Behaviour

Unit 5

Contents

5.1 An introduction to behaviour

By the end of this section you should be able to:

- Explain what is meant by the term behaviour and describe its types.
- Explain the importance of studying behaviour.

Activity 5.1

Before you study this chapter, work in small groups and brainstorm what you think is meant by the term behaviour. How would you define behaviour? What examples of animal behaviour can you think of? Keep your brainstorm and look back at it when you have completed this chapter.

What is behaviour?

Behaviour can be defined in a number of ways, depending on your perspective, or viewpoint. We very often use the term in a 'social' context and speak of 'bad behaviour' or 'good behaviour'. Some definitions of behaviour are listed below.

DID YOU KNOW?

A stimulus is a change in the external or internal environment of an organism.

KEY WORDS

receptor *a cell or group of cells that receives and processes stimuli*

effector *any part of an organism that produces a response*

phototropism *the tendency for parts of plants to grow towards light (positive phototropism) or away from light (negative phototropism).*

auxin *a hormone that helps to produce the phototropic response*

- The observable response a person makes to any situation.
- A manner of acting or conducting yourself.
- The way a person behaves towards other people.
- The actions or reactions of a person or animal in response to external or internal stimuli.
- The responses or reactions or movements made by an organism in any situation.

However, from a biological viewpoint, none of these is quite complete. The last two come the closest, but a still better definition would be:

The co-ordinated response of an organism to an internal or external stimulus.

For an organism to show a co-ordinated response, then any behaviour must have these components:

- a **receptor** of some kind to detect the stimulus
- an **effector** of some kind to produce the response, and
- some kind of linking system or co-ordinating system that is influenced by the receptor and can influence the effector.

This is represented diagrammatically in figure 5.1.

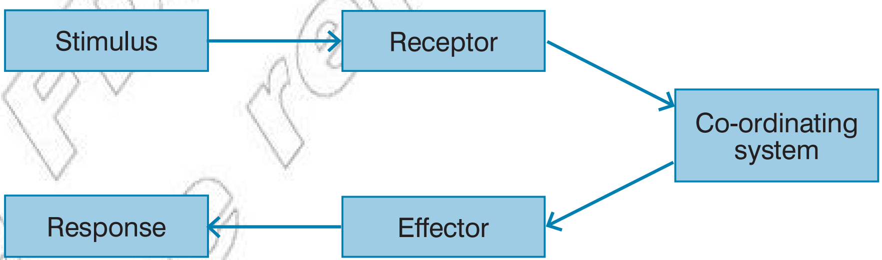


Figure 5.1 *A generalised model of the components of behaviour*

We can now apply this model to specific behaviours in both animals and plants.

How do plants respond to unidirectional stimuli?

Everyone has noticed that if you put a plant on a windowsill (where the intensity of the light will be greater on the window side than on the other side), the plant shoots grow towards the window. They grow towards the greater light intensity. This behaviour is called **phototropism**. Plant shoots are positively phototropic because they grow towards light. The response is even more marked in young seedlings.

Figure 5.2 *Plant stems grow towards the area of greatest light intensity*

The benefit in plant stems growing towards the greatest intensity of light is that stems automatically direct their leaves in this direction as well. This means that the chlorophyll and other pigments in the leaf cells can absorb the maximum amount of light for photosynthesis.

This response is co-ordinated by plant growth substances called **auxins**. These are produced in the shoot tip in response to light and move downwards and away from light to the 'dark' side of the shoot. The auxins stimulate the shoot cells to divide and enlarge, so growth is greatest on the side away from the light. As this side grows more, it causes the shoot to bend towards the light. Figure 5.3 shows how this fits our general model of behaviour.

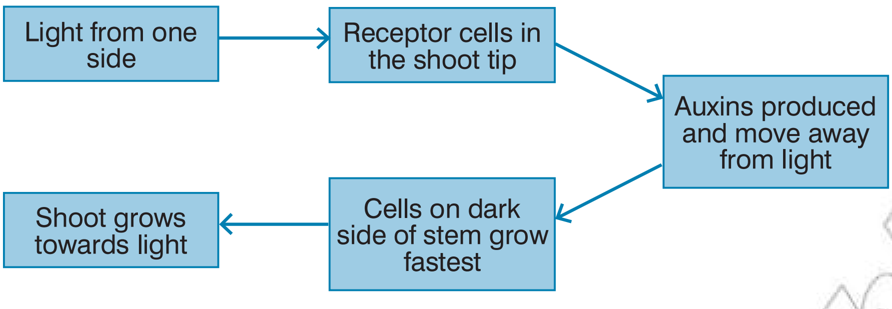


Figure 5.3 *Phototropism in plant shoots*

Everyone also knows that plant stems grow upwards and roots grow more or less downwards. The unidirectional stimulus producing this response is gravity. The response by plants to gravity is called gravitropism. Plant roots are positively gravitropic, because they grow towards gravity; plant shoots are negatively gravitropic, because they grow away from gravity. This means that the roots will grow towards an environment in which they can anchor the plant, absorb water and absorb mineral ions.

How do simple animals respond to stimuli?

Just as some plant responses serve to maintain the plant in a favourable environment, some responses of simple animals do the same. Two different types of responses in simple organisms are given below.

- **Taxes** (singular **taxis**), in which the animal moves along a gradient of intensity of a stimulus towards the greatest intensity of the stimulus (a positive taxis) and sometimes away from the greatest intensity (a negative taxis); there is a directional response to a directional stimulus. For example, the unicellular protoctistan *Euglena* swims (using its flagellum) towards areas of increased light intensity. This is positive phototaxis and allows the organism to photosynthesise efficiently.
- **Kineses** (singular **kinesis**), in which a change in the intensity of the stimulus brings about a change in the rate of movement, not a change in the direction of movement. For example, woodlice increase their rate of movement in bright light. This increases the probability that they will move into a dark area, where it is usually more humid and they will lose less water.

How do woodlice respond to a change in the intensity of light?

Woodlice are small land-dwelling crustaceans. There are many different species, but all are quite similar. Because of their flattened shape and small size, they have a relatively large surface-area-to-volume ratio. This means that they tend to lose water quickly

Activity 5.2

In people, reflexes are the simplest form of behaviour. List as many simple human reflexes as you can. Plan an investigation into the speed of one of these reflexes.

through their body surface. This happens quickly because they have no waxy cuticle covering their bodies to limit loss of water. They are typically found under logs, stones, bark and amongst leaf litter. These areas all have a more humid atmosphere, which reduces the rate of water loss from the woodlice. They are all also dark areas.

When brought into the light, the woodlice start to move around much more quickly. This increased rate of movement is a response to the increased intensity of light – it is a kinesis. Figure 5.4 shows how this behaviour fits the general model.

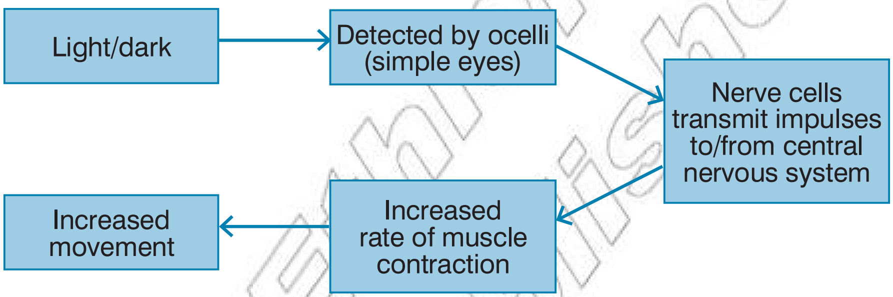


***Figure 5.4** The response of woodlice to light*

Activity 5.3: Investigating behaviour in woodlice

The responses of woodlice can be investigated using a choice chamber. A simple choice chamber can be constructed from plastic Petri dishes and perforated zinc gauze to make a floor. The edges of the chamber should be sealed to the zinc floor using Plasticine.

By covering one area of the choice chamber to make it dark and leaving the other area uncovered, the choice chamber can be used to test the preferences of woodlice for light/dark.

- Place 20 woodlice in the choice chamber; 10 in each half of the chamber.
- Cover one area of the choice chamber with black polythene or other opaque material.
- Record the numbers of woodlice in each of the two areas every minute for 10 minutes.

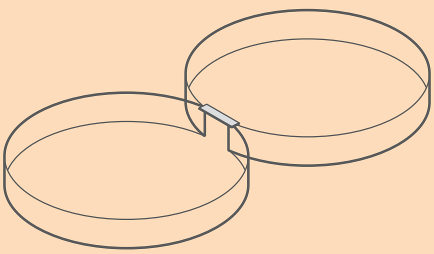


***Figure 5.5** A simple choice chamber*

Alternatively the areas of the choice chamber could be arranged to have humid or dry atmospheres. This can be done by placing wet filter paper under the gauze in one half and anhydrous calcium chloride (to absorb water vapour in the air) under the gauze in the other half. Then we can proceed as with the light/dark investigation.

However, because we can *see* both areas in this investigation, we can make an assessment of the kinetic response of woodlice. To do this, we need also to mark the surface of the choice chamber with a grid of squares 1 cm by 1 cm. Then, we can place a woodlouse in each side of the chamber and:

- count the number of squares the woodlouse covers in a 10-minute period (this is a measure of the total movement of the woodlouse)
- count the number of turns made by the woodlouse (this is a measure of how frequently the woodlouse changes direction), and
- repeat the experiments with other woodlice to obtain an average.

The increased movement makes it more likely that the woodlice will, quite by chance, move into dark, humid conditions once more. Once they do, their rate of movement decreases again, making it more likely that they will remain in these more favourable conditions.

Why is it important to study behaviour?

So far, we have considered behaviour in its widest possible sense, to include the responses of all organisms. For the rest of the unit, we shall confine ourselves to the study of animal behaviour, including human behaviour. So, why study animal behaviour? The study of animal behaviour is often called ethology and the biologists who work in this field are known as ethologists.

Studying animal behaviour is important in its own right as a field of scientific knowledge, just as is subatomic physics. But studying animal behaviour has made many contributions to other areas of science, in particular to the study of human behaviour, but also including:

- **neuroscience**
- the environment and resource management
- animal welfare
- science education

The impact of the study of animal behaviour on human society

Many problems in human society can be related to the interaction of environment and behaviour, or genetics and behaviour. Social scientists often now turn to animal behaviour as a basis for interpreting human society and understanding possible causes of problems in society. Specific examples include:

- Research by de Waal on chimpanzees and monkeys has illustrated the importance of co-operation and reconciliation in social groups. This work has implications for aggressive behaviour among human beings.
- Harlow's work on social development in rhesus monkeys has been of major importance to theories of child development and attachment formation.
- Basic research on circadian and other endogenous rhythms in animals has led on to research relevant to humans in areas such as coping with jet-lag or shift-working.

The impact of the study of animal behaviour on neuroscience

Specific examples of this include:

- **neuroethology**: carefully collected behavioural data allows neurobiologists to focus their studies on specific stimuli and specific responses to determine **neural pathways**
- recent work in animal behaviour has demonstrated the influence

KEY WORDS

neuroscience *the branch of science concerned with the brain and the nervous system*

neuroethology *the study of how behaviour is linked to neural pathways*

neural pathway *a sequence of nerve cells involved in bringing about a specific behaviour*

More about Harlow's rhesus monkeys

In a famous experiment with rhesus monkeys, Harry Harlow investigated whether food or comfort was more important in forming attachments. Infant monkeys were offered the choice of a wire 'mother' that gave milk or a fur-covered 'mother' that gave no milk. They chose comfort over food every time. Research in humans triggered by this shows that feeding is not a major stimulus for attachment formation.

