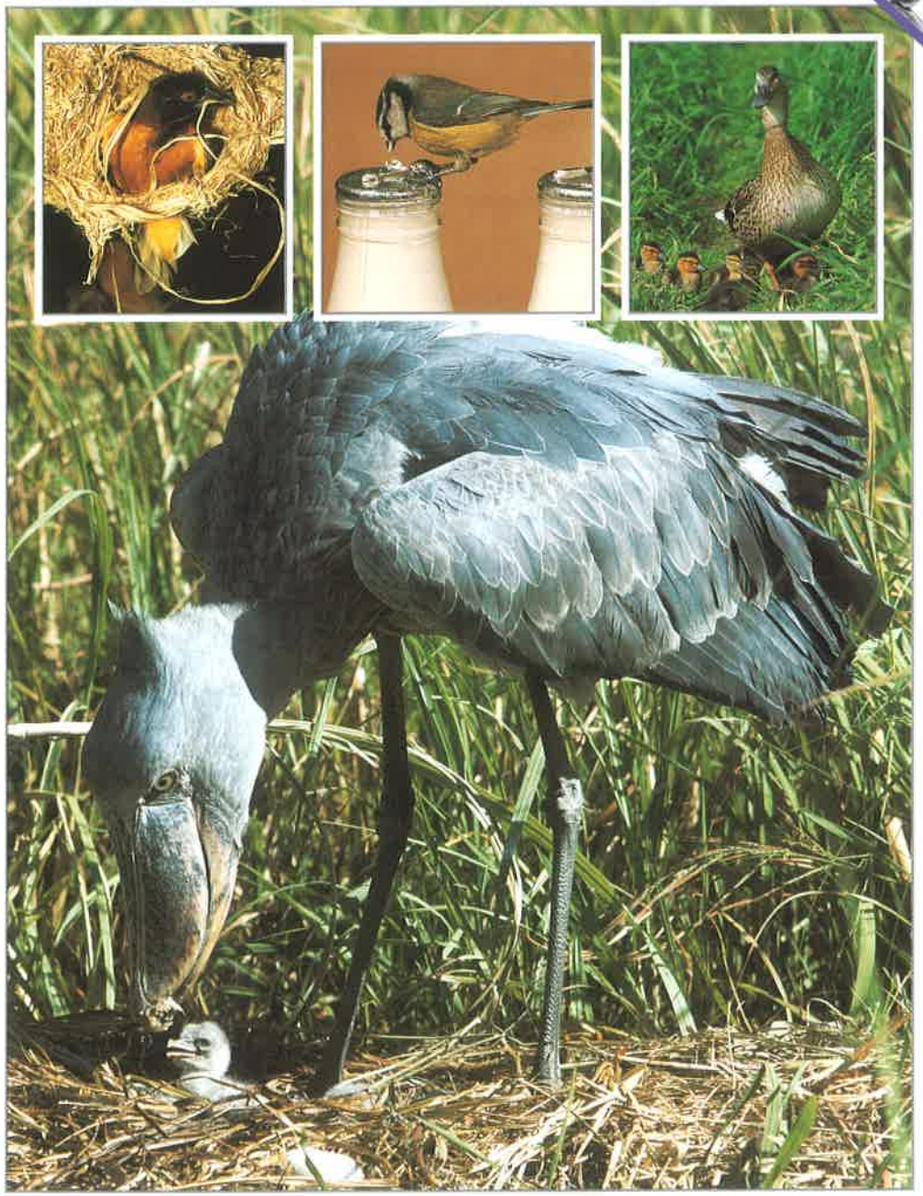
CARD 7

HOW BIRDS LEARN

GROUP 8: ANIMAL BEHAVIOR



Already, while they are still in the egg, birds learn to recognize their parents' calls. Most activities, from feeding to singing, involve learning, and learning is vital to survival.

KEY FACTS

HOW BIRDS LEARN TO SING

Young male songbirds such as the chaffinch are born with the ability to sing, but the nerves and muscles that enable them to make sounds take time to develop fully.

The young bird usually learns a simple version of his father's song in the fall of his first year. The following spring the young male begins to develop his song by hearing himself and other males sing. If a chaffinch is raised away from other birds, he will try to sing, but the song will bear little resemblance to a chaffinch's song.

By learning his father's version, the young bird is also taught to recognize and identify with his own family. If a male songbird is raised by parents of another species, he may learn the foster father's song rather than his own, although he usually attempts the song of his own species first.

The Australian lyrebird collects the songs of other species and weaves them into its own. Like other birds that live in dense undergrowth, it needs a long song to identify its location, so it adds bits of other bird songs to its own. Another form of imitation occurs with the great tit and the blackbird. The young bird does not learn its family's song, but its neighbor's.

Above: ***A young chaffinch must develop physically before it can sing.***

Left: ***The chaffinch perfects his song by listening to his father, other males, and himself.***

Left: ***Eighty percent of the lyrebird's song may be imitation.***

©MCMXCVI JMP BY JMP INC. WILDLIFE FACT FILE™ PRINTED IN U.S.A.

US P 6001 12 036 PACKET 36

Like all young animals, young birds learn to tell good food from bad, friends from enemies, parents from other members of the same species, and useful from unnecessary information. Learning these distinctions helps them cope with changes in their surroundings.

IMPRINTING

Young ducks learn to recognize their mother's call when they are in the egg, so they can identify their parent when they hatch. The mother duck is probably the first thing that a duckling fresh out of the egg sees, and it *imprints* on her, following her everywhere.

Young geese do not imprint by sound but by movement. They will imprint on another species if it is the first moving object they see. They then follow it around as they would follow a parent.

Imprinting helps the young bird to get food and protection from the parent. But if a bird is fostered by another species, it may unsuccessfully try to mate with a member of its foster species.

LEARNING WHAT IS IMPORTANT

When a predator such as a hawk flies overhead, young geese hide in the grass. But they soon learn that a goose flying above is not a threat. They learn to ignore information not vital to their survival. In this task they are aided by their parents' calls, to which they react instinctively.

