

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.

Much of the thylacine DNA present in the museum specimens has broken down. In order to assemble an entire thylacine genome, it is necessary to supplement the thylacine DNA with DNA from a living close relative of the thylacine.

The thylacine belonged to the order Dasyuromorphia. The table shows the classification of the thylacine and some living species of the order Dasyuromorphia.

Common name	A	Genus	Species
Thylacine	Thylacinidae	<i>Thylacinus</i>	<i>T. cynocephalus</i>
Tasmanian devil	Dasyuridae	<i>Sarcophilus</i>	<i>S. harrisii</i>
Quoll	Dasyuridae	<i>Dasyurus</i>	<i>D. maculatus</i>
Fat-tailed dunnart	Dasyuridae	<i>Sminthopsis</i>	<i>S. crassicaudata</i>
Numbat	Myrmecobiidae	<i>Myrmecobius</i>	<i>M. fasciatus</i>

- i. Name the classification taxon represented by the column headed **A**.

[1]

- ii. Using the information in the table, describe the evolutionary and genetic relationships between the species that are listed.

[3]

- iii. Explain why it is difficult to decide which of the other species would be the most appropriate to use as a source of DNA for constructing a thylacine genome.

[2]

- iv. All the species in the table belong to the animal kingdom.

Other than the presence or absence of vacuoles, state **two** features of the cells of these multicellular organisms that would mean they could be classified only in the animal kingdom.

1

2

[1]

2. Ring rot is an infection that can kill potato plants.

Which kingdom does the organism that causes ring rot belong to?

- A** Fungi
B Prokaryotae
C Protocista
D Viruses

Your answer

☐

[1]

3. Bats are mammals that hunt insects while flying. Dolphins are mammals that hunt fish while swimming. Some bats and all dolphins use a technique known as echolocation to hunt their prey. They emit sound waves which reflect back to them to show the location of prey.

What explains why bats and dolphins show the same adaptation of having echolocation?

- A** Bats and dolphins are in the same family
B Both had different environmental conditions
C Both had the same selection pressure
D The environment caused both to have the same mutation

Your answer

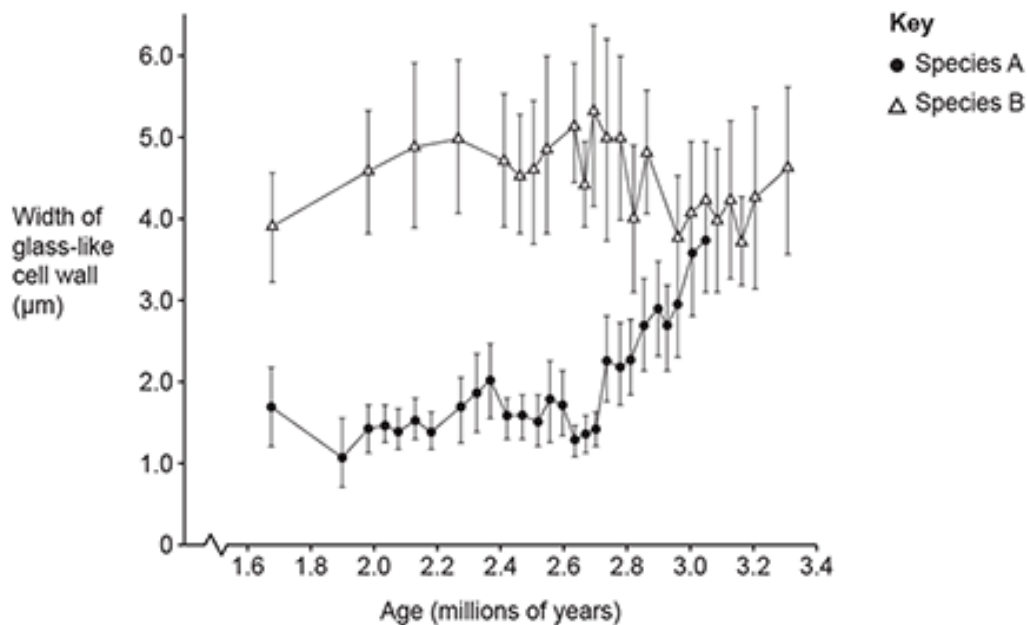
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[1]

4(a). The age of a fossil can be calculated based on its position in rock layers in the ground. Fossils of different ages can be compared to provide evidence of evolution and to help construct phylogenies.

Diatoms are single-celled organisms that have glass-like cell walls, which can be preserved as fossils.

The graph shows the fossil record for two species of diatom.



Explain whether the data in this graph show evidence for evolution by natural selection.