Figure 5.6 *One of Harlow's monkeys and its two 'mothers'*

of behaviour and social organisation on physiological and cellular processes. Variations in social environment can inhibit or stimulate ovulation, induce miscarriages and so on; the neural pathways for these effects are being studied

- other animal studies show that the quality of the social environment has a direct effect on immune system functioning. Again, research is currently being undertaken to discover the neural pathways controlling these responses

Activity 5.4: Conserving endangered species

If we are to conserve endangered species, we need to know about natural behaviour patterns, such as:

- migratory patterns
- home range size
- interactions with other groups
- foraging demands
- reproductive behaviour

so that we can build up populations again.

Suggest why a knowledge of each of these might help in conserving an endangered species.

The impact of the study of animal behaviour on management of the environment and resources

The behaviour of animals often provides early clues of environmental damage. Changes in sexual and other behaviour occur much sooner and at lower levels of environmental disruption than changes in population size. Waiting to see if numbers of animal populations are declining may be leaving it too late to take action to save the environment if it is needed.

Specific examples related to resource management include:

- research on how salmon migrate back to their home streams has taught us much about the mechanisms of migration. This has been valuable in preserving the salmon industry in the Pacific Northwest and has also helped in the development of a salmon fishing industry in the Great Lakes of the USA
- knowledge of honeybees' foraging behaviour has given important information about mechanisms of pollination, which in turn has been important for plant breeding and propagation

The impact of the study of animal behaviour on animal welfare

We now place increased emphasis on the welfare of research and exhibit animals. Animal behaviour researchers look at the behaviour and well-being of animals in the lab and in their natural environment. Such research has ensured reasonable and effective standards for the care and well-being of research animals.

Further developments in animal welfare will require information from animal-behaviour researchers. Improved conditions for farm animals, breeding of endangered species and proper care of companion animals all require information about behaviour patterns.

The impact of the study of animal behaviour on science education

In some countries there is a concern about the lack of interest in science and the fact that women and minority groups are under-represented in science. Courses at universities in animal behaviour and behavioural ecology often interest students in behavioural biology.

For many students these courses are a first introduction to behavioural biology and may lead on to wider scientific studies.

Review questions

Choose the correct answer from A to D.

1. The correct sequence of the components of any behaviour is:
   A stimulus – co-ordinating system – receptor – effector – response
   B co-ordinating system – receptor – stimulus – effector – response
   C co-ordinating system – stimulus – receptor – effector – response
   D stimulus – receptor – co-ordinating system – effector – response
2. The best definition of behaviour is:
   A the pattern of responses shown by an animal
   B the pattern of responses shown by an organism
   C the co-ordinated response of an organism to an internal or external stimulus
   D the co-ordinated response of an animal to an internal or external stimulus
3. Examples of behaviour include:
   A the positive phototropism of plant shoots
   B the positive photokinesis of woodlice
   C the negative gravitropism of plant shoots
   D all of the above
4. A response to a stimulus that involves increased movement as the intensity of the stimulus increases is called a:
   A tropism
   B taxis
   C kinesis
   D none of the above
5. Reasons to study animal behaviour include:
   A findings from animal behaviour experiments may help to predict human behaviour
   B understanding animal foraging behaviour can help in conservation
   C it is a valid study in its own right
   D all of the above

5.2 Innate behaviour

By the end of this section you should be able to:

- Explain what is meant by innate behaviour.
- Describe and explain the characteristics of innate behaviour.
- Describe and give examples of different types of innate behaviour.
- Describe reflex behaviour in humans.
- Describe instinctive behaviour in non-human animals.
- Describe and explain biological clocks in non-human animals.

What is innate behaviour?

The word 'innate' literally means 'inborn'. **Innate behaviour** is behaviour that is present (potentially) at birth or hatching. It does not have to be learned. An example of innate behaviour is shown in figure 5.7. The young herring gull 'knows' that if it pecks the orange spot on the beak of the adult gull, it will receive food. It did not have to learn this behaviour.

However, this is not quite the same as saying that the behaviour is coded for directly in the genes. There is not a gene that 'directly' codes for 'pecking mother's beak'. However, there are genes that code for the development of the appropriate neural pathways to allow the behaviour to be carried out as well as other genes that code for the presence of a mechanism that causes the behaviour to be carried out. This varies according to the type of innate behaviour.

***Figure 5.7** Innate behaviour in herring gulls*

What types of innate behaviour are there?

There are three types of innate behaviour:

- Reflex actions – these are the simplest of the innate behaviours; a single action is performed in response to a specific stimulus. They are nearly always protective. For example, the withdrawal reflex in which a limb is moved from a stimulus such as heat or pain.
- Orientational – such as the kineses and taxes of woodlice and other simple animals. These more complex behaviours result in the organism behaving in a way that it is most likely to move from unfavourable conditions and remain in favourable conditions.

- Instinctive behaviours – these often involve the most complex behaviours, but there is always a **fixed action pattern** for each **key stimulus**. Once begun, the fixed action pattern is carried out to completion, even if other stimuli intervene.

Examples of innate behaviour include:

- the withdrawal of your hand from a hot object (reflex)
- blinking when some dust gets in your eye (reflex)
- the kineses of woodlice in responding to changes in light intensity and humidity (orientational)
- nest-building (instinctive)
- imprinting (instinctive)
- weaving a web (instinctive)

How are human reflex actions brought about?

There are, broadly speaking, two main kinds of reflex actions:

- Those that involve our special senses (eyes, ears, pressure detectors, etc.) and produce a response by a muscle, called **somatic reflexes**. These include the 'knee-jerk reflex' and the 'withdrawal from heat' reflex. Many of these reflexes are protective.
- Those that involve sensors in internal organs and produce responses also in internal organs, called **autonomic reflexes**. These include the reflex actions controlling heart rate and breathing rate.

To understand how these two types of reflex action operate, we must look at the structure of the nervous system. Our nervous system is divided physically into two major components:

- the **central nervous system** (**CNS**), comprising the brain and spinal cord, and
- the **peripheral nervous system** (**PNS**), comprising the cranial and spinal nerves, each containing many sensory and motor neurones.

However, we can also divide our nervous system functionally into:

- the **somatic nervous system** (**SNS**), which integrates information from the special senses to produce responses in skeletal muscles, and
- the **autonomic nervous system** (**ANS**), which integrates information from receptors in internal organs and produces responses in the same or other organs or glands.

KEY WORDS

innate behaviour *any type of behaviour that does not need to be learned*

fixed action pattern *the predetermined behaviour (or behaviours) produced as a response to the key stimulus*

key stimulus *the stimulus (out of several stimuli) that triggers the fixed action pattern response*

More about fixed action patterns

These aren't always quite as 'fixed' as the term suggests. For this reason, some behavioural scientists prefer the terms 'behaviour pattern' or 'behaviour act'. However, the concept of a fixed response is still useful in many cases and so the term is still used.

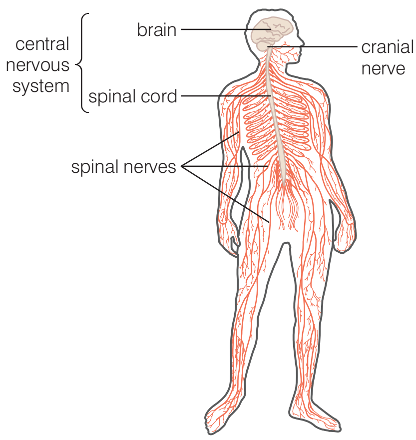


***Figure 5.8** The components of the nervous system*

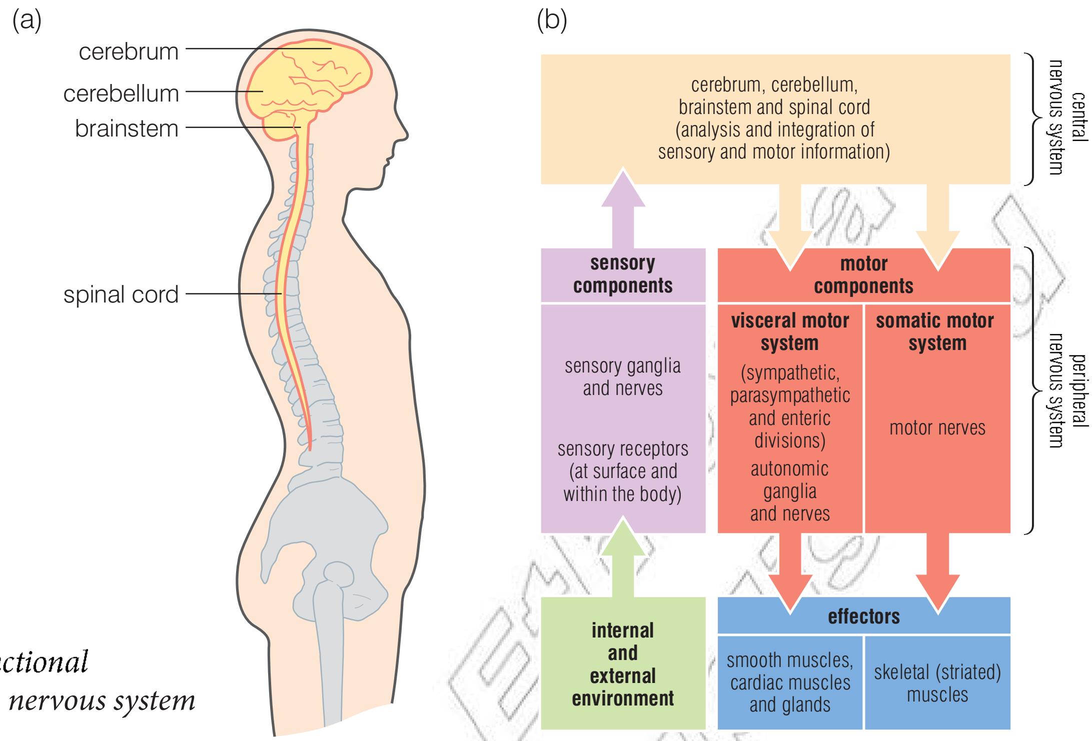


***Figure 5.9** The functional organisation of the nervous system*

The autonomic nervous system is further subdivided into:

- the **sensory division**, which transmits sensory nerve impulses into the central nervous system
- the **sympathetic division**, which transmits impulses from the central nervous system to the organs, generally preparing the body for 'fight or flight' – for example, by increasing cardiac output and pulmonary ventilation, and
- the **parasympathetic division**, which acts antagonistically to the sympathetic branch and prepares the body for 'rest and repair', decreasing cardiac output and pulmonary ventilation.

What are biological clocks?

The term 'biological clock' is used to describe some internal regulatory mechanism that controls various cyclical responses in living things. Both plants and animals show yearly, monthly, daily and other cyclical changes that are genetically programmed. Because these clocks are present in so many different types of organisms, biologists believe that they have evolved independently in these groups and are an example of convergent evolution.

Daily rhythms are called circadian rhythms (from the Latin words '*circa*', meaning about, and '*dies*', meaning a day). Circadian clocks have two main features:

- They will persist with a period of about 24 hours in the absence of environmental cues.
- They can synchronise to a 24-hour cue, such as the light–dark cycle; this is called entrainment.

The biological clock of mammals and of some other animals is found in a small area of the hypothalamus of the brain, called the suprachiasmatic nucleus. This sends impulses to a gland called the pineal gland, which secretes a hormone called melatonin during the night, which promotes sleepfulness and so controls the sleep–wake cycle. Because of this, if we did not have other cues to wake us and send us to sleep, we might expect to have a different sleep–wake cycle in the summer compared to the winter. In a study of 26 people maintained in a constant environment for six days in summer and six days in winter, the results shown in table 5.1 were obtained.

