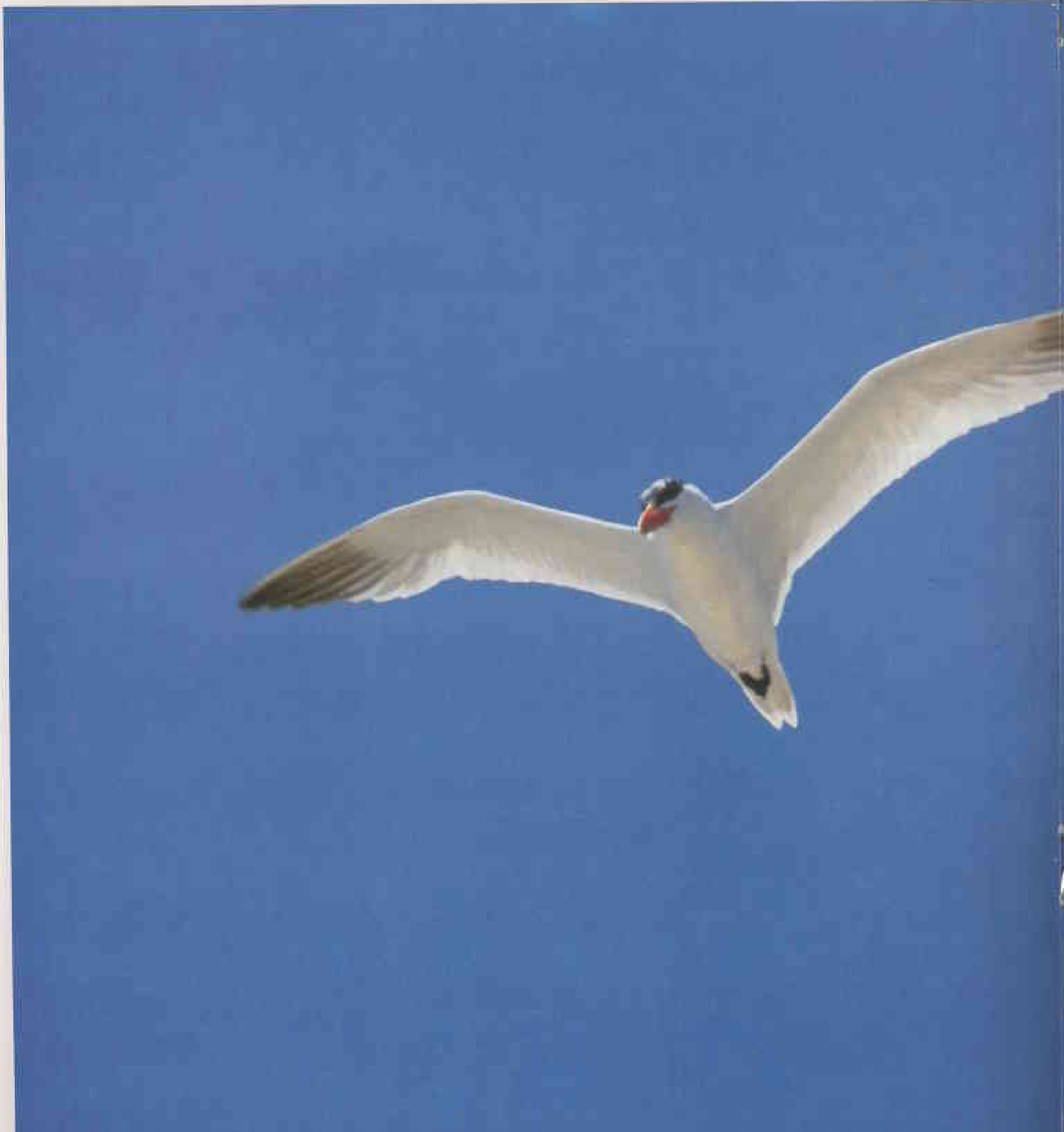
To Fly Like



e A Bird!

How can an albatross fly for hours with scarcely a wingbeat? Which birds can fly backwards?

Jim Lane unravels some of the mysteries of avian aerodynamics.

Photo left - Cliff Winfield
Photo above - Robert Karri-Davies

TO fly like a bird! Who has not imagined how exhilarating it would be? To launch from the ground and soar into the sky; to swoop and dive and climb again; to plummet towards the earth at breakneck speed; to chase or harry; to glide effortlessly over land and sea.