Front insets from left: ***A weaver, a blue tit, and mallards show examples of learning by instinct, experience, and imprinting.***

Above: ***Nest building is instinctive, but building the complicated weaver bird's nest takes practice.***

LEARNING BY IMITATION

Mating, nest building, and caring for the young are instinctive behaviors. Other behaviors are learned by copying parents or other birds.

Oystercatchers eat mussels by picking at the shell's weakest part or by prying it open with their bill. Chicks use their parents' method, but fostered chicks adopt their foster parents' habits.

In the wild mynah birds do not copy other species' calls. In captivity, if they have not heard other mynahs, they copy human sounds most like their natural call, such as whistles, coughs, and shouts.

Parrots in the wild imitate their mate's call to strengthen their bond. Imitating humans may be a substitute.

Left: ***How an oystercatcher eats mussels depends on the method it learned from its parents.***

LEARNING BY EXPLORING

By exploring their environment, young birds learn the landmarks of their home area. This information is important for migration. Homing pigeons recognize their own loft, while long-distance migrants learn the relative positions of their seasonal homes.

This ability is not acquired immediately. If an experienced adult is taken away from its migration route, it can still find its way home, but an inexperienced young bird will get lost.

ASSOCIATION OF IDEAS

Young birds learn to tell good experiences from bad by trial and error. A chick pecks at everything, even pebbles, but it soon learns what is and is not good to eat. The cinnabar moth caterpillar, which has a yellow-striped body, tastes horrible, and the bird learns to avoid all yellow-striped caterpillars. Through "good" and "bad" experiences, it also learns to behave in ways that bring food. Pigeons learn to peck at an object if they are rewarded with food, because they associate the two events.

In 1921 a blue tit was seen pecking at the cardboard top of a milk bottle to get at the milk. Once the association with food was learned, other birds copied the behavior.

A green-backed heron in Miami accidentally learned to use bread as bait for catching fish. It was playing with a scrap of bread, when a fish was attracted by the movement. The heron caught the fish. It then associated the bread with catching the food and repeated the behavior.

Although mating behavior is instinctive, it can be affected by association. Anything that improves a bird's mating success may be learned and repeated.

Left: ***A mallard is most susceptible to imprinting at 16 hours, when it first takes to water.***

Left: ***In the wild mynahs make sudden, loud calls. In captivity they imitate human sounds because there are no mynahs to learn calls from. But instinct plays a part, for these mynahs most often copy sounds that resemble the natural call.***

HOW LIZARDS LOSE THEIR TAILS

CARD 6

GROUP 8: ANIMAL BEHAVIOR

Many lizards are able to shed their tails when caught by a predator. By deliberately sacrificing its own tail, a lizard can

KEY FACTS

COST OF TAIL LOSS

A lizard sheds its tail as an escape tactic. Where predators are rare, this drastic method of defense is less likely to be used. It is also less common among lizards that have other means of defense, such as thick armor or powerful teeth and claws.

Because the lizard gives up its tail to escape, tail shedding is more common among fast-moving lizards than among larger, less agile species. These slower-moving lizards are more likely to fall victim to a predator's second attack. The cost of tail loss may be higher than it appears. Losing a tail may save the lizard from a predator, but it may prevent the lizard from catching food or reproducing successfully.

Lizards use their tails for balance when running and for climbing and swimming. A few species run faster without their tails. But most tailless lizards are actually slower without the proper body balance that a tail provides.

Climbing species use their tails as a fifth limb. Iguanas and some geckos, for example, have adhesive pads on their tails and use them in gravity-defying maneuvers—even feeding while suspended by their tails. Skinks and other aquatic lizards cannot swim after losing their tails.

Some lizard species use their tails to signal status. Tailless lizards lose rank and find it difficult to hold territories or to mate. Lizards also use their tails for energy storage. A tailless lizard may starve if food becomes scarce.

Top: *An agama lizard has shed its tail to distract predators from its body.*

Above left: *This agama lizard still has its distinctive tail.*

Left: *Two green lizards flee from a predator. One has shed its tail.*

©MCMXCVI IMP BV/IMP INC. WILDLIFE FACT FILE™

PRINTED IN U.S.A.

US P 6001 12 019 PACKET 19

Tail shedding is an effective and very complex defense mechanism. Many factors—including the danger of its circumstances and the normal escape strategies of its species—dictate whether or not a reptile will shed its valuable tail.

WHY TAILS ARE SHED

Lizards are popular prey for many kinds of predators—from eagles to snakes. The lizards' main defenses are their camouflaged skin and the ability to stay motionless or to rush away. As a last resort, many lizards have the ability to lose their tails.

In some species the tail is brighter than the rest of the body. This provides a more visible target for a predator than the head or body. Many lizards have green or blue tails that are bright enough to distract a predator, yet not so conspicuous that they make the lizard easy to spot from far off.

As a lizard runs away from a predator, it can easily shed its tail. But it is more difficult to shed the tail when the lizard is being held in place. Thus, shedding is probably not an automatic or purely physical response, but a choice made by the lizard according to the circumstance.

Front cover: *Green lizards have their original tails.* **Inset:** *A tail regrows after shedding.*

ABILITY TO SHED

Some lizards lose all or part of their tails, depending upon the escape strategies of their species. A larger, slow-moving lizard will usually give up more of its tail than a smaller, faster one, but there are exceptions. A desert lizard, for example, loses its whole tail because hiding places in its habitat are scarce, so the lizard needs time to escape.

Some iguanas are able to shed their tails when they are young. But they lose this ability as they mature. Instead they develop the ability to defend themselves.

The tail does not always break at the same place each time, nor does it always snap off when pulled with the same amount of force.

HOW TAILS ARE SHED

Tail shedding is not common to all lizard species. But for those that do shed, two different methods of tail loss have evolved. Most lizards have areas of weakness in the *vertebrae,* or backbones, of their tails that run through the surrounding connective tissue and muscle. If a lizard is caught by its tail, it will contract the muscles in front of the weak area to split a vertebra and shed the part of its tail held by the attacker. Splitting a vertebra is called *intravertebral autonomy.*

A more primitive method of tail loss involves the tail's breaking between vertebrae *(intervertebral autotomy).* Tails lost in this way are less likely to regrow.