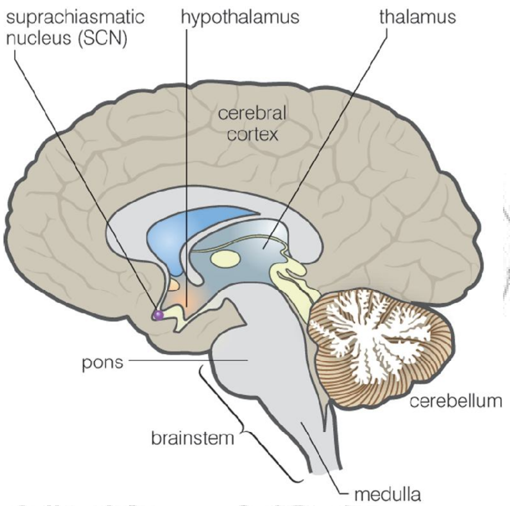


Figure 5.10 *The location of the supra-chiasmatic nucleus*

Table 5.1 *Mean sleep times and wake times in summer and winter*

Season	Mean wake time and sleep time	
	Wake time	Bed time
Winter	08.53	23.48
Summer	08.05	23.21
Summer vs winter	48 minutes earlier	27 minutes earlier

Clearly the shorter nights of summer have an effect – but not quite what one would expect. The subjects woke earlier in summer, but also went to bed earlier. However, the shorter nights did result in a reduction of 21 minutes of sleep.

Changes in the light–dark ratio can also control reproductive behaviour on an annual basis. Such rhythms are called circannual (yearly) rhythms. As the day length changes, so will the duration of melatonin secretion. This change in duration links reproductive behaviour in many animals to specific times of the year. Some animals are long-day (summer) breeders and others are short-day (winter) breeders. The point is that it is day length that triggers the changes.

Many other animals show circannual rhythms in behaviours such as:

- migration (for example, swallows)
- hibernation (for example, hedgehogs)
- coat growth (for example, arctic foxes)
- camouflage colouring (for example, arctic foxes)

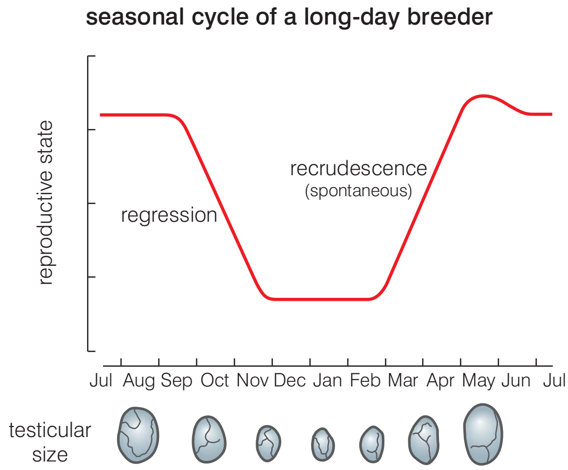


Figure 5.11 *The relationship between size of testis and time of year in a hamster (a long-day breeder)*

KEY WORD

imprinting *the process by which animals acquire their first forms of behaviour, particularly their attachment to their mother*

What is instinctive behaviour?

Instinctive behaviours are pre-programmed patterns of behaviour. They are not just single actions in response to a simple change in the environment like reflex actions. Instinctive behaviours often involve a complex sequence of actions. A good example to illustrate this point is the spinning of a web by spiders. It involves many complex actions, yet the spider does not have to learn how to do it. It spins a perfect web the very first time – as well as every other time afterwards.

Instinctive behaviours have the following characteristics:

- they are common to all members of a species
- they are fully functional the first time they are performed (they require no learning)
- there is a key stimulus that triggers the behaviour
- there is an innate releasing mechanism that links the stimulus to the response (this may be nervous or hormonal)
- there is a fixed action pattern in response to the key stimulus that is always the same, and
- instinctive behaviours are adaptive – they have been retained in the species by natural selection because they confer a survival advantage.

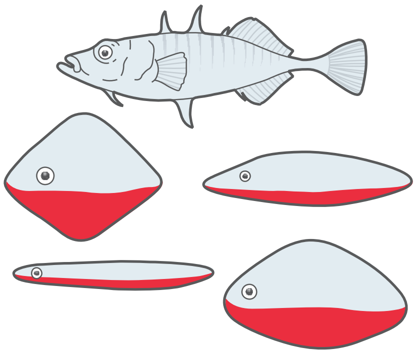


Figure 5.12 *The models used by Niko Tinbergen*

The feeding behaviour of herring gulls discussed at the start of this chapter is an example of instinctive behaviour. The orange spot on the beak is the key stimulus and pecking it is the fixed action pattern. This is not much more complex than some reflex actions. However, aggression in sticklebacks (fish) involves more complex responses. Male sticklebacks are very territorial; they will attack any other male that invades their territory. In some famous experiments, the ethologist Niko Tinbergen was able to show that the key stimulus was the red belly of the entering male. The 'defending' male attacked any non-fish model that had red on its ventral (lower) surface.

However, it turns out that the red belly – the key stimulus – provokes a very different fixed action pattern in female sticklebacks. They find it irresistible and it stimulates mating behaviour!

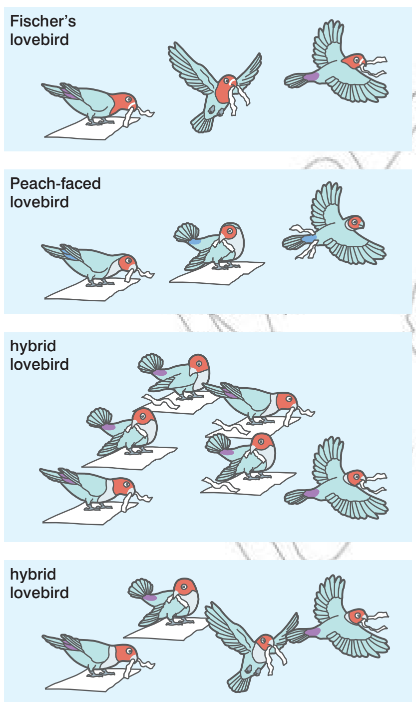


Figure 5.13 *Modification of fixed action patterns in lovebirds*

There is some evidence that some fixed action patterns can be modified slightly by experience. In an investigation into nesting behaviour in lovebirds, two different species of lovebirds with different nesting behaviours were interbred.

- Female Fischer's Lovebirds cut long strips of nesting material, which are carried individually to the nest.
- Female Peach-faced Lovebirds cut short strips and carry several at a time by tucking them into their back feathers.

Hybrid females from the crosses exhibited the following behaviours. In the first mating season they:

- cut intermediate length strips
- tried, but failed, to transport them by tucking into back feathers

- learned to carry strips in their beaks

In subsequent seasons they always carried the strips in their beaks, but never gave up all 'tucking' behaviour.

Imprinting is another kind of instinctive behaviour in which the fixed action pattern is for newly born/hatched organisms to imprint on (or become attached to) the first thing they see that has certain general features (those of an adult of its species).

In a famous experiment, Konrad Lorenz split a batch of goose eggs into two batches. One batch was hatched normally by the geese. The other batch was hatched by Lorenz in an incubator. He was the first moving thing they saw …

***Figure 5.14** Konrad Lorenz and the geese that had imprinted on him*

There is a 'time window' for imprinting to take place. Generally, if it does not take place in the first two days after hatching, then the gosling will not imprint. This, too, may have survival value. If 'mother goose' hasn't appeared in the first two days, imprinting on and following the first moving object after that could be more dangerous than not imprinting at all.

Many evolutionary psychologists believe that a similar pattern of behaviour is found in human infants. It is called attachment formation and involves the formation of a strong emotional bond between an infant and its primary caregiver – often, but not exclusively, the mother. This occurs in three stages:

- 0–2 months – pre-attachment; the infant prefers people to objects but does not really discriminate between different people
- 2–7 months – indiscriminate attachment; the infant begins to show a preference for familiar people, and
- 7 months onwards – true emotional attachment to one person initially, although multiple attachments often form soon afterwards.

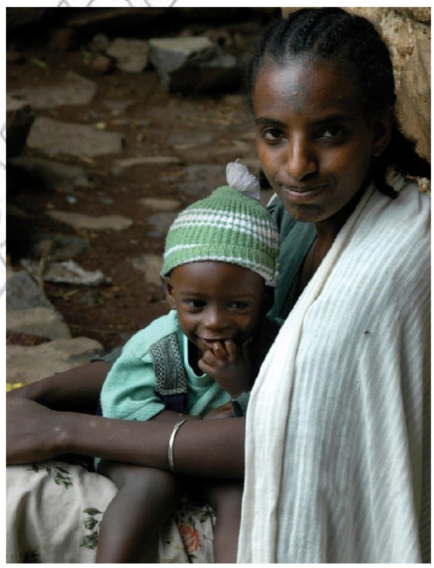


***Figure 5.15** Infants form attachments with their caregivers*

According to John Bowlby (who was influenced by the work of Lorenz and other ethologists) attachment formation in humans would also have survival value and natural selection could act to make this behaviour pattern widespread in the species.

Activity 5.5: Classifying innate behaviour

Copy and complete the table to classify the examples of innate behaviour given as:

- somatic reflex
- autonomic reflex
- orientational
- instinctive

Example of innate behaviour	Type of innate behaviour
Increasing breathing rate during exercise	
Maggots moving into a more humid environment	
Geese moving eggs that have rolled out of the nest back to the nest	
Producing tears when dust gets in your eye	
Scratching behaviour in dogs	
Small aquatic crustaceans accumulating at the surface of the water	
A newborn human grasping a rope strongly enough so that he can be lifted by it	

Review questions

Choose the correct answer from A to D.

1. Innate behaviour is best defined as behaviour that:
   A is instinctive
   B involves a fixed action pattern
   C is present at birth and does not have to be learned
   D is reflex
2. Which of the following is not an example of innate behaviour?
   A Aggression in sticklebacks.
   B A chimpanzee choosing a long stick over a short one to retrieve food from outside a cage.
   C Nesting behaviour in lovebirds.
   D Imprinting in goslings.
3. The central nervous system comprises:
   A the brain and spinal cord
   B the brain and cranial nerves
   C the spinal cord and spinal nerves
   D the cranial nerves and spinal nerves
4. Reflex actions:
   A are automatic
   B always produce the same response to the same stimulus
   C are actioned by reflex arcs of neurones
   D all of the above
5. Which of the following statements about instinctive actions is not true? Instinctive actions:
   A are innate
   B are adaptive
   C require some learning
   D can sometimes be modified by experience
6. Which of the following statements about biological clocks is not true? Biological clocks:
   A control circadian rhythms
   B are the result of divergent evolution
   C control circannual rhythms
   D can be entrained
7. Instinctive behaviours always:
   A require a key stimulus
   B show a fixed action pattern response
   C have an innate releasing mechanism
   D all of the above
8. An increase in the dark–light ratio can have which of the following effects in mammals? It can cause:
   A a decrease in the secretion of melatonin
   B regression of testes in long-day breeding animals
   C emergence from hibernation
   D none of the above
9. Which of the following sequences best describes the events in a somatic reflex action?
   A Receptor is stimulated – impulses along motor neurone from CNS – impulses along sensory neurone to CNS – impulses through relay neurone in CNS – effector produces response.
   B Impulses along sensory neurone to CNS – impulses through relay neurone in CNS – receptor is stimulated – impulses along motor neurone from CNS – effector produces response.
   C Impulses along sensory neurone to CNS – impulses along motor neurone from CNS – impulses through relay neurone in CNS – receptor is stimulated – effector produces response.
   D Receptor is stimulated – impulses along sensory neurone to CNS – impulses through relay neurone in CNS – impulses along motor neurone from CNS – effector produces response.

10. Examples of circannual rhythms include:
    A hibernation
    B migration
    C reproduction in short-day breeding animals
    D all of the above

5.3 Learned behaviour

By the end of this section you should be able to:

- List the different types of learned behaviour.
- Explain how the learning process takes place in each type.
- Describe examples of each type of learning (habituation, classical conditioning, operant conditioning, imprinting, insight learning and latent learning).
- Compare innate and learned behaviour patterns.

What is learned behaviour?

