1 **(a)** Great tits, *Parus major*, are birds that form male-female pairs. The male of each pair then establishes an area of territory, which he defends against other great tits by singing and threat displays.

The birds build a nest within the territory in which the eggs are laid and young chicks are reared. Weasels, *Mustela nivalis*, are predators which eat eggs and young chicks.

Fig. 6.1 shows how the territory size of great tits affects the risk of nest predation by weasels.

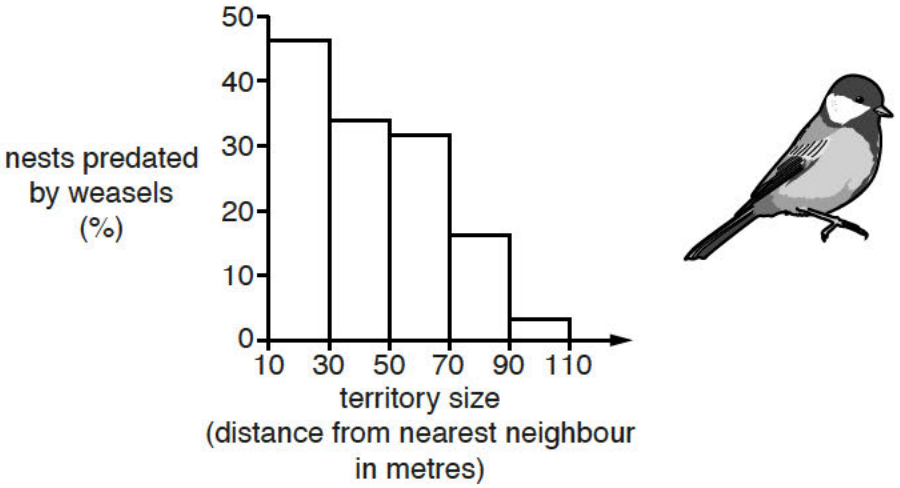


Fig. 6.1

(i) Describe the relationship shown in Fig. 6.1.

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

(ii) Suggest and explain what effect weasels may have on the population size of the great tit.

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

(b) The ochre starfish, *Pisaster ochraceus*, is a starfish that lives on rocky intertidal shores. It is the top predator in its habitat.

Fig. 6.2 shows part of the food web for this starfish.

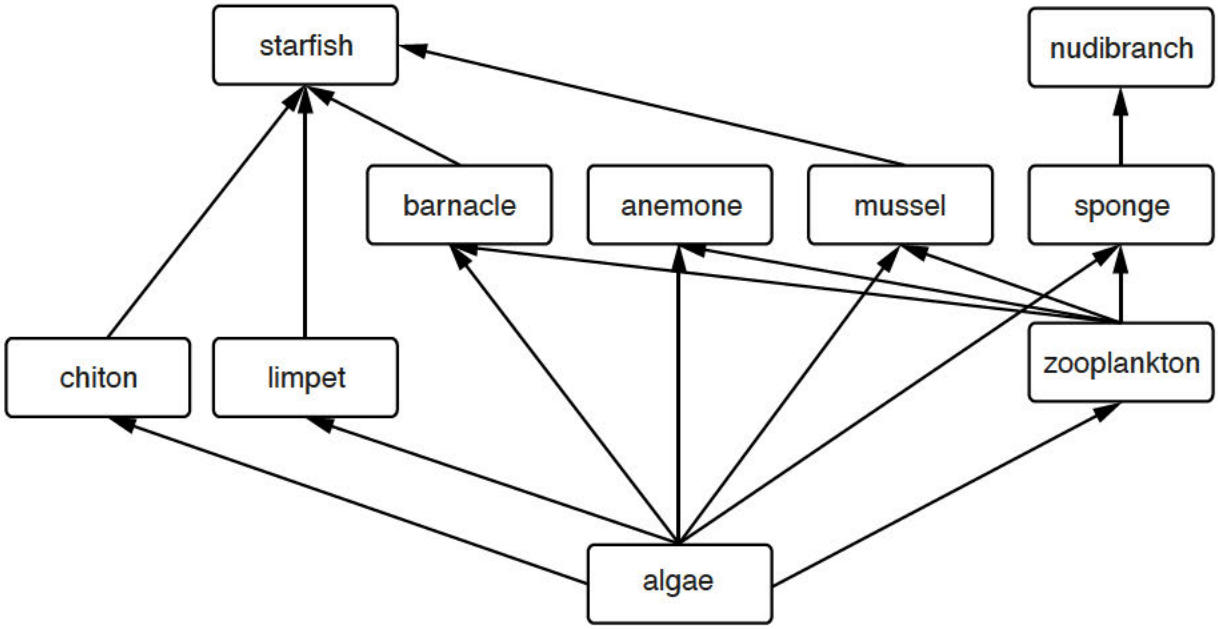


Fig. 6.2

An experiment was carried out in which all the starfish were removed from an 8 m × 2 m area of the shore. In an equivalent area of the same size, the starfish were not removed.

