1 The elk, *Cervus canadensis*, is a large herbivore.

Fig. 2.1, **on page 2 of the Insert**, shows figures relating to the number of elk in Yellowstone National Park in the USA between 1965 and 2002.

The figures were obtained in two different ways:

- the white bars show estimated numbers of live elk obtained by ecological sampling
- the black bars show numbers of elk that were legally shot by hunters.

In some years no data for live elk were obtained.

(a) (i) Using Fig. 2.1, describe the pattern shown by the data for the estimated number of live elk from 1965 to 2002.

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(ii) The recorded number of elk legally shot by hunters provides accurate data.

Suggest why these data are accurate, but the method used to obtain these data is not a valid way of estimating the number of elk in the population.

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..... **[2]**

(b) The grey wolf, *Canis lupus*, is a large predator whose diet includes elk.

By 1926, grey wolves had been hunted to extinction in Yellowstone Park. However, this species could still be found in other parts of the world.

In 1995, a population of grey wolves was introduced to Yellowstone Park and their numbers increased.

(i) With reference to Fig. 2.1, discuss the factors that may have affected the size of the elk population:

- before 1995
- after 1995.

In your answer you should provide a balanced account referring to factors before and after 1995.

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(ii) Explain why the introduction of wolves to Yellowstone Park in 1995 is an example of conservation.

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[Total: 14]

2 **(a)** *Bombus pratorum* and *Bombus terrestris* are two British species of bumble bee.

These bumble bees are social insects. They live in colonies founded by a female queen bee who lays eggs. The eggs develop into female worker bees, who collect food (nectar and pollen) and look after the young and the nest.

When the number of worker bees starts to decrease, young queens and males are produced. These mate and the mated queens survive winter underground and start a new colony the following spring.

Why do the two bee species share the first name *Bombus*?

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..... **[1]**

(b) Fig. 2.1 shows the number of worker bees of *B. pratorum* and *B. terrestris* observed at one location over a year.

Table 2.1 shows some differences in the food collecting behaviour of worker bees of these species.