Before we can answer that question, we need to have a working definition of what we mean by learning. Most biologists would now define learning as:

The strengthening of existing responses or the formation of new responses to existing stimuli that occurs because of practice or repetition.

Unlike innate behaviours, learned behaviour patterns are rarely fully functional the first time they are performed. At the very simplest level of learning, trial and error brings about an improvement in the effectiveness of the behaviour pattern. Table 5.2 describes the main differences between innate behaviour and learned behaviour.

KEY WORD

learned behaviour *behaviour that is acquired through experience (such as trial and error) or by insight*

Table 5.2 *The differences between innate and learned behaviour*

Innate behaviour	Learned behaviour
Genetically determined and common to all members of a species	The behaviour is changed by, or develops through, experience and may vary from individual to individual
Behaviour is fully functional at the first attempt	The animal develops the behaviour through trial and error or by insight
There is, generally, no modification of the behaviour	The behaviour may be modified by new experiences
Adaptive behaviour that has been retained as a result of natural selection	Behaviour is learned anew by each member of the species and may not be adaptive

DID YOU KNOW?

Imprinting is sometimes described as a learned behaviour because repeated exposure is needed to some environmental stimulus to produce the fixed action pattern response. In this sense it is 'learned', even though development of the neural pathways to facilitate the response is innate.

Activity 5.6: Habituation of mosquito larvae

You will need:

- a small tank or glass container filled to about 3-4 cm depth with deionised water
- a pipette to transfer the larvae
- a watch
- a lamp

Investigation 1

Do mosquito larvae habituate to light?

Procedure:

- Place the lamp above the container, but do not turn on yet
- Place 3 larvae into your container and do not disturb for 5 minutes.
- Focus on one individual which is currently hanging upside down at the water surface and
- turn on the lamp above tank for five minutes,
- after the five minutes is up, turn off lamp
- Estimate how far from the surface the larva moves and measure how long the larva stays away from the surface.
- Leave the lamp off for three minutes
- Repeat steps 3 to 5 another three times

Is there any evidence of habituation?

Investigation 2

Do mosquito larvae habituate to sound?

Use the same apparatus and same initial set up as in investigation 1.

Procedure:

- Place 3 larvae into your container and do not disturb for 5 minutes.
- Focus on one individual which is currently hanging upside down at the water surface and tap three times on the side of the container with your fingers
- Estimate how far from the surface the larva moves and measure how long the larva stays away from the surface.
- Wait three minutes
- Repeat steps 3 to 5 another three times

Is there any evidence of habituation?

There are many different kinds of learned behaviour, including:

- habituation
- sensitisation
- insight learning
- associative learning
  - – classical conditioning
  - – latent learning

What is habituation?

Habituation is a process which results in a decreased response to a stimulus after repeated exposure to that stimulus over a period of time.

For example, we all have experienced noticing a quite strong smell on entering a room, but some time later we don't even notice that there is any odour present. In this example, your sense of smell has demonstrated habituation. You have stopped responding to the odour even though it is still present.

Habituation can occur at different levels in the nervous system. It can happen because:

- sensory systems may stop, after a while, sending signals to the brain in response to a continuously present or often-repeated stimulus; this is sensory habituation
- the brain still perceives the stimulus is still present, but has simply decided no longer to pay attention

An example of habituation to humans occurs in prairie dogs. Because they have several predators, they give alarm calls when large mammals, large birds or snakes approach them. This allows the group to retreat into their burrows. When populations of prairie dogs are located near areas regularly used by humans, the alarm call is not given when humans pass, despite being large mammals. This is an important example of habituation as the alarm response would waste the time and energy of the group when they could be foraging.

DID YOU KNOW?

Ethologists often rely on habituation in order to carry out their research effectively. After some time of being among the animals they are investigating, the animals become 'habituated' to them and, largely, ignore them. The ethologists can then carry out their research assuming normal behaviour by the animals.

Figure 5.16 *Prairie dogs in their burrow*

Research into habituation using *Aplysia*

Aplysia is a sea slug and is used a great deal in studies of memory and behaviour because its neurones are large and easily observed. In a simple reflex action, a snail ordinarily withdraws its gill if it is touched gently on the siphon. However, repeated stimulation of the siphon results in the gill-withdrawal reflex diminishing in both strength and duration.

If the habituation is just one training session of fewer than 10 stimulations in less than one hour, then the habituation lasts for only a few hours after the training. But if four or more individual training sessions are given, the habituation can last for several weeks. These two forms of habituation have been interpreted as models of short- and long-term memory.

Research has also shown that the nerve network that brings about the response is altered as a result of habituation.

Figure 5.17 *The sea slug* Aplysia.

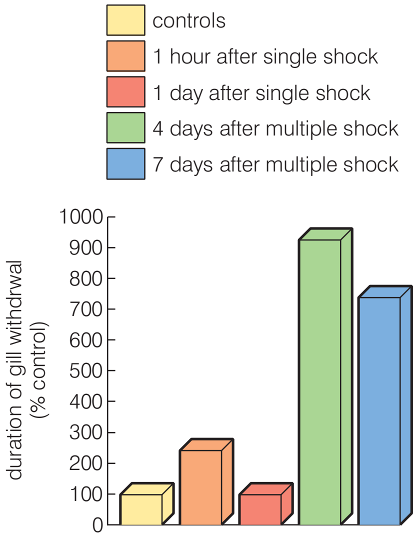


Figure 5.18 The effect of the strength of the initial sensitisation on the duration of the sensitised response in Aplysia

KEY WORDS

conditioning *a technique used to get an animal to learn a particular behaviour by associating that behaviour with an event or stimulus (classical conditioning) or with a consequence, such as reward or punishment (operant conditioning)*

Notice that habituation occurs when the stimulus is harmless – a gentle touch on the siphon of *Aplysia*, prairie dogs becoming habituated to the presence of humans who do them no harm, you becoming habituated to a smell which may be unpleasant, but is not harmful.

What is sensitisation?

Sensitisation is an increase in the response to a *harmless* stimulus when that stimulus occurs *after* a *harmful* stimulus. Again, research with the sea slug *Aplysia* has provided us with a good deal of information about the process. Touching the siphon of *Aplysia* gently causes the animal to withdraw its gill – until it becomes habituated to the harmless stimulus.

However, if the gentle touch on the siphon is preceded by an electric shock (or other mildly harmful stimulus) to the tail, then the gill withdrawal response is much stronger. The events in one pathway of neurones (the painful stimulation of the tail) are clearly affecting the reflex arc that controls the gill withdrawal reflex. The strength and duration of the sensitised response depend on the extent of the initial sensitisation, as figure 5.18 shows.

In higher animals, **peripheral sensitisation** refers to the sensitisation that results from changes in neurones of the peripheral nervous system. **Central sensitisation** refers to the same process occurring in neurones of the central nervous system.

What is classical conditioning?

In classical **conditioning** a naturally occurring stimulus becomes associated with a different stimulus, which now also produces the same response. It was discovered by the Russian physiologist Ivan Pavlov, who worked with dogs to develop this theory. The various stimuli and responses are:

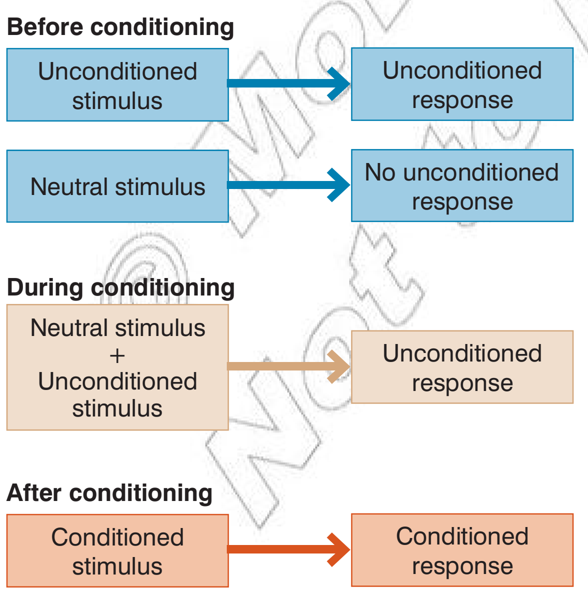


Figure 5.19 The phases of classical conditioning

The unconditioned stimulus (US)

This 'unconditionally', naturally and automatically triggers a response. For example, when you smell a favourite food, you immediately feel very hungry. The smell of the food is the unconditioned stimulus.

The unconditioned response (UR)

The unconditioned response is the unlearned response that occurs naturally to the unconditioned stimulus. In the 'feeling hungry' example, feeling hungry is the unconditioned response.

The conditioned stimulus (CS)

This neutral stimulus does not initially produce the unconditioned response. But, after association with the unconditioned stimulus, it triggers the same response.

The conditioned response (CR)

The conditioned response is the response to the previously neutral stimulus (which is the same as the unconditioned response to the unconditioned stimulus).

Pavlov's research involved the following phases:

- He fed the dogs at regular intervals to establish a routine; as he fed them, they salivated: this is a natural unconditioned response to the (natural) unconditioned stimulus of food.
- Then, as he fed them, he rang a bell; they continued to produce the same unconditioned response (salivation) as the food was presented and the bell was rung.
- After a period, the dogs salivated when the bell was rung without food being presented; this is now a conditioned response to a conditioned stimulus.

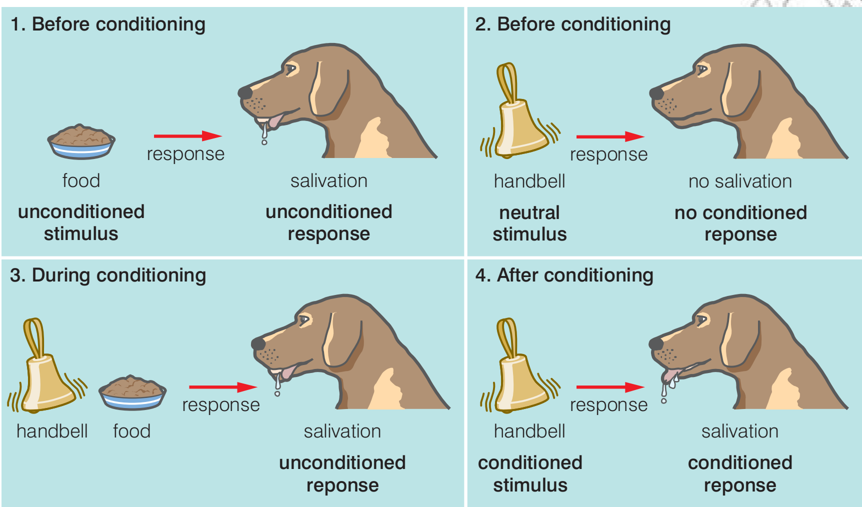


***Figure 5.20** Pavlov's famous experiment on classical conditioning*

It is possible to classically condition humans as a famous study called 'Little Albert' demonstrated.

'Little Albert' was an 11-month-old infant, who rarely showed fear of anything. He was not afraid of animals, including the white laboratory rat. He was, however, afraid of loud noises (US). Two psychologists (Watson and Rayner) used his fear of loud noises (UR) to condition Little Albert to fear the white laboratory rat. They showed Albert the rat and at the same time made a loud noise (they banged a steel pipe with a hammer). After only seven pairings of the rat and the loud noise, Little Albert began to cry and try to crawl away (CR) as soon as he saw the rat (CR), even though the rat was not linked with the loud noise on this occasion. He had been conditioned to fear the rat.

If the pairing of conditioned stimulus with the unconditioned stimulus is not maintained, then the conditioned response diminishes and eventually is lost. This is called extinction. Little Albert lost his fear of the white rat after a period of it no longer being paired with the loud noise.

What is operant conditioning?

Classical conditioning involves modifying an innate response by pairing it with a previously neutral stimulus. Operant conditioning can modify more complex, voluntary behaviours by the animal/person learning to associate the behaviour with certain specific consequences. Figure 5.21 summarises operant conditioning.