The population sizes of the other organisms in the food web were monitored at intervals. It was found that in the area in which starfish were removed:

- chitons and limpets disappeared
- anemones, sponges and nudibranchs decreased in abundance.

(i) Explain why two areas of the same size were monitored.

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

(ii) Using Fig. 6.2, explain why the chitons and limpets disappeared in the area from which starfish were removed.

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

(iii) Using Fig. 6.2, suggest the sequence of events that led to the decrease in abundance in nudibranchs in the area from which starfish were removed.

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

[Total: 9]

2 **(a)** Fig. 7.1 shows a suggested evolutionary relationship between bears, raccoons and the two species of panda, the giant panda, *Ailuropoda melanoleuca*, and the red panda, *Ailurus fulgens*.

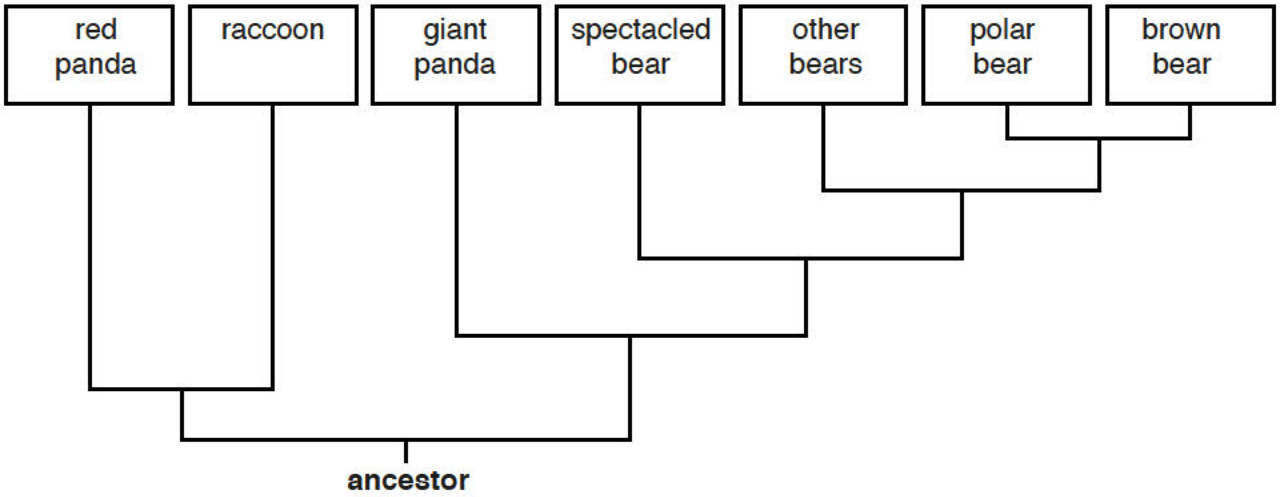


Fig. 7.1

(i) Using Fig. 7.1, name the **two** animals that share the most recent common ancestor.

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

(ii) State whether pandas form a distinct taxonomic group. Use information from Fig. 7.1 to justify your answer.

.....

.....

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

(b) The evolutionary relationship of the giant panda and red panda has been a matter of scientific debate for many years. It was hoped that molecular evidence would provide a definite answer. Some of the results of scientific studies are listed in Table 7.1.

Table 7.1

year	protein sequenced	conclusion
1985	albumen	Giant panda is more closely related to bears, and red panda is more closely related to raccoons, than pandas are to each other.
1986	haemoglobin	Giant and red panda are more closely related to each other than the giant panda is to bears or the red panda is to raccoons.
1993	cytochrome c	Giant panda is more closely related to bears, and red panda is more closely related to raccoons, than pandas are to each other.

(i) Comment on what the results in Table 7.1 show about the nature of scientific knowledge **and** the role of the scientific community in validating new knowledge.

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

(ii) The roles of the three proteins sequenced in the studies shown in Table 7.1 are as follows:

- albumen carries molecules such as hormones in the blood
- haemoglobin carries oxygen in the blood
- cytochrome c plays a role in oxidative phosphorylation in mitochondria.

