CHAPTER 9

Adaptations for Survival

Adaptation is the process by which an organism gradually or rapidly becomes better suited to survive in a habitat. Organisms generally have certain features – structural (morphological) and behavioural – which enable them live successfully in a given habitat. Such features which enable organisms live well in a habitat are called **adaptive features.** Many of the adaptations shown by various animals and plants in different habitats have been discussed in chapters 8 and 9 of Book 2.

Competition

In any community, organisms do not only depend on one another directly or indirectly to survive, but also compete with one another for the limited resources they need for their well-being. This relationship is called **competition.**

Factors that bring about competition

Generally, the need for organisms to share the favourable conditions and scarce resources in their environments is the primary cause of competition. The factors that bring about competition include, inadequate supplies of food, space, water and light. Thus, while plants tend to compete for space, light, water and other nutrients, animals tend to compete for space and food. Competition is more pronounced when environmental resources needed for organismsâ€™ survival are very limited. In such a competition, only the well-adapted species are successful and survive. The poorly-adapted ones do not succeed and do not survive.

Types of competition

Competitions are of two types: **intra-specific competition** and **interspecies** or **inter-specific** competition.

Intraspecific competition: This is a type of competition that occurs among members of the same species, for example, among rice plants, a herd of cattle or a flock of sheep. The above mentioned organisms belong to the same species and compete with one another. For example, rice plants grown on a farmland will compete with one another.

Interspecific competition (inter species competition): In this type of competition, organisms of different species compete in an enviroment. For example, a farmland containing rice, maize, cassava and pumpkin is said to undergo interspecific competition.

Another example of interspecific (inter-species) competition is illustrated by two species of *Paramecium* namely *Paramecium caudatum* and *Paramecium aurelia.* When *P. caudatum* and *P. aurelia* are grown in culture solutions separately, the increase in number of individuals shows a characteristic pattern (Fig. 9.1A). When the two species are grown together, *P. aurelia* eliminates *P. caudatum* (Fig. 9.1B), both species compete for almost all the same mineral salts and food items but do not prey upon each other.

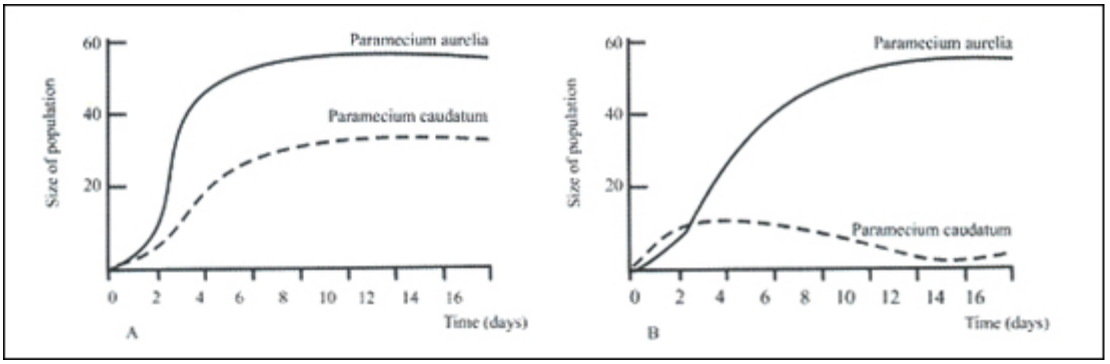

Fig. 9.1 Changes in population of two paramecium species A. Each cultured separately B. Both grown together

Experiment 9.1 *To show the effect of interspecific competition in plants*

Method

1. Fill two germination boxes with soil.
2. Plant in the first box, some maize grains and space them out very well.
3. In the second box, plant the maize grains very closely to bring about overcrowding.
4. Leave the boxes for 2 to 3 weeks and water them regularly.

Observation

The maize seedlings in the second box will appear very healthy, while those in the first box will appear yellow, with slender stems.

Conclusion

Intraspecific competition prevents the maize grains that are not well spaced out from growing properly.

Generally, when two species are competing for the same resources, only one species will normally survive. To avoid competition, and ensure their survival, many groups of animals (e.g. insects and mammals) inhabit all types of environment (e.g. air, land and water) and feed on different types of food. For example, while the adult male *Anopheles* mosquito feeds on plant juices, the adult female feeds on the mammalian blood.

Competition is a mode of survival among organisms. Seeds and fruit dispersal in many plants; dispersal of spores in some animals and plants; diseases, emigration of animals; and decrease in the rate of reproduction in animals also reduce intraspecific and interspecific competitions in a community.

Relationship between competition and succession

In a succession, newly-formed habitats are gradually colonized by different plant species one after the other, until a relatively stable community is established. When plants are established, animals will eventually inhabit the habitat. The change in a population caused by the replacement of the old members, or the additions of new ones as a result of competition is called **succession** (see Book 2, Chapter 10). Competition occurs in newly-established and already established habitats among different species of animals and plants.

In a succession, the early colonizers make the environment suitable for their successors and unsuitable for themselves (Book 2, Chapter 10). Hence, the competition that occurs during a succession makes it possible for the successors (new species) to eliminate their predecessors. In short, competition accelerates succession and there can be no succession without competition.

Structural Adaptations

You have learnt that organisms show different adaptations in their form and function to survive in their environments. Let us now examine some of the special structural adaptations shown by organisms to obtain food, protect and defend themselves, secure mates for reproduction, regulate body temperature and conserve water.

Feeding adaptation of birds and insects

The beaks of birds are adapted to their individual speciesâ€™ diets. Fig. 9.2 shows the beaks of some birds, while Table 9.1 shows the beaks of some birds and the food they eat.

The feet of birds (Fig. 9.3) are also adapted to their modes of life. Each foot has four toes. In most birds, three toes point forwards, and one backwards so they can hold supports firmly when perching. Parrots and wood peckers have two toes pointing backwards

The domestic fowl has blunt claws used for scratching the ground for food. Ducks and herons have webbed feet used as paddles during swimming which also enable them walk on water without sinking. The ostrichâ€™s large feet with long toes enable it maintain its balance when walking and run at great speed. Eagles, hawks, kites and owls have long, curved, sharp claws with which they catch and hold their preys.

Table 9.1 Birdsâ€™ beak structure and feeding habits.

Birds	**Structure of Beak**	**Food Eaten**
Eagle, falcon, hawk, kite	Hooked, sharp beak used to kill preys and tear off flesh	Flesh
Heron	Long, strong, pointed beak	Fish
Humming bird	Long beak and tubular-tipped tongue	Nectar from flowers
Swallow	Short beak held wide open	Insects caugh in flight
Weaver bird	Short, cone-shaped beak	Seeds
Woodpecker	Long, narrow, pointed beak	Insects in tree bark

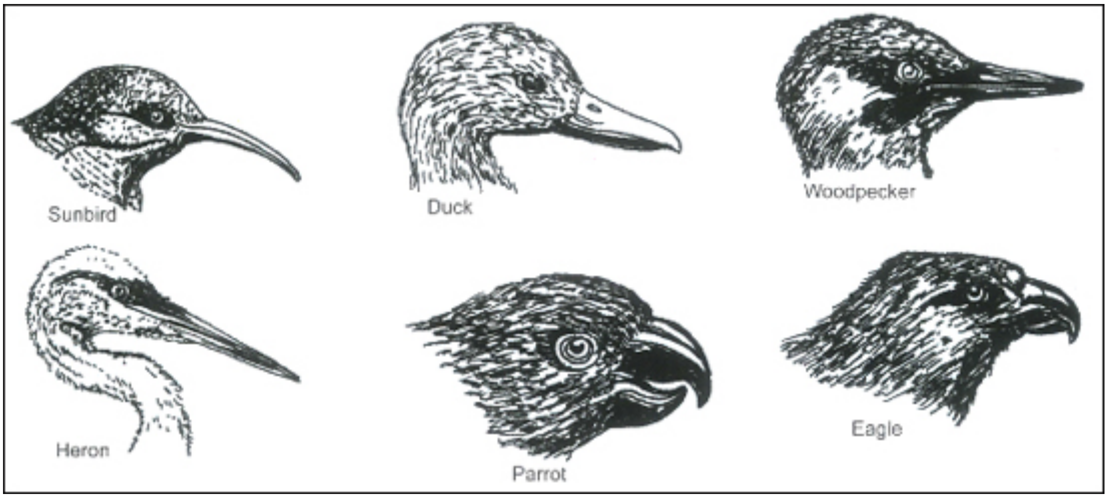

Fig. 9.2 Different beaks of birds.