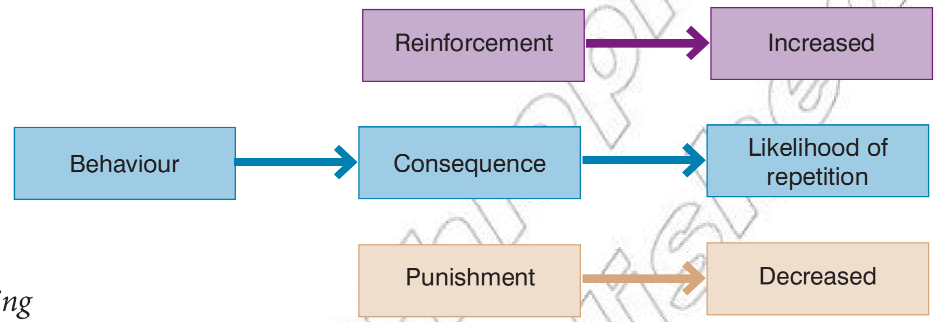


Figure 5.21 *Operant conditioning*

The term 'operant conditioning' was first used by B F Skinner, a behaviourist psychologist who carried out a great deal of pioneering research in this area.

Skinner identified three types of responses that he called operants that can follow behaviour:

- **Neutral operants:** responses from the environment that neither increase nor decrease the probability of a behaviour being repeated.
- **Reinforcers:** responses from the environment that increase the probability of a behaviour being repeated, reinforcers can be either positive or negative.
- **Punishers:** responses from the environment that decrease the likelihood of a behaviour being repeated.

Activity 5.7: Behaviour

Think carefully about the way in which your behaviour is controlled and modified by others.

Give three examples of your behaviour that you consider to be the result of classical conditioning and three that you consider to be the result of operant conditioning.

DID YOU KNOW?

Behaviourist psychologists

These psychologists are more concerned with the scientific measurement of observed behaviours rather than with internal processes such as thinking and emotion. There are several basic assumptions in behaviourism:

- When we are born, our minds are a blank slate.
- There is little difference between the learning that takes place in other animals and that which takes place in humans.
- All behaviour, no matter how complex, is the result of a stimulus–response association.
- All behaviour is learnt from the environment (this includes the actions of other people).
- We have no free will; a person's environment determines their behaviour.

How far do you agree with this? Try to justify what you think.

Skinner carried out much of his research on rats and other animals using what is now called a Skinner box. One variant of the Skinner box is shown in figure 5.22.

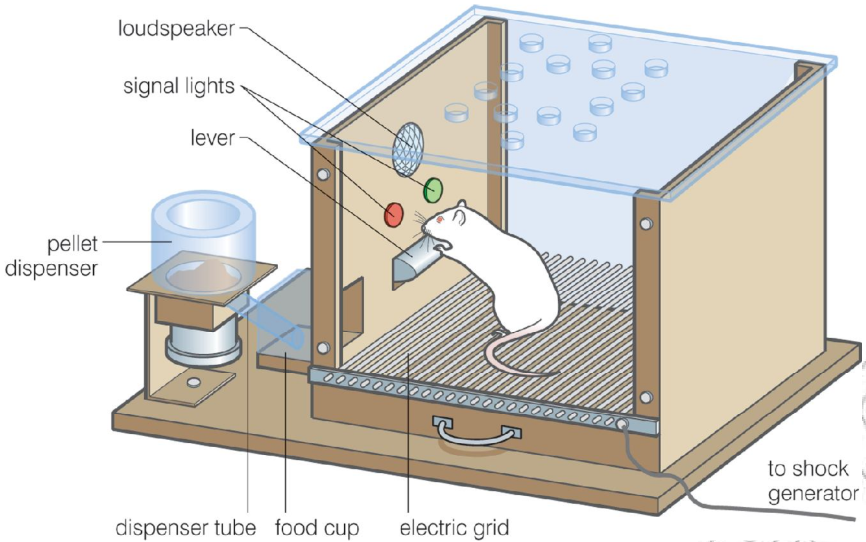


Figure 5.22 *A Skinner box*

The Skinner box has various signal stimuli that include:

- different coloured lights
- a speaker to deliver a sound stimulus
- an electric grid in the floor to deliver a mild electric shock

There is also a lever that the animal can press, which is linked to the delivery of pellets of food. The animal can be conditioned in several ways, such as by:

- simply learning that pressing the lever will result in food being delivered – the 'pressing action' is reinforced by the reward of food
- only pressing the lever when either light is lit up, resulting in the reinforcement of food being delivered
- only pressing the lever when one of the lights is lit; the other is linked to the electric shock system. The 'punishment' of the shock on pressing this light results in the behaviour being diminished or extincted

We can all think of examples of how our own behaviour has been affected by reinforcers and punishers. For example, many people start to smoke so that they will be accepted by a certain peer group. Acceptance by this peer group acts as a positive reinforcer for the smoking and, unfortunately, is often a much stronger influence than other advice and punishers.

Animal trainers use a technique called shaping, which is based on operant conditioning, to train animals to perform in specific ways. It is often not possible to reward the desired behaviour at the outset, because it doesn't exist. Trainers look for a natural behaviour that, if modified, could lead to the desired behaviour and reward this. They then reward a slight modification of this behaviour that is nearer to the desired behaviour, but not the natural behaviour itself. Each step

DID YOU KNOW?

Both classical and operant conditioning are sometimes referred to as associative learning because the animals learn to modify their behaviour as a result of either associating two different stimuli or associating particular behaviour patterns with operant responses.

Activity 5.8

Latent learning is an important part of how we behave. Make a list of as many examples of latent learning as you can think of. Share your list with a partner and see how many different ideas you have had.

in the learning process is called an approximation. An animal may be reinforced for each successive approximation towards the final goal of the desired trained behaviour. Specific examples of where shaping is used include:

- training guide dogs for the blind
- training horses
- training dolphins and killer whales at marine parks
- training zoo animals

What is latent learning?

The word 'latent' means 'hidden' – so we are talking about 'hidden learning' or learning that is not apparent as it takes place. Latent learning happens when the brain acquires knowledge at a certain time, without reinforcement, but does not use it until later, at a time when that knowledge is needed.

An example of this could be:

One teacher drives another to school every day. Then, on one day, the 'driver' is ill. The other teacher drives himself to school without getting lost. This is an example of latent learning. He learned the route to the school without reinforcement, but never had to use it until the usual driver was ill.

Edward Tolman, a behaviourist psychologist, conducted an experiment with rats in 1938. He placed three groups of rats in a maze and observed how they behaved over a two-week period.

- The rats in group 1 always received a food reward when they reached the end of the maze without wandering down dead ends; they soon did this regularly.
- The rats in group 2 never received a food reward and seemed like they followed no particular path through the maze, although they did sometimes reach the end.
- The rats in Group 3 were treated in a different way at different times of the experiment:
  - for the first 10 days of the experiment, like group 2 they received no food reward even if they did reach the end of the maze and behaved in a similar manner to group 2
  - on the eleventh day, Tolman placed food in the maze, and
  - on the twelfth day, the rats from group 3 were doing as well as the rats from group 1, which had been rewarded with food from the very beginning of the test; it appears that they had learned to go to the end of the maze without reinforcement, but did not desire to until there was some reason (the food).

The rats from group 3 used latent learning since they did not immediately display the same performance as the rats in group 1.

In other experiments, Tolman was able to demonstrate that the rats were building a 'cognitive map' of the maze. This means that they were storing information, without reinforcement of the structure of the maze. In the maze shown in figure 5.23, the rats quickly learned that the shortest route to the end of the maze was path A. They also 'knew' that if:

- path A was blocked at X, then the new shortest path was path B
- path A was blocked at Y, the new shortest path was path C

It is important to note that, although there was food at the end of the maze, this could not act as a reinforcer for the building of the cognitive map. It only gave a 'reason' to get to the end of the maze.

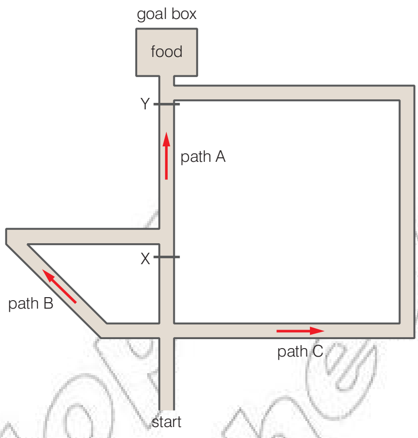


***Figure 5.23** One of Tolman's mazes*

What is insight learning?

This is very different from the trial-and-error learning that is often an important part of learning through operant conditioning. Insight learning involves finding solutions to problems that are not based on actual experience (as with trial and error) but on 'trials' occurring mentally. Often the solution is learned suddenly, such as when a person has been trying to solve a problem for a period of time and suddenly the solution appears almost 'out of nowhere'. The 'eureka' moment.

Much of the pioneering research on insight learning was carried out by Wolfgang Kohler, working with chimpanzees.

For the experiments, the chimpanzees were placed in an enclosed area. Kohler placed desirable 'lures' such as fruit outside the enclosure and out of their reach. He placed a variety of objects that could be used to obtain it inside the enclosure. The chimpanzees had to work out a way of using one or more of the objects to obtain the 'lure'.

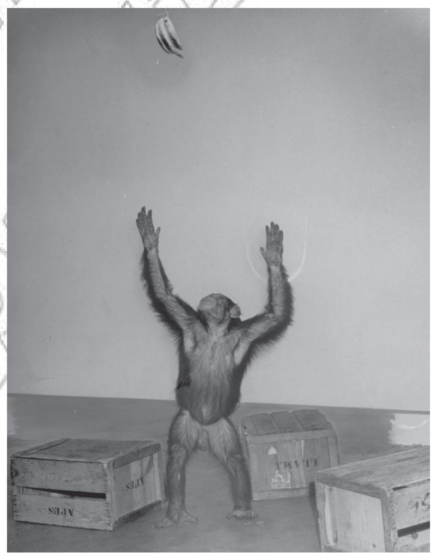


***Figure 5.24** A chimpanzee assesses the problem*

They were more successful in this than Kohler had anticipated. The chimpanzees learned to use boxes to obtain bananas placed on the top of the enclosure. They dragged them under the banana and then climbed on them to reach the fruit. They became quite accomplished builders, piling box on box to erect structures with a height of four boxes.

Some of the chimpanzees learned how to make or modify suitable tools from the materials they were given. One chimpanzee, Sultan, was particularly gifted in this. Sultan was given the problem of obtaining a banana far out of reach. There were two hollow bamboo sticks in his cage, but neither was long enough to rake in the lure. After many attempts to reach the banana with one stick or the other, he sat and looked at the sticks. Suddenly Sultan hit upon the solution. He pushed the thinner of the two sticks into the hollow inside of the thicker one and then drew the banana towards himself, his reach now enlarged by the length of two sticks. Eureka!

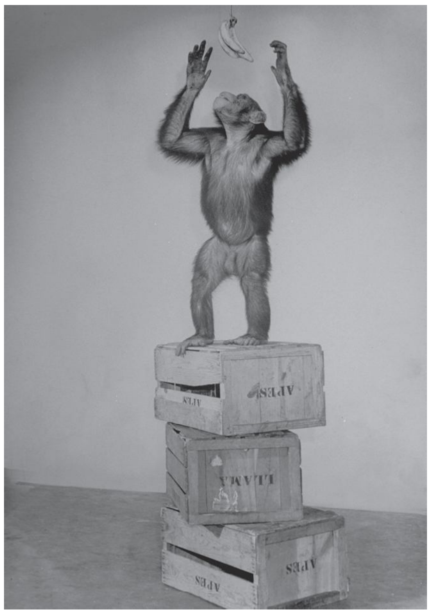


***Figure 5.25** Through 'building' the chimpanzee achieves his goal*

Review questions

Choose the correct answer from A to D.