Humans have long been fascinated by the flying abilities of birds, and have made many attempts to understand the physics of flight and emulate their aerial performance. Even in this era of satellites, space shuttles, supersonic aircraft, vertical take-off jets and backward-flying helicopters, bird flight retains its fascination.

Picture a bird, let's say an Australian pelican, gliding horizontally in motionless air. As it glides, it will slowly lose speed because of drag, caused by the air friction against its body surface, and by the disturbed air or "wake" which trails behind its wing tips. Slowing continues until the pelican eventually reaches stalling speed, when the streamlined flow of air over the wings' upper surfaces breaks into eddies. This causes a sudden, dramatic loss in the amount of lift provided by the wings. Without corrective action, the pelican will drop from the sky like a stone.

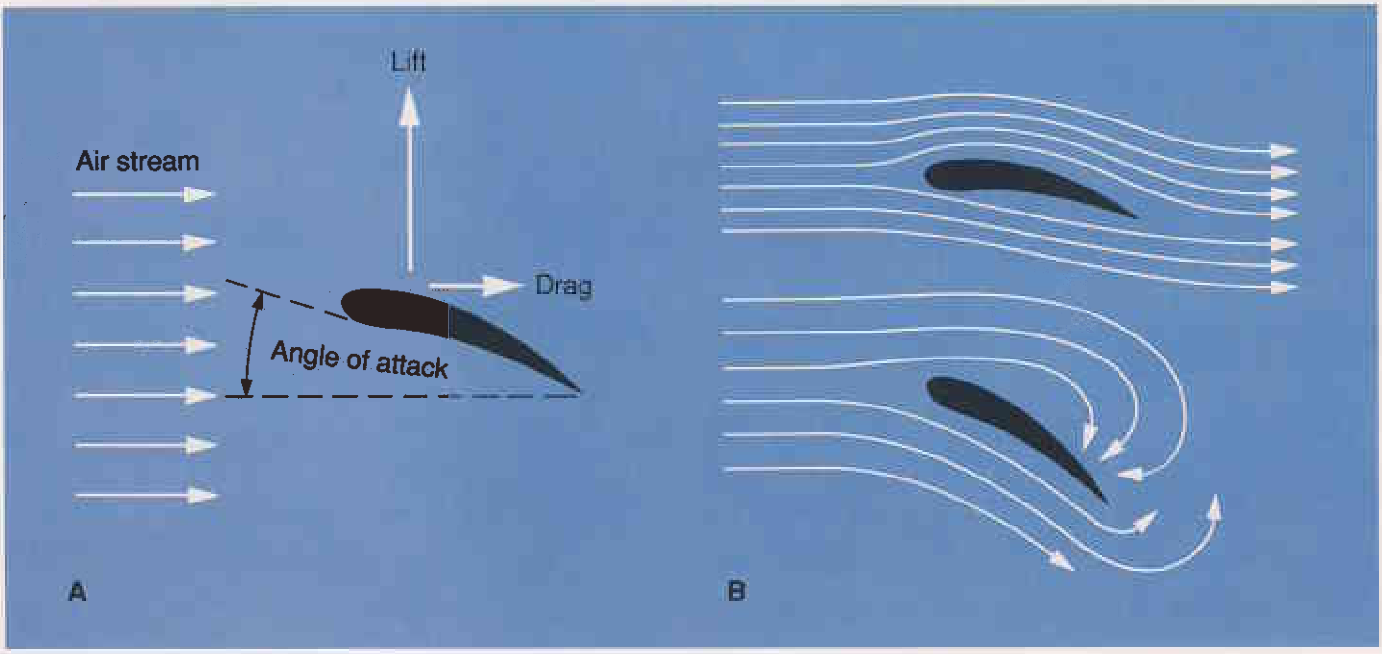
GLIDE, FLAP OR SOAR

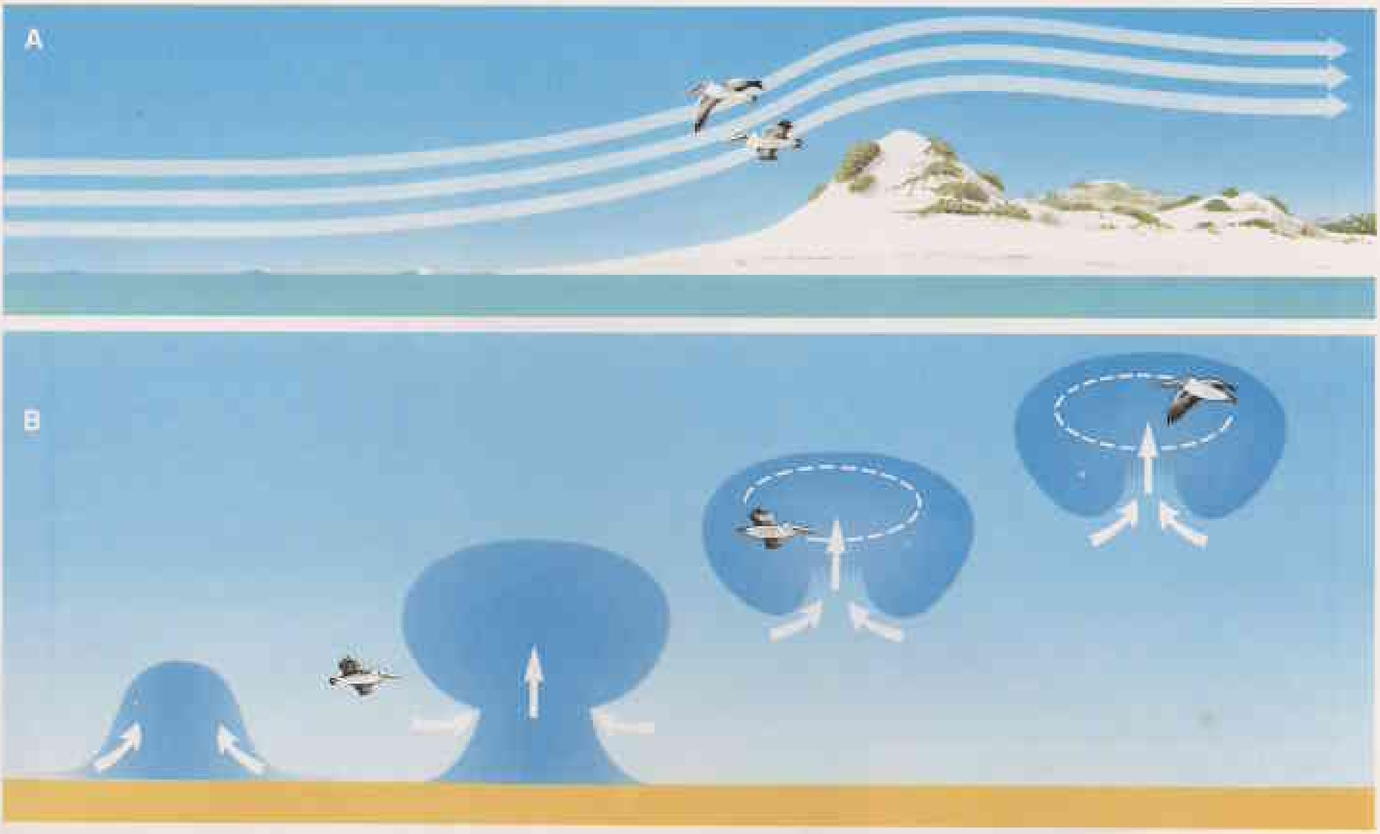
To continue forward, the pelican has two options. It can flap its wings, providing the power needed to overcome the slowing effect of drag, or it can tilt down slightly and begin a shallow glide towards the ground, using the pull of gravity to maintain the necessary airspeed. If it can find an area of updraft, then the bird can use a third strategy: it can maintain or even gain altitude while gliding downwards through steadily rising air. Updrafts are common over land, and may be caused either by an obstacle to the wind's progress (such as a cliff-face,

Pelicans' large wings enable them to take off almost vertically when a headwind is blowing.
Photo - Michael Morcombe ▶

A. The amount of lift (and drag) produced by a wing depends upon the airspeed and 'angle of attack'.

B. A bird gliding horizontally is slowed by drag, and the amount of lift produced by the wings lessens. To maintain lift, the wings' angle of attack is steadily increased until stalling point is reached. At this point the smooth flow of air over the wing's upper surface breaks into eddies. The wing stops producing lift and the bird must take corrective action, such as gliding downwards or flapping.▼





a range of hills or belt of trees) or by localised heating of the earth's surface giving rise to what are known as thermals.