The adaptations shown by some insects for feeding are shown in Table 9.2 and Fig. 9.4 shows the head and mouth parts of a female mosquito in relation to its feeding habits.

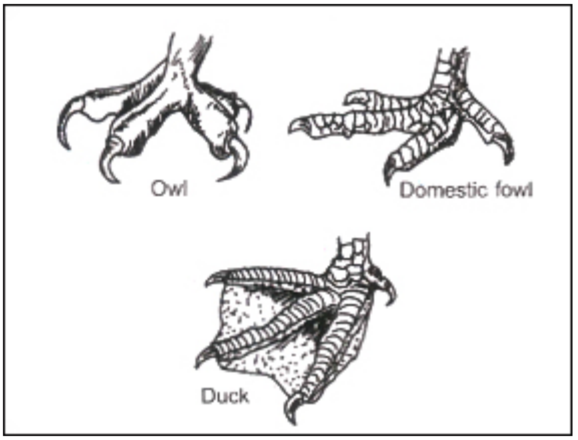

Fig. 9.3 Adaptation of some birdsâ€™ feet

Table 9.2 Feeding adaptations of some insects

Insects	*Feeding Organ*	*Feeding habit*	*Use of mouth parts*
1. Ants	Mandible and maxillae	Some carnivorous many herbivorous	Biting
2. Beetles	Mandible	Many are herbivorous, some carnivorous (e.g. ladybirds)	Biting and chewing
3. Cockroaches	Mandible and maxillae	Omnivorous	Biting and chewing
4. Grasshoppers	Mandible and maxillae	Herbivorous	Biting and chewing
5. Mantids	Mandible and maxillae	Carnivorous	Biting and chewing
6. Termites	Mandible and maxillae	Herbivorous (eat plant materials)	Biting and chewing
7. Butterflies and moths	Caterpillars use mandibles Adults use Proboscis	Herbivorous Fluid feeders (nectar and fruit juices)	Biting and chewing Sucking
8. Flies and mosquitoes	Proboscis	Fluid feeder	Sucking (e.g. housefly) Piercing and sucking (e.g. tsetse-fly, mosquito)
9. Bees	Proboscis	Fluid feeders (i.e. suck nectar)	Sucking
10. Bugs	Proboscis	Fluid feeders (feed on animal and plant juices)	Piercing and sucking
11. Lice	Proboscis	Fluid feeders	Piercing and sucking

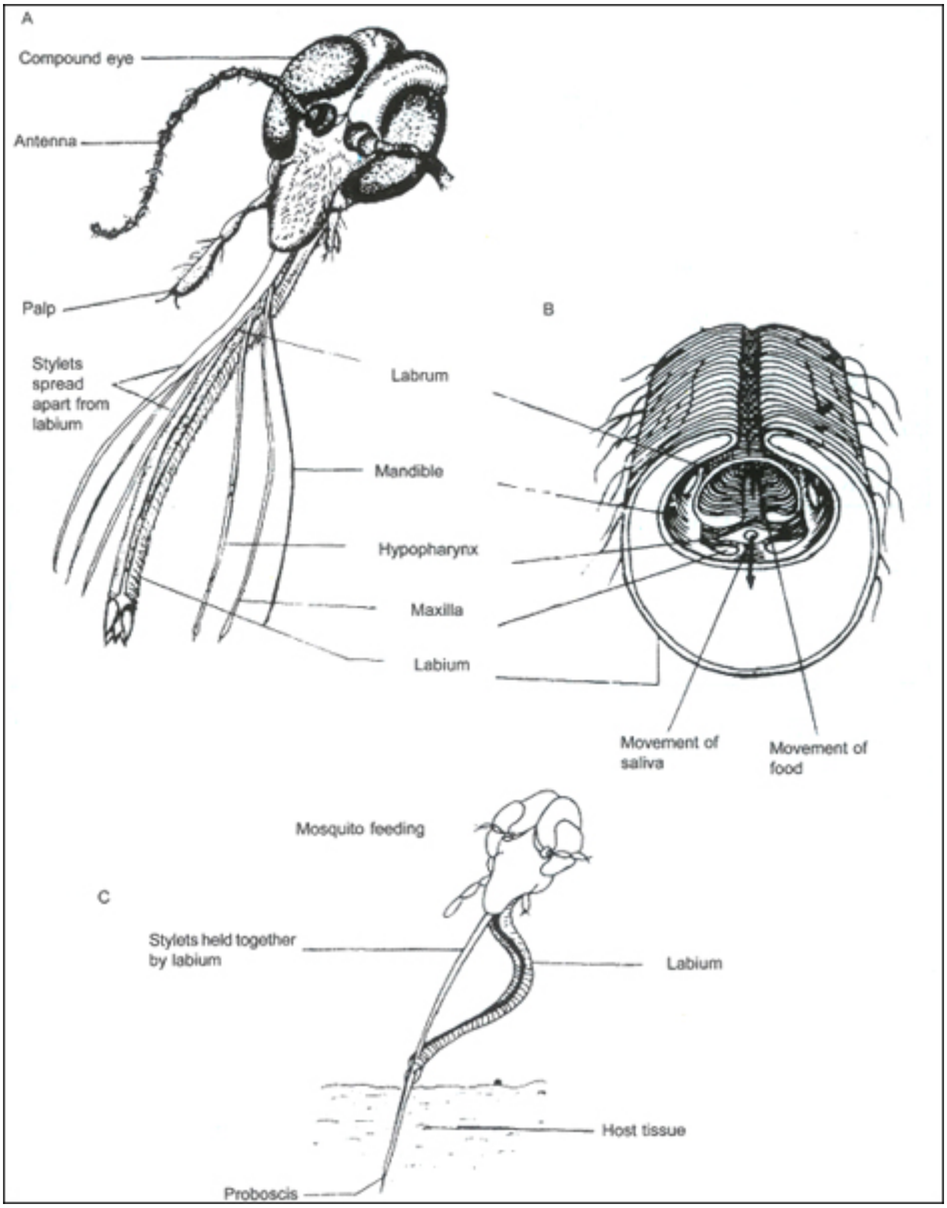

Fig. 9.4 A. Head and mouth parts of female mosquito. B. Section through the mouth parts. C. Feeding position.

The structural adaptations for feeding shown by some insectivorous plants, e.g. the sundew (*Drosera*) and *Utricularia* are discussed in Chapter 4, Book 1. The long neck of the giraffe enables it to feed on tender leaves on tree tops. The nose (trunk) of the elephant is elongated and can reach down to the ground or up to tree tops for plucking food and passing it into the mouth. The *giant anteater (aadvark*) and the scaly ant-eater (pangolin) have long, cylindrical tongues for feeding (Fig. 9.5).

Structural adaptations for protection and defence

The exoskeletons possessed by many organisms protect them from predators and some other unfavourable environmental conditions. These include the hard coverings on crabs, centipedes, millipedes, and armadillos, shells of clams, oysters and snails and the bony plates of tortoises and turtles. Others include the sharp thorns on some plants, e.g. Acacia, or spines on some plants (e.g. *Asparagus*); spines on hedge hogs and porcupines (see Fig. 9.6) and on some grasshoppersâ€™ hind legs. Some mammals (e.g. cattle, deer and buffallo) use horns to defend and protect themselves.

