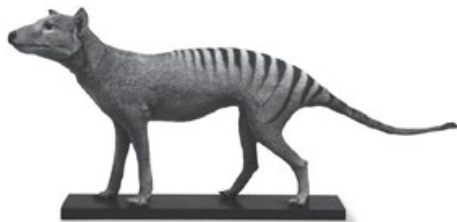


1. Bioinformatics, computational biology and synthetic biology are relatively new techniques in biology that have a variety of uses.

This is a preserved thylacine, *Thylacinus cynocephalus*, a large Australian carnivore that became extinct in 1936.



Many preserved thylacine specimens in museums contain DNA. Scientists have used DNA sequencing, bioinformatics and computational biology to reconstruct the genome of the thylacine. Some scientists hope to be able to use bioinformatics and synthetic biology to produce a living thylacine in the future.

The thylacine finally became extinct in 1936 as a result of hunting by humans. However, its population had been in decline for many years before.

Some scientists have concluded that the thylacine was particularly vulnerable to extinction because of low genetic diversity within the species.

The table shows the proportion of heterozygous loci in a range of Australian mammal species together with information about how endangered they are.

Species	Genetic diversity (proportion of heterozygous loci)	Conservation status
Brown antechinus	0.0040	least concern
Fat-tailed dunnart	0.0037	least concern
Common wombat	0.0017	least concern
Koala	0.0013	vulnerable
Tammar wallaby	0.0007	least concern
Tasmanian devil	0.0003	endangered
Thylacine	0.0001	extinct

- i. Describe the evidence in the table that supports the conclusion that low genetic diversity contributed to the extinction of the thylacine.

[2]

- ii. Identify **one** piece of evidence that does **not** support the conclusion that low genetic diversity contributed to the extinction of the thylacine.

[1]

2. On a biology field trip, some students are studying an area of mixed woodland.

Three tree species dominate the woodland: oak, ash and sycamore.

There are many small herbaceous plants in the woodland, but the students choose to collect data on only one: wood sorrel.

The students choose an oak tree, an ash tree and a sycamore tree and count every individual wood sorrel plant within a 3 m radius of each tree.

The results are shown in the table.

Species	Wood sorrel population (total within 3 m radius)					
Ash	44					
Oak	56					
Sycamore	20					

The null hypothesis of the students' investigation is that the species of tree would not affect the number of wood sorrel growing near it.

The students conclude that the conditions under oak trees are the most favourable of the three trees studied and that conditions under sycamore trees are the least favourable.

- i. Calculate the χ^2 value for the students' data.

Use the equation $\chi^2 = \sum \frac{(O - E)^2}{E}$

You may use the empty columns in the table to help with your calculation.

$$\chi^2 = \dots\dots\dots [3]$$

- ii. The critical value for χ^2 in this investigation at $p = 0.05$ is 5.991.

Discuss what can be concluded from the χ^2 calculation in part (i).

[3]

- iii. The teacher suggested that, in order to have confidence in their results, the students should include data from more than one tree for each species.

The students collect all their results on the same day.

Identify **two** other variables the students should attempt to control when carrying out an investigation such as this.

1 _____

2 _____

[2]

3(a). Black oak trees are an example of a keystone species within an oak woodland ecosystem in England.

Suggest what would happen to the ecosystem if the black oak trees died out.

[1]

(b). Students used a transect line to sample species of wildflowers in a field.

- i. Name the type of sampling method used in a transect line.

[1]

- ii. This table shows their findings.

Species	Number of organisms (n)	n / N	$(n / N)^2$
Foxglove	3	0.13	0.02
Meadow buttercup	7		
Oxeye daisy	9		
Yellow rattle	4		
	$N =$		$\Sigma(n / N)^2 =$
			$1 - \Sigma(n / N)^2 =$

Calculate the Simpson's Index of Diversity for the field using the data in the above table

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$$

Use the formula:

Give your answer to **2** significant figures.

Simpson's Index of Diversity = **[3]**

- ii. State what can be concluded about the diversity of the field from your answer in **(a)(ii)**.