The first type of updraft is most useful to our imaginary pelican if it continues horizontally from the bird's position to its intended destination. For example, where a ridge of coastal dunes extends between two favoured fishing grounds, and where an onshore breeze is blowing, the pelican could ride the updraft on the windward side of the coastal dunes from one fishing spot to the other. This practice is known as slope soaring.

It is rare, however, for ridges of dunes, hills or other obstacles to stretch continuously between favoured locations of long-distance travellers like our pelican.

Thermal updrafts are much more common. They form where the sun's rays cause certain areas of ground, such as rocky outcrops, to heat more rapidly than the surrounding land. This, in turn, causes the air above to warm. Being less dense, this "blister" of warmer air rises, being displaced by cooler air which, in turn, is heated by the warm ground below. The result is a column of rising, warmed air. As the column grows, more and more cool air rushes to its base, until it finally breaks free from the ground and becomes a bubble of steadily rising air.

Birds that find these thermals and glide in circles within them can gain great heights - several thousand metres or more - with very few beats of their wings. A pelican travelling cross-country may use a succession of thermals, alternately rising within and gliding between them, to reach its destination.

Large birds travelling this way save an enormous amount of energy. Indeed, pelicans would be unable to make their extensive journeys if they had to flap their wings continuously. This practice of gaining altitude by using thermals is known as thermal soaring, and is also used by herons, ibis, gulls, ravens, vultures, eagles and other birds. Soaring birds often travel in flocks, rather than singly, increasing the probability of finding each new thermal.

RISE STEEP, DIVE DEEP

Some of the larger seabirds use another kind of soaring, known as dynamic soaring. Albatrosses are the most aerodynamically efficient gliding birds of all. They can fly for hours with scarcely a wingbeat, travelling great distances in any direction, by using wind speed gradients. The albatross is mainly found in the "roaring forty" latitudes of 40-50 degrees south, where constant strong winds provide the energy needed for its special flight technique.

At sea, winds are horizontal, but their speed varies with height above the ocean surface. Near the water, friction causes the air to slow. Higher up, the friction lessens and wind speed increases. Above a height of 20-30 metres the frictional effect of the sea is minimal and wind speed is fairly constant.

Albatrosses glide in great loops within the 20-30 metre band of increasing wind speed. They rise steeply into the wind, then turn downwind in a steep or shallow dive until close to the waves, then glide

A. Surface winds may be deflected upwards by obstacles, producing what is known as 'slope lift'. Some birds, such as kestrels, use slope lift to maintain a 'hovering' position. Others, such as pelicans, may use slope lift to save energy when travelling. A pelican wing-tagged by the author used coastal upcurrents during regular trips between Augusta and Denmark on WA's south coast. On one occasion this bird made the trip three times in less than two and a half days, a total distance of 700 km.

B. Uneven heating of the earth's surface causes 'hot spots' to form. Air above these spots is warmed and rises to form a column. Cool air rushes in at the base and eventually a bubble is formed, which may rise for several thousand metres or more. Birds gliding in circles within these 'thermals' can soar to great heights with minimal effort.▲

back into the wind before beginning the next cycle. When they rise into stronger winds their airspeed, and therefore the amount of lift generated by their wings, increases, offsetting the slowing effect of gravity. The birds can rise steadily in a wind gradient with motionless wings.

Recent research using satellite transmitter packs has shown that wandering albatrosses travel enormous distances, between 3 600 and 15 000 kilometres in 14 to 24 days, while foraging for food during the nesting season. They begin their journeys by soaring downwind. When it is time to return to the nest site, albatrosses do so, not by attempting flapping flight (which would be far too exhausting), but by clever use of changes in wind direction while soaring at right angles to it. They fly at speeds of up to 80 kilometres per hour and may travel more than 900 kilometres each day; an astonishing feat by any standard.

HEAVE AND FLAP

Flapping, or powered flight, is much more energy-demanding than gliding or soaring. The mute swan of Europe and the trumpeter swan of North America are the largest birds to use flapping flight exclusively. These species weigh about 12 kilograms, which is close to the upper limit for flying birds. (The margin between the power available and the power needed for flight decreases with increasing body weight until a point is reached - around 15 kilograms - where level flight is impossible.) Not surprisingly, swans rise into the air with some difficulty.

