1 Rhubarb, *Rheum x hybridum*, is a plant that is grown for its edible stems. In Spring, the stems and leaves grow from fleshy roots which survive the Winter underground.

Growers have developed many new varieties of rhubarb by growing plants from seed, choosing the best young plants and then asexually reproducing them.

Seeds are produced by sexual reproduction and the rhubarb plants that grow from seed show variation in characteristics such as stem colour, dormancy period and the concentration of oxalic acid in their leaves.

(a) Outline the events that lead to genetic variation in gametes **and** in the plants grown from seed.

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

(b) Traditionally, rhubarb plants have been produced by vegetative propagation. The best young rhubarb plants are allowed to grow for three seasons until their underground root systems are large enough. They are then dug up in Winter, the roots are cut into pieces and the pieces are replanted. Each piece is then able to grow into a new rhubarb plant that is identical to the parent.

(i) State the biotechnological term for this type of vegetative propagation.

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

(ii) A gardener wished to multiply his rhubarb plants using the traditional method, but he discovered that his plants were infected by a virus.

Name the modern technique which allows commercial growers to produce large numbers of genetically identical plants that are also virus-free.

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

(iii) Rhubarb plants must spend seven to nine weeks at a temperature below 3 °C in order to break their winter dormancy and allow them to start growing stems and leaves again.

The length of the cold period that is required depends on the variety of rhubarb.

In the variety 'Timperley Early', the length of the cold period is shorter, so the plants grow and produce a crop earlier in the year than the variety 'Victoria'.

Suggest **two** ways in which the varieties may differ from one another **biochemically** to account for the difference in the length of the cold period required by each.

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

(c) Rhubarb leaves contain oxalic acid, a relatively strong acid which is soluble in water and alcohol. High concentrations of oxalic acid makes rhubarb leaves poisonous to humans and other animals.

(i) The amount of oxalic acid in the leaves varies according to the variety of rhubarb, the age of the plant and environmental factors.

Suggest and plan an experiment to compare how the variety of rhubarb affects the amount of oxalic acid in rhubarb leaves.

Include in your plan:

- the variables that you could control
- an outline of the experimental procedure you would use
- any measurements that you would make.

In your answer you should make clear which are the independent, dependent and controlled variables.

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(ii) As rhubarb leaves are poisonous, they are cut off when the stems are harvested and may be left to decompose on the compost heap.

Outline the role of **decomposers** in the decomposition of leaves.

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..... **[3]**

(d) An early harvest of rhubarb stems can be obtained by placing an upturned bin over the root when it comes out of dormancy, so the emerging shoots are kept in the dark. The shoots then grow more quickly to a height suitable for picking.

Use your knowledge of **plant growth regulators** (plant hormones) to suggest why shoots kept in the dark grow taller than those left in the light.

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

2 The leaves of flowering plants have the ability to develop differently, depending on environmental conditions such as the amount of sun or shade a leaf receives.

A student carried out an investigation into sun and shade leaves from different parts of the same plant. Her observations and results are shown in Table 6.1.

Table 6.1

type of leaf	number of leaves studied	mean no. of stomata per mm^2 on lower surface	mean thickness of leaf (μm)	cuticle
sun	55	170	208	thick
shade	8	92	93	thin

(a) Calculate the percentage difference in the **mean thickness** of the sun leaves compared to the shade leaves.

Show your working.

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

(b) Suggest **and** explain one benefit of the greater **mean number** of stomata per mm^2 on the lower surfaces of the sun leaves.

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

(c) Describe **two** ways in which the student could improve her investigation.

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[Total: 6]

3 **(a)** Many species of insects have evolved resistance to chemical insecticides.

Three different patterns of resistance in insect species **R**, **S** and **T** are shown in Fig. 6.1.