[2]

(b). A student analyses the estimated ages of 16 species of diatom. The estimated ages show how long ago the species evolved from an ancestor. The student compares estimated ages from two different sources:

- the position of each species in the fossil record
- molecular and genetic data, which has been used to construct the current phylogenetic tree of diatom species.

The student tests whether a positive correlation exists between the two sets of data for the 16 diatom species using Spearman's rank correlation coefficient.

The student's null hypothesis is:

'There is no correlation between the estimated ages of diatom species based on the fossil record and the estimated ages based on molecular and genetic data.'

The calculated r_s is 0.979.

The student compares the r_s of 0.979 to the critical values in the table.

n	Probability (p)	
	0.05	0.01
14	0.4637	0.6264
15	0.4464	0.6063
16	0.4294	0.5824
17	0.4142	0.5662
18	0.4014	0.5501

Explain what the student can conclude based on their r_s value of 0.979.

[3]

(c). Diatoms are members of the domain Eukarya.

Complete the sentences about domains using the most appropriate terms.

The process of sorting of organisms into taxonomic groups is called
 Domains represent the highest taxonomic level; they are the groups that contain the largest number of species.
 The number of kingdoms in each domain is different. The domain Eukarya contains
 different kingdoms. The domains Bacteria and both contain species from only the
 kingdom Prokaryotae.

[3]

5. The giraffe is a species of mammal with the species name 'camelopardalis' and the genus name 'Giraffa'.
 What is the correct format for the binomial name of the giraffe?

- A *camelopardalis giraffa*
- B Camelopardalis giraffa
- C G. camelopardalis
- D *Giraffa camelopardalis*

Your answer

[1]

6. Which kingdom contains species that are heterotrophic and composed of hyphae?

- A Fungi
- B Plantae
- C Prokaryotae
- D Protocista

Your answer

☐

[1]

7. Organisms are named using the binomial system.

What is the correct way to represent the binomial name for domestic dogs?

- A *Canis familiaris*
- B Canis familiaris
- C *canis familiaris*
- D canis familiaris

Your answer

☐

[1]

8. 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.

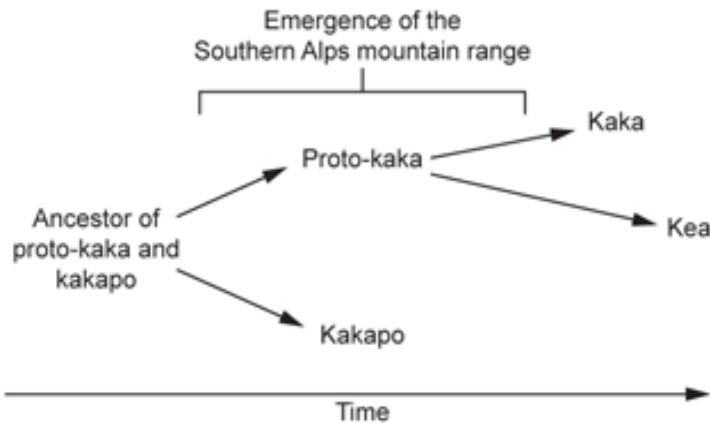
Complete the table by naming the type of adaptation represented by each of the four kakapo traits.

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.

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

[2]

Scientists have compared the structures of molecules, such as DNA polymerase and helicase, and organelles in the three domains.

Feature	Archaea	Bacteria	Eukarya
Type of DNA polymerase	SFB and SFD	SFA and SFC	SFB
Type of helicase	SF1 and SF2	SF1 and SF2	SF1 and SF2
Histone proteins	Present	Absent	Present
Size of ribosomes	70S	70S	80S
Mitochondria	Absent	Absent	Present

Explain what conclusions can be drawn from the table about which two domains are most closely related.

[3]

10(a). Fig. 6.1 shows a larva of the gum-leaf skeletoniser moth, *Uraba lugens*, found in Australia and New Zealand.

- The larva has an exoskeleton.
- The exoskeleton is the external skeleton that supports and protects the soft tissues and organs of the larva. It is shed periodically to allow the larva to grow.
- Each time it sheds its exoskeleton, the exoskeleton head remains attached to its body and these old exoskeleton heads stack up on top of each other.
- The larva is given the name mad hatterpillar because of this unusual adaptation.

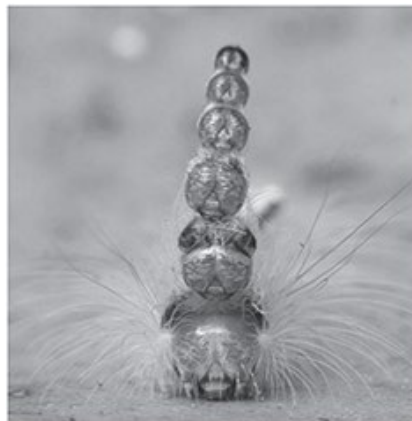


Fig. 6.1

- i. With reference to **Fig. 6.1**, suggest a purpose for the adaptation of attaching and stacking the old exoskeleton heads.