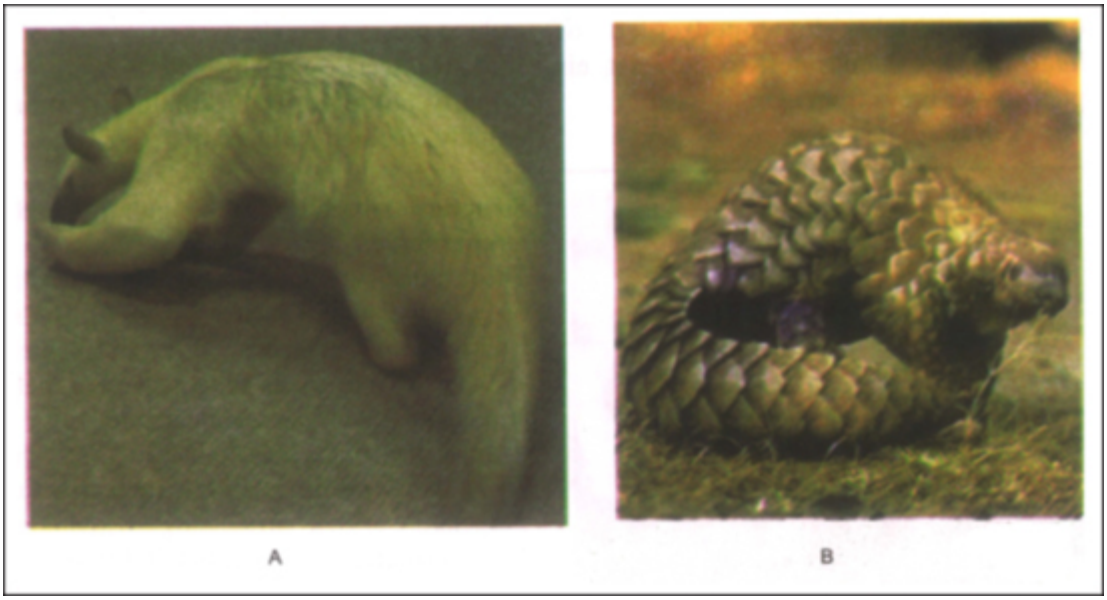

Fig. 9.5 A. Giant anteater and B. Scaly anteater

Many animals defend and protect themselves from large predators with poisonous or toxic secretions when they are attacked. The toad produces a bitter, poisonous fluid from its skin glands when attacked. This toxin makes it unpalatable to some predators. A dog may develop fever and convulsions if it tries to kill a toad. Arthropods, like bees, centipedes, scorpions and wasps use stings to drive off predators and intruders. Similarly, some snakes spray poisonous venoms on their predators.

For attack or defence, many animals bite their preys, predators or intruders with their teeth or mouth parts. Examples are fishes like barracuda and some sharks which can kill humans, sawfish and swordfish. Others are insects like ants, and termites; mammals such as cat, civet, dog, fox, hyena, leopard, lion and some snakes, e.g. vipers.

To catch preys, protect or defend themselves from predators, some animals show a variety of movements. Some fishes swim fast, while the slow-swimming ones, at water bottoms, have colours that blend with their background. Some reptiles and mammals can run fast, while some of them hide in burrows. Many birds, insects and few mammals, e.g. bats and flying squirrels can fly away from predators. These animals possess well-developed, locomotory organs and highly-developed organs of hearing, sight and smell to detect their predators or preys from afar.

Fig. 9.6 The porcupine, Hystrix cristata, with erected sharp quills in a defensive mood.

Structural adaptations for securing mates

Vertebrates use various ways in securing mates for reproduction. Usually, it is the males that look out for females as sexual partners. During the breeding season, the adult male toads and frogs usually croak to attract adult females for mating. The males have nuptial pads on their thumbs with which they hold the females firmly during mating. Many adult male birds usually have beautiful feathers used during courtship displays to attract the dull-coloured adult females for mating (Chapter 5).

The brightly coloured flowers of many plants and the scented, brightly coloured flowers of some plants help in attracting animals to pollinate them. The flower of the orchid looks just like a female bee so that male bees try to mate with it. By so doing, the male bees pollinate the orchid.

The male lizard is bigger than the female. This is called **sexual dimorphism** and it helps the male to secure a female.

Many insects, especially butterflies, are also brightly coloured. The females are more brightly coloured to males.

Structural adaptations for regulating body temperature

The mammalian skin is adapted to regulate the body temperature (Chapter 1 page 6). Birdsâ€™ feathers, the scales on many fishes and reptiles, and the shells of snails and crustaceans, help in regulating their body temperature.

Since lizard are poikilothermic, i.e. their body temperature is determined by the temperature of their surrounding environment. Thus, at sunrise, they come out of their resting places to bask in the sun for some time. This raises their body temperature. When they are warm enough, they start hunting for food. Whenever the body temperature is above 40Â°C, the lizard will spend the day resting in a shade to avoid dying.

Green plants have pigments (e.g. chlorophyll) which reflect large quantity of sunlight that falls on them (e.g. leaves). This prevents their protoplasm from being damaged by excessive heat. Transpiration helps in cooling the body of plants. Plants are naturally **poikilothermic.** This means that their body temperature changes in response to that of their surrounding environments.

Structural adaptations for water conservation

Plants that can live in places with limited water supply are called **xerophytes** and have various adaptations that enable them conserve water. These include:

1. Succulent leaves for storing water (e.g. in *Portulaca* (Fig. 9.7), *Bryophyllum,* and sisal hemp)
2. Succulent stem for storing water (e.g. baobab and *Euphorbia*)
3. Xerophytes reduce the rate of transpiration in various ways. Some have their leaves reduced into spines (e.g. Acacia) or tiny scale leaves (e.g. Casuarina Fig. 9.8). In some, the stomata is sunken into pits while some develop hairy leaves or waxy cuticle on their leaves.

Some plants droop their leaves, e.g. Sahara grass. Others shed their leaves in the dry season to reduce transpiration rate and conserve water (e.g. iroko (*Chlorophora excelsa),* silk cotton, *Terminalia* and Indian almond.

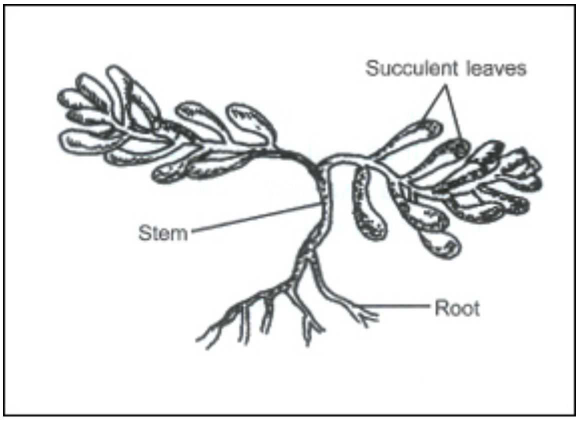

Fig. 9.7 Portulaca with succulent leaves

Convergent adaptation

Quite often, different species that live in the same habitat have similar structural adaptive features which enable them survive. For example, ducks, geese, pelicans and toads have webbed feet for swimming. Some birds, e.g. humming birds have long slender beaks and butterflies have proboscis. Both are used for sucking nectar from flowers. The Aardvark (anteater Fig. 9.5A), Pangolin (scaly anteater Fig. 9.5B) that live in Africa and the spiny anteater living in South America, feed on ants and termites. All these animals have long, cylindrical tongues for feeding.