Top left: *This lizard has just shed its tail.*

Right: *Tail shed by an adult iguana.*

Below: *A slow-worm with a broken tail.*

TAIL RENEWAL

A regrown tail looks like the original tail, but there is often a joint or a change in color where the old tail broke off. Also, a new tail has tough cartilage instead of bone. A lizard can shed a regrown tail only above the place where the old one broke off.

TAIL LOSS AND RENEWAL

Some lizards have developed a technique of releasing their tails in exchange for freedom from a predator. A smaller, quicker lizard sheds only the tail's tip, but a slow-moving species may shed most or all of its tail.

Loss: Fleeing lizards shed their tails more readily than those whose bodies are being held while their tails are tugged off.

Renewal: Most lizards regrow their tails in a month. Larger lizards take a year.

New tail: The regrown tail contains cartilage instead of bone.

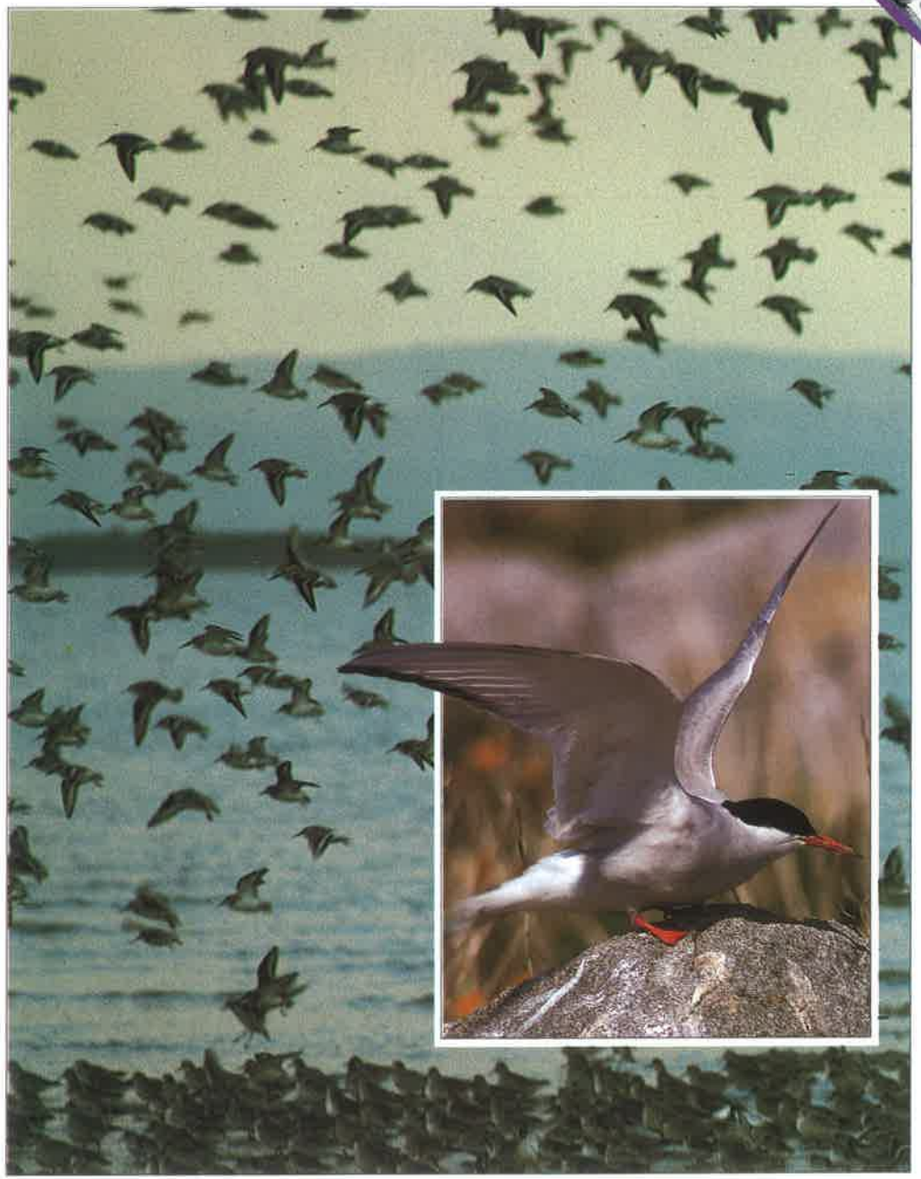
DID YOU KNOW?

- Some lizards store up to 60 percent of their body fat in their tails. Skinks, which can survive 35 days without food, may die within 24 days after losing their tails. Geckos can live for up to 3 months without food—but they seldom last for more than 50 days without tails.
- Lizards sometimes eat their own tails after shedding them to recover the energy stored in the tails.
- Tailless female lizards tend to produce fewer eggs, since much of their energy goes to regrowing their tails.

CARD 5

HOW BIRDS MIGRATE

GROUP 8: ANIMAL BEHAVIOR



Great flocks of birds, gathering for their winter migration, are a familiar sight every fall. But how do they know where to go, and how do they find their way to and from their destination?

KEY FACTS

MIGRATION PATTERNS

The migration routes used by birds in the United States are called flyways. To give migrating birds safe resting spots, wildlife sanctuaries have been established along many of these flyways. There are four flyways, named after their geographic locations: the Atlantic flyway follows the East Coast; the Mississippi flyway follows the Mississippi River; the central flyway follows the Rocky Mountains; and the Pacific flyway follows the West Coast.

Migrating birds found in Europe use flyways that extend as far as southern Africa. Swallows are among the best known of all migrating birds, and their arrival in Europe heralds the start of summer. They come from southern Africa, stay until fall, and return south for the winter.

Migration is not restricted to the Northern Hemisphere during the summer, but because there is less land south of the equator, the north provides them with habitats that are better suited to breeding.

