ACTIVITY 3-5

CHANGES IN SPECIES THROUGH TIME

BACKGROUND

Scientists can trace the history of species over long periods of time by comparing fossils of different ages with one another and with living organisms. This evidence allows us to observe how organisms have changed. The changes are the result of shifts in the relative numbers of a particular inherited variant in a population. If a new variant becomes increasingly common, individuals with the new variant will eventually replace those without it, and the characteristics of the species will thereby be altered (Figure 3.8). As each change is added to the changes that came before, a population of organisms in time becomes less and less like its original ancestors and is classified as a new species. In Investigation A of this activity, you will study changes such as this by analyzing the appearance of fossil molluscs over time.

Evolution does not involve only a single line of change from one variant into another. Several variants might develop from the same ancestor, each variant having a particular advantage in a particular environment or way of life. If this happens, the change over time appears as a forked branch, with one species giving rise to two (Figure 3.9). By piecing together relationships such as these, scientists can build up a family tree or *phylogeny*. In Investigation B of this activity, you will reconstruct a phylogeny linking a variety of modern carnivorous mammals to their extinct ancestors.

Text Reference: *Biology Directions*, pages 182–202.

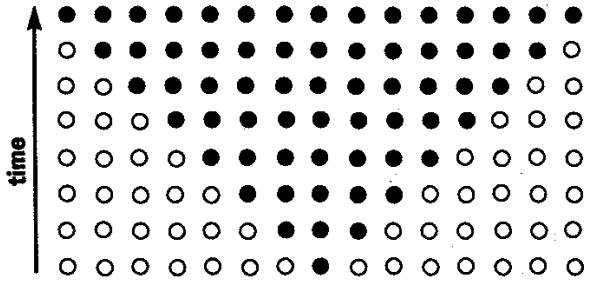

Figure 3.8: A simple change in successive generations of a species. The variant shown as a black circle has a trait that improves its chances of reproducing. In time, the black variant spreads in the population and the white variant disappears.

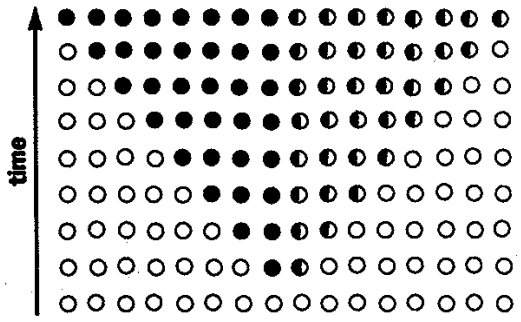

Figure 3.9: Two variants, black and half-black, occur in a population of white circles. Each variant has an advantage in a different environment. As a result, the original population develops into two populations with different characteristics. Again, the original white variant disappears, or becomes extinct.

INVESTIGATION A

Finding patterns in fossil shells

PROBLEM

How has a species of mollusc changed over geological time?

EXPERIMENTAL DESIGN

Gryphaea is a genus of extinct molluscs similar to oysters. Many fossils of *Gryphaea* have been found in rocks from between 190 million years ago to 38 million years ago. Unlike oysters, *Gryphaea* have coiled shells. However, different fossil specimens have different degrees of coiling. Some shells have only a quarter of a whorl, while others have about one-and-a-half whorls. Shells with variations between these two extremes are also commonly found (Figure 3.10).

Does this wide range of variation occur within the same population, or do some populations have a little coiling while others have a lot? If there is one population showing half a whorl and a different population showing one whorl, did both populations live at the same time or at different times in geological history? And, if all the *Gryphaea* living at a particular period of geological history had the same amount of coiling, did the change in coiling from one period to the next follow a pattern, or