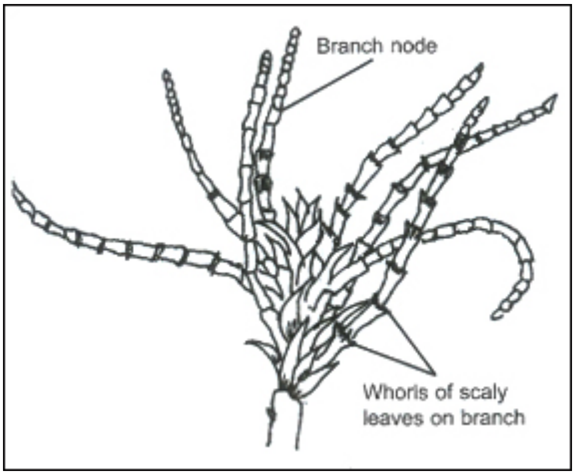

Fig. 9.8 Casuarina (whistling pine) twig with scaly leaves)

Some plants, found in different continents, have very similar structural adaptations. For example, the *Euphorbia* found in Africa are similar to the cacti, found in America. This tendency for unrelated organisms to develop similar adaptive structures for a particular mode of life is called **convergent adaptation.**

Adaptive colourations

To obtain food, escape or hide from enemies and secure mates, many organisms possess attractive colours and special patterns or markings on their bodies. As mentioned earlier, many plants have brightly coloured flowers which attract animals for pollination.

Let us now examine some of the various ways in which the body surface colours (adaptive colourations) of animals enable them to catch their preys, avoid their predators or enemies and ensure their survival.

Warning colouration

Many vertebrate predators very quickly learn to avoid preying, brightly coloured animals, which are usually bitter (unpalatable). Hence, the bright body colouration of many animals is used to warn their predators that they are unpalatable.

Most distasteful insects are brightly coloured and conspicuous, with a contrasting pattern of different coloured bands. Black and yellow or black and red are two common colour combinations. Examples are ladybirds (or beetles see Fig. 9.9), a number of wasps, and most brightly coloured butterflies and grasshoppers. Brightly coloured insects therefore,tend to be avoided by birds. Moreover, some insects that taste nice have similar colourations like the unpalatable ones in order to survive.

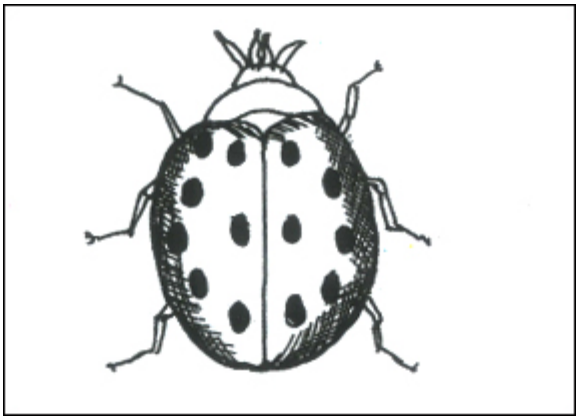

Fig. 9.9 A ladybird (i.e. a beetle)

Mimicry

This is the resemblance of an animal (called a mimic) to another different object (the model) in order to increase its chances of survival. For example, a harmless animal is protected from its predator by resembling (mimicking) a dangerous species with warning colouration. Mimics obtain protection by looking like something else with which they are naturally unrelated.

Fig. 9.10 The African weasel, poecilogale, bears a colour pattern that blends with undergrowth where it dwells

To be successful, the mimic must not just resemble its model, it must also) behave in the same way. For example, whereas most moths are nocturnal, moths that mimick brightly coloured butterflies are diurnal, when their models are always flying about.

Camouflage

Many animals are protected from their predators by the close matching of their body appearance with their surrounding backgrounds. For example, many grasshoppers and praying mantis have a green pigment in their cuticles. This makes it hard for predators like birds, lizards and mammals to see them especially among green vegetation (Figs. 9.11 and 9.12).

Fig. 9.11 A moth camouflaging a dead leaf and blending with its background

Fig. 9.12 A bush cricket is green and resembles a living leaf.

Many of the species of mammals that live in the Sahara Desert have sand-like skin colours like their soil background. In the Rift valley, around Lake Magadi, South-West of Nairobi in Kenya, the big, nocturnal mammals like warthog, wilderbeast and zebra, have pale, sandy colour, like their sand – coloured environment. Normally, these animals have grey or brown skin colouration.

Mating colouration

Some animals possess bright body colourations, which helps in the mating process. This bright colouration attracts the opposite sex for mating. For example, in most birds, the males are always more brightly coloured than females. The males therefore shows off their bright colours to attract the females during the breeding season.

Countershading

In some animals, the upper part of the body has a different colour from the lower part. Such animals are said to be **countershaded.** In most fishes, the dark dorsal colour tends to blend with the dark coloured water, while the light ventral surface blends with the sky colour above them. This protects them from predators looking at them from above or below.

In Fig. 9.13A, a uniformly coloured fish is illuminated from above. It is easily seen since the shadow on the ventral surface contrasts with the brighter, upper one. Fig. 9.13B shows a countershaded fish illuminated from the sides. The dark upper surface contrasts with the lighter, ventral surface so the fish can be seen. Fig. 9.13C shows a countershaded fish illuminated from above. The light, ventral surface reduces the effect of the shadow and the dark dorsal surface reduces the bright reflections observed in Fig. 9.13A. Hence, it is very hard to see the fish.

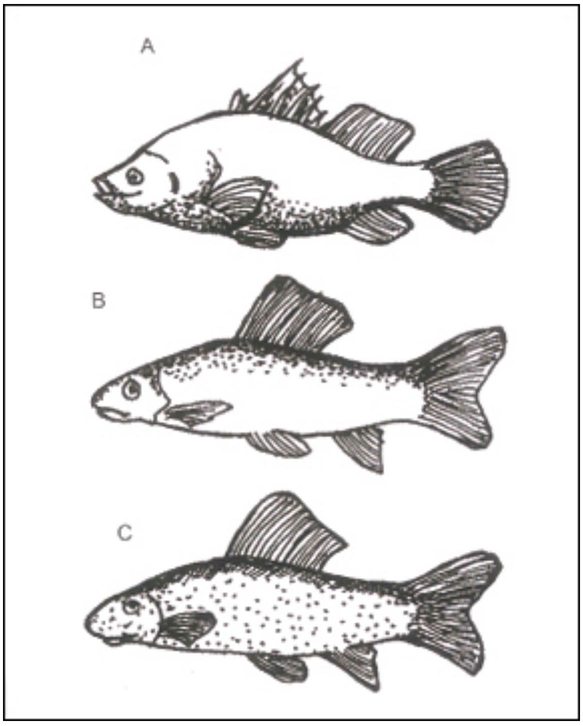

Fig. 9.13 Countershading in a fish

Countershading, which protects preys from predators is found in many animals, such as toad, whose brown skin of the back clearly contrasts with its white belly, and in birds like francolins with light-coloured breast feathers. Countershading is pronounced in swift-swimming fishes whose silvery ventral scales contrast with the darker dorsal ones.

Changing of body colour

Some animals have the ability to change the colours of their body surface or skin as the seasons change. This protects them from predators. In some mantids and grasshoppers, the skin colours change to blend with the changing colour of the grasses. Hence, these animals become green during the rainy season and brown during the dry season. They can even change to black after a fire. The seasonal colour changes are slow.

Many animals can change their skin (body) colours rapidly as they move from one background to another. The most well-known is the chameleon. Others include a number of prawns and shrimps, octopuses and squids, bottom-living fishes, frogs and lizards.

Protective pigmentation

Animal skin colours tend to be light in cold climates and dark in warm climates. Hence, dark-skinned people are found in the tropics.Their skinâ€™s black pigment(melanin) absorbs the sunâ€™s ultraviolet rays thereby protecting them from being sunburnt. A low melanin level is observed in the skin of people living in temperate countries. This is partly due to the fact that sun rays in such countries are not as strong as in tropical countries.

