1. Nov/2023/Paper_9700/41/No.2

Biodiversity can be assessed at three different levels. One of these is the genetic variation within each species.

(a) Outline **two** other levels at which biodiversity can be measured.

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..... [2]

To calculate the genetic variation that exists within a species, scientists:

- obtain DNA sequences from many individuals of one species
- count the number of nucleotides that differ when the sequences of two individuals are compared
- repeat this with different pairs of individuals.

This allows scientists to calculate the **mean** number of differences at every nucleotide position along the sequence (mean number of nucleotide differences per site).

(b) Explain why scientists use databases and computers to calculate the mean number of nucleotide differences per site.

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..... [3]

(c) Table 2.1 shows the mean number of nucleotide differences per site of some species.

Table 2.1

species	mean number of nucleotide differences per site
Drosophila melanogaster, fruit fly	0.0087
Anopheles gambiae, mosquito vector of malaria	0.0301
Plasmodium falciparum, malarial pathogen	0.0015
Zea mays, wild maize	0.0139

(i) State the **genus** name of the species that shows the most genetic variation.

..... [1]

(ii) State how many kingdoms of organisms are represented in Table 2.1.

..... [1]

(d) Genetic variation is considered important in the conservation of species. Low genetic variation is assumed to decrease the chance of the long-term survival of a species.

(i) Give reasons why low genetic variation may decrease the long-term survival of a species.

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Fig. 2.1 shows how the International Union for the Conservation of Nature (IUCN) categorises species according to their conservation status.

Common species with the lowest conservation status (least risk of extinction) are categorised as Least Concern (LC).

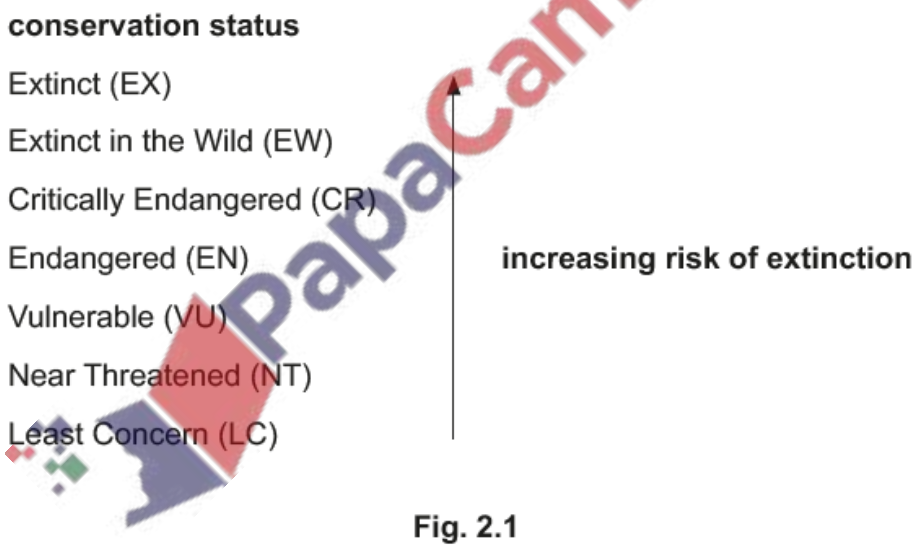

Fig. 2.1

(ii) Question **2(d)** states that 'low genetic variation is assumed to decrease the chance of the long-term survival of a species'.

Predict the relationship between genetic variation and conservation status if this assumption is true.

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Fig. 2.2 shows the mean number of nucleotide differences per site of some species and sub-species of mammal and their conservation status.

