allowing repolarisation to begin and impulses to be separated.

[2]

[Turn over]



DFP is a pesticide which interacts with the active site of acetylcholinesterase. It is a neurotoxin, causing paralysis and resulting in the death of an insect pest.

(b) (i) Suggest how DFP affects the post-synaptic neurone of an insect.

*DFP blocks the active site of acetylcholinesterase, preventing
formation of the enzyme-substrate complex,
so acetylcholine remains bound to the receptors and the
post-synaptic neurone cannot repolarise (remains depolarised).*

[2]

DFP has been useful in controlling insect pest populations in the past. However, some populations now appear to have become resistant to DFP.

(ii) Explain how a population may become resistant to a pesticide such as DFP.

*Some insects in the population possess a mutation (gene) conferring
resistance, so they survive treatment with the pesticide.
With reduced competition they breed successfully, passing on the
resistance gene to successive generations, so its frequency increases.*

[2]





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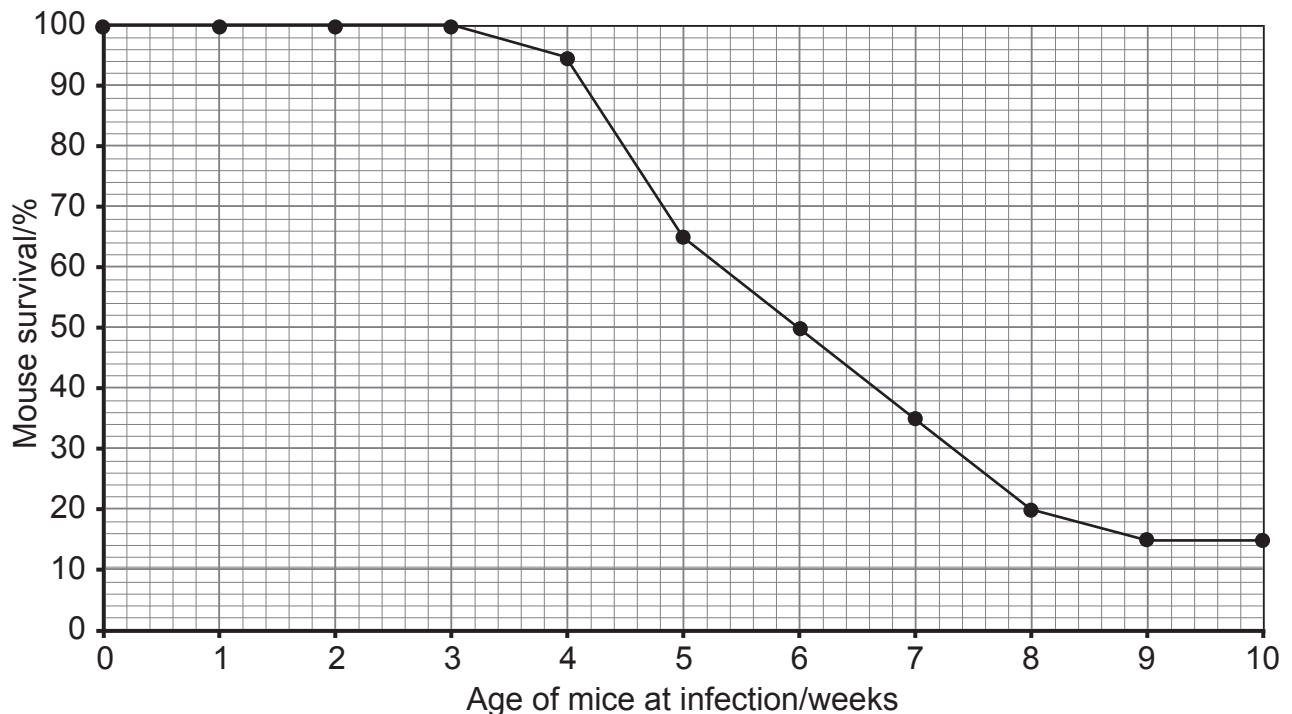
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- 8 Young rabbits often die of a disease called rabbit haemorrhagic disease (RHD), caused by a virus. To learn more about this disease, young mice were used as models. Scientists investigated the survival rates of young mice following infection with the virus at different ages. The results are shown in the graph below.



- (a) (i) Given that young mice feed on milk produced by their mother, suggest a possible explanation for the high survival rates of mice infected during the three weeks following birth.

Antibodies are acquired by the young mice from the mother by
placental transfer and in the milk (colostrum).

[1]

- (ii) Suggest a reason why mice were used as disease models for this investigation.

The immune response in mice is similar to that in rabbits, and mice
are small, so easy to keep in large numbers in the lab.