Left: *A pair of house martins perch on a ship's rigging. Like many other birds that migrate long distances over the sea, house martins often stop on passing ships to rest and recuperate along the way.*

Left: *Bewick's swans migrate from northern Europe to winter in warmer regions.*

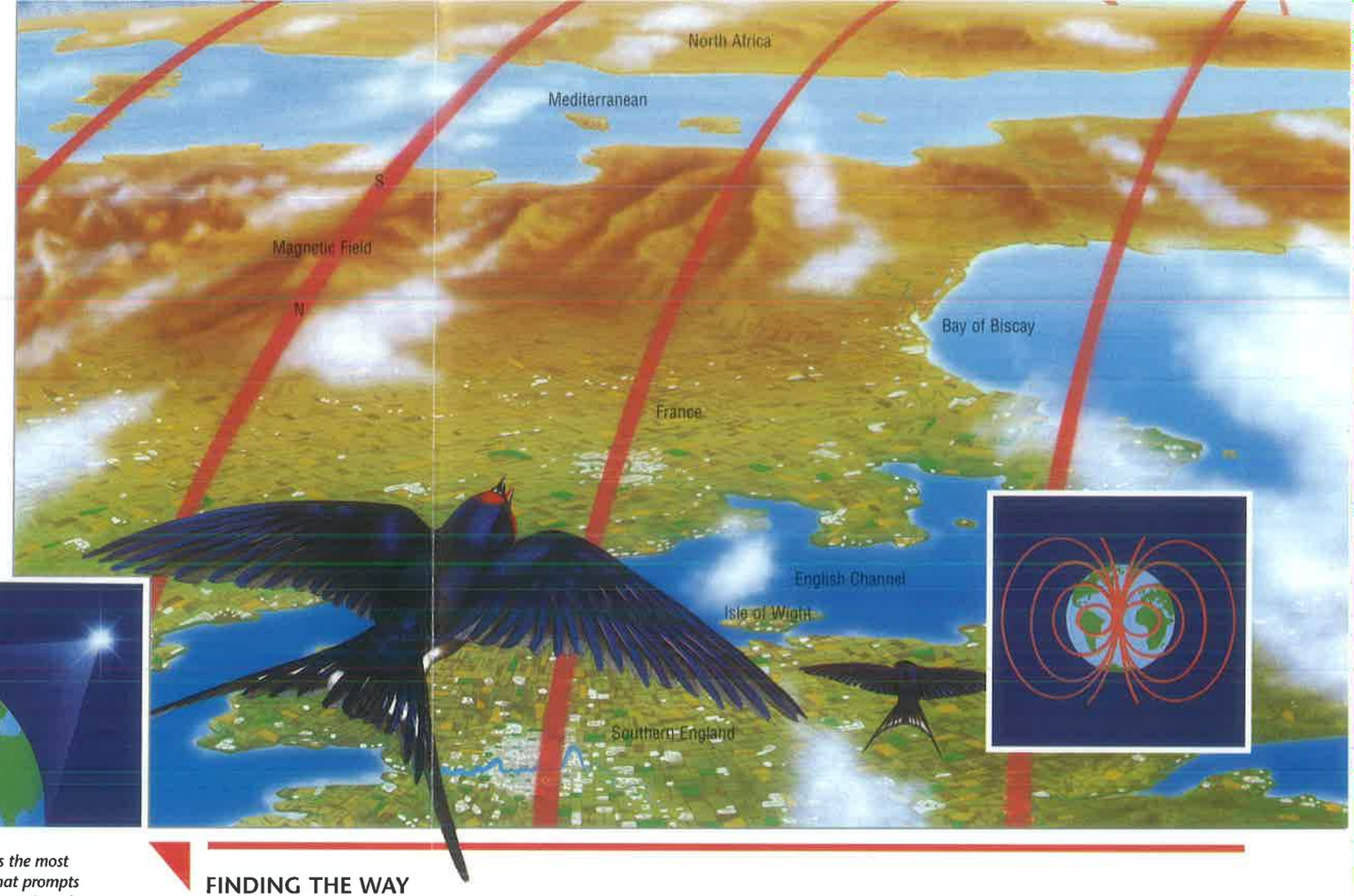
Below: *Sandpipers in Florida. In winter, they migrate to South America.*

Right: *The Arctic tern migrates farther than any other bird species—some travel from the Arctic to the Antarctic.*

©MCMXCIV IMP BV/IMP INC. Wildlife Fact File™ International Masters Publishers AB, produced under license. Printed in U.S.A.

US P 6001 12 009 Packet 8R

Migration is essential to many birds' survival. Their seasonal migrations take them to the most inhabitable climates, where enough food and nesting sites are available.



WHY & WHEN?

The seasonal availability of food, the search for suitable nest sites, the need to escape from predators, and overcrowding are the main reasons that birds migrate. The distance traveled during migration, as well as its duration, varies greatly between species.

During fall in the Northern Hemisphere, the days get shorter and colder and plant growth slows down, diminishing the food supply. These factors prompt the birds to head south.

In the spring, their southern wintering grounds gradually become hotter and drier, causing the birds to once again migrate north. After arriving in a place where weather conditions are cooler and food is plentiful, they will breed before returning south the following winter.

Seasonal change is the most common trigger that prompts birds to migrate. In spring, the axis of the earth is tipped toward the sun, and the hours of daylight increase **(above).** ***As winter approaches, the axis turns away from the sun, and the amount of daylight decreases*** **(below).**

FINDING THE WAY

Many species migrate in flocks, and it is thought that the experienced adults guide the young and teach them where to go. In this way, knowledge of the route is passed on from generation to generation. But then there are some birds that migrate singly, so how do they know where to go and how to get there? Birds clearly have an instinct that guides them during migration.

Birds that migrate during the day may very well navigate by using the sun's position as a guide. It is believed that birds that fly at night during migration navigate in a similar way, using star configurations to find their direction.

It also appears that birds use the earth's magnetic field to help them find their way. Functioning somewhat like a compass, the birds have an instinct that is sensitive to the magnetic field, and that allows them to use it as a directional reference. As a bird migrates using the magnetic field as a guide, it is believed that it remembers in which direction it is traveling and simply reverses its flight on the return migration.

It is also possible that some birds use their sense of smell to recognize odors along their particular flyway. By following the odors, they find their way. Birds may also keep on course by recognizing landmarks.

Many migrating birds navigate by the sun's posltion.

Some birds navigate by the earth's magnetic field.

CARD 4

WHY DO ANIMALS HIBERNATE?

GROUP 8: ANIMAL BEHAVIOR

Hibernation is a necessary means of surviving the dark, cold months of winter. For species such as the hedgehog (above), hamster, and brown bat, the only alternative is starvation.