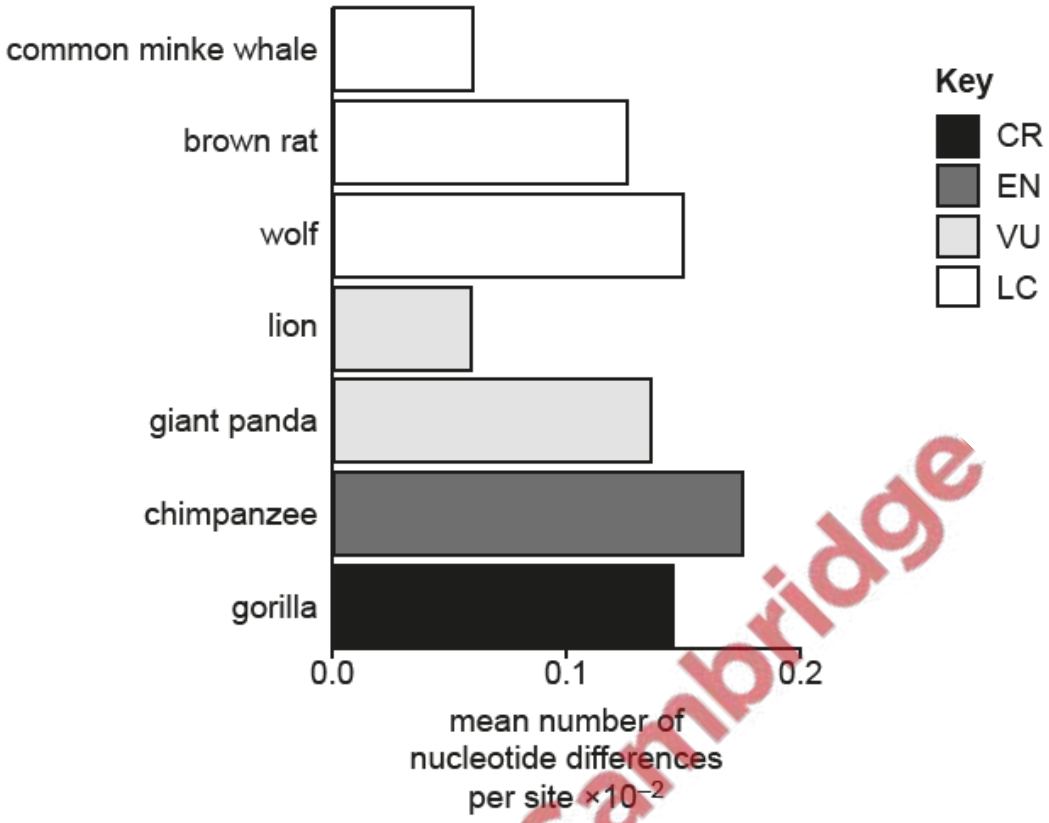

Fig. 2.2

(iii) Assess whether the data in Fig. 2.2 provide support for the prediction you made in **2(d)(ii)**.

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[Total: 14]

2. Nov/2023/Paper_9700/41/No.3

There are more than 600 plant species in the genus *Ipomoea*. Many species are grown for their attractive flowers, and some species are used as crop plants.

(a) Fig. 3.1 shows *Ipomoea purpurea*, the common morning glory.

Fig. 3.1

The gene that determines flower colour in *I. purpurea* has two alleles:

- a dominant allele that results in purple flowers
- a recessive allele that results in red flowers.

A student recorded the flower colour of all the *I. purpurea* plants in a field.

The student recorded 660 plants with purple flowers and 440 plants with red flowers.

Assuming the Hardy-Weinberg principle applies to this population, calculate the number of plants in the field that are heterozygous.

Use the equations:

$p + q = 1$

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

Show your working and give your answer to the nearest whole number.

number of heterozygous plants ..... [3]

(b) The Japanese morning glory, *I. nil*, has over 20 different flower colour phenotypes, including shades of blue, purple, red and pink.

The flower colour of *I. nil* is controlled by at least four genes. The flower colour can change gradually after the flowers open each morning and can change with fluctuations in the carbon dioxide concentration of the surrounding air.

A student concluded that the flower colour phenotype in *I. nil* shows continuous variation.

Suggest **two** reasons why the student made this conclusion.

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2 .....

..... [2]

(c) Scientists investigated the response of stomata to changing carbon dioxide (CO_2) concentrations in the beach morning glory, *I. pes-caprae*.

The scientists placed *I. pes-caprae* plants in chambers. They measured the width of open stomata (stomatal apertures) after the plants had been exposed to different CO_2 concentrations for 40 minutes. Light intensity and temperature were kept constant.

The relationship between CO_2 concentration and the mean width of stomatal apertures is shown in Fig. 3.2.