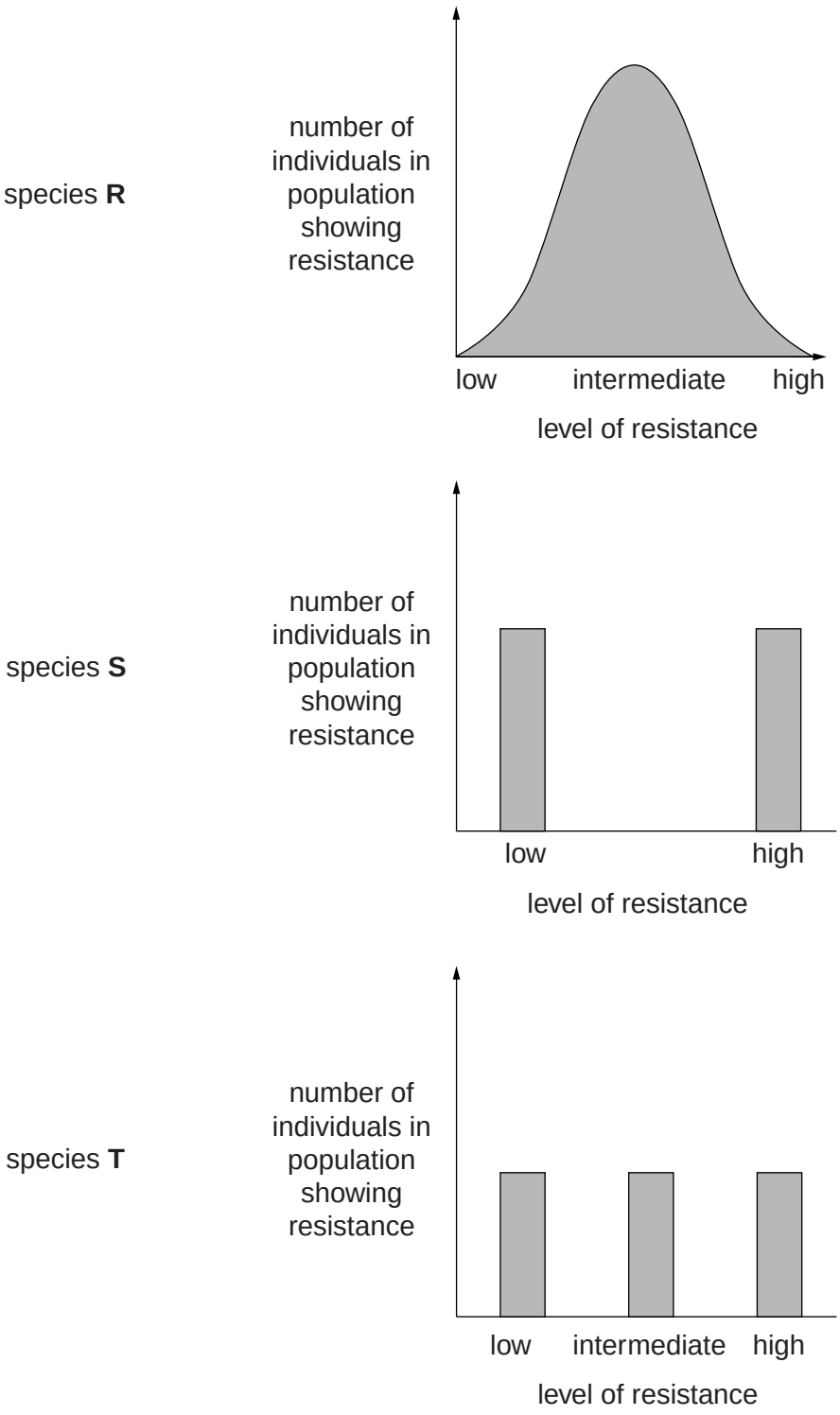

Fig. 6.1

(i) Complete the table below with the letter(s), **R**, **S** and **T**, to indicate which species show a continuous pattern of variation and which species show a discontinuous pattern.

	Discontinuous	**Continuous**
Species identified by letter		

[2]

(ii) A student noted a number of statements on his revision card that referred to the patterns of resistance shown in species **R**, **S** and **T** in Fig. 6.1.

Revision card – patterns of resistance

1. It's controlled by a single gene
2. There is an additive effect
3. May involve multiple alleles
4. Heterozygote shows a distinct phenotype
5. It's controlled by many genes (polygenic)
6. Involves a dominant and a recessive allele
7. Shows co-dominance or incomplete dominance
8. Involves just two alleles

Complete Table 6.1 below, by selecting the correct numbered statement(s) that explain the genetic basis of each pattern of resistance for each species.

You may select a number more than once.

Species	**Statement number(s)**
R	
S	
T	

Table 6.1

[6]

(b) Dog fleas are small parasitic insects that live in the fur of dogs and feed on their blood. Dogs are routinely treated with sprays or powders to kill fleas.

A vet believes that dog fleas may have become resistant to a popular flea-killer product.

He asks an A-level work experience student to plan an experiment to test this hypothesis.

The student needs to sample fleas from dogs visiting the surgery and also fleas from long grass in fields visited by dog-walkers. The fleas then need to be tested for resistance to the flea-killer.

Describe the methods the student could use to:

- collect both samples of fleas
- find out the proportion of fleas that are resistant
- process the data.

In your answer you should describe the methods for collection, testing and data processing in a logical series of steps.

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