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

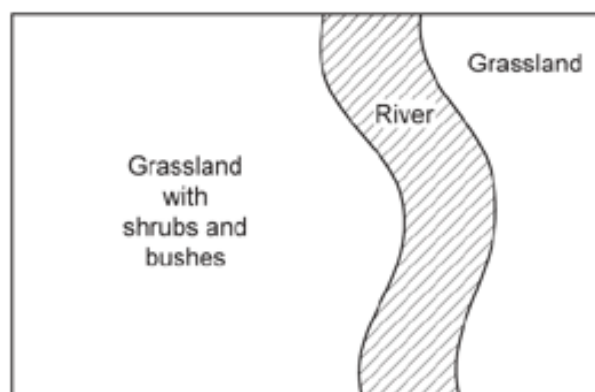
(c). Students used a sweep net to sample animals in two different parts of a river.

They did this by holding the sweep net in the water and at the same time kicking the riverbed downstream.

Suggest how they could improve their sampling method to obtain more valid results.

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

4(a). A student plans to sample the plant species in the area shown below to assess the area's species biodiversity.



The student plans to:

- use a random number generator to generate 10 coordinates
- sample at each of the 10 coordinates
- use a point quadrat and an identification key to estimate the percentage cover of each species at each coordinate.

Describe **two** improvements to the student's plan **and** explain why they would be improvements.

Improvement _____

Explanation _____

Improvement _____

Explanation _____

[4]

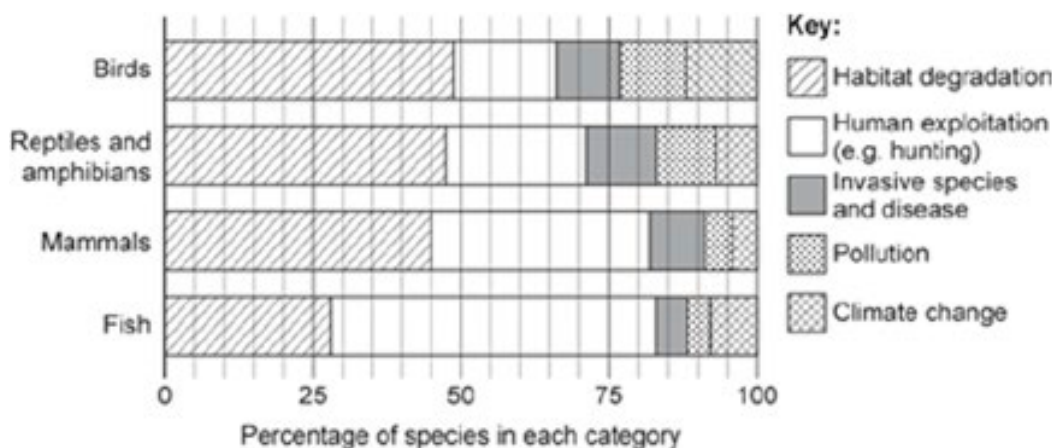
(b). The International Union for Conservation of Nature (IUCN) compiles a list of species and their conservation status, known as the Red List of Threatened Species.

A study in 2016 assessed which factors were threats to populations of animal species.

The scientists carrying out the study selected 3789 species on the IUCN List.

They classified each population into one of five categories, based on the greatest threat to the survival of the population.

The graph shows the results of the study.



- i. Outline the differences between the bird and mammal results shown in the graph.

[2]

- ii. A student looking at the graph concluded that 'climate change is not a major threat to species biodiversity'.

Evaluate this conclusion.

..... [4]

5(a). Explain how agriculture can have a negative effect on biodiversity.

..... [3]

(b). Several factors can have a negative effect on biodiversity.

State **one** factor other than agriculture that can have a negative effect on biodiversity.

..... [1]

6. Which statement describes species evenness?

- A The number of different species
- B The number of organisms in a community
- C The number of organisms of a particular species
- D The relative number of individuals of each species in an ecosystem

Your answer

[1]

7. Students carried out fieldwork in two different woodlands. They marked out an area measuring 10 m by 10 m in each woodland. For each plant species present they recorded the number of individuals of each species.

The table shows their results.