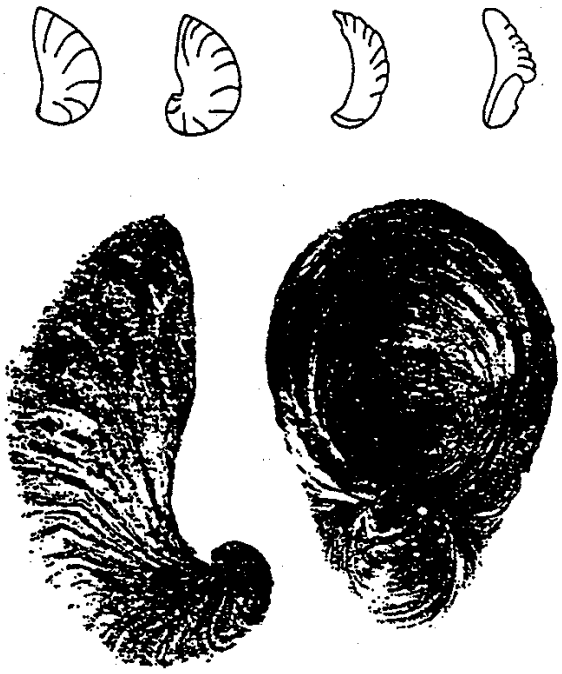

Figure 3.10: Gryphaea *fossils come in a variety of shapes, with different degrees of coiling.*

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were the changes random? You will be able to answer all of these questions by plotting the amount of coiling in *Gryphaea* fossils against time. Time estimate: 30 minutes.

PROCEDURE

Plot the data from Table 3.4 onto a single graph. Put time on the vertical axis and amount of coiling on the horizontal axis. Sketch each population of *Gryphaea* as a bell-shaped curve, with the bottom of each curve showing the age of the fossils, the ends of the curve showing the range, and the top of the curve showing the mean amount of coiling.

Table 3.4 Amount of coiling in *Gryphaea* fossils of different ages.

Age of fossils (millions of years ago)	Amount of coiling	
	Range	Mean
190–160	0.2–0.4	0.3
160–120	0.4–1.0	0.75
120–80	0.7–1.3	1.0
80–40	0.9–1.6	1.3

ANALYSIS AND INTERPRETATION

1. Describe any pattern of change that you observe in the shape of *Gryphaea* shells over time.
2. If you were given a fossil *Gryphaea*, could you tell its age from its amount of coiling? Explain your answer.
3. Imagine you are on an undersea journey with a time traveller. The gauge of the time machine is broken, and the time traveller is not sure whether you are back either 70 million or 170 million years ago. Explain how you can be certain of the time by observing the living *Gryphaea* around you.

EXTENSION

1. *Gryphaea* had a way of life similar to that of oysters. Find out how oysters live, and use this information to suggest why the shape of *Gryphaea* altered in the way that it did. What might be an advantage of a more coiled shell? What change in the ocean environment might have led to this change in the shape of *Gryphaea*?
2. Do you think all changes that occur during evolution are adaptive? Explain, giving examples.
3. Carry out research on current ideas about rates of evolutionary change. Does evolution always proceed slowly and gradually? Support your answer with evidence.

INVESTIGATION B

Phylogeny of carnivores

PROBLEM

How are carnivorous mammals related to one another?

EXPERIMENTAL DESIGN

The order of mammals named Carnivora includes cats, dogs, bears, weasels, and raccoons. These animals are grouped together because of similarities in their type of teeth and way of life. Fossil evidence shows that carnivorous mammals lived on Earth approximately 60 million years ago. At that time, the different carnivore families we see today were not distinct from one another. Many carnivores, now extinct, were intermediate between cats and dogs, or between dogs and bears. By approximately 40 million years ago, these early carnivores had developed into two branches — cat-like carnivores and dog-like carnivores.

These two branches can be distinguished by differences in their jaws, teeth, and faces.

Compare the skulls of a modern wild dog and cat (Figure 3.11). The most obvious difference is that a dog has a long snout, indicating its well-developed sense of smell. The cat has a shorter, flatter face with large eye sockets, indicating its

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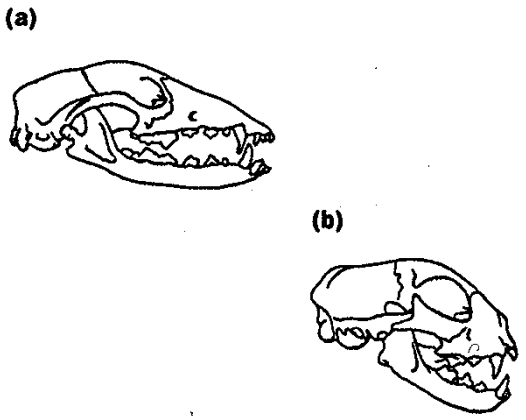

Figure 3.11: (a) Wild dog skull; (b) wild cat skull

good sense of vision. These differences are connected to differences in the way of life of cats and dogs. Using their noses, dogs track by scent, running after their prey over long distances. As runners, dogs have short, sturdy, non-retractable claws. Using their eyes, cats stalk their prey and then pounce. To help hold their prey, cats have long, curved, retractable claws. Apart from such differences, dogs and cats are very similar in other ways. In this activity, you will use similarities and differences among other carnivores to fit them into a phylogeny with cats and dogs.
Time estimate: 30 minutes.