Behavioural adaptation

Behavioural adaptations for protection from predators

(i) Some animals are able to run away from predators. Some feign death so that the predator will not feed on them. For example, millipedes stop movement once touched.

(ii) A toad that is to be preyed upon by the snake swells up so that the snake finds it diffucult to swallow it. Therefore, swelling up is an adaptive behaviour of a frog/toad.

(iii) Some animals sway in the air so that it will be difficult for their predators to catch and feed on them. An example is the bat.

(iv) When some insects are attacked by their predators, they give off some repulsive odour. This drives or irriates their predators and makes preying a difficult task, e.g. bugs. Toads also secrete an irritating secretion.

(v) Some animals retract into their burrows once attacked by a predator, e.g. the earthworm. In a termitarium, the soldiers fight any intruders that want to disturb the hive.

(vi) Some animals can camouflage their form or colour to blend with their environment, to avoid easy detection by predators, for example, chameleon, grasshopper etc.

(vii) Some species of animal flock together in groups called **aggregation** to lunch cooperate attack on their enemies, e.g. foxes, bees etc.

(viii) Some are fortified with defensive structures that help them scare their enemies. For instance, the porcupine shoots out thornlike structures from its body to scare predators; the eels and electric fish

when touched, produce high electric current that shocks their enemies.
(ix) The big size of some animals scares their enemies from approaching them; example, elephants.
(x) Some weak animals have well-developed sense organs to detect any slight change in their environment and can outrun their predators, e.g. ostrich, antelope etc.

Co-operative behaviours among aggregations

1. Alarm pheromones

A member of a group may give an alarm to alert others, so that they can show the normal protective behaviour of the group when danger threatens. Among insects, these warning signals are commonly chemicals. The substances released by one member of a species, which cause changes in the behaviour of other members of the same species, are called **pheromones.** Alarm pheromones are released by social insects like ants, bees, wasps and termites.

The type of behaviour produced by the liberation of an alarm pheromone depends on the particular species. In species living in small colonies, it may cause the members to scatter for shelter or move away from the source of warning.

2. Warning calls.

Many social animals co-operate in protecting themselves from danger by producing warning cries. For example, the baboons and weaver birds give warning cries which cause members of the group to run and fly to safety respectively. The dog may bark to frighten away a foe, while some female birds (e.g. domestic hens) will call their young to themselves when danger threatens. The fries of the mouth-breeding fishes like *Tilapia* will return to their parentsâ€™ mouth when there is danger. When the parent is aware of any danger, it signals the young to return by swimming backwards slowly. The young swim towards any dark object and thus, are usually led to their parentâ€™s mouth.

3. Contact notes

Parents and offspring of birds and mammals produce contact notes of two types. One is the distress call, such as the mew of the kitten, the wail of an infant monkey and a human babyâ€™s cry. The other is the pleasure sound such as the purr of kittens and the laughter of human babies. When the young make distress calls, their parents usually move near them to help and protect them, e.g. rodents, dogs and hens.

Other adaptive behaviours

In order to survive, many organisms show the capacity to change their ways of life when their environmental conditions become unfavourable. Such adaptive behaviours include the following:

Behaviour of organisms as members of a group When organisms live together in a group, they move together at all times. Whatever one of the members of the group does, the others follow suit. Animals that move in group include, the baboons, sheep, chicken and other species of birds.

The effect of grouping in the behaviour of an organism When organisms are in groups, they communicate effectively. For example, when a hen spots food, its loud quacks alert the chicken to come to the food.

In times of danger, an organism may sense danger and emit a special sound which alerts the rest.

Communication is very important among organisms in a group. It also makes reproduction in the group successful. When a female organism is ready to mate, it emits a special sound which draws the attention of the male.

Aestivation This is a method of survival during periods of acute food and water shortage. Aestivation is a situation in which the bodyâ€™s metabolic processes slow down, while the animal remains inactive. Many animals in the tropics survive the dry season by this method. At the start of the dry season, land snails (*Acathina*) settle in hollows in the soil, or under stones and logs of wood. They withdraw into their shells and remain in a state of inactivity (aestivation). Many rodents also aestivate by burrowing under the ground. Earthworms too aestivate in burrows during the dry season.

Hibernation This is the form of aestivation practised by animals in the temperate regions. Many small mammals, e.g. bats, field mice and hedgehogs, hibernate throughout the cold winter to be able to survive the period of great heat loss and high food scarcity. During hibernation, mammals remain inactive and sleep in specially prepared nests. Their metabolic processes are reduced to a minimum. The animals use the fats stored in their body for very slow respiration. At the end of hibernation, the metabolic processes become normal and the animals become active again.

Dormancy Under unfavourable environmental situations, seeds of many plants, spores of bacteria and some plants, and cysts of protozoa, can become inactive (dormant) for a long time. This is usually during periods of drought when food or moisture is very scarce.

During such periods, their rates of metabolic activities are reduced to a minimum. Under favourable conditions however (e.g. when moisture returns), the seeds, spores and cysts can germinate or develop normally.

Migration Many animals tend to travel over long distances to new habitats where conditions are more favourable than in their original habitats. To avoid overcrowding, some animals migrate to new habitats. Many social insects (e.g. bees), migrate to establish new colonies and avoid overcrowding. Many fishes also migrate to reproduce.

Many birds that breed in temperate Asia and Europe spend the winter (September – March) in tropical Africa. Since many of them are insectivorous, their migration could be related to the food supply they obtain readily in the tropics. (See chapter 5).

Encystment Under unfavourable conditions, some organisms, e.g. protozoans like *Amoeba* and *Euglena* form protective coverings called cysts round themselves. They remain dormant inside the cyst until favourable conditions return to their habitat. Then, they become active again.

Social animals

Animals that live together in groups that are highly organised are called social animals. These include social insects like ants, bees, termites and wasps, and mammals like gorillas, baboons, elephants and humans.

Social insects live in colonies or communities which have the following features:

1. There are distinct individuals or castes, i.e., workers, soldiers, queens and kings performing different functions.
2. The reproductive activity is restricted to one female (the queen) and a male (the king).
3. There is strict control over the production of the reproductive (the future queen and king), workers and soldiers.
4. There is a highly organized division of labour as in human societies. The members of the colony are specialized in performing different functions and each individual is dependent upon the others.

Termites

Termites are very common throughout the tropical world. They live commonly in nests either in underground tunnels or above the ground in nests or mounds called **termitaria** (sing:- termitarium). Termitaria, which may be as high as 8m, are built by the workers from soil particles cemented together using clay and saliva. Some live in tunnels and chamber built inside wood-work or dead trees.

Termites feed mainly on cellulose. As a result, they damage wooden materials, crops and young trees. However, they help in maintaining soil fertility by breaking down dead trees into humus, improving soil drainage and aeration through their channels. In some countries, flying termites are eaten as a source of fat and protein.

Castes

The colony of the commonest African termites called **macrotemes** contains thousands of termites comprising a **queen,** a **king, soldiers** (about 5%), **workers** and **nymphs.** (Fig. 9.14).

The **queen** and **king** are the only members of the colony that produce eggs. Each has two compound eyes. For a brief period, they bear a pair of transparent wings. The queen and king at this period, and a few fertile males and females (potential kings and queens) are called winged reproductives. A fully developed queen may be about 9cm long.

The workers are sterile females.They have no eyes and their exoskeleton is soft and pale throughout life. They have well-developed mouthparts. They build the mound, search for food, tend the fungal gardens, collect eggs and take care of the nymphs. They also feed the other members of the colony on regurgitated, partially digested food.

The soldiers are the blind wingless males with sterile reproductive organs, large heads, thick exoskeleton and huge mandibles. Their main tasks are to protect the colony from invaders and protect the workers while they are gathering food.

Nests of termites in West Africa are commonly attacked by driver-ants, giant anteaters (aadvarks) and pangolins (scaly anteaters). Nests destroyed or damaged are repaired very quickly.