Both the giant and the red panda live in mountain habitats and are physiologically adapted to living at high altitude. Oxygen partial pressure is lower at high altitude than it is at sea level.

Explain how these facts could provide an argument for rejecting the conclusion of the 1986 study.

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

(c) Research on another protein from the giant panda was carried out in 2008. This protein, called crystallin, is found in the lens of the eye, and has a sequence that has been highly conserved in all mammals.

The steps in the procedure used in the study are summarised in Fig. 7.2.

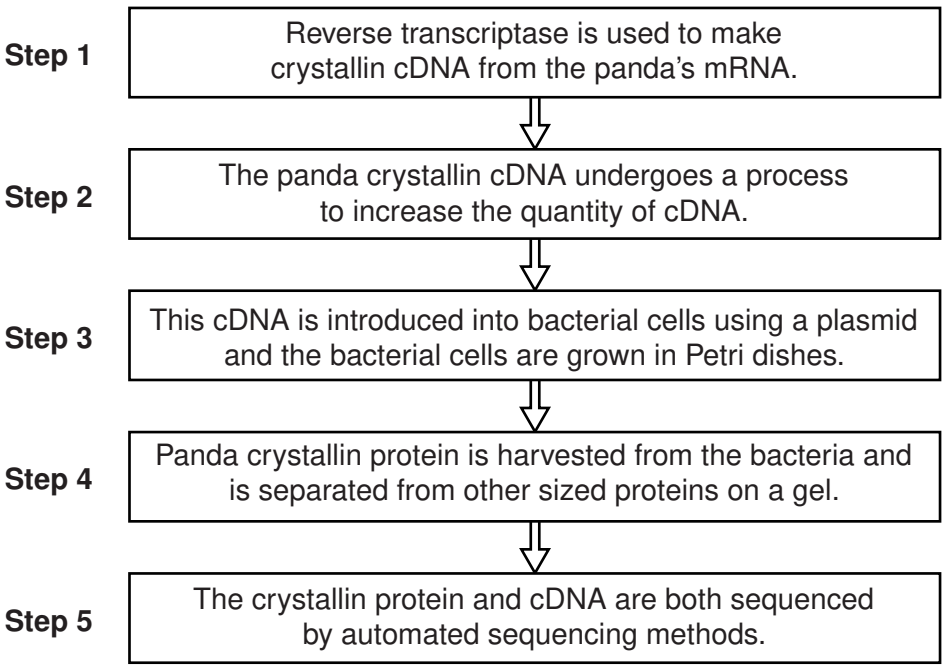


Fig. 7.2

Identify the **technique** used in each case to carry out steps **2**, **3** and **4**.

step **2** .....

step **3** .....

step **4** ..... **[3]**

(d) The panda crystallin protein obtained was 175 amino acids long, corresponding to a 528 base pair cDNA gene.

Explain why a protein that is 175 amino acids long is coded for by 528 base pairs of DNA.

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

(e) The crystallin protein and cDNA sequences of the giant panda were compared with those of three other mammals.

The results are shown in Table 7.2.

Table 7.2

	percentage of sequence that is the **same** in the giant panda and other mammal	
mammal	nucleotides in cDNA	amino acids in protein
human	93.9	98.3
mouse	91.5	97.1
ox	95.3	99.4

(i) Using the data in Table 7.2, name the mammal that is the closest relative of the giant panda.

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

(ii) Explain why the figures in Table 7.2 are higher for the protein sequences than for the cDNA sequences.

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

[Total: 17]

3 **(a)** Organisms do not live in isolation, but interact with other organisms and with their physical environment.

State the word used to describe:

(i) the study of the interactions between organisms and their environment

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

(ii) the physical (non-living) factors in the environment

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

(iii) a physical area that includes all the organisms present **and** their interactions with each other **and** with the physical environment.

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

(b) State and describe **two types** of ecological interaction that can occur between different species in a habitat.

As part of each description, you should **name** the two species involved in your chosen example.

1 .....

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2 .....

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..... **[6]**

(c) Plants are able to respond to changes in their environment.

(i) Describe **two** ways in which hormones may alter a plant's growth in response to overcrowding by other plants.

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..... **[4]**

(ii) Suggest how hormones alter a plant's growth if the top of the plant shoot is eaten by an animal.

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

(d) The distribution and abundance of plants in a habitat can show how a physical factor varies across the habitat.

Describe how you would measure the distribution and abundance of plants over a distance of 100 metres.

In your answer you should make clear the sequence of procedures you would follow.

[6]

[Total: 22]