1. Which of the following statements about learned behaviour is *not* true? The behaviour is:
   - A fully functional the first time it is performed
   - B acquired anew by each member of the species
   - C modified by experience
   - D developed by trial and error or insight
2. In Pavlov's experiment on the classical conditioning of dogs, the ringing of the bell represents:
   - A the conditioned stimulus
   - B the conditioned response
   - C the unconditioned response
   - D the unconditioned stimulus
3. Which of the following are examples of learned behaviour?
   - A Classical conditioning
   - B Operant learning
   - C Innate behaviour
   - D Insight learning
4. Insight learning involves:
   - A trial and error
   - B innate behaviour
   - C operant conditioning
   - D none of the above
5. Latent learning is different from learning through operant conditioning because it:
   - A is a kind of innate behaviour
   - B does not require any input from the environment
   - C does not require reinforcement
   - D is a kind of insight learning
6. Operant conditioning differs from classical conditioning in that:
   - A classical conditioning involves modifying innate behaviour whereas operant conditioning may involve modifying learned behaviour
   - B classical conditioning does not involve rewarding behaviour but operant conditioning may

C classical conditioning involves associating two stimuli whereas operant conditioning involves associating a behaviour and a consequence

D all of the above

7. Which of the following is not one of the assumptions of behaviourist psychology?

A All behaviour is learnt from the environment (this includes the actions of other people).

B All behaviour, no matter how complex, is the result of stimulus–response association.

C The learning that takes place in other animals is fundamentally different from that which takes place in humans.

D When we are born, our minds are a blank slate.

8. Which of the following forms of learning is mainly used in shaping animal behaviour?

A classical conditioning

B operant conditioning

C latent learning

D insight learning

9. When Sultan the chimpanzee solved the problem of reaching a banana with two bamboo canes, this was an example of insight learning because:

A it demonstrated species specific behaviour

B it was the result of conditioned reflexes

C he solved the problem mentally when doing something not directly related to reaching the banana

D it involved hours of trial and error

10. The behaviour of the rats in a Skinner box shows operant conditioning because they may:

A associate pressing a lever with reward (positive reinforcement)

B associate pressing the lever when only one light flashes with reward (positive reinforcement)

C not press the lever when one light flashes because it is linked with an electric shock (punishment)

D all of the above

5.4 Examples of behaviour patterns

By the end of this section you should be able to:

- Describe and explain courtship, territorial and social patterns of behaviour.
- Give examples of each type of behaviour.

DID YOU KNOW?

Geese and swans typically form pair bonds that last for life, not just for the period necessary to raise young.

What is courtship behaviour?

Courtship behaviour is an activity that precedes and results in mating and reproduction. It allows members of a species to recognise each other and prevents or reduces attempts at interbreeding between different species. Courtship may simply involve a few chemical, visual or auditory stimuli, or it may be a complex series of acts by two or more individuals using several methods of communication. Elaborate courtship rituals can also help to strengthen already established pair bonds. These may then last through the time it takes to rear the young and, in some cases, even longer.

There are many different methods of communication that are used to attract a mate. These include:

- the use of pheromones by some female insects to attract males from a distance
- the use of touch by painted turtles
- the courtship songs of frogs heard on spring nights in many different countries
- the song of a humpback whale under the sea, which can be heard hundreds of miles away

In most animals, courtship behaviour is innate and consists of a pre-programmed set of fixed action patterns in response to a key stimulus. Despite being innate, the fixed action patterns are often complex behaviours with the fixed action pattern in one animal (say the male) serving as the stimulus for another fixed action pattern in the other animal (the female). This interaction of fixed action patterns continues until courtship is successful or until one of the pair tires.

Figure 5.26 shows the sequence of fixed action patterns that make up the courtship behaviour of zebra fish. Figure 5.27 shows the role of each fixed action pattern in the overall courtship behaviour.

Pheromones

This is yet another term derived in part from a Greek word and translates as 'hormone bearer'. It is a chemical secreted by one animal, usually the female, to produce a behavioural response in another. There are many different pheromones, including:

- alarm pheromones that are secreted by animals when attacked and produce the response of flight or aggression by others of the same species
- releaser pheromones that are highly volatile and can attract a mate from a distance of two miles or more
- territorial pheromones that are used to mark the boundaries of a territory by the owner; dog urine contains a powerful territorial pheromone
- sex pheromones that signal the availability of a female for mating

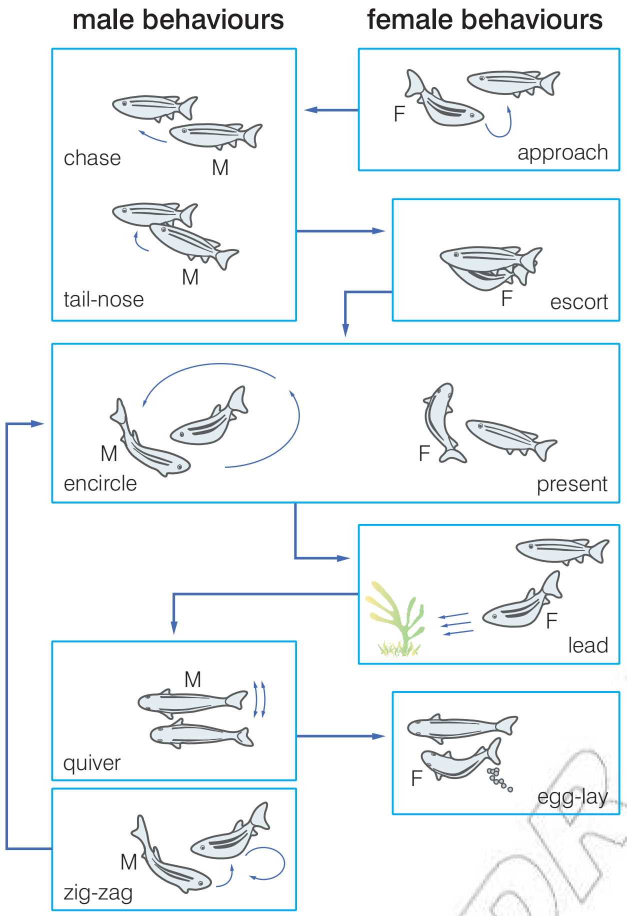


Figure 5.26 Courtship behaviour in zebra fish

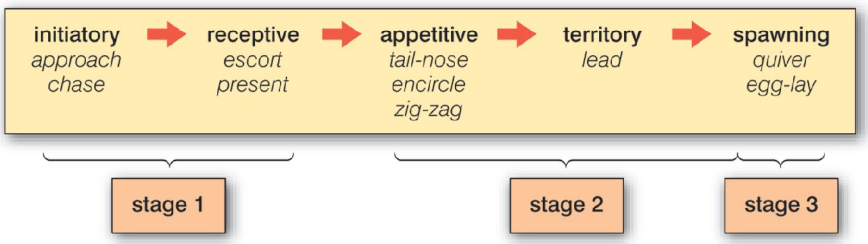


***Figure 5.27** The role of each fixed action pattern in the courtship behaviour*

Fixed action patterns in courtship form an important part of the mating displays of birds also. Figure 5.28 shows the fixed action patterns of a mallard drake (male) during courtship.

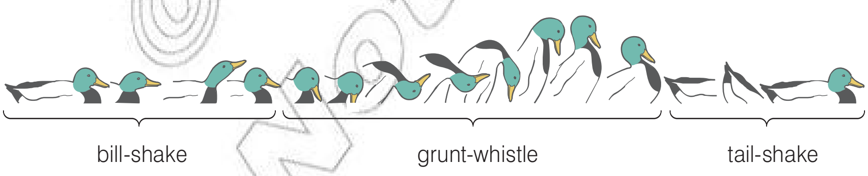


***Figure 5.28** The courtship behaviour of a mallard drake*

DID YOU KNOW?

No one can state this for certain, but research with fruit flies has shown that flies with a mutant version of a single gene were much less adept at courting female mates. We don't actually share this gene with fruit flies, but we do share many others with them, so the principle may be the same in humans.

KEY WORD

territory *an area that an animal or a group of animals reserves for itself so as to exclude other members of the same species*

Activity 5.9: The cost of defending a territory

The territory holder usually maintains ground only by spending a lot of time and energy in its defence. Sunbirds can expend up to 3000 calories per hour patrolling and defending territory! Is it worth it?

Suggest one advantage and one disadvantage of being territorial when food supplies are:

- low
- average
- abundant

Figure 5.29 *Ethiopian wolves*

What is territorial behaviour?

Before we describe this kind of behaviour, we must make clear what we understand by **territory**. Most animal behavioural biologists would define territory as:

Any space that an animal defends against intruders of the same species.

Territorial behaviour is found in nearly every species of animal, even humans. Possessing territory gives the holder areas to forage for food and so increases the chances of attracting a mate. It also reduces vulnerability to predators. Animals that do not have a territory of their own may contest with the owner for a territory that is already occupied. Such contests are called conspecific (same species) conflicts.

Territorial animals usually defend areas that contain one or more of:

- a nest
- a den, or mating site
- sufficient food for themselves and their young

Males are usually the territorial sex, but in some species (such as fiddler crabs) females maintain a territory also. When conspecific conflicts occur, they usually involve ritualistic displays and rarely involve the animals actually fighting. Residents of a territory are difficult to dislodge as they are often older and more experienced.

Defence threat displays may be visual as in the colour of feathers or fur, auditory as in birdsong or the howls of gibbons or olfactory through the deposition of scent marks. Many territorial mammals use scent marking (containing pheromones) to signal the boundaries of their territories.

The resident animal usually holds on to his (or her) territory only by expending considerable time and effort in its defence. Sunbirds, for example, can use up to 13 000 kilojoules per hour patrolling and defending their territory. This is more than the recommended daily energy intake for the average adult human male! Clearly, to expend that amount of energy, the territory must contain, at the very least, an abundance of food to support it.

The Ethiopian wolf (*Canis simensis*) is a social animal; the wolves live and hunt in packs. As a result, they maintain a group territory by marking with urine (containing pheromones). All adult animals (male and female) contribute to this marking behaviour, particularly during patrols of the territory. Some of the subadult (younger) males occasionally mark but subadult females never mark. Direct encounters between neighbouring wolves at the borders were aggressive and involved repeated chases, with the larger group more likely to win.

Defending a territory

Some animals defend their territory by fighting with those who try to invade it. But this is the exception, rather than the rule. Fighting uses up a large amount of energy, and can result in injury or death. So, behaviour has evolved that makes fighting the 'last resort'. Marking a territory usually 'warns off' intruders. Animals that do not mark territories use threats from one, or more, of vocalisations, smells and visual displays.

The songs of birds and the loud calls of monkeys are warnings that carry for considerable distances, and warn intruders that they are approaching someone else's territory. If these warnings are ignored, and the intruder enters the territory, or two animals meet near the border of their adjacent territories, they usually threaten each other with visual displays. These displays often either:

- exaggerate an animal's size by the fluffing up of feathers or fur, or
- show off the animal's weapons.

Also, the animals may go through all the motions of fighting without ever actually touching each other, a behaviour known as **ritual fighting**.

Ritual fighting is more intense the further into an animal's territory it takes place. In this situation, the territory holder has 'nowhere to go' – he cannot retreat. If the encounter takes place nearer to the border, the ritual fighting becomes less intense and more fragmented because the territory holder has the option of retreating. This variation in the intensity of the display helps to define territorial boundaries, where the displays of neighbours are about equal in intensity, or where the tendency to attack and the tendency to retreat are about equally balanced.