Bees

Honey bees are social insects, which like ants, hornets and wasps, belong to the same group called **hymenoptera.** A colony of honey bees live in a hive made up of thousands of hexagonal cells composed of wax.

There are two types of cells: one is used for the developing larvae and the other for the storage of honey and pollen.

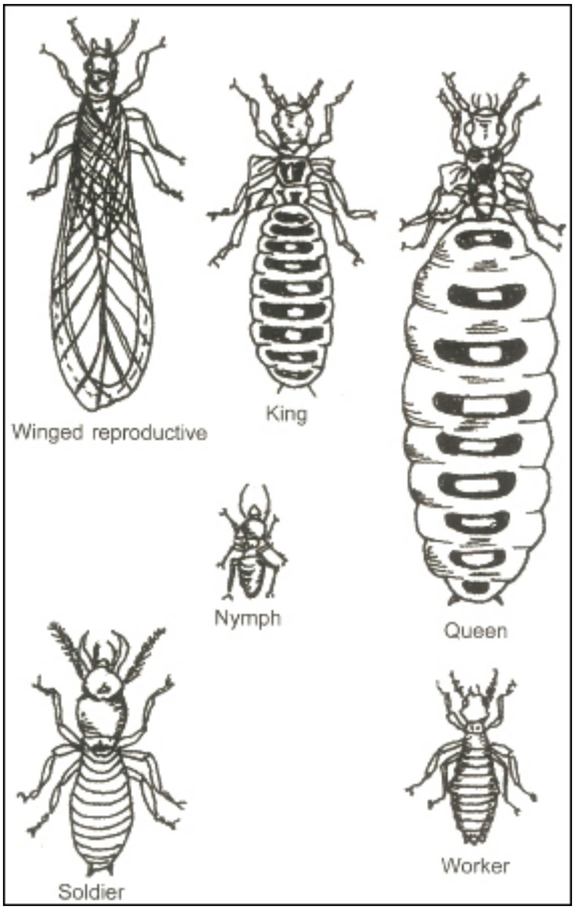

Fig. 9.14 Termite castes

Honey bees are reared in artificial hives by humans for their honey which is used as food (as a source of sugar). Bees pollinate the flowers of many cultivated plants, e.g. citrus trees, beans, peas, guavas, gourds, melons and peppers.

Castes

There are three types of individuals or castes in the bee hive namely: the queen – a fertile female; the drones-the fertile males; and the workers the sterile females. Thus, a queen, a few hundred drones and thousands of workers live in a bee hive (see Fig. 9.15).

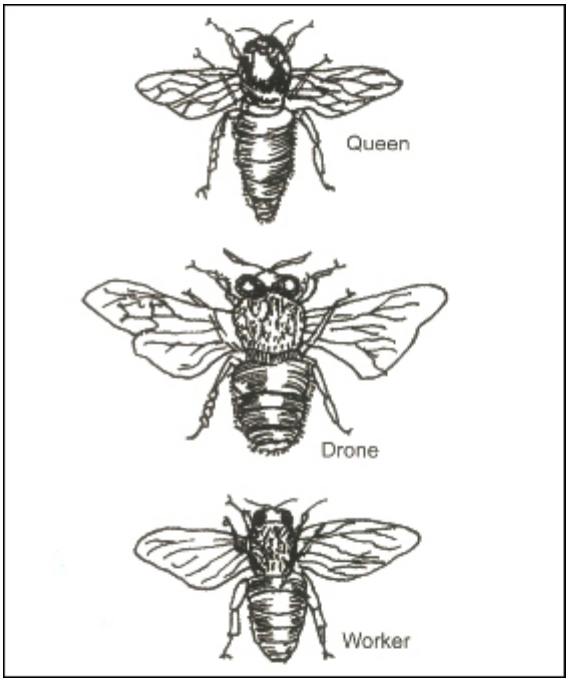

Fig. 9.15 Honey bee castes

The **queen** which is about 1.7cm in length is a fertile female. It has a larger abdomen than the worker but shorter wings. Her mouth parts are poorly developed, while her legs lack pollen baskets and brushes. It has a sting which is unbarbed and, hence, can be used continuously.

The **drone** is a winged fertile male with a stout body and poorly developed mouth part. It lacks pollen baskets and a sting. Only one of the drones fertilizes the queen during her nuptial flight.

The **worker** is a small sterile female. Its head bears two compound eyes and three pairs of simple eyes. The mouth parts, modified for sucking nectar and cell construction, consists of the proboscis (composed of the labium and maxillae and the mandibles. The proboscis is used for sucking nectar, while the blunt mandibles are used for collecting pollen grains and moulding wax into cells. The head also bears a pair of antennae and many olfactory pits.

The workers have two pairs of well-developed wings for flight and three pairs of legs. Each leg ends in two movable claws with a sticky pad between them. The claws enable the bee to climb and cling firmly to objects, while the sticky pad enables it walk on slippery surfaces.

Between the tibia and tarsus of each first or fore-leg is a semi-circular depression bearing a comb of stiff hairs. The comb is used for cleaning the pollen off the body. On the tibia of each second leg, is a seta called prong which is used for picking up wax and digging the pollen out of the pollen basket.

On each third or hind leg is the pollen basket. This is a deeply grooved structure with short bristles along the edges of the groove. Just below the pollen brush, on the outer surface, is pollen comb made of rows of stiff hairs on the inner surface. The basket is used to store pollen grains, while the brush on one leg is used to clean the pollen from the hairs of the body into the basket on the other leg. (see Fig.

9.16).

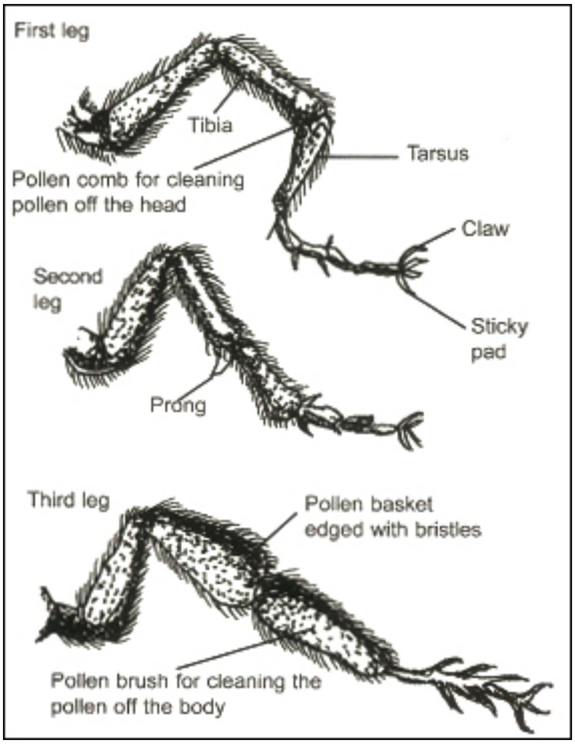

Fig. 9.16 A worker bees legs

The ovipositor at the tip of the workerâ€™s abdomen is modified into a barbed sting. Hence, the worker usually dies after stinging an animal since its abdominal organs are forced out as it tries to free itself.

When a honey bee finds a rich source of nectar or pollen grains, it dances onto the comb on her return to the hive. Other bees join in and exchange food with it. This gives them the taste and smell of the food it has found. If the food is within about 100m of the hive, the bee does a round dance. If the food is farther than 100m, the worker does a waggle dance. The faster the worker dances, the nearer the food. This means of communication is unique among the honey bees.

Wolves

Wolves are temperate animals found in Canada, the Northern states of the USA, and in Northern Europe. Wolves belong to the genus, *Canis.* Wolves are social animals because they live and hunt in packs. That is why we say â€œpack of wolvesâ€. A pack of wolves contain about two to ten wolves. During hunting, a dominant male leads the way, and stands in defence of the pack. If any other male from another pack threatens to enter into their pack, it is the dominant male that will attack it, thus this makes all the other males in the pack to be submissive to it. There is also a dominant female which behaves in the same manner as the dominant male.