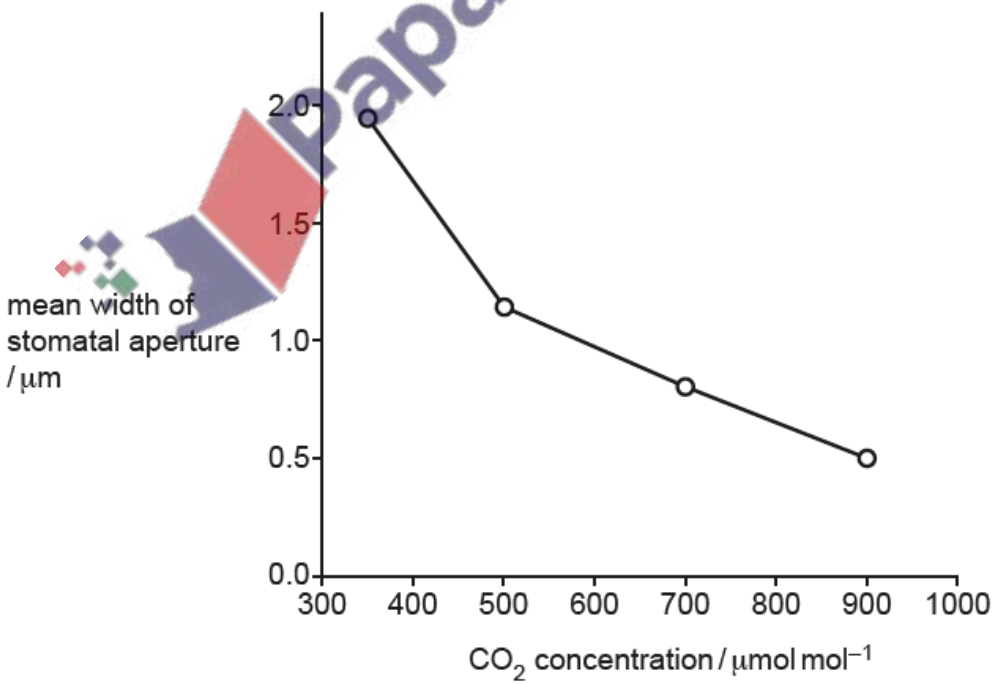

Fig. 3.2

(i) In 2016, a study measured the atmospheric CO_2 concentration as 400 μmol mol^{-1}.

In the future, climate change may reduce water availability and increase atmospheric CO_2 concentrations in some habitats.

Suggest how the stomatal response shown in Fig. 3.2 would allow *I. pes-caprae* to survive the effects of climate change.

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(ii) Under certain conditions, the closure of stomata is controlled by abscisic acid.

Describe how abscisic acid causes the closure of stomata.

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(d) Scientists are researching whether abscisic acid can be used in crop treatment to increase yield. Evidence suggests that abscisic acid modifies the effect of auxin on elongation growth in plants.

(i) Scientists investigated the effect of different concentrations of abscisic acid on root elongation in seedlings of thale cress, *Arabidopsis thaliana*.

The seedlings were divided into four groups:

- a control group (0.0 μmol abscisic acid)
- three experimental groups, each treated with a different concentration of abscisic acid: 0.1 μmol, 1.0 μmol, or 10.0 μmol.

For each group of seedlings, root length was measured for six days during treatment. The rate of root elongation was calculated each day.

The results are shown in Fig. 3.3.