[1]

- ii. Name the genus of the gum-leaf skeletoniser moth.

[1]

- iii.
- The table shows some taxonomic descriptions for the gum-leaf skeletoniser moth. They are **not** in the correct hierarchical sequence.

Complete the table to show the correct hierarchical sequence. Use the numbers 1 to 4. One row has been completed for you.

Taxonomic description	Hierarchical position
Phylum Arthropoda	
Order Lepidoptera	
Kingdom Animalia	1
Class Insecta	

[1]

- (b).
- The peppered moth, *Biston betularia*, has two forms, a pale form and a dark form, both shown in **Fig. 6.2**.

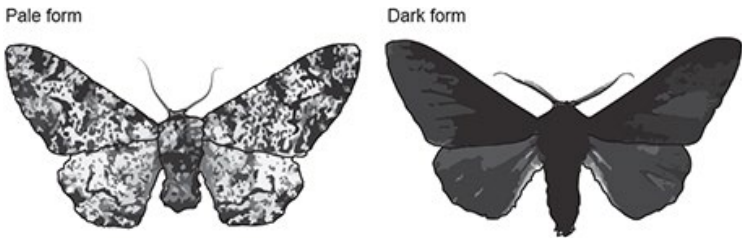


Fig. 6.2

Predators of the peppered moth include birds such as the robin and nuthatch. Peppered moths avoid these predators by flying at night and resting on tree trunks during the day. Many trees have light coloured lichens growing on them. However, many lichens are unable to tolerate high levels of air pollution. Without lichens the bark of trees appears darker.

The dark form of the peppered moth first appeared in Britain during the industrial revolution.

Various surveys have shown that the percentage of the dark form of the peppered moth population is higher in parts of England where there is a lot of heavy industry compared with more rural areas.

Explain how the process of natural selection has resulted in this distribution of the two forms of the peppered moth.

[4]

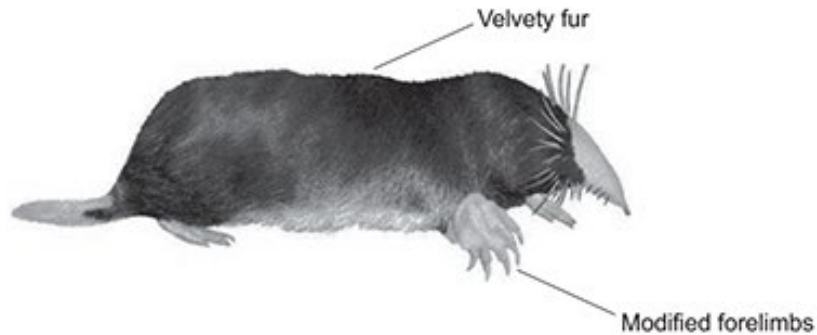
(c). **Fig. 6.3** shows two types of mole and some information about each type.

Placental mole family *Talpidae*

Found in: North America, Asia and Europe

Habitat: Lives in burrows in soft soil

Food: Grubs and worms



Marsupial mole family *Notoryctidae*

Found in: Australia

Habitat: Lives in burrows in soft soil

Food: Grubs and worms

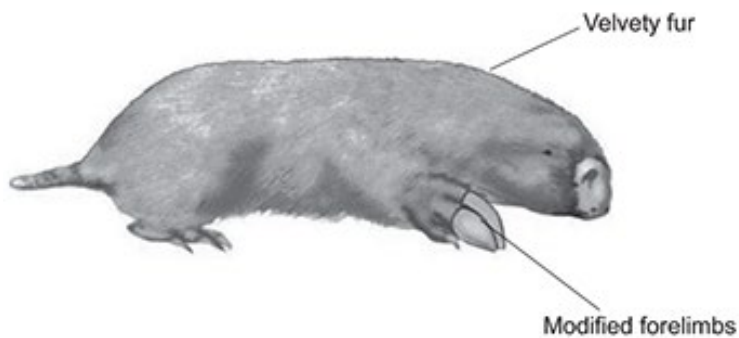


Fig. 6.3

Explain how **Fig. 6.3** supports the theory of convergent evolution.