Swans cannot generate the power which would be required for birds of their large size and relatively small wing area to take off vertically. In order to generate the lift needed to rise into the air they must first develop a high airspeed over their wing surfaces. To do this they face the prevailing wind, then drive forward with flapping wings and flailing feet. Even then they need a long take-off distance - as much as 50 metres in still air. As the swan's speed increases, so does the amount of lift generated by the faster airflow over the wings, until, eventually, enough lift is produced to

Swans are so large that they require a long runway to generate the lift needed for take-off.
Photo - Michael Morcombe ▸

Wandering albatrosses use a 30-metre band of increasing wind speed to soar in large loops with motionless wings.▾

raise the bird's considerable mass into the air. They are not unlike jumbo aircraft lumbering into the air, after what seems an interminably long journey down the runway.

Once in the air, swans are powerful fliers capable of travelling great distances. Swans of the northern hemisphere migrate several thousand kilometres each year using powered flight all the way. Australia's black swan also travels widely throughout the continent. Swans are fast fliers (they need to be, to stay in the air) and their speed has been measured at 60-80 kilometres per hour. With strong tail winds, swans are capable of ground speeds of 100 kilometres per hour or more.

WING MOVEMENT

It is also interesting to consider how these birds propel themselves forward. Swans' wings develop aerodynamic lift as air flows at speed over the cambered surfaces. The wings act as aerofoils, like the fixed wings of aircraft. But swans have no propellers. So how do they produce propulsion as well as lift?

Detailed studies of bird flight have shown that the outermost feathers of the wings (the primary feathers) produce most of the propulsive force. During the powerful downstroke of the wingbeat, the wing is moved forward as well as down. Slight downward twisting of the leading edge of the outer wing, and of individual primary feathers, also occurs during the downbeat, and together these result in the lifting force on the outer wing being tilted forward. This provides the propulsion needed to maintain or increase air speed.

The inner wing, which consists mainly of secondary feathers, is scarcely twisted, if at all, and provides little propulsive force. However, this part of the wing provides most of the lift. During the upstroke the wings are flexed, moving upwards and backwards to resume position for the next propulsive downstroke. During fast flight, the wings are not raised by muscular force, but respond passively to the pressure of air from below.

FLAPPING TO STAY STILL

Birds vary in their ability to sustain flapping flight. The Andean condor - at around 12.5 kilograms, one of the world's largest flying birds - rarely flaps its wings. It depends on the abundant updrafts of mountainous regions to provide the lift for flight. At the other extreme, the most energy-demanding form of flying, hovering for prolonged periods in still air, can only be achieved by the smallest birds of all - hummingbirds. Hummingbirds are like miniature helicopters. These tiny creatures, weighing as little as two or three grams (smaller than many large insects), maintain their hovering position by rapid wingbeats (up to 80 per second), backward and forward in a figure of eight. By swivelling the wing at the shoulder, hummingbirds can produce lift in both the forward and backward strokes. They fly forward by tilting the whole body, and therefore the lifting force produced by the wings, in the desired direction. They fly backward in similar fashion.

The wing tips of many large soaring birds are slotted, and the 'winglets' so produced are staggered in height. These features reduce the amount of induced drag developed by the wing tips.▲

Swans have a high 'wing-loading' (body weight divided by wing area) and have to fly fast to maintain lift.◄
Photos - Michael Morcombe

Gliding, soaring, flapping and hovering - these are the four main types of bird flight. How close have we come to achieving them? With mechanical inventions we are now able to glide, soar and hover, and even flap over very short distances. But to fly like a bird? I don't think so. To fly like a bird is to feel the rush of air over every surface of your body, the wind at your fingertips, the sky at your command. For the birdwatcher, the freedom of flight remains an elusive dream.

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LANDSCOPE

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Each weekend, hundreds of novice scuba divers take the plunge. Get the most out of your diving on page 10.

A very different landscape replaces what was once a thriving timber industry. Rediscover Cannington in the 1850s. See page 42.

Seaweed! Delicate and beautiful, or slimy and smelly? Decide for yourself on page 20.

How do birds fly? How do some reach speeds of over 80 kilometres per hour? Learn about avian aerodynamics on page 28.

Western Australia grows some rare and stunning native spider orchids. Their alluring nature will delight the reader on page 34.

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REGULARS

COVER

Back in the early 1970s, Western Australia proclaimed the numbat (Myrmecobius fasciatus) as its State emblem which may have saved its life. With the help of scientists and new techniques, these delightful creatures are now fighting back against extinction. See page 15.

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