Species	Number of Individuals	
	Area 1	Area 2
Greater celandine	5	25
Lesser celandine	7	10
Herb robert	2	5
Wild strawberry	8	0
Dog's mercury	4	0
Violet	4	0
Snowdrop	0	2

The students made some conclusions about their data.

Which of these conclusions is supported by their data?

- A Area 1 has a lower value of Simpson's index of diversity
- B Area 1 is a more stable habitat
- C Area 2 has a greater species evenness
- D Both area 1 and area 2 have the same species richness

Your answer

[1]

8. *In situ* and *ex situ* conservation methods maintain biodiversity.

Which example describes an *ex situ* conservation method?

- A Collecting and storing seeds of clover glycine after an Australian forest fire
- B Estimating the number of mountain hares in the Peak District National Park
- C Protecting ancient oak trees by restricting access to their location
- D Protecting the nesting grounds of leatherback sea turtles in the Great Barrier Reef

Your answer

☐

[1]

9. What is an example of *in situ* conservation?

- A A botanical garden
- B A breeding programme in a zoo
- C A marine conservation zone
- D A seed bank

Your answer

☐

[1]

10. Simpson's Index of Diversity (D) can be used to estimate the biodiversity of a habitat.

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$$

Scientists calculated D for a grassland habitat. One year later, the scientists calculated D again for the same habitat.

The number of plants recorded from one of the species increased from 100 to 400. All the other values remained the same.

What would be the result of this change?

- A Species richness would increase.
- B The estimate of biodiversity would increase.
- C The value of D would decrease.
- D The value of N would decrease.

Your answer

☐

[1]

11(a). The kakapo, shown in the photograph below, is an endangered species of flightless bird that lives in New Zealand. The population size of kakapos has experienced a large decrease over the past few hundred years. There are now fewer than 250 kakapos living in the wild.



i. State the term for a large decrease in population size that reduces the gene pool.

[1]

ii. Adaptations can be categorised into three different types:

- anatomical
- behavioural
- physiological.

The table lists four traits that kakapos have evolved.

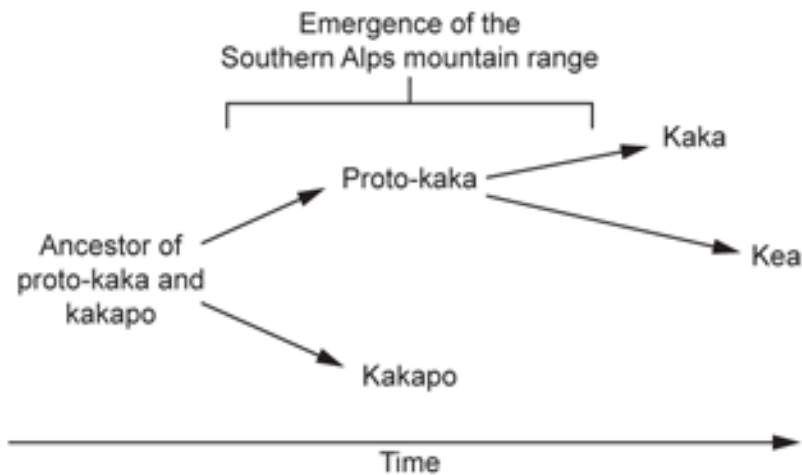
Complete the table by naming the type of adaptation represented by each of the four kakapo traits.

Kakapo trait	Type of adaptation
Active at night to avoid predators	
Green feathers that camouflage with its surroundings	
Slow digestion to extract nutrients from a high-fibre, low-protein diet	
Strong beak and claws to climb trees	

[2]

- iii. The kakapo and two other species of bird, the kaka and the kea, evolved from a common ancestor approximately 70 million years ago.

The evolutionary timeline of the three species is shown in the figure below.



- The kakapo cannot fly. It forages for leaves and roots on the ground in forests and grasslands.
- The kaka can fly. It eats seeds, fruit, and occasionally the eggs of other birds in forest habitats.
- The kea can fly. It eats plants, larvae and other small animals. It lives in mountainous forest habitats.
- All three species live on the South Island of New Zealand and had overlapping ranges until the population size of kakapos started to decrease. Populations of kakas also live on the North Island of New Zealand.