PROCEDURE

1. Figure 3.12 illustrates the skulls of a number of modern and extinct carnivores. The identity and geological age of each animal are given in the figure. You will use the information in this figure to construct a family tree.
2. Divide a sheet of paper into four horizontal rows. Label the bottom row *Eocene Epoch* and the top *Modern Epoch*. Label the *Oligocene* and *Miocene* in order of age.
3. Copy each skull onto your sheet of paper in the appropriate row.
4. Draw lines connecting the skulls of each modern carnivore to an earlier carnivore that it most resembles. If it does not resemble a carnivore in the epoch immediately preceding, go back to an earlier epoch. Several modern carnivores might resemble the same extinct carnivore.
5. In turn, connect each extinct carnivore to a carnivore in the preceding epoch. You will end up with a branching pattern that indicates the closeness of possible relationships.

ANALYSIS AND INTERPRETATION

1. Does a bear more closely resemble a cat or a wolf? Explain your answer.
2. What difficulties do you encounter building a phylogeny in this manner?
3. What additional information would help you to construct a phylogeny or family tree?

EXTENSION

Carry out research to find out how sea lions might be related to carnivores. Is a sea lion most like a dog, a cat, a bear, or some other animal?

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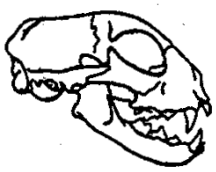
Figure 3.12: Some extinct and some modern carnivores

(a) Eocene carnivore (60 million years ago)

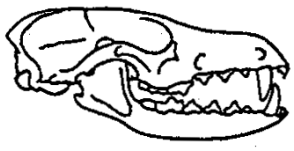


(e) modern cat

(b) Oligocene carnivore (40 million years ago)

(f) modern wolf

(c) Oligocene carnivore (40 million years ago)



(g) modern fox

(d) Miocene carnivore (25 million years ago)

(h) modern bear

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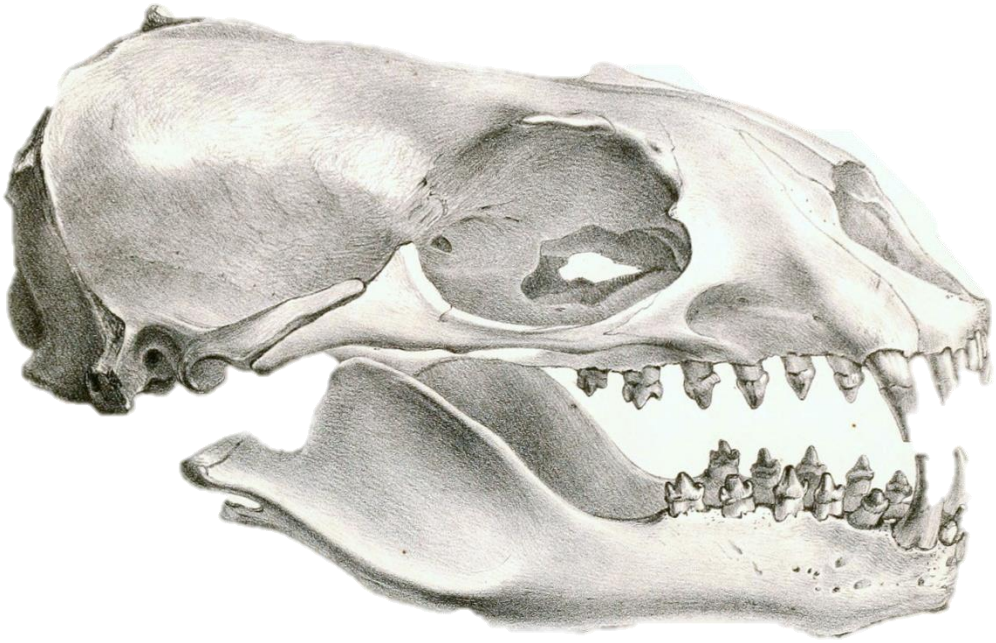

Modern Sea lion