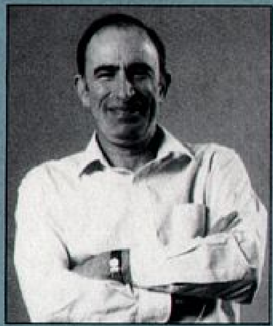
Paul R. Ehrlich

BIRDING FOR FUN



Avian Adaptation

Illustration by Darryl Wheye

The transition from being adapted to aerial flight to being adapted to submarine flight is not so rare or strange as it might seem at first.

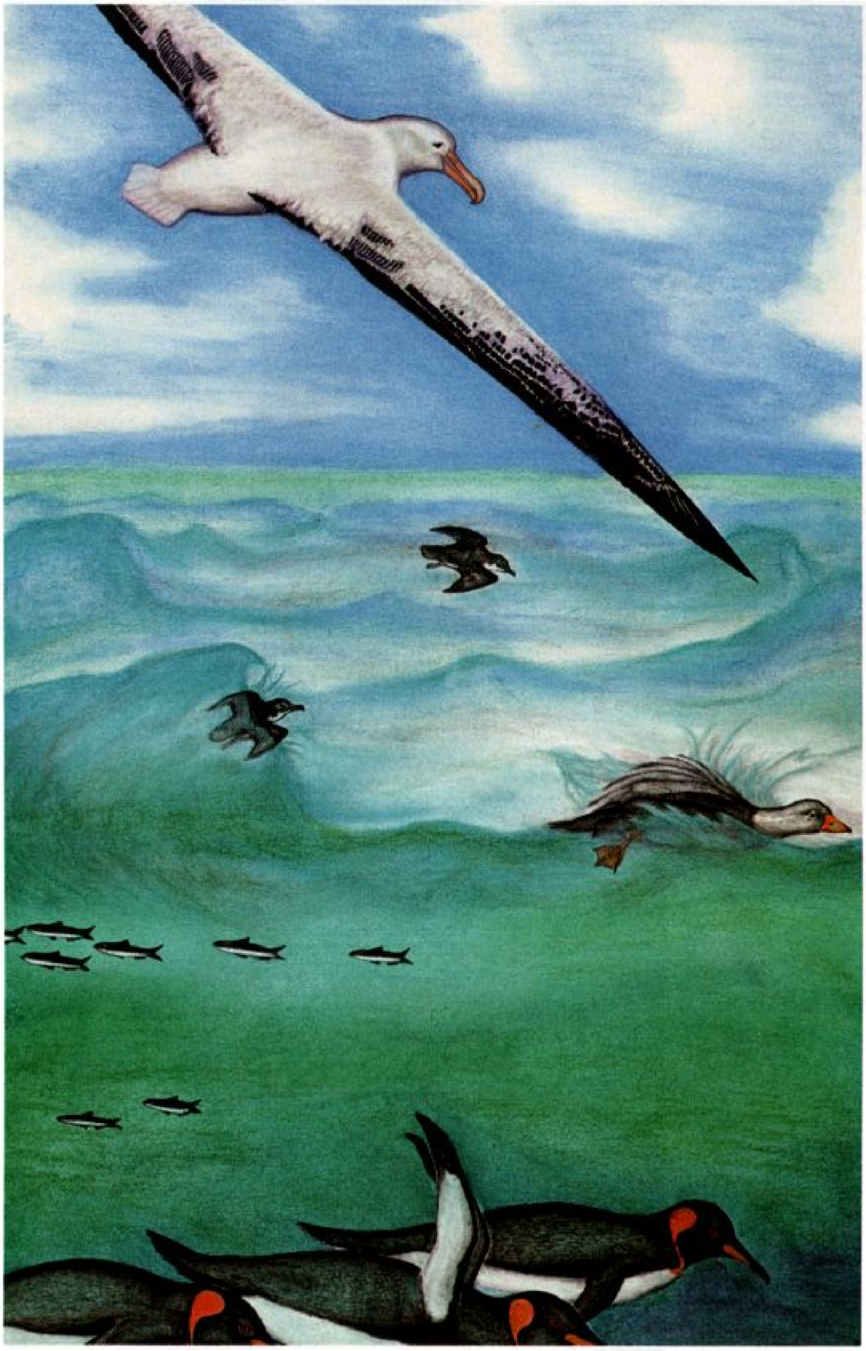
In 1975, my wife and I were fortunate enough to travel to the Antarctic. It was a marvelous trip on which I fell in love with penguins and Black-browed Albatrosses. But great as that trip was, it occurred before my rebirth as a birder. I've been kicking myself ever since because I paid only casual attention to the less spectacular birds I saw.

So when the Stanford Alumni Association asked me to lecture on an "Alumni College" trip to the Antarctic, I jumped at the chance. I was especially pleased because the expedition aboard the MV *World Discoverer* would stop at South Georgia Island, one thousand miles east of the tip of South America and one of the great wildlife destinations on the planet. Not only would we have the chance to see what changes had taken place in a key area over nearly two decades, but I also would likely be able to spend a great deal of time watching pelagic birds, and check off a few lifers to boot.

The trip more than fulfilled my expectations. The Antarctic is still virtually pristine, although the few areas accessible to tourists are under increasing pressure, especially from groups that are not carefully guided by experienced naturalists and conservationists. There are also concerns about the impact of krill fishing and ozone depletion on the Antarctic fauna. But whales were much more abundant than on our previous trip, a very hopeful sign. Overall, I think the Antarctic is the most interesting tourist destination on the planet, but one quite vulnerable to overvisitation.