A student studied the information and suggested that all three species evolved by sympatric speciation.

Evaluate the student's conclusion.

- iv. New Zealand has a high species biodiversity compared to many countries.

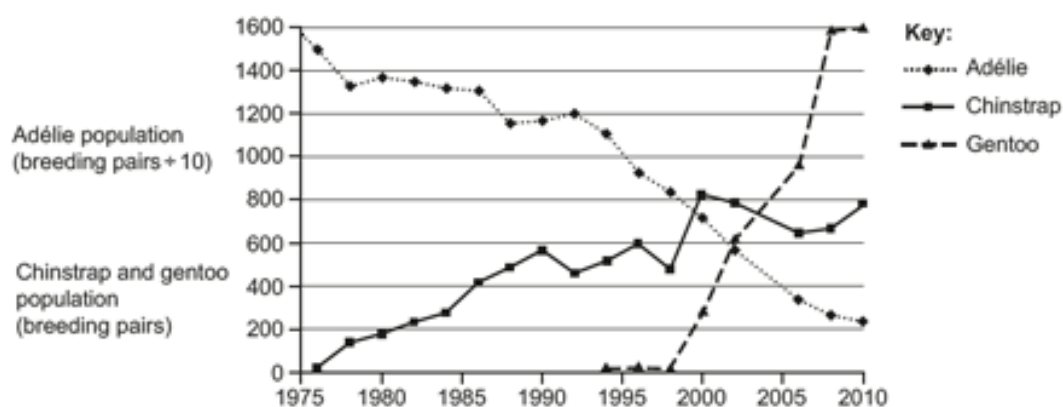
Species biodiversity includes the concepts of species richness and species evenness.

Explain the difference between species richness and species evenness.

[2]

- 12(a).** A study was carried out to monitor the population of three penguin species on an island near Antarctica.

The graph shows the results of this study.



Use the graph to compare the species richness and species evenness of the penguins found on the island in the years 1980 and 2010.

[3]

(b). The Humboldt penguin is protected by the Convention on International Trade in Endangered Species (CITES).

- The Humboldt penguin lives on the Pacific coast of South America.
- The breeding grounds for the Humboldt Penguin contains layers of guano.
- Guano is the accumulated excrement of seabirds.
- Guano was collected by humans as it is a valuable fertiliser.
- Penguins were killed for their oils and skin.

Suggest how CITES can help prevent the decline of the Humboldt penguin.

-----[2]

13(a). The abundance and distribution of plants can be surveyed in different ways.

Some students wanted to survey abundance and distribution of plants on a small area of grass outside the school. The area was roughly 20 m × 20 m in size.

They used the following method:

- 1 Lay two 20 m tape measures at right angles starting in the south east corner of the grass area.
- 2 Use a random number generator to select x and y coordinates.
- 3 While facing north, place the left-hand corner of a quadrat on the point where the coordinates meet.
- 4 Identify the species present in the quadrat using a key.
- 5 Count the number of each species present.
- 6 Record the information in a table.
- 7 Generate a new set of coordinates and repeat steps 2 to 6 until 10 quadrats have been sampled.

The teacher said that this method would not allow the students to measure the distribution of plant species.

- i. Suggest an improvement to the method that would allow the distribution of plants to be measured.

-----[2]

- ii. Identify a limitation with step 3 of the students' method and explain why this limitation might affect the data collected.

[2]

(b). The students' results are shown in the table.

Plant species	Mean number of individuals per quadrat
Creeping buttercup	3
Daisy	7
Dandelion	1
Grass	26
Red clover	4
Ribwort plantain	3
White clover	6

- i. Calculate the Simpson's Index of Diversity (D) for the students' data.

Use the formula: $D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$

$D = \dots\dots\dots$ [3]

- ii. The students found grass species difficult to distinguish from one another so they decided to record any grass species as 'grass'.

Explain how the students' decision might have affected the calculated value for D .