MAMMALS THAT HIBERNATE

Left: *The duck-billed platypus hibernates in brief stretches.*

Below left: *The black bear sleeps most of the winter in its den but is not a true hibernator.*

Below right: *The tiny water shrew is a light sleeper.*

TRUE HIBERNATORS

Only true hibernators are able to lower their body temperature to near freezing and then generate enough warmth to revive themselves.

Both the echidna and the duck-billed platypus hibernate for several periods of 5 to 10 days. The koala and the Tasmanian pygmy opossum are two of the few marsupials that are true hibernators.

The majority of true hibernators are either rodents or bats. Rodent hibernators include ground squirrels, marmots, woodchucks, dormice, and hamsters. The hedgehog spends the cold winter months curled up in a nest of dried leaves. Among bats, hibernators include the noctule and serotine bats that spend the winter in deep, damp caves, wrapped in their wings.

WINTER SLEEPERS

Certain large mammals such as American black bears spend much of the winter asleep in their dens, but they are not true hibernators. Although their heartbeat slows to just 10 beats per minute, their body temperature is actually maintained at 86° F. Badgers, raccoons, and skunks also sleep through cold spells, but they, too, must maintain relatively high body temperatures.

©MCMXCVI JIMP PYMP INC. WILDLIFE FACT FILE™ PRINTED IN U.S.A. US P 6001 12 013 PACKET 13

Hibernation—a long winter sleep—enables some warm-blooded animals to survive the months when their food supplies become unreliable or disappear altogether. True hibernators save precious energy by reducing their body temperature to a level that would normally prove fatal.

WHAT IS HIBERNATION?

Throughout the summer, small, warm-blooded animals such as ground squirrels and marmots keep their body temperature at about 99° F, no matter what the air temperature is. Their breathing and heartbeat are also quite normal at approximately 16 breaths and 88 beats per minute.

As soon as winter comes and the temperature drops, the marmot curls up and falls into what appears to be a deep sleep but is actually hibernation. This is a state that the animal enters deliberately, and during which it retains some control over its body temperature. Such control allows the animal to revive itself periodically when it needs to eat, or if some emergency arises, such as its nest's becoming flooded.

During hibernation, the marmot's body temperature drops to 50° F—low enough to be fatal to any non-hibernating species.

Right: *A long-eared bat hibernates in a secluded crevice, ears tucked under wings.*

WHY HIBERNATE?

During the winter, most plants stop growing, and cold-blooded animals such as insects become inactive. Warm-blooded animals—birds and mammals—cannot respond in the same manner. Although some animals can survive even in the below-freezing conditions of Antarctica, they all must keep their body temperatures constant within very narrow limits. If their temperatures rise or fall beyond these limits, the animals will die.

For most animals, keeping warm presents the greatest challenge in winter, because the body temperature of birds and mammals is almost always higher than the surrounding air temperature. Maintaining a high body temperature requires energy in the form of food—and food is scarce in most places in winter.

Many animals that live in the extreme cold of the world's polar regions conserve energy by growing thick winter coats. The husky, a hardy breed of dog that lives in the polar regions, grows a coat so thick and warm that it can sleep on the snow in temperatures that may get as low as -22° F. Smaller animals lose heat more quickly and must burn their food faster to stay warm. A mouse, for example, burns energy 20 times faster than a sheep. Furthermore, there is a limit to how thick a coat a small animal can grow. As a result, many smaller animals build themselves snug, well-insulated nests, often in deep, underground tunnels.

For a warm-blooded mammal to keep its body temperature at 100° F, it must eat. Some species of mouse build up reserves of fat on which they rely when food becomes scarce. Other animals live on stored supplies of nuts and seeds. For many, especially those that feed mainly on insects, the only way to survive is to reduce their energy by hibernating.

Above and below: *The raccoon and badger both sleep through cold spells without actually going into hibernation.*

A RESTLESS SLEEP

Hibernators do not remain constantly asleep throughout the winter. Small bats hibernate for the longest periods, but even they remain dormant for no longer than a month. The hedgehog, by comparison, hibernates for only several weeks before waking briefly.

At the other extreme, the tiny shrew, which weighs barely two grams, hibernates for less then eight hours at a time, and its body temperature falls to just 64° F.

While hibernating, some animals may appear to be dead. They are cold to the touch and seem lifeless. Other species wake almost instantly if they are disturbed.

Almost all hibernators will wake up when the temperature falls below the point from which they could not recover. Waking is usually accompanied by shivering as the animal begins to raise its body temperature.

Although constant reawakening uses up energy, it seems vital to the animal's survival. Since the animal uses some energy during hibernation, the resultant waste products must be expelled.

HIBERNATION IN BIRDS

It was once thought that swallows spent the winter underwater, hibernating at the bottom of rivers and ponds. But it is now known that they migrate south to warmer climates each fall.