But in this tourists' paradise, the questions of our passengers repeatedly reminded me of a major gap in our educational system. Outside of specialized college courses, the teaching of evolution is probably less sophisticated than it was seventy years ago—and it was no great shakes then. In part, this is the result of the activities of the most successful group of crackpots in our society, the anti-evolutionists or "creationists." Even though they have repeatedly been defeated in the courts, the creationists have persuaded some school boards and textbook publishers to bowdlerize texts and install "creation science" (an oxymoron) in school curricula as an equally valid explanation of the diversity of life and human origins. Thus, many otherwise educated persons, never having been exposed to a good college-level evolution course, are unable to interpret much of what they see in nature.

This was demonstrated by the persistent amazement among many of our fellow passengers at the absence of fear of human beings among penguins and other Antarctic birds. The basic reason for the birds' boldness, of course, is that penguins have no significant evolutionary experience with terrestrial mammalian predators. Similar lack of fear—often com-



While the long-winged Wandering Albatross can take advantage of the lift created by updrafts on the windward side of waves, the Common Diving-Petrel zips right through the waves. In contrast, the Falkland Flightless Steamer Duck uses tiny wings to scoot across the surface, and flightless King Penguins torpedo themselves underwater with ease.

bined with the evolution of flightlessness—has been a major factor in the extermination of many bird species native to islands free of endemic land animals as soon as people introduced foxes, cats, rats, and so on.

Avian fearlessness and flightlessness are counterintuitive to those accustomed to birds that hastily flee at the slightest disturbance, but in appropriate circumstances it is expected by evolutionists. Through the slow process of natural selection, organisms adapt to the conditions of their environments. Natural selection is, to oversimplify a bit, the differential reproduction of genetic types, where individuals with some hereditary constitutions are more successful in a given environment and out-breed those with different genetic makeups. Gradually the genetic makeup of the whole population changes and it "evolves." Since the name of the game in natural selection is out-reproducing other members of your own population, it does not pay to put energy into wings if there is no need for them. That energy would better be allocated to successfully rearing more young. And, for birds lacking experience with mammalian predators, there is no mechanism by which they are likely to evolve avoidance reactions.

People seem accustomed to the idea of flightlessness in penguins, but they are puzzled by its appearance in relatives of flying birds they can watch in the Northern Hemisphere. One Stanford traveler asked me about flightlessness when we were watching Falkland Flightless Steamer Ducks. These are members of a small genus of diving ducks, confined to waters around southern South America and the Falklands, that seem to be on a penguin-like evolutionary trajectory—moving toward using their wings for swimming rather than flying. After giving an explanation similar to that just outlined, the traveler asked: "How long do you think it took those ducks to lose the ability to fly?"

The answer to that, of course, is "it depends." The pace of evolution is set by several factors. Evolutionary time is measured in generations—so that in actual time fruit flies can evolve more rapidly than steamer ducks, and steamer ducks more rapidly than people. (Fruit flies can have about 700 generations in the span of a single human generation; steamer ducks perhaps seven.)

The strength of selection pressures is important, too. If 99 percent of all the fruit flies in an experiment are killed in each generation by a high concentration of DDT, DDT resistance will evolve much more rapidly than if the concentration of DDT to which the flies are exposed is so low that only one percent are killed. The comparative advantage of being a genetic type that happens to be somewhat resistant to DDT is much greater in the former case than in the latter. With sufficient selection pressure—that is, with relatively few individuals doing most of the reproducing—a strain of fruit flies can become very resistant to DDT in a few months. One suspects that small bird species (with short generation times) can undergo substantial evolutionary modification in a few decades if the environment is changing drastically enough. Indeed, there is recent evidence that the migratory habitats of one European songbird have evolved on just such a time scale in response to increasing droughts in its subSaharan wintering grounds (for another possible explanation, see J.P. Myers, *Am. Birds* Vol. 46, No. 5).

Finally, of course, the pace of evolution depends on where you define the start and finish of flightlessness. Flying (as opposed to flightless) Steamer Ducks seem to have started down the road to flightlessness already; some larger "flying" steamer ducks cannot fly at all. On the other hand, some individuals of the "flightless" species can actually get clumsily airborne if they stay very close to the water where air from their wingbeats rebounding from the surface provides extra lift (ground effect). But with these caveats, I would guess that flightlessness in steamer ducks has evolved on a time scale of tens of thousands of years. Most of the time, evolution is a pretty slow process.

One imagines that the situation was comparably complex when totally flightless penguins were evolving from the flying ancestors of today's tubenoses (petrels, shearwaters, albatrosses, etc.) and loons some 50 million years ago. Then, some of the larger proto-penguins were perhaps better able to reproduce than their smaller relatives, possibly because they were more efficient divers and hunters. Large size, however, carries penalties for flying birds. As size increases, wing loading (the ratio of weight to wing area) goes up disproportionately. If the length of a bird (and of its wings) doubles, its weight will increase roughly eight times, while its wing area will only increase fourfold. Natural selection did not increase the length of penguins' wings to compensate for their greater bulk; rather it shortened them as it adapted penguins to "fly" in a more supportive medium than air. Penguins now use their stubby, powerful wings to propel themselves through water, a more viscous medium where long wings are difficult to move rapidly against the friction.

But it seems virtually certain that at some time populations of proto-penguins contained some individuals that could fly (if clumsily) and others that could not, just like some steamer ducks today.

The transition from being adapted to aerial flight to being adapted to submarine flight is not so rare or strange as it might seem at first. Dippers use their wings to