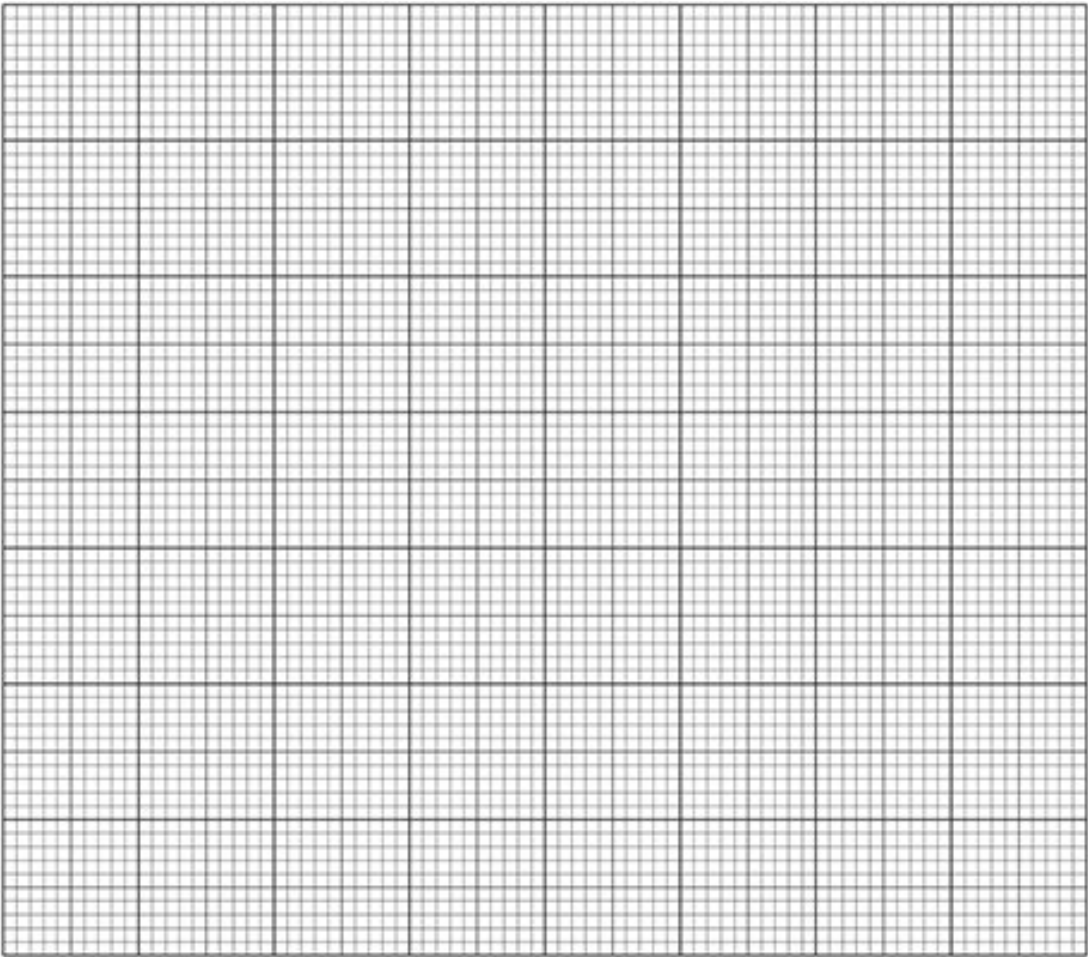
11. The Atlantic cod, *Gadus morhua*, is a large fish that is often eaten by humans.

The body length of Atlantic cod varies between individuals.

The table below shows some data on the size of cod caught in one area of the Atlantic Ocean during one survey.

Body length (mm)	Frequency
$100 \leq x < 200$	10
$200 \leq x < 300$	48
$300 \leq x < 400$	121
$400 \leq x < 500$	130
$500 \leq x < 600$	119
$600 \leq x < 800$	46

- i. In the space provided, plot the results from the table as a suitable graph.



- ii. Variation can be caused by genetic and environmental factors.

Explain why your graph shows that at least some of the variation in body length in Atlantic cod is caused by environmental factors.

----- [2]

12. What chemical is produced by plants in response to attack by pathogens?

- A Amylopectin
- B Amylose
- C Callose
- D Cellulose

Your answer

☐

[1]

13. Evolutionary relationships can be determined by comparing certain biological molecules between species.

Which option is commonly used to determine evolutionary relationships?

- A The amino acid sequence of collagen
- B The amino acid sequence of messenger RNA
- C The base sequence of cytochrome c
- D The base sequence of ribosomal RNA

Your answer

☐

[1]

14. A student is studying three unicellular organisms: the bacterium *Escherichia coli*, the protist *Euglena gracilis* and the fungus *Saccharomyces cerevisiae*.

Which feature is common to all three unicellular organisms?

- A Cell wall
- B Mitochondria
- C Nucleus
- D Ribosomes

Your answer

☐

[1]

END OF QUESTION PAPER