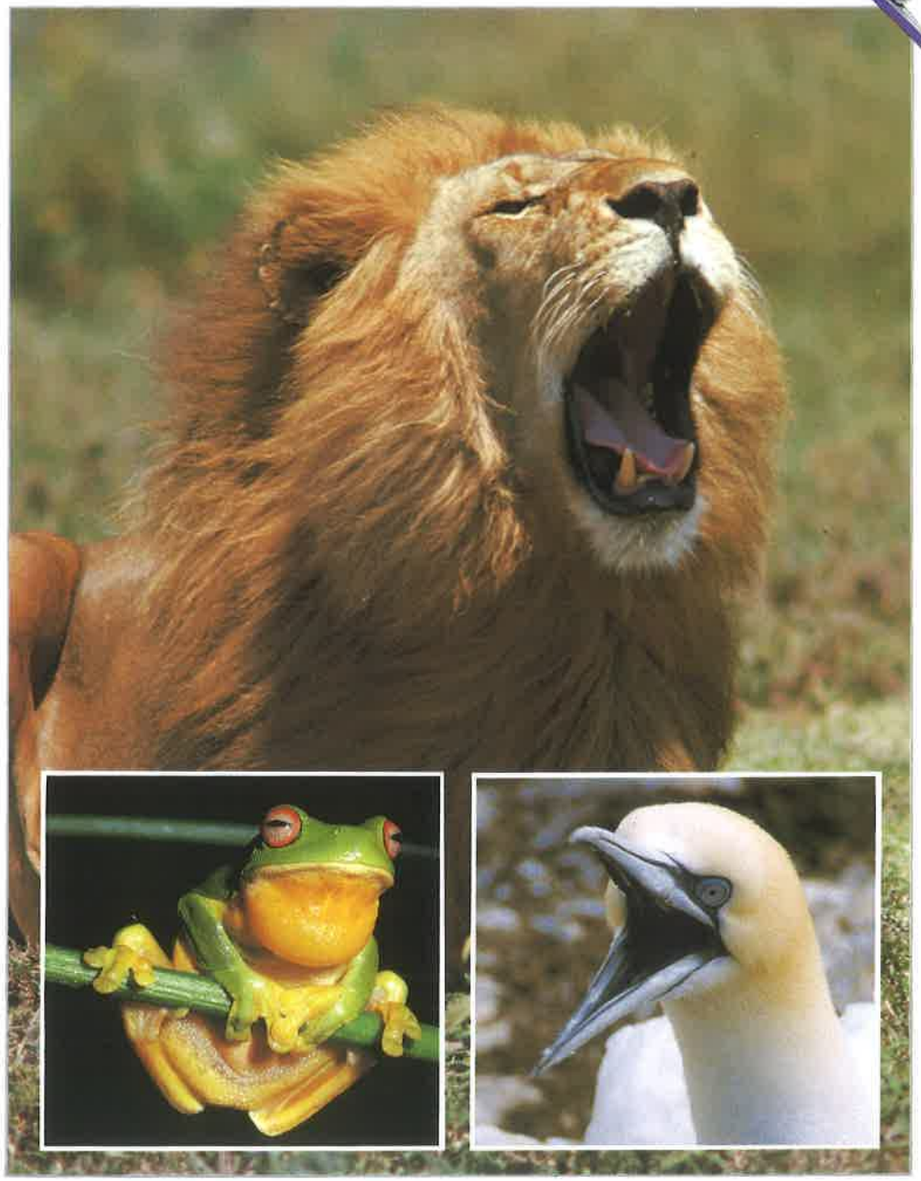
More recently, however, it has been discovered that certain species of bird do appear to hibernate, if only for short periods of time. The white-throated poorwill feeds on insects, and when they become scarce in winter, it hibernates. For several hours at a time, its body temperature drops from 104° F to as low as 43° F.

Several species of tropical hummingbird also appear to hibernate for a few hours each night, when their body temperature falls to 46° F.

CARD 3

DO ANIMALS TALK?

GROUP 8: ANIMAL BEHAVIOR



It is easy to think of a lion's roar or a chimp's chatter as words in an animal language. But what do these sounds mean, and do animals really use them to communicate with one another?

KEY FACTS

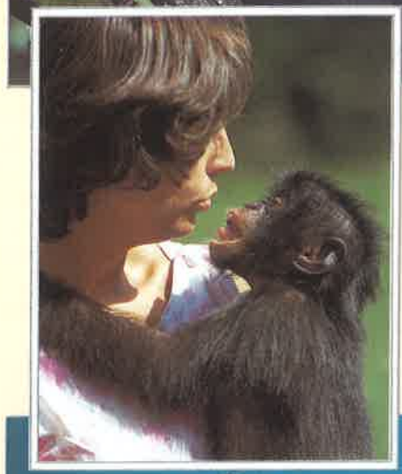
TALKING CHIMPS

Although the chimpanzee is man's closest relative and uses many of the same facial expressions, wild chimpanzees do not appear to use language as we understand it. Still, chimpanzees raised in captivity have been taught to use sign and symbolic languages, proving that they have the capacity to communicate through language.

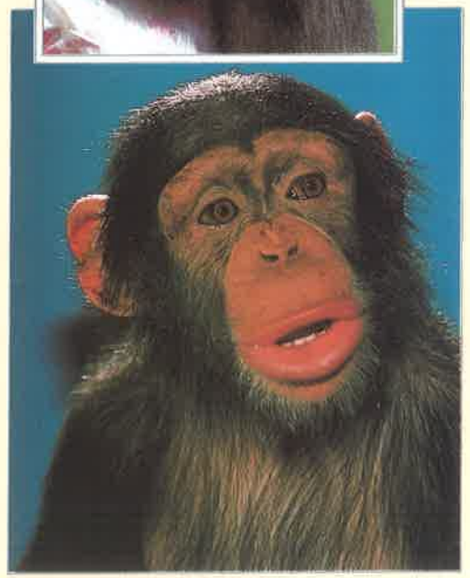
The first chimpanzee to learn sign language was Washoe, who, in the 1960s, was raised in a human environment and taught to communicate using American Sign Language. Washoe eventually learned 160 different word signs and proved capable of conveying ideas with word combinations. One day, surprised to see a toy doll placed in her cup, she signed her most famous phrase, "Baby in my drink."

Other researchers have used new, artificial languages in similar studies. Two chimps, Austin and Sherman, were taught to use Yerkish—a language that substitutes symbols for words.

When given suitable linguistic tools, then, chimpanzees demonstrate that they can express ideas and even grasp some concept of grammar. While they may not possess a language in the wild, it does appear that chimpanzees can learn to communicate through the use of language.



Above: *The chimpanzee's intelligence and its well-developed hands have enabled it to learn sign language.*



Center: *Chimps used to human contact have been taught methods of communication that involve thinking for themselves.*

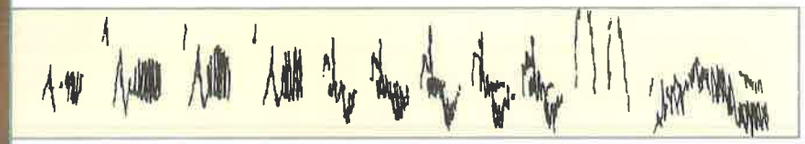
Left: *More than any other animal except man, chimpanzees use facial expressions to communicate and display moods and emotion.*

©MCMXCIV IMP BV/IMP INC. Wildlife Fact File™ International Masters Publishers AB, produced under license. Printed in U.S.A.

