1 Molecular evidence E *Ulmus procera*, form a genetically isolated clone. English Elms developed from a variety of elm brought to Britain from Rome in the first century A.D.

Although English Elm trees make pollen, they rarely produce seeds. Instead they spread by developing structures known as suckers from their roots. Each sucker can grow into a new tree.

This tendency of elms to create suckers has been exploited by humans, who have separated the suckers, with roots attached, and used them to plant hedges and establish new woodlands.

(a) (i) Suggest a technique that could be used to provide **molecular** evidence that all English Elm trees form a clone.

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(ii) State why the English Elm clone is genetically isolated from other varieties of elm.

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

(iii) State the name given to the process in which plants reproduce asexually by means such as suckers.

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

(b) In 1967, a new, virulent strain of an elm disease fungus arrived in Great Britain on imported timber. Beetles that lived under the bark of elm trees spread the fungus.

The saws used to cut down dead branches were not sterilised after use. When the saws were used to prune healthy trees, these trees became infected. Approximately 25 million elm trees, most of the English Elm population, died within a few years of the arrival of this fungus.

Explain why there was such a rapid loss of elm trees in Britain as a result of this elm disease.

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(c) Elm trees respond to fungal infection by plugging their xylem vessels. The leaves on the upper branches of the tree then turn yellow and die. When most of the branches have lost their leaves and died, the roots are weakened and may also die.

(i) Explain why the plugging of xylem vessels will result in the leaves of the upper branches turning yellow.

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(ii) Explain why the loss of leaves from the tree may result in the death of the tree's roots.

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(d) Many ornamental plants for gardens can be cloned by tissue culture.

Describe the process of cloning plants by tissue culture.

In your answer you should make clear the order in which the steps of the process occur.

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(e) List **two** advantages and **two** disadvantages of cloning plants by tissue culture.

advantage 1 .....

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advantage 2 .....

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disadvantage 1 .....

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disadvantage 2 .....

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[Total: 22]

2 This question is about genetic engineering and the techniques used for making multiple copies of genes (gene cloning).

(a) Genetic engineering uses the following:

A an enzyme that synthesises new DNA
B an enzyme that cuts DNA at specific sequences
C an enzyme that reseals cut ends of DNA
D small circular pieces of DNA found in bacteria; these pieces of DNA have antibiotic resistance genes
E an enzyme found in some viruses with an RNA genome; this enzyme converts RNA into DNA.

Name **A** to **E**.

A .....

B .....

C .....

D .....

E ..... **[5]**

(b) Genes are cloned for a number of reasons. For example,

- one group of research scientists at a hospital wanted to sequence a disease-causing mutation to learn more about a human disease; these scientists started their research using white blood cells;

- another group of scientists at a biotechnology company wanted to clone the insulin gene in order to manufacture its protein product to treat diabetes; these scientists started their research using cells from the pancreas.

Suggest **and** explain the biological reasons why the two groups each started with a different cell.

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(c) A gene can be cloned *in vitro* (in a test-tube) by the polymerase chain reaction (PCR). Alternatively, a gene can be cloned *in vivo* (in living cells) by introducing the gene into bacterial host cells.

Table 5.1 identifies some of the key steps in each process.

Table 5.1

in vitro gene cloning (PCR)	*in vivo* gene cloning
At 95 °C, DNA extracted from a cell separates into two strands.	A library of gene fragments is produced and introduced into host bacteria.
At 50 °C, specially-made primer sequences attach to the ends of the desired gene only.	Bacteria are screened for antibiotic resistance to identify those with recombinant DNA.
At 72 °C complementary copies of both DNA strands are made.	A gene probe is used to select the bacterial colony containing the desired gene.
The cycle of temperature changes is repeated and more copies of the gene are made.	This colony is grown on in nutrient broth and the DNA is then purified.

Compare the two processes of gene cloning by explaining the advantages of each.

In your answer you should ensure that clear comparisons between the two processes are made and explained.

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[Total: 17]

3 **(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.