Behaviours exhibited by the dominant male in a pack to make other males submissive include wrinkling of the brows, fixing stares at them, barring of teeth, raising of ears. The other males show submissiveness by lowering their heads and tails, and flattening their ears.

During territorial defence, all the wolves in the packs begin to howl at different pitches and can be heard at a great distance. This tells the intruding pack how many wolves there are in the pack and also, the area they are controlling. An average size of a wolf territory is about 120 km^2.

Theories of evolution

We have seen that adaptation is the process by which organisms change their structure, physiology and behaviour in order to survive. This has led to diversity in form, structure and function among organisms. The theory of evolution is an attempt to explain how this diversity has taken place.

Lamarckâ€™s Theory

Jean Lamarck (1744 – 1829), a French zoologist, was the first biologist to suggest that organisms undergo evolution. He propounded his theory of evolution in 1801.

According to Lamarck, organisms develop specialized characteristics by the use or disuse of organs. Frequently used organs will become well developed, while the ones not used will degenerate and become useless. For example, the long neck of giraffe arose from a need to browse on tree tops. Since this was a useful adaptation, subsequent generations of giraffe have been inheriting this acquired character. A wading bird might develop long legs by stretching. Its offsprings would inherit the long legs.

Although the inheritance of acquired characteristics seems to be logical, no evidence has been found to support this view. As you must have learnt, genetic material is contained in the chromosomes. Except for rare mutations, genetic information is passed on unchanged from generation to generation. If acquired characteristics could be inherited, then the children of concert pianists would be born with the knowledge of how to play the piano. As you know this is not the case. Acquired skills are usually developed anew in each generation.

Darwinâ€™s Theory

About 50 years after Lamarck proposed his theory of evolution, the British naturalist, Charles Darwin, revolutionised the thinking of most biologists. In 1859, Darwin published a book called the *Origin of Species by Means of Natural Selection.* Like Lamarck, Darwin stated that living things gradually evolve adaptations to the environment. However, Darwin proposed an entirely different mechanism to account for the changes in species. Unlike Lamarck, Darwin recognised the variations among members of a species. It is these variations rather than the acquired characteristics that aid natural selection. Darwinâ€™s theory of natural selection can be summarized as follows:

1. Species have the ability to produce a large numbers of offsprings.
2. The resources of the natural world are limited.
3. Therefore, there must be competition for survival among the offsprings in each generation.
4. There is great variability within the population of organisms. No two individuals are the same. Much of these varieties are inherited.
5. The organisms that survive and produce offsprings are those that have inherited the most beneficial traits for surviving in a particular environment.
6. As this process continues through many generations, the population gradually becomes better adapted to the environment. Modern genetic research supports Darwinâ€™s theory.

Both Lamarck and Darwin recognized the importance of the environment in evolution. Many biologists generally accept that it is by natural selection of the better adapted organisms by chance and the elimination of the much less adapted ones that evolution or change occurs. However, while Darwin recognized that organisms vary, he had no idea of why they vary. This became better understood through the works of Gregor Mendel, and modern discoveries in genetics resulting in the modern theories of evolution.

MODERN THEORIES OF EVOLUTION

Mutation theory of evolution

In 1901, Hugo de Vries, a Dutch botanist, presented his, **mutation theory of evolution.** He based his theory on many years of work with primrose plants. Of the 50,000 plants, about 800 showed spectacular new traits not present in the parent plants. Yet, these new traits were passed on to the offsprings of the plants in which mutation had occurred. De Vries concluded that mutations must occur often in other organisms too, and that the change by mutation was the basis of evolution.

Modern genetic studies have made it possible to confirm that mutations (changes in genes and chromosomes) in gametes produce new species. Mutations have been found in every kind of plant and animal studied by geneticists. It has also been confirmed that chromosomal mutations, though occur less often than gene mutations, result in larger and better adapted plants. Today, many biologists believe that mutations contribute significantly to evolution.

Evolution is believed to occur when new species of organisms are formed. Other ways, besides mutations, in which evolution is believed to occur in modern times include **isolation** and the **migration** of a population to different environments.

Formation of new species by isolation

Normally, when members of the same species mate, their offsprings tend to resemble members of the species because the genes (see chapter 10) of the species are distinct and similar. However, if members of a species become isolated or separated into two or more populations for a long period, their genes may change to the extent that they can no longer interbreed. At this stage, the two populations have produced new species. Even if they interbreed, their offsprings may be infertile. Continued isolation thus enables different populations of the same species to form new species completely different from the original species. This is evolution in action.

Members of species are isolated by natural barriers like deserts, mountains, oceans, lakes and rivers. Organisms may be separated by having a preference for slightly different habitats or by breeding at different times.

Evidence of evolution

Darwinâ€™s book, *The Origin of Species,* contained a great deal of indirect evidence to show that evolution had occurred. For example, Darwin used evidence from the fossil records to show that different forms of life once existed on earth. Because evolution occurs over long periods of time, it is very difficult to observe visibly. Since Darwinâ€™s time, biologists have amassed a huge amount of information to support his theory of evolution.

Evidence from fossil records

Fossils are found mostly in sedentary rocks. The oldest fossil-bearing rocks contained the lower animals, mainly invertebrates. This is followed by fishes, amphibians, reptiles and birds in the more recent fossil-bearing rocks. From this point, we can trace lifeâ€™s development in greater detail.

Evidence from anatomical features and structure

There are evidences of evolution in certain anatomical features of vertebrates. There is a progressive evolutionary change in the anatomy of the heart in the various classes of vertebrates (Fig. 9.17). Fishes have a simple heart with one auricle and one ventricle, reptiles two auricles and a partially divided ventricle, and birds and mammals have two auricles and two ventricles. In the course of these changes, the circulation of blood also changed from a single to a double circulation

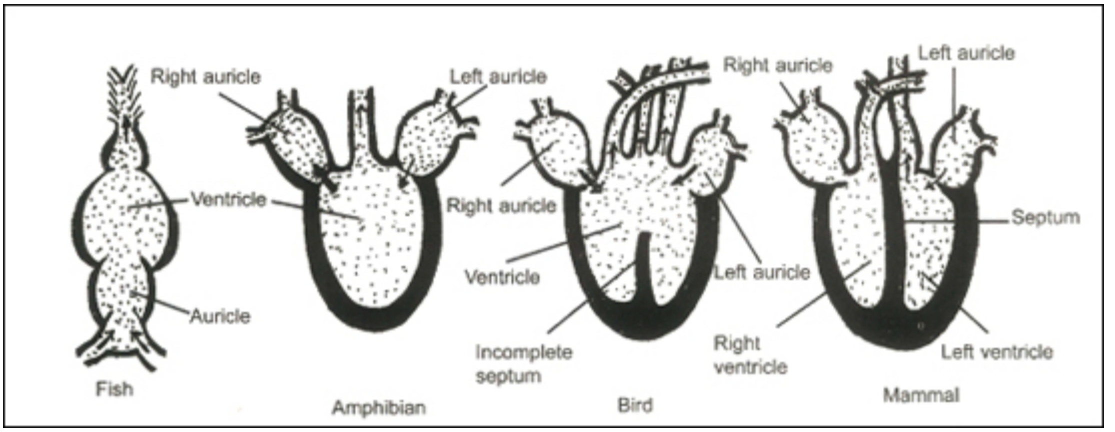

Fig. 9.17 Progressive evolutionary changes in the anatomy of the vertebrate heart

The limbs of various vertebrates have been modified for different functions like

(i) wings for flying in birds and bats.

(ii) flippers for swimming in whales.

(iii) legs for walking and running in horses.