Actual fighting usually only happens in overcrowded conditions where resources are scarce. Serious injury can result, and old or sick animals may die, leading to a more balanced and biologically fit population. Fighting can occur when a young male animal challenges an older one for the territory, which may be 'home' to several females as well as being a foraging area. Older animals are more experienced, but, eventually, experience will give way to the strength of a younger animal and the territory holder will be displaced. Usually, however, territoriality is an effective way of maintaining a healthy population.

Figure 5.30 *A male robin threatening an intruder by using vocalisations and by exaggerating its size*

Figure 5.31 *A younger male zebra challenges the older resident male*

What is social behaviour?

Social behaviour is the set of interactions that occur between two or more individuals of the same species that modify the behaviour of individuals of the same species in a way that is usually beneficial to the group as a whole. It is thought to have been selected for because it has survival value to the species as a whole. Social behaviour serves many purposes and is found in a wide variety of animals, including some invertebrates, fish, birds and mammals.

KEY WORD

ritual fighting *behaviour in which the acts of fighting are displayed, without any physical contact*

Some of the benefits of social behaviour are that it allows animals to:

- form stable groups in which intra-specific aggression is reduced, sometimes as a result of hierarchies being established
- improve the effectiveness of reproduction and/or parenting through courtship behaviour (a kind of social behaviour) and pair-bond formation
- forage more efficiently – especially if sources of food are localised. Examples of this include:
  - dolphins often surround shoals of fish and take turns to swim quickly in and eat the fish trapped in the centre of the shoal
  - lions hunt in small groups when hunting large prey (such as wildebeest) but may hunt smaller prey singly
- protect themselves against attack more effectively. Examples of this include:
  - baboons co-operate to fight off a leopard, which would be extremely difficult for a single baboon
  - fish and birds moving in groups in which the movement of the whole group is co-ordinated; rapid movements one way and then another make it more difficult for a predator to attack; individuals who cannot maintain position in the group are most vulnerable
- increase the chance of surviving migration – some birds travel in large groups, for example, many geese fly in a 'V' formation, which reduces the total wind resistance on the birds; the lead position is rotated as this is the position that receives most wind resistance
- increase the chance of surviving extreme conditions – some birds huddle together in very cold weather, this effectively reduces the overall surface-area-to-volume ratio and can reduce heat loss by up to 50%; the birds constantly change position as the ones at the outside of the group lose heat most rapidly
- communicate across long distances

Figure 5.32 *Penguins 'huddling' to reduce heat loss*

Social behaviour in bees

Honeybees and bumblebees and other species of insects exhibit what is called eusociality. Eusociality has three main features:

- there is co-operation in caring for the offspring; as a consequence, many individuals are caring for offspring that are not their own
- there are usually several generations in the colony so that it will sustain for longer and allow offspring to assist parents, and
- there is division of labour – not every individual in the group is reproductively active; in the case of bees, the queen is the only

reproductively active female with the male drones also being active; the female worker bees are more or less sterile.

Figure 5.33 *Honeybees nesting in a tree*

Honeybees nest in large cavities such as hollowed-out trees or other enclosed spaces. They will use man-made beehives just as readily as a hollow tree trunk. Honey bees build vertical sheets of hexagonal honeycomb from wax secreted by glands in their abdomens, in which they store honey and pollen. An individual hexagon (a cell) can also be used as a home for a single developing bee larva.

There are three different types or **castes** of bees in a nest. They are:

- the queen – the only truly reproductively active female (1st caste)
- workers – non-reproductively active females (2nd caste)
- drones – reproductively active males (3rd caste)

Table 5.3 *A summary of the roles of different castes of bees*

Type of adult bee	What they do	How many in a honey-bee colony	How many in a bumble-bee colony	What they look like in a honeybee colony	What they look like in a bumblebee colony
Queen	Lay eggs	1	1		
Worker	Take care of larvae, build and clean nest, forage	10 000–50 000	Less than 50 to over 400, depending on species		
Male	Leave nest to mate, then die	100–500	0–50, depending on species and season		

The queen secretes powerful pheromones within the nest that control the behaviour of the workers at different stages of their development and so help to maintain the social structure of the nest. She may also make aggressive attacks on maturing worker bees.

KEY WORD

caste *a group within a social structure*

If the queen does not produce these pheromones, or if she produces too few eggs, then the structure of the nest breaks down. She may be attacked by mature workers, one of whom will replace her.

A honeybee colony may last for several years, with the male drones being driven out of the nest over winter to preserve resources for the workers and the queen. More drones will emerge the following spring.

At the end of the colony cycle, the queen, the drones and most workers will die, leaving just a few large workers, who will assume the status of queens and, the following spring, fly away to establish their own colonies.

Activity 5.10

Social insects show fascinating behaviour and have complex and interesting lifestyles. Work in a group to produce a classroom display on social insects. You may choose to focus on bees, which are covered in this book. Alternatively you can do some extra research and find out more about a different type of social insect, e.g. ants or termites. Make sure your display is big, clear, colourful and informative.

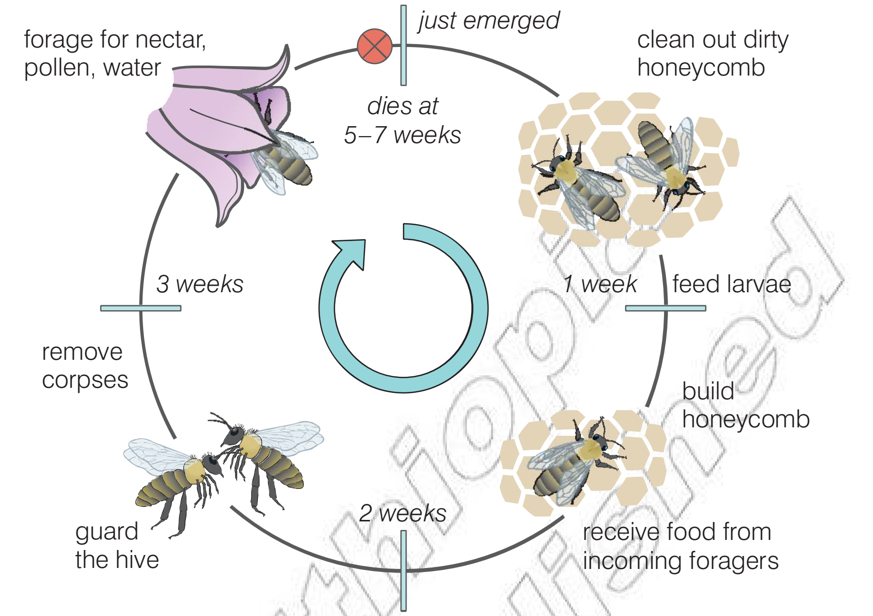


***Figure 5.34** The roles of a worker bee at different stages of development*

Worker bees communicate with each other in a very special way to convey information about a source of nectar. Foragers perform a 'wag-dance' on the honeycomb to inform other workers of the direction of the nectar source and its distance. The dance takes the form of a 'figure of eight' on the vertical face of the honeycomb. Information about the nectar is conveyed in two ways:

- the angle of the dance away from the vertical corresponds with the angle of the nectar from the Sun
- the length of the 'straight-run' part of the dance is proportional to the distance from the nest

Figures 5.35A and B show the orientation of the wag-dance on the honeycomb.

Figure 5.35C shows the relationship of this dance to the position of the Sun and the position of the nectar source.

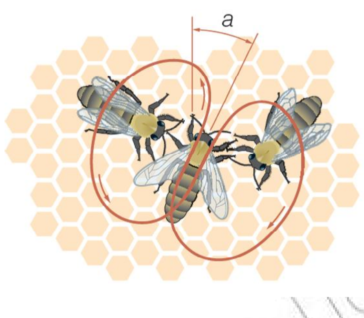


Figure 5.35A

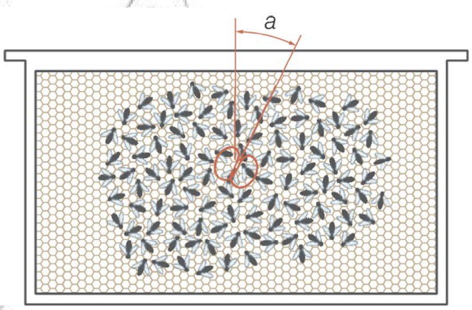


Figure 5.35B

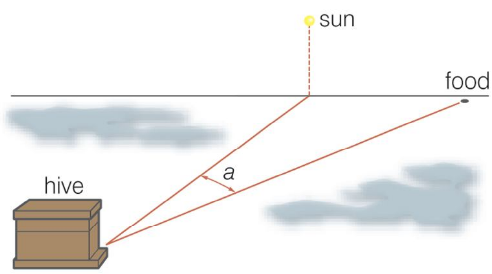


Figure 5.35C

Recent research shows that the foraging bees also use sound to inform other bees about the distance of the source, and, perhaps, to help to 'recruit' these other workers. The time for which they produce their sounds is directly correlated with the distance to the nectar source, as figure 5.36 shows.

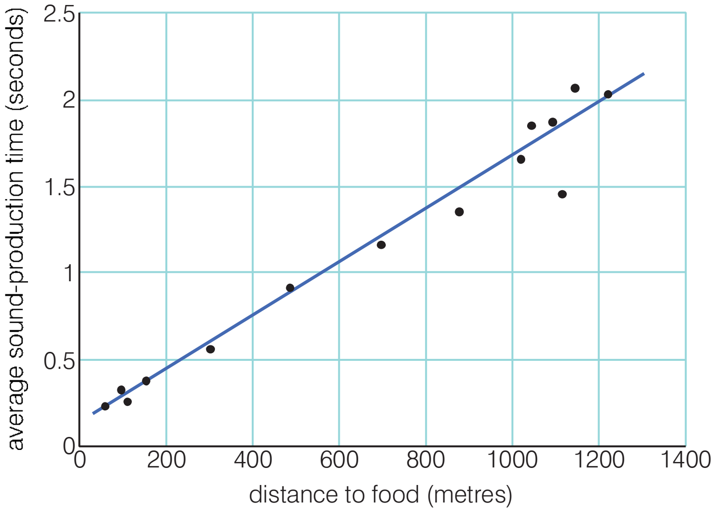


Figure 5.36 *The length of sound production by foraging workers is proportional to the distance to a food source.*

The roles of the castes are the same in bumblebees and the queen maintains 'order' in the same way.

However, these nests are annual nests and a new colony establishes itself every spring.

Review questions

Choose the correct answer from A to D.

1. Which of the following statements concerning courtship behaviour is true?
   - A It precedes and can result in mating behaviour.
   - B It allows members of a species to recognise each other.
   - C It prevents attempts at interbreeding between different species.
   - D All of the above.
2. Pheromones can be used to:
   - A attract a mate
   - B trigger alarm
   - C define territories
   - D all of the above
3. Worker bees are:
   - A sterile males
   - B fertile males
   - C fertile females
   - D sterile females
4. Communication within a honeybee nest can take the form of:
   - A pheromones secreted by the queen
   - B sound produced by returning foragers

C wag-dances

D all of the above

5. In courtship behaviour in fish and birds, which of the following is often true?

A A key stimulus produces a reflex response.

B A key stimulus produces an isolated fixed action pattern.

C A fixed action pattern in one animal acts as a key stimulus for a fixed action pattern in another animal.

D None of the above.