US P 6001 12 005 PACKET 5R

Animals communicate in many ways. Some spray scent, others perform startling visual displays, and still more use gestures to convey a wide variety of messages. But it is the use of sound that provides the most immediate and flexible means of communication.

R. Wilmshurst/Bruce Coleman Ltd



Above: *A chaffinch's song shown in a visual image called a* **sonogram.**

Left: *A male chaffinch singing to establish his territory.*

DID YOU KNOW?

- Traveling through channels in the ocean floor 2,000 to 4,000 feet beneath the water's surface, the sounds of the humpback whale are carried from one side of the Pacific to the other.
- Few animals use more than 12 calls; a human vocabulary may contain 40,000 words.
- Some scientists believe that the dance of the honeybee is the best example of true animal language, which bees use to communicate information about food sources.

TRUE LANGUAGE

Language is any method by which information is exchanged. But true language is the means by which a range of information is conveyed, including the expression of abstract ideas, displays of emotion, and past and future thoughts and actions.

Most animals communicate, not through language, but by instinctive behavior that informs others.

TALKING ANIMALS

Animals make a wide variety of sounds, from the musical song of a bird, to the howl of wolf, to the contented purr of a cat. While they are unable to talk in the same way as humans, they do communicate with sound in a way that is understood only by other members of their own species.

Still, researchers have been unable to translate individual animal sounds in a framework that can be called true language.

VOCAL VERVET MONKEYS

The vervet monkey is one of the most vocal of all animals. It has developed three or four distinct sounds that it uses to identify different predators to fellow members of a troop.

If a monkey spots an eagle, it gives the appropriate call of warning, which makes any monkeys in the trees drop to the ground. A different sound is used to communicate the presence of a leopard.

It is believed that the distinct sounds that the vervet monkeys make are learned, rather than instinctual. Young vervets often make the wrong calls, and different troops use their own sounds when identifying the same predator.

Below: *Vervet monkeys are known to use different sounds as they communicate dangers to one another.* **Inset:** *A monky screeches a word of warning.*

Mike Mockler/Swift Picture Library

VOCABULARIES

Although humans often attribute subtle and complicated meaning to the various sounds that animals make, most animal communication is actually simple in context. Animal communication is most often used in situations in which attracting a mate or defending territory or food from rivals is involved. Furthermore, such communication is an instinctive form of behavior, rather than a learned skill, and not a sign of true language.

So, although every dog makes a different sound when it barks, the bark is simply used to announce its presence to a mate or as a warning to a rival. The message is simple, and the ability to bark is inherited.

Some animals do show some sophistication in language. Some birds whistle as a warning that a predator is near, but use a remarkably different series of chirps to rally a group to defend against less

Jeff Foot/Bruce Coleman Ltd.

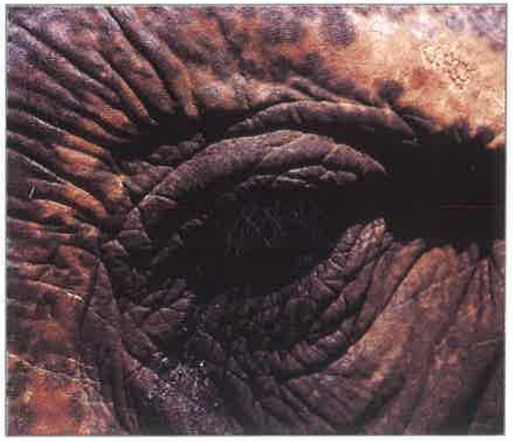
Above: *Humpback whales make very loud whistling noises.*
Below: *The grasshopper mouse of Mexico makes a wide range of noises and calls.*

M.P.L. Fodgen/Bruce Coleman Ltd

CARD 2

HOW MAMMALS SEE

GROUP 8: ANIMAL BEHAVIOR



Our ability to see greatly influences our perception of the world around us. Do all mammals see in the same way that we do? Is sight as important to their ways of life?

WHAT DIFFERENT MAMMALS SEE

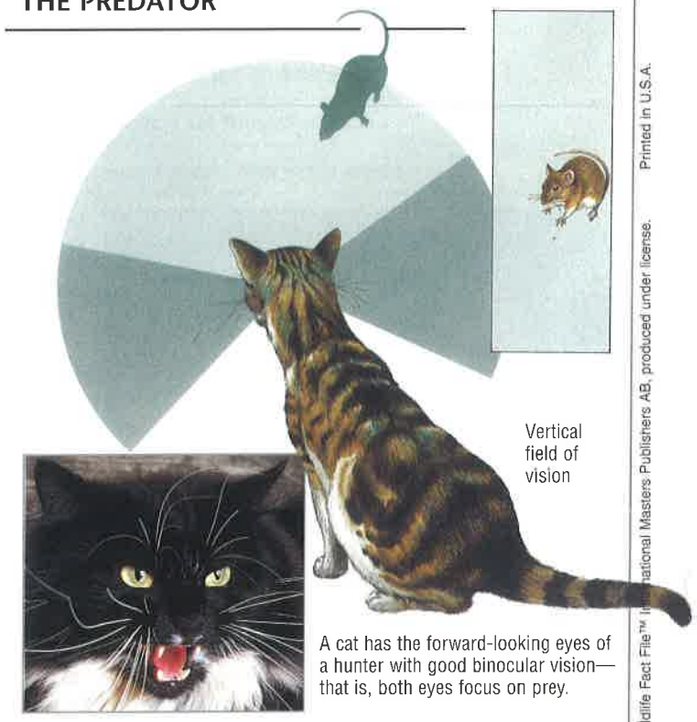
All mammals have the same basic eye construction. But it is the position of the eyes on the head that most dramatically affects the way in which different mammals see.

Successful predators, such as cats, must be able to focus their vision exactly in order to pinpoint prey. They generally have eyes that face forward. Although their peripheral vision is limited, their binocular vision (the ability to focus both eyes together on one object) and depth perception allow them to gauge the exact distance between themselves and their prey.