[2]

14. DNA analysis can be used to assess genetic biodiversity within populations.

A scientist assessed genetic biodiversity in four populations, **A** to **D**, of yellow horn, which is a small tree. They used two measures of genetic biodiversity:

- the percentage of polymorphic gene loci
- observed heterozygosity (the proportion of heterozygous loci in a population)

and analysed 23 gene loci in each individual tree they sampled.

The results are shown in the table.

Population	Number of trees sampled	Percentage of polymorphic loci	Observed heterozygosity
A	6	86.96	0.68
B	16	100.00	0.66
C	6	91.30	0.63
D	6	100.00	0.80

Another scientist stated that these results may not allow an accurate assessment of genetic biodiversity in these four populations.

Identify **two** pieces of evidence that support this scientist’s evaluation.

1

2

15. The Maasai Mara is a grassland ecosystem in east Africa with a large range of wildlife.

The human population in the area is increasing.

An increasing human population can affect the biodiversity of an area.

Maintaining biodiversity in the Maasai Mara is important.

The following are some statements about biodiversity in the Maasai Mara:

- A People visit the Maasai Mara to see animals such as lions, giraffes and rhinoceros.
- B Wild animals are sometimes killed for food by local people.
- C Large herbivores such as wildebeest are the main source of food for large predators such as lions.
- D Part of the area is used by farmers for grazing livestock.
- E Soil erosion has occurred where trees have been removed by humans for fuel or to clear land for grazing.
- F In and around the Maasai Mara there is accommodation for over 7000 tourists.

The reasons for maintaining biodiversity can be grouped into three categories: ecological, economic and aesthetic.

Fill in the table to show which of the statements, A to F, could be used as an example of the importance of each of the three categories.

You may use each letter once, more than once, or not at all.

Reason for maintaining biodiversity	Letter or letters
Ecological	
Economic	
Aesthetic	

[3]

16. On a biology field trip, a student calculated that an area of ancient woodland had a Simpson's Index of Diversity of 0.85.

Which interpretation of a Simpson's Index of Diversity of 0.85 is correct?

- A Biodiversity is high.
- B Biodiversity is low.
- C Interspecific variation is high.
- D Intraspecific variation is low.

Your answer

[1]

17(a). A student gives a definition of one level of biodiversity as:

The number of different alleles for all the genes in a population.

Name **and** define **two** other levels of biodiversity.

Name _____

Definition _____

Name _____

Definition _____

[2]

(b). During the 20th Century, there was a very large decrease in the size of wild populations of the cheetah, *Acinonyx jubatus*. This decrease was largely due to hunting. Recent research shows that wild populations of the cheetah have a very low number of polymorphic genes.

There are 17 863 gene loci in the genome of the cheetah and now only 10% of these gene loci are polymorphic in wild populations.

Scientists investigated the genetic biodiversity of cheetah populations in European zoos.

They sampled 256 gene loci and found 18 gene loci to be polymorphic.

- i. Calculate the proportion of polymorphic gene loci in the European zoo population.

Proportion = [2]

- ii. A second group of scientists carried out a separate investigation to calculate the proportion of polymorphic gene loci of cheetahs in European zoos and found that their results were different. These new results were accepted as being accurate.

Suggest **two** reasons why the calculated proportion of polymorphic gene loci in the European zoo population of cheetahs might have been less accurate in the investigation carried out by the first group of scientists.

1 _____

2 _____

[2]

- iii. Suggest **and** explain reasons why, in the 21st Century, only 10% of the gene loci are polymorphic in wild populations of cheetah.

[3]

18. The table shows the numbers of different species of invertebrates found in four different areas in a woodland.

Area	Invertebrate species			
	Woodlice	Spiders	Beetles	Millipedes
A	15	20	1	0
B	2	7	6	7
C	25	1	7	3
D	8	0	2	17

Which row shows the area that has the greatest species richness **and** greatest species evenness?

Your answer

[1]

19. International trade in parts of the rhinoceros including rhino horn has been illegal since 1977.

Which organisation regulates this trade?

- A** CBD
- B** CITES
- C** CSS
- D** IUCN

Your answer

[1]

END OF QUESTION PAPER