(iv) arms for grasping and holding in human beings and other bipeds.

The fact that these various types of limbs have the same basic pentadactyl structure indicates that all these animals come from a common ancestor. (Fig. 9.18)

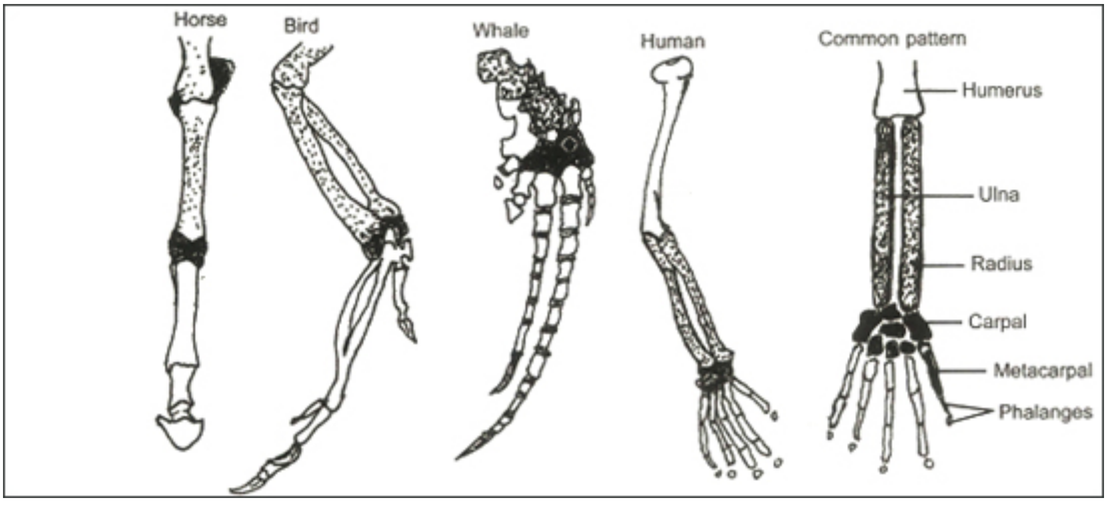

Fig. 9.18 Adaptive modifications of pentadactyl forelimb in vertebrates

Evidence from vestigial organs

The presence of vestigial organs helps to explain evolution. Vestigial organs are small or incomplete organs that have no apparent function. According to evolutionary theory, vestigial organs are the remaining parts of once-functioning organs. The muscles of the ear usually have more vestiges in man unlike those found in the horse. The reason is this: should a noise come from one side, man is able to move his neck quickly, while the horse cannot turn its neck so easily but instead twists back its ears to catch the sound.

Evidence from embryology

When comparing the development of closely related organisms, it is often difficult to tell the early stages of one species from the early stages of another. The similarity of organisms is often used as evidence of evolution. If two organisms descended from a common ancestor, they may still have developmental stages that are very similar (Fig. 9.19).

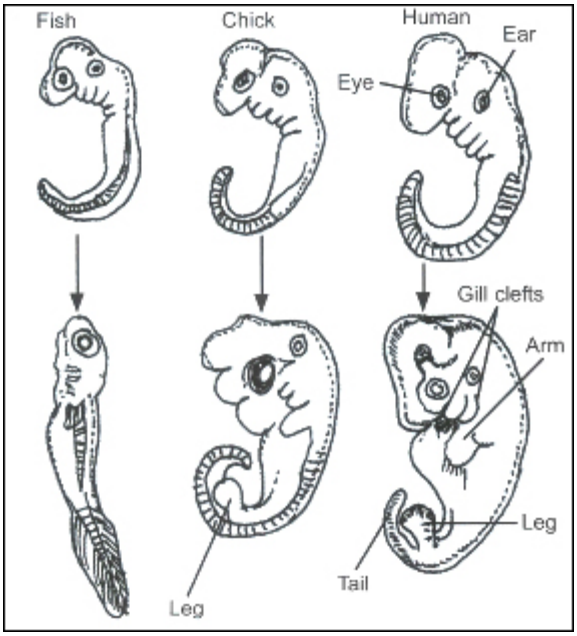

Fig. 9.19 Similarities in some vertebrate Embryos

Evidence from biochemistry and genetics

Modern genetics also provides evidence of evolution. All organisms use the same genetic code to synthesise proteins. A universal genetic code is consistent with the idea that all organisms evolved from a single organism that used the code.

Biochemists have compared the amino acid sequences of proteins found in different organisms. Organisms that are closely related often have proteins with similar amino acid sequences. In disimilar organisms, the amino acid sequences of proteins show many more differences.

The evolutionary trend in plants and animals such as from simple to complex structural adaptation and from aquatic to terrestrial is illustrated in the classification done in Chapter 1 of Book 1.

Suggested Practicals

1. *Observation of fish*

   (a) Examine a fish in an aquarium

   (b) List the special structures you can observe that enable it live in water.

2. *Observation of chameleon*

(a) You will be provided with a chameleon

(b) Observe and record its reactions to green, brown and white colour backgrounds.

Summary

1. Organisms are adapted to their environment in order to survive.
2. Competition is an important limiting factor to survival.
3. Factors that bring about competition include limited supplies of food, space, water, light and mates.
4. The two kinds of competition are interspecies and intraspecies competition.
5. Competition brings about succession in an environment.
6. Structural adaptations are developed in response to environmental changes and function.
7. Organisms show many structural adaptations for obtaining food, for protection, defence, reproduction, regulation of temperature, and water conservation.
8. Organisms possess various adaptive colourations to suit different factors of the environment like, obtaining food, escaping from enemies, and securing mates.
9. In many organisms, co-operative behaviour is common among individuals in the group. The members of the group often evolve means of transmitting information among themselves.
10. The theories of evolution have attempted to explain the numerous similarities and diversities in form, structure and behaviour of organisms.
11. Evidences of evolution include those from anatomical features, embryology, biochemistry, genetics and fossil records.
12. Among the modern theories of evolution are the *Mutation theory* and *Isolation theory.*

Objective Questions

1. Which of the following people proposed the theory of acquired characteristics?
   - A. De Vries.
   - B. Lamarck.
   - C. Darwin.
   - D. Leuwenhoek.
   - E. Wallace.
2. Which of the following lines of enquiry is not generally used to provide evidence to support the scientific theory of evolution?
   - A. Analysis of fossil records.

B. Analysis of mutation.
C. Comparative embryology.
D. Comparative anatomy.
E. Analysis of vestigial organs.

3. The possession of thick and succulent stems by plants growing in dry conditions is an adaptation for
   A. the reduction of photosynthesis.
   B. water conservation.
   C. an increase in the transpiratory surface.
   D. exposing the axillary buds to more light.
   E. reducing the production of branches.
4. Which of the following is a social insect?
   A. Butterfly.
   B. Housefly.
   C. Mosquito.
   D. Honey bee.
   E. Cockroach.
5. The chemical contained in a dogâ€™s urine which enables other dogs to show that a territory has been occupied is called
   A. thyroxin.
   B. pheromone.
   C. adrenalin.
   D. auxin.
   E. insulin.

Essay Questions

1. (a) What is the importance of competition to organisms?
   (b) Explain what is meant by interspecific and intraspecific competition giving an example in each case.
   (c) Describe how competition leads to the phenomenon of succession.
2. (a) Discuss how three named animals are adapted for
   (i) feeding.
   (ii) protection and defence.
   (iii) securing mates for reproduction.
   (iv) regulation of body temperature.
3. (a) Describe with relevant examples, five types of adaptive colouration shown by organisms.
   (b) Describe briefly the various castes of the honey bee and show their behavioural adaptation to their social life.

4. (a) Discuss the contributions of Lamarck and Darwin to evolution.

(b) Outline five evidences you could use to convince your friend that evolution is a continuous process.

(c) Explain two of the modern theories of evolution.