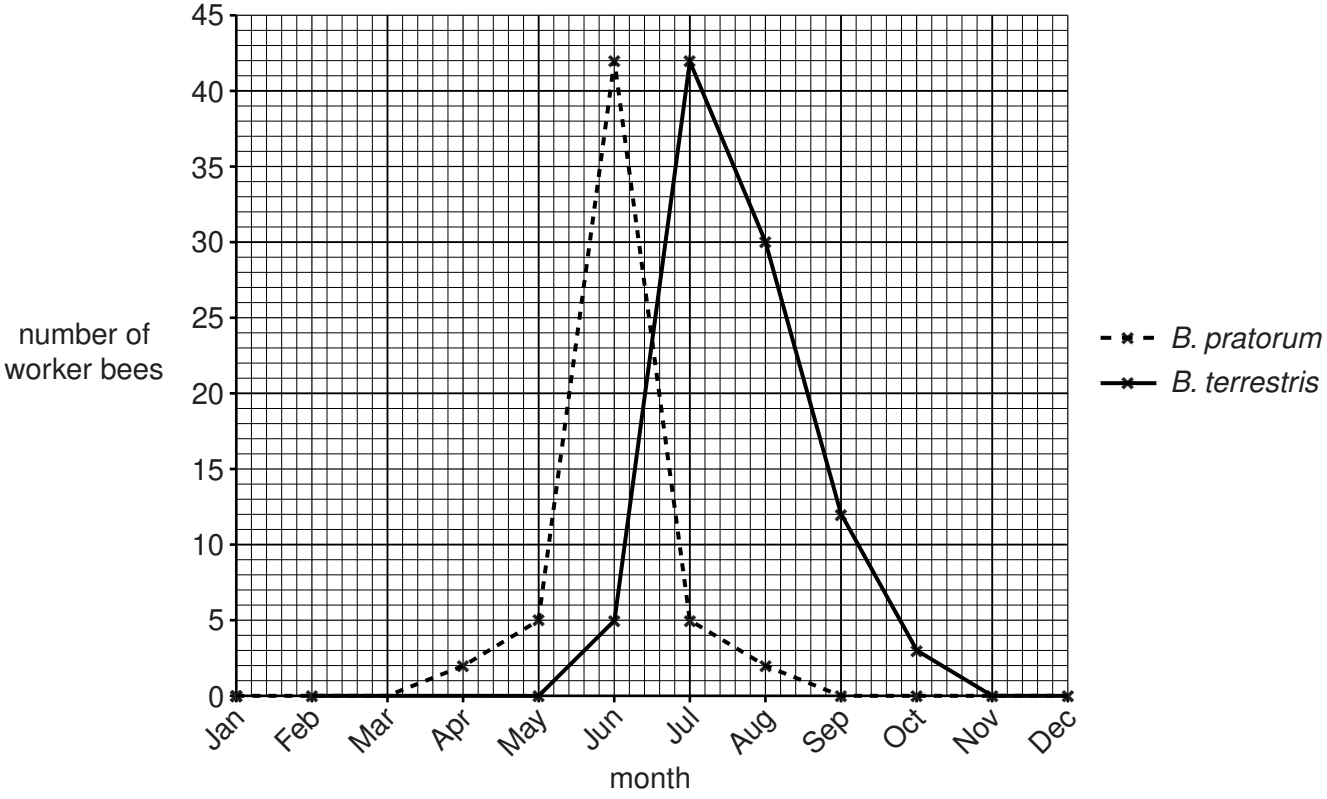


Fig. 2.1

Species of bumble bee	Mean depth of flower visited (mm)	Visits to flowers when nectar only collected (%)	Visits to flowers when pollen only collected (%)	Visits to flowers when both nectar and pollen collected (%)
Bombus pratorum	7.4	23	10	67
Bombus terrestris	6.3	80	11	9

Table 2.1

(i) *B. pratorum* and *B. terrestris* both live in Britain. They can often be found in the same location, as their geographical distributions overlap.

Use Fig. 2.1 and Table 2.1 to evaluate the extent to which the two species may compete.

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(ii) Use Fig. 2.1 and Table 2.1, and the information given on page 7, to suggest how an ancestral species might have evolved into the two species, *B. pratorum* and *B. terrestris*.

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(c) Bees show a variety of interesting behaviour patterns.

(i) Consider the following observations about bee behaviour and suggest what type of behaviour is being shown in each observation.

Observation	Type of behaviour
The time taken for a worker bee to collect food from a flower decreases with practice.	
All bumble bees start at the bottom of a vertical spike of flowers and work upwards.	

[2]

(ii) On returning to the colony, worker bees perform 'dances' to tell other bees the direction and distance of a food source.

How might this social behaviour benefit the colony?

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..... **[1]**

(d) In a colony of bees, about 5% of the workers are more adventurous than other workers. These bees are known as scout bees. They actively seek out new food sources and, if necessary, new nest sites.

Researchers investigated how gene expression differed in the brains of the scout bees compared to the normal worker bees.

The researchers extracted mRNA from the brain cells of **normal worker** bees.

This mRNA was used to produce lengths of single-stranded DNA, which were then attached to a fluorescent dye.

These lengths of single-stranded DNA were used as gene probes fixed onto a device known as a 'microarray DNA chip'.

mRNA extracted from the brain cells of **scout** bees would only bind to the gene probes that matched it, causing these probes to fluoresce.

The locations of the brightest fluorescent spots on the DNA chip revealed which genes were most active.

(i) Name the enzyme that can be used to convert mRNA to single-stranded DNA.

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(ii) Explain how the locations of the fluorescent spots on the DNA chip reveal which genes are most active.

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(iii) The researchers found many differences in gene activity in the scout bees compared to the normal worker bees. One of these differences in activity was in a gene used to make the neurotransmitter, dopamine.

In a follow-up experiment, scout bees became less adventurous if dopamine signalling was prevented.

Use your knowledge of the DRD4 dopamine receptor in humans to comment on the findings of this research into scout bee behaviour.

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[Total: 18]

3 Describe the differences between the following biological terms:

(a) a pioneer community and a climax community

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(b) decomposition and denitrification

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(c) conservation and preservation

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(d) nitrogen fixation and nitrification.

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[Total: 8]

4 The Galapagos Islands are 600 miles away from the nearest land mass, South America. They consist of 15 main islands, 3 smaller islands, and 107 rocks and islets. This collection of islands is home to many endemic species of animals and plants. This means that these species are found nowhere else in the world.

(a) Explain, using scientific terms, why a collection of small islands remote from the mainland provides optimal conditions for speciation.

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(b) In 1978, the United Nations (UN) declared the Galapagos Islands a World Heritage Site. This led to a rise in the resident human population and the number of visitors to the Islands.

Table 2.1 shows how the number of people living on and visiting the Galapagos Islands changed between 1980 and 2005.

Year	Resident population	Number of visitors
1980	5500	16000
1985	7000	19000
1990	9500	42000
1995	12500	58000
2000	17500	68000
2005	27500	125000

Table 2.1

(i) Calculate the percentage increase in the number of visitors to the Galapagos Islands between 1980 and 2005.

Show your working. **Give your answer to the nearest whole number.**

Answer = ...% **[2]**

(ii) Outline the main ways in which increased human presence and activity have put endemic species on the Galapagos Islands, and in the sea around them, at risk of extinction.



In your answer you should link the ecological pressures imposed by human activity to examples of Galapagos Island species that have been affected.

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(c) In 2007, the United Nations (UN) put the Galapagos Islands on its Red List of endangered sites. The Galapagos government's response to this action included making new laws and placing restrictions on human activity, issuing eviction orders and culling introduced species of animals.

Suggest **one** economic and **one** ethical problem that might have arisen from this 2007 UN decision.

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[Total: 13]