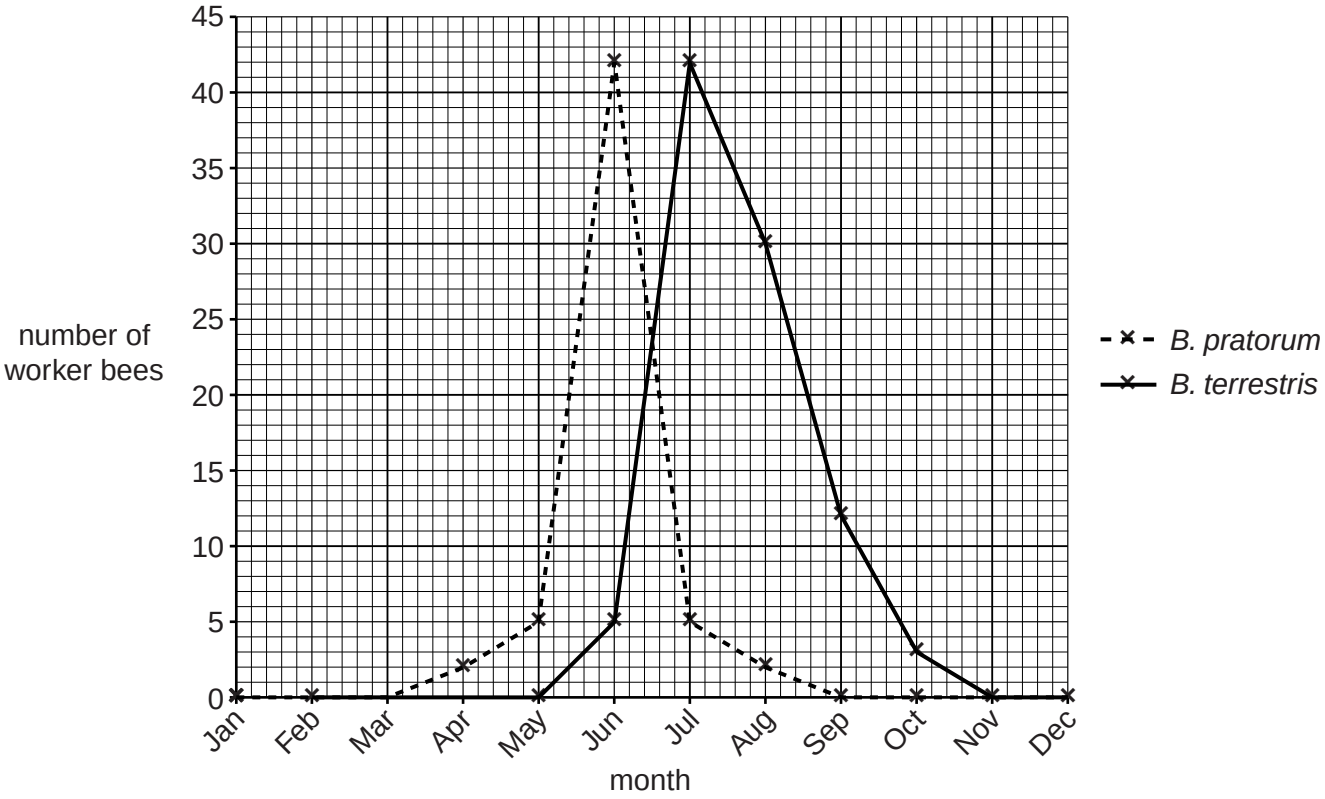

Fig. 2.1

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]

4 **(a)** Animals and plants need to respond to changes in their environment.

(i) Give **two** reasons why **both** plants and animals need to be able to respond to changes in their environment.

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(ii) Plants co-ordinate their responses to environmental stimuli using hormones. Mammals also co-ordinate responses to some stimuli using hormones.

State **three differences** in the ways in which plant and mammalian hormones operate.

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(b) Most mammalian hormones are made of protein. An example is human growth hormone (HGH). Lack of this hormone causes dwarfism (short height).

(i) Explain why dwarfism can be described as a genetic condition.

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(ii) Children with dwarfism can be given HGH produced by genetic engineering. A method for engineering bacteria to make HGH has many stages that are similar to the method used to produce human insulin, and is described below.

Complete the following paragraph using the most suitable term or terms to fill in the gaps.

The ..... for HGH is cut from human DNA using a restriction enzyme. The human DNA fragments are then inserted into plasmids using the enzyme called ..... . Bacterial cells are treated so that they take up these plasmids. Bacteria that contain the new DNA are described as ..... bacteria. They are first grown on agar plates containing ..... which allow scientists to distinguish them from bacteria that have not taken up any new DNA. A ..... can then be used to identify the bacteria that have the desired sequence of DNA. **[5]**

(c) Steroid hormones are not made of protein. They are classed as lipids. Their structure means that they can diffuse through the cell surface and nuclear membranes. The hormones then bind to DNA in the nucleus and switch genes on and off.

Explain why steroid hormones can diffuse through cell membranes.

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(d) Steroid hormones are one example of molecules that can switch genes on and off in mammalian cells.

Other molecules involved in genetic control have been studied in both eukaryotes and prokaryotes.

Describe **one** other example of genes being switched on or being switched off by a molecule that binds directly to DNA.

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[Total: 18]