6. Territories are most often maintained by:

A male animals

B female animals

C both sexes

D groups of animals

7. Which of the following is not true of social behaviour? Social behaviour is likely to:

A reduce the risk of intra-specific aggression

B reduce the danger from predators

C reduce foraging efficiency

D reduce the risk from extreme conditions

8. Before a territorial dispute leads to actual fighting, which of the following may occur?

A vocalisations

B threat displays

C ritual fighting

D all of the above

9. Which of the following is an additional 'cost' to an animal of defending a territory?

A an increased chance of mating

B access to a good foraging area

C the expenditure of considerable time and energy

D decreased vulnerability to predators

10. Which of the following is not a feature of eusociality?

A the presence of several generations in the colony

B co-operative foraging

C co-operative caring for the young

D division of labour

Summary

In this unit you have learnt that:

- Behaviour is the co-ordinated response of an organism to an internal or external stimulus.
- Any behaviour involves:
  - a receptor of some kind to detect the stimulus
  - an effector of some kind to produce the response
  - some kind of linking system or co-ordinating system that is influenced by the receptor and can influence the effector
- Plants show behaviour patterns that involve tropisms (growth responses to unidirectional stimuli).
- Simple animals respond to stimuli by taxes and kineses.
- Studying animal behaviour is important because we can gain information that can be used in:
  - neuroscience
  - the environment and resource management
  - animal welfare
  - science education
- Innate behaviour is any behaviour that is 'inborn' and genetically pre-programmed in some way.
- Innate behaviour includes:
  - reflex actions
  - orientational behaviour, such as taxes and kineses
  - instinctive behaviours
  - behaviours determined by biological clocks
- Reflex actions are brought about by reflex arcs comprising a sensory neurone, a relay neurone (inter-neurone) and a motor neurone.
- Somatic reflexes are usually protective, whereas autonomic reflexes control the rate of working of internal organs.
- A biological clock is an internal regulatory mechanism that controls a cyclical process in an organism; it may be:
  - circadian (controls a daily cycle)
  - lunar (controls a monthly cycle)
  - circannual (controls a yearly cycle)
- Instinctive behaviour patterns are:
  - common to all members of a species
  - fully functional the first time they are performed
  - there is a key stimulus that triggers the behaviour

- mediated by an innate releasing mechanism and a fixed action pattern
- adaptive

- Learned behaviours involve the strengthening of existing responses or the formation of new responses to existing stimuli that occur because of practice or repetition.
- Types of learned behaviour include:
  - habituation, in which a response to a stimulus becomes weaker as the stimulus is repeated more and more often
  - sensitisation, in which there is an increase in the response to a harmless stimulus when that stimulus occurs after a harmful stimulus
  - classical conditioning, in which, during the conditioning process, a naturally occurring stimulus becomes associated with a different stimulus, which now also produces the same response
  - operant conditioning, in which a behaviour is strengthened or weakened as a result of the consequences (operants) of that behaviour; reward will strengthen (reinforce) the behaviour, punishment will weaken (extinct) the behaviour
  - latent learning, in which knowledge of some kind is acquired without reinforcement and is only used later, when the need arises
  - insight learning, in which problems are solved by mental processing, rather than by trial and error
- Courtship behaviour is an activity that precedes and results in mating and reproduction and allows members of a species to recognise each other whilst preventing or reducing attempts at interbreeding between different species.
- Courtship behaviour may involve:
  - secretion of sex pheromones
  - courtship vocalisations
  - touch
  - complex displays involving a series of fixed action patterns
- Territorial behaviour is any behaviour that is used to defend an area that gives access to:
  - good foraging
  - increased mating chances
  - a den or similar
- Territorial behaviour can involve:
  - marking the area
  - threatening vocalisations

  - threat displays (exaggerating size or displaying weapons)
  - ritual fighting
- Social behaviour is behaviour that may allow animals to:
  - form stable groups and reduce intra-specific aggression
  - improve the effectiveness of reproduction and/or parenting
  - forage more efficiently – especially if sources of food are localised
  - protect themselves against attack more effectively
  - increase the chance of surviving migration
  - increase the chance of surviving extreme conditions
  - communicate across long distances.
- The honeybee is a social insect that has a caste system.
- The queen maintains the social structure of the colony by secreting pheromones and by aggressive attacks on maturing worker bees.

End of unit questions

1. (a) Explain what is meant by behaviour. Illustrate your answer by reference to two examples.

   (b) Explain three reasons why we should study animal behaviour.

2. Our reflex actions can be classified into two types:

   1. somatic reflexes
   2. autonomic reflexes

   (a) Give two examples of each type.

   (b) (i) Give two similarities between the two types.

   (ii) Give two differences between the two types.

3. Herring gull chicks will peck at an orange spot on the beak of the adult bird. When they do this, the adults regurgitate food. This is an example of innate behaviour.

   (a) For this behaviour, state, with reasons:

   (i) the key stimulus for the behaviour

   (ii) the fixed action pattern response

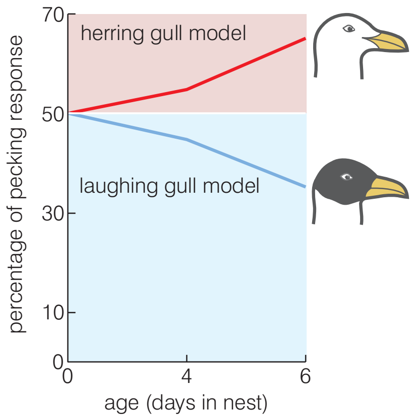


Figure 5.37 *Development of pecking responses in young herring gulls*

(b) In an investigation into this response, herring gull chicks were presented with models of adult herring gulls and adult laughing gulls after different periods of time in the nest. The chicks were fed normally throughout by their parents.

The results are shown in the graph in figure 5.37.

(i) Describe the pattern of results shown in the graph.

(ii) How do these results show that the behaviour is innate?

(iii) How do these results show that some learning is also involved?

4. What type of learned behaviour is described in each of the following examples? Give a reason for each of your answers.

(a) A dog is trained to herd stock animals.

(b) A snail is moving along a bench; an experimenter taps the bench and the snail withdraws into its shell. After several repeats of this, the snail just keeps on moving.

(c) After a painful blow, even relatively light pressure feels painful.

(d) You walk into a room where there is a loud noise and start to read a book. Initially, the noise is disturbing, but after a while you do not notice it.

(e) A boy watches his father changing a plug on a lamp. Some time later, he is able to carry out the same task himself without instruction.

5. (a) Describe three benefits of territorial behaviour.

(b) Explain how territorial behaviour can reduce intra-specific fighting.

6. (a) Explain how you could use a Skinner box to condition a rat to press a lever only when one of the lights in the box flashes.

(b) Explain how operant conditioning is used in shaping behaviour. Illustrate your answer by reference to two examples.

7. (a) Explain what is meant by 'insight behaviour'. Illustrate your answer by reference to two examples.

(b) Explain how insight behaviour is different from:

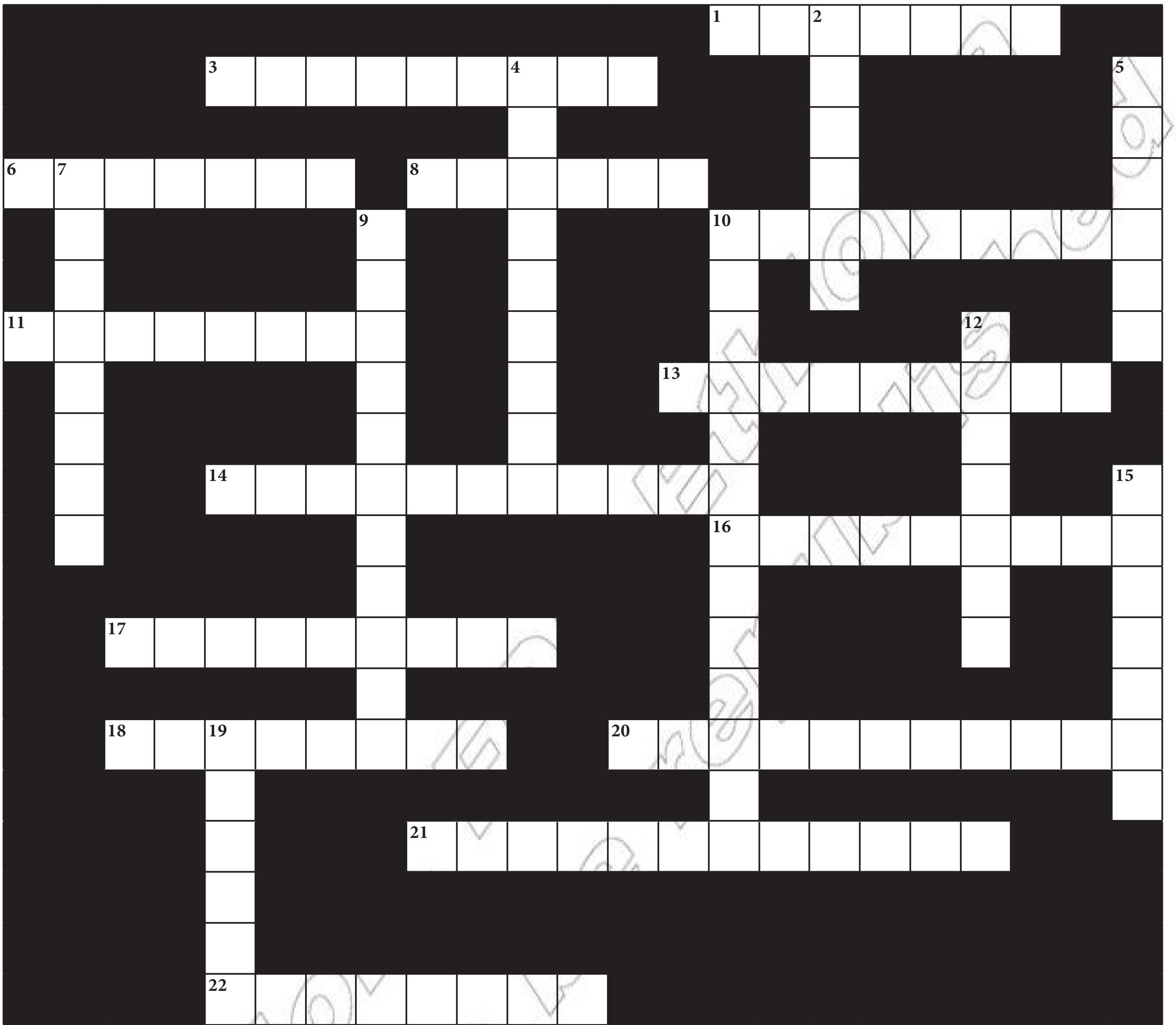
(i) classical conditioning

(ii) operant conditioning

8. Write a short essay on behaviour. Include the following aspects of behaviour in the essay:

- the nature of behaviour
- the different types of behaviour, including examples of each
- the benefits of studying behaviour

Copy the crossword puzzle below into your exercise book (or your teacher may give you a photocopy) and solve the numbered clues to complete it.



Across

1. Finding solutions to a problem without trial and error is called … learning (7)
3. The neurones that bring about a reflex action form a … (6, 3)
6. Behaviour that develops through trial and error or insight is called … behaviour (7)
8. Learning that takes pace without reinforcement (6)
10. Conditioning that involves associating two unrelated stimuli so that both produce the same response (9)
11. A structure that detects a change in the internal or external environment (8)
13. Patterns of behaviour that are repeated every twenty-four hours are said to have a … rhythm (9)

14. Innate behaviour that involves a fixed action pattern response (11)
16. Behaviour to attract a mate is … behaviour (9)
17. The co-ordinated response of an organism to a stimulus is … (9)
18. A change in the external or internal environment that leads to a response by an organism (8)
20. Type of learned behaviour in which the response to a stimulus decreases with repeated exposure (11)
21. The response of a plant to light is … (12)
22. The study of animal behaviour (8)

Down

2. Behaviour that modifies the actions of members of a group so that it is easier for the members of the group to co-exist (6)
4. This type of reflex action co-ordinates the activity of the internal organs (9)
5. Innate behaviour that produces a single response to a specific stimulus (6)
7. A structure that brings about a response (8)
9. Behaviour to defend an area of land rich in resources (11)
10. Apparatus for studying the environmental preferences of small invertebrates (13)
12. Animal behaviour in which a change in intensity of the stimulus causes a change in the rate of movement of the animal (7)
15. Conditioning that modifies behaviour through reinforcement or punishment (7)
19. Behaviour that is ‘inborn’ (6)