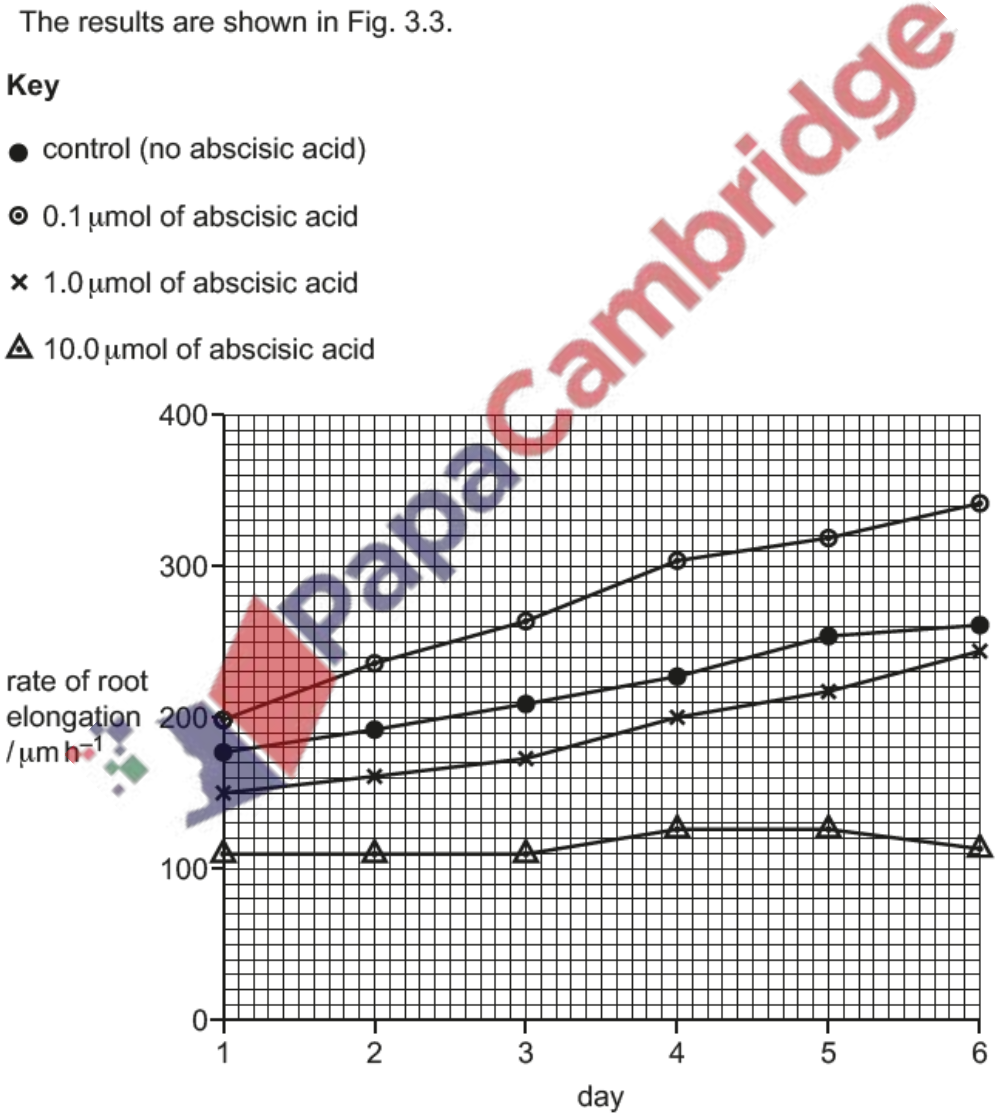

Fig. 3.3

With reference to Fig. 3.3, describe the effect of treatment with abscisic acid on the rate of root elongation.

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(ii) The passage outlines the role of auxin in elongation growth in plants.

Complete the passage by using the most appropriate scientific terms.

The binding of auxin to receptors causes ..... to be pumped into cell walls.

This activates proteins called expansins, which disrupt the links between

..... microfibrils. The cell walls are then able to expand.

[2]

[Total: 16]

3. Nov/2023/Paper_9700/41/No.9

Green lacewings are a family of insects with more than 1300 species.

The common green lacewing, *Chrysoperla carnea*, is shown in Fig. 9.1.

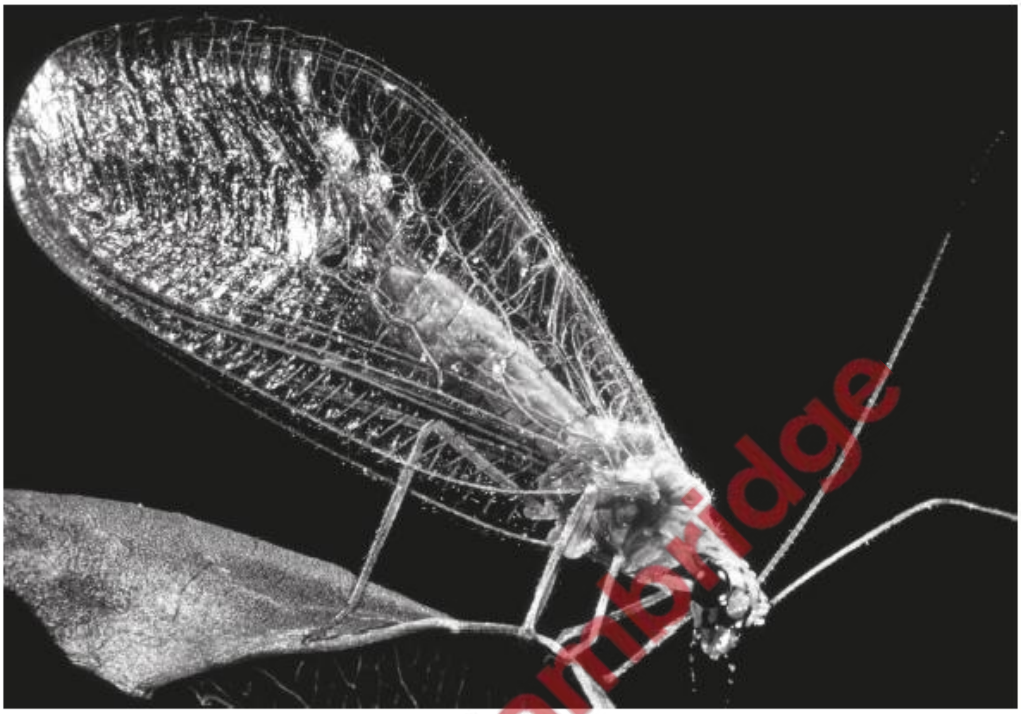

Fig. 9.1

(a) Green lacewings have sense organs, known as tympanal organs, that detect sound.