Animals that are preyed upon, however, such as rabbits, mice, and deer, have eyes that are located on either side of their head, which allows them a much wider range of vision. This positioning diminishes their binocular vision, but their panoramic field of vision is increased because their eyes work independently to survey their surroundings for predators. A rabbit, for example, has an almost 360-degree field of vision, which means it can spot danger from every direction.

By contrast, a human being looking straight ahead can see about 200 degrees around without moving the head. A cat's field of vision is slightly narrower—about 185 degrees.

THE PREDATOR



Vertical field of vision

A cat has the forward-looking eyes of a hunter with good binocular vision—that is, both eyes focus on prey.

THE PREY

As a hunted animal, the mouse needs good all-around vision. It therefore has eyes situated on either side of its head. But, as a result, its binocular vision is very limited.

Horizontal field of vision

©MCMXCIV IMP BV/IMP INC. Wildlife Fact File™ International Masters Publishers AB, produced under license. Printed in U.S.A.

US P 6001 11 103 PACKET 3R

All mammals depend on light to see.

Objects in the world reflect light at

different levels in the form of electromagnetic waves.

Our eyes pick up the waves and,

with the help of the brain,

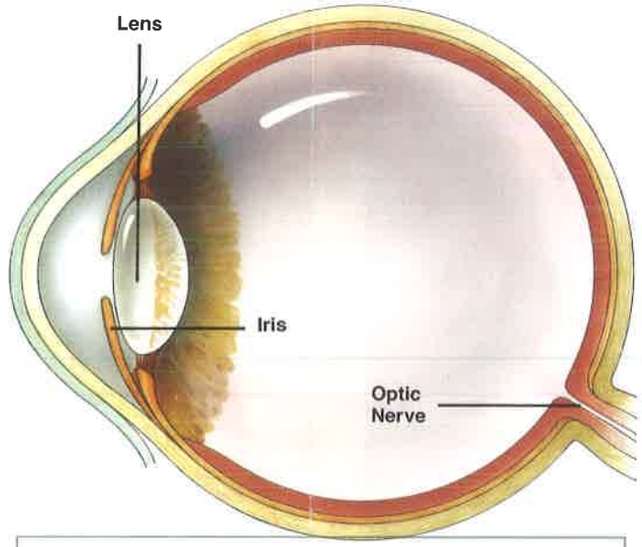
convert them into visual images.

DID YOU KNOW?

- The retinas of many mammals have only two types of cones, so they are less able to see shades of red and yellow-green.
- Different mammals' eyes reflect light in different colors; A fox's eyes are yellow, and a rabbit's eyes are red.
- Whales have no binocular vision. Because of the position of their eyes, they can never focus both of them on the same object at once.

Left: *Whatever the shape—big and round, or small and beady—the basic design of all mammals' eyes is the same.*

Right: *Light enters the eye via the iris; the lens focuses the light onto the retina. The image is then sent to the brain by the optic nerve.*



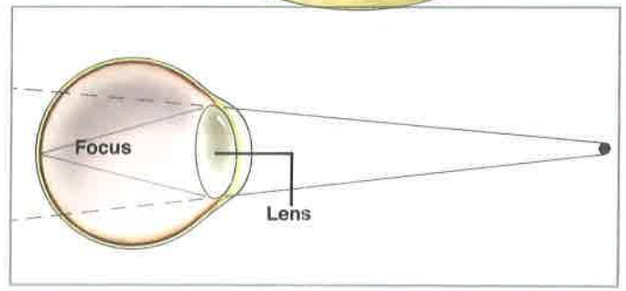
HOW THE EYE WORKS

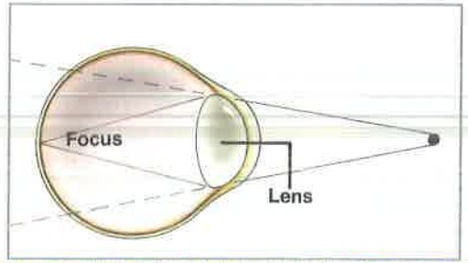
The eyes of all mammals have the same basic design, so they all work in the same way. At the front of the eye is the transparent *cornea*, which acts as a window, allowing light to enter the eye. Behind the cornea is a colored area known as the *iris*, which can change its diameter to vary the intensity of light entering the eye.

Behind the iris is the *lens*, which directs the light rays onto a light-sensitive surface at the back of the eye, known as the *retina*. The lens is surrounded by muscles that expand and contract, allowing the eye to focus on an object.

The retina is made up of closely packed, light-sensitive cells. These are connected to the *optic nerve*, which is in turn connected to the brain. The cells receive an upside-down image, and they pass it on to the brain through the optic nerve.

The brain interprets, or decodes, this image, turns it right-side-up, and transforms it into a three-dimensional picture. Thus, the brain can be considered as much a sight organ as the parts of the eye.





When focusing at a distance, the muscles around the lens are relaxed. They contract, altering the shape of the lens, when they focus on a nearby object.

NIGHTTIME VISION

If vision depends on light reaching the retina, how can some animals see in the dark?

The design of the eyes of nocturnal species is almost the same as in other mammals. The most obvious difference, though, is that the eyes of mammals that have excellent nighttime vision are larger and more bulbous, and thus are more sensitive to light.

Nocturnal mammals also have a reflective layer behind the retina, which bounces light back through the eye, giving the light-sensitive cells—called rods—in the retina another chance to absorb the light-waves. The effect is visible when the headlights of a car shine on cat's eyes, the cat's eyes shine back.

In addition, the retinas of these animals generally contain more rods, which increases their sensitivity in dim light.

SEEING IN COLOR

How do our eyes interpret color, and do all mammals see different colors to the same extent?

The electromagnetic waves sent out by objects vary in length: the longer ones are interpreted by our eyes as reds and oranges, and the shorter ones as greens and blues.

The light-sensitive cells in the retina are divided into two different types—rods and cones. The *rods* cannot distinguish colors, but they are sensitive and pick up even very low levels of light. The *cones* interpret and relay information about the colors of the wavelengths that they receive. Mammals with the best color vision have three different types of cones.

The brain transforms the messages received by the cones into the multicolored images that we see in front of us.

The cones receive color wavelengths only under good lighting conditions. This may be why it has long been thought that nocturnal animals do not see in color. However, it is now generally accepted that all mammals have some degree of color vision.