[1]



- (b) The virus can enter the cells in the respiratory and digestive tracts, using a molecule found in the plasma (cell surface) membrane of these cells. The virus binds to this molecule and then enters the host cell. Production of this molecule increases with age.

Most damage associated with RHD occurs to the cells of the liver. Liver cells do not have this molecule on their plasma membrane.

Using the information provided:

- (i) Suggest **another** possible reason for the high survival rate of mice infected during the three weeks following birth.

Young mice have a low level of expression (lower number) of the molecule on the cells of the respiratory and digestive tracts, consequently there are fewer successful binding events between the virus and host cells, reducing the chance of the virus entering cells.

[2]

- (ii) Explain why there is thought to be more than one mechanism by which the virus can enter a cell.

Liver cells do not possess the molecule on their plasma membrane, yet they are the major target of damage, so there must be another molecule or pathway that allows viral entry into host cells.

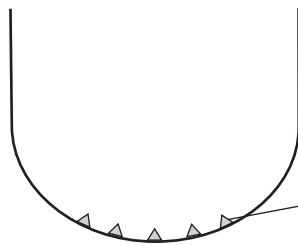
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A test for RHD virus in rabbits detects the presence of RHD antibodies in the blood serum of infected rabbits. The technique is summarised below.

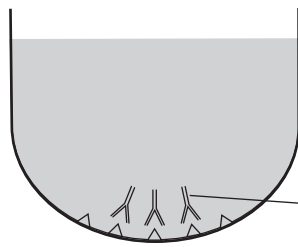
Step 1



Antigens are attached to the wall of a well (a small chamber)

antigen

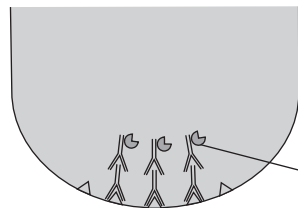
Step 2



Serum from a rabbit is added. If the serum contains RHD antibodies these will bind to the antigens

antibody

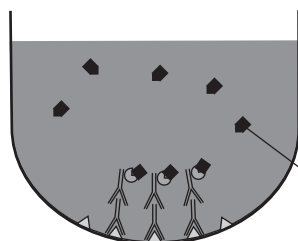
Step 3



A second antibody (with attached enzyme) is added and binds to the original RHD antibodies. The enzyme is only activated if the second antibodies are attached to RHD antibodies

antibody with attached enzyme

Step 4



A substrate is added which binds to activated enzymes and a coloured product is released

substrate

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(c) (i) Define the term antigen.

A substance capable of stimulating a specific immune response, i.e. production of complementary antibodies.

[1]



- (ii) Describe and explain the result you would expect if the rabbit was **not** infected by the RHD virus.

There would be no colour change (no coloured product released).

There are no RHD antibodies in the serum, so no antibodies bind to the antigens in the well and they are washed away.

Consequently the second antibody with attached enzyme cannot bind, the enzyme is not activated and no enzyme-substrate complex forms, so no coloured product is made.

[3]

It is sometimes necessary to carry out a dilution of the serum sample using a buffer.

- (iii) Calculate the volume of undiluted serum in μl ($1000 \mu\text{l} = 1 \text{ ml}$), which must be added to a buffer to give 10 ml of solution at a final dilution of 1/500. (Show your working.)

$$10 \text{ ml} = 10\,000 \mu\text{l}$$

$$\text{volume of serum} = 10\,000 \div 500$$

20 μl [2]

[Turn over]



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- (iv) Describe an immune response that may occur in rabbits infected with RHD virus.

Both cell-mediated and antibody-mediated (humoral) responses occur.

T lymphocytes and B lymphocytes become sensitised by the viral

antigens binding to specific receptors on their cell surface.

They divide by mitosis (clonal expansion) to produce T helper cells, T

killer cells and plasma cells.

Plasma cells secrete complementary antibodies; T helper cells stimulate

the action of B cells; T killer cells kill virus-infected cells by secreting

perforins.

B memory and T memory cells are also produced, providing long-term

immunity.

[4]

In some countries rabbit farming is an important activity, providing a source of meat and fur products.

- (d) Suggest and explain a possible way to protect rabbits from this potentially fatal disease.

Vaccination of the farmed rabbits with RHD antigens (attenuated virus),

allowing active long-term immunity through the production of memory

cells, so a rapid secondary response occurs on infection.

[2]

[Turn over

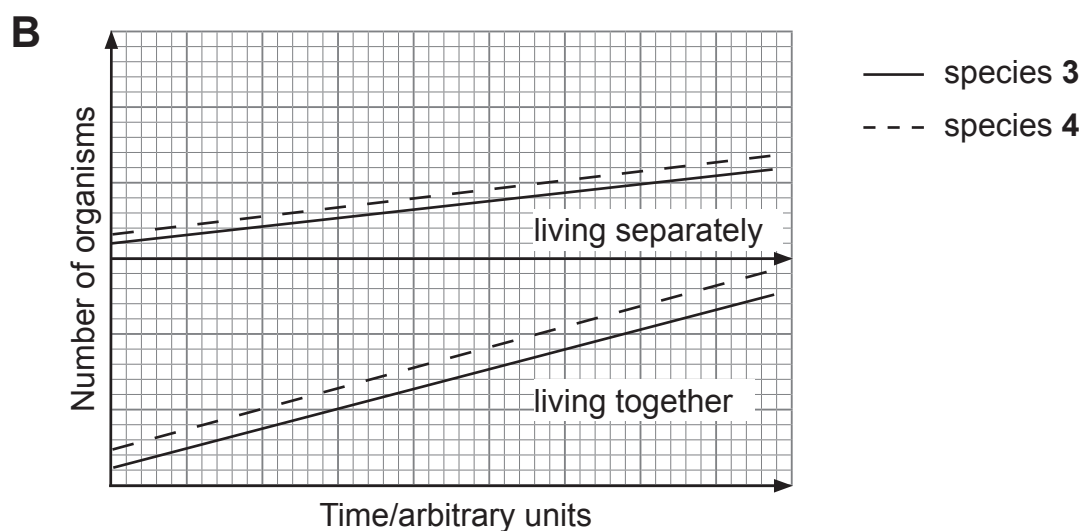
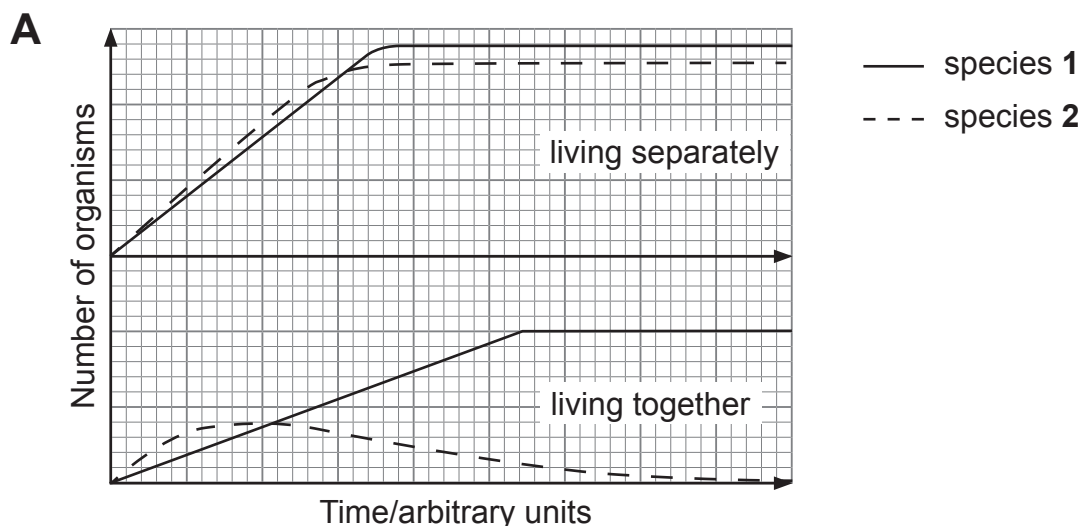


Section B

Quality of written communication is assessed in this section.

- 9 The interactions of some populations are shown in graphs **A**, **B** and **C**.

Graphs **A** and **B** summarise the results of two separate investigations into the growth of populations of four different species, **1**, **2**, **3** and **4**.

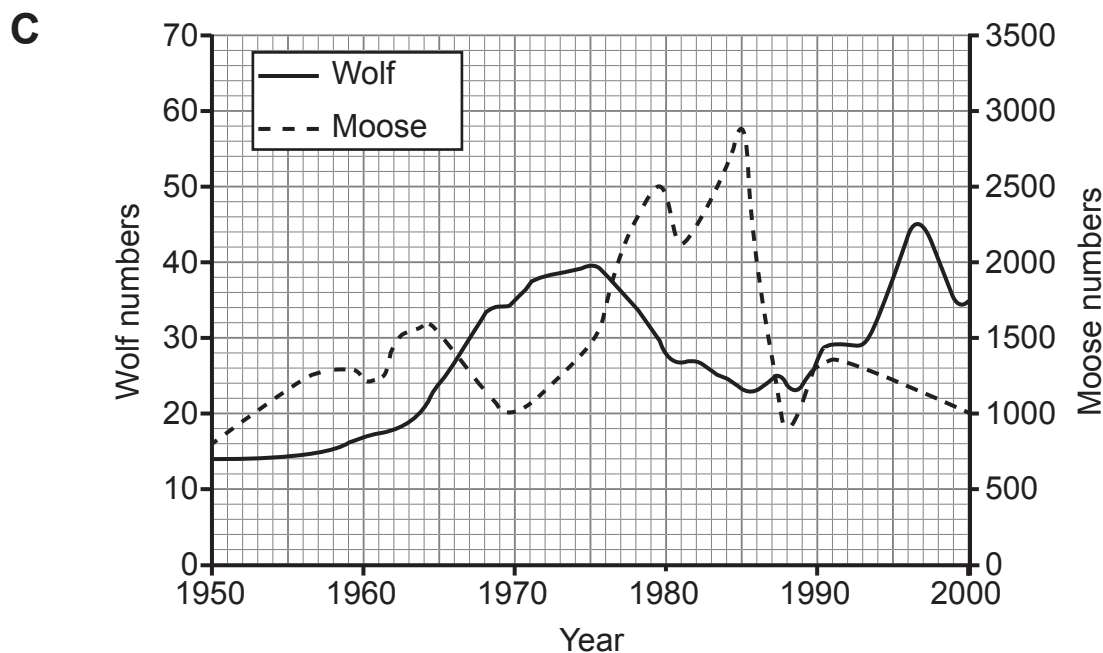


- (a) Identify the population interactions shown in graph **A** and graph **B**. Explain reasons for your choices.

[9]



Graph C shows a predator–prey interaction.



- (b) Comment on the predator–prey interaction shown and contrast this type of interaction with grazing and with parasitism.

[9]

- (a) Identify the population interactions shown in graph A and graph B. Explain reasons for your choices.

Graph A *Graph A shows interspecific competition: competition between two different species, 1 and 2, for a resource that is in short supply, such as food, space or light.*

It is a -/- interaction, because both populations grow better when living separately than when living together.

When living separately both populations increase and then reach a plateau, which indicates the carrying capacity of the environment for each

[Turn over]



population.

When living together, species 1 still increases, although more slowly and to a lower plateau, while species 2 increases briefly and then declines towards zero.

Therefore species 1 is the better competitor and wins the competition, while species 2 is the poorer competitor.

Species 2 may become competitively excluded from the habitat (the competitive exclusion principle), as two species cannot occupy the same niche indefinitely.

Graph B Graph B shows mutualism, a close relationship between two different species, 3 and 4, in which both benefit.

It is a +/+ interaction: both populations grow better (faster) when living together than when grown separately, when neither does as well.



When living together the populations of species 3 and 4 increase at a greater rate, so each species must provide something the other needs.

An example is the root nodules of legumes such as clover, which contain nitrogen-fixing bacteria (*Rhizobium*). The bacteria fix nitrogen gas into ammonium compounds that the plant uses to make amino acids and proteins, while the plant supplies the bacteria with carbohydrates (sugars) from photosynthesis and a protected habitat.

Another example is cellulose-digesting microorganisms in the gut of a herbivore, such as a cow: the microorganisms digest cellulose for the herbivore and in return receive a constant supply of food and a warm, stable environment.

Similarly a lichen consists of a fungus and an alga: the alga provides sugars from photosynthesis and the fungus provides water, minerals and protection.

[Turn over]



- (b) Comment on the predator–prey interaction shown and contrast this type of interaction with grazing and with parasitism.

Predation is a +/- interaction: the predator (wolf) benefits and the prey (moose) is harmed.

Graph C shows that an increase in moose numbers results in an increase in wolf numbers, e.g. moose rise from about 1000 in 1972 to about 2400 in 1980, followed by wolves rising to about 50 in the early 1980s, because there is more food available for the wolves, so more survive and reproduce.

As wolf numbers increase, more moose are eaten by the wolves, causing a decrease in moose numbers.

With fewer moose, food availability falls and this increases competition (intraspecific) amongst the wolves, so wolf numbers then decrease, which allows the moose population to recover.

There is a time lag between an increase in prey numbers and the increase in predator numbers, because the predators take time to reproduce, so the peaks in wolf numbers occur after the peaks in moose numbers.

This produces oscillations of a fairly regular period in both populations, with the predator population always much smaller than the prey population.

Grazing involves herbivores feeding on plants. A greater biomass of plant material supports greater numbers of herbivores, and plants usually survive



grazing because they can regrow, so the plant is not killed.

In contrast, carnivores are more efficient at obtaining energy, so they can be supported by smaller prey numbers, but they require strategies to capture prey, such as hunting in packs.

Parasitism is also a +/- interaction, but the oscillations in numbers occur over a much longer time frame and are not as obvious.

Parasites are usually much smaller than their host and live in or on the host (endoparasites and ectoparasites) for a long period, feeding on it.

A parasite rarely kills its host, since this would destroy its own food source and habitat, whereas a predator kills its prey.

Parasites often require a vector to transfer them to a new host, e.g. the mosquito carrying the malaria parasite Plasmodium.



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