The tympanal organ of green lacewings has evolved to detect the high frequency sounds that bats make when they are hunting. Bats eat green lacewings.

When a green lacewing senses the presence of a bat, it moves away or closes its wings in flight to escape.

(i) Outline how the tympanal organ of green lacewings could have evolved by natural selection.

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(ii) When high frequency sound is detected, the receptor cells in the tympanal organ stimulate the transmission of impulses in sensory neurones.

Describe the sequence of events that results in an action potential in a sensory neurone.

The first event in the sequence has been given for you.

Calcium ions enter the cytoplasm of the receptor cell .....

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(b) Two species of green lacewing, *C. carnea* and *C. downesi*, evolved from a common ancestor.

The two species have populations with overlapping distributions in parts of North America.

Table 9.1 shows a comparison of the characteristics of overlapping populations of the two species.

Table 9.1

characteristic	*C. carnea*	*C. downesi*
breeding months	June to September	April to May
courtship song	song with a regular rhythm	song with no regular rhythm
colour	light green	dark green

Suggest how speciation occurred to produce the two different species of green lacewing.

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[Total: 10]

4. Nov/2023/Paper_9700/42/No.10

(a) The passage outlines one method of estimating the size of an animal population.

Complete the passage by using the most appropriate scientific terms.

The size of a population of animals can be estimated using the mark-release-recapture method. A sample of animals is captured using a humane (harmless) trap and is counted. The animals are marked using a method that does not harm them. This can be done using a small tag or ..... . The marked animals are released into the area where they were captured. Time is allowed for the marked animals to mix into the population. This period of time must be short so that emigration, immigration, migration or ..... do not occur.

A second sample of animals is then captured and the number of marked and unmarked animals is counted. The population size can be estimated using the ..... Index. For reliability, the method should be ..... .

[4]

(b) Himalayan balsam, *Impatiens glandulifera*, is an annual plant native to Pakistan, India and Nepal. It was first introduced into the United Kingdom (UK) in 1839 because of its attractive flowers. Individual plants can produce thousands of mature seeds. These can be dispersed for long distances when the capsules that contain the seeds burst.

Fig. 10.1 shows Himalayan balsam growing in a woodland.

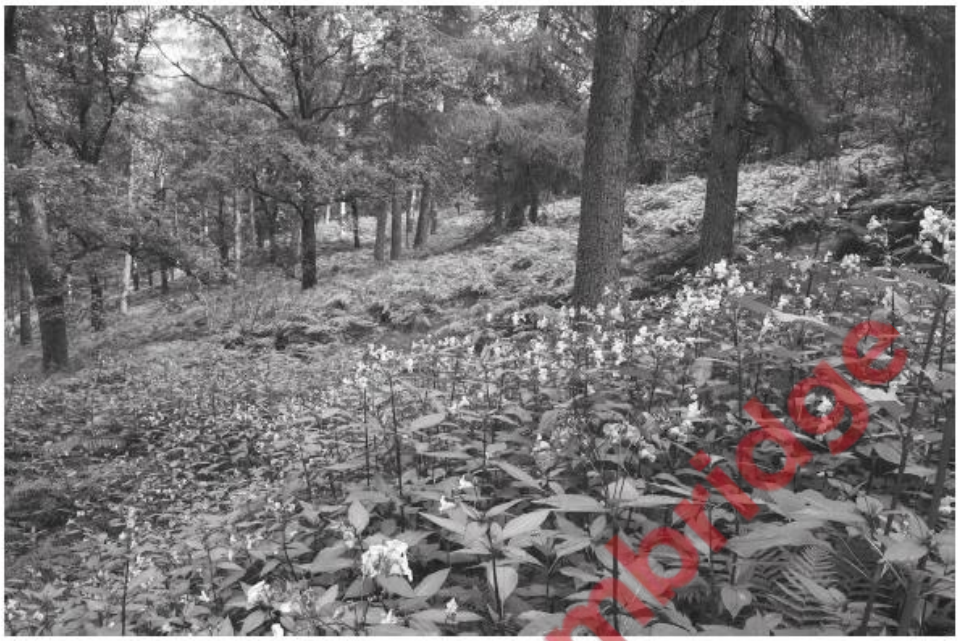

Fig. 10.1

Himalayan balsam has now become established in the UK. It is listed as an invasive alien species and attempts are being made to eradicate (remove) the plant.

Not all alien plant species are considered to be invasive.

Suggest why Himalayan balsam has been listed as an invasive alien species in the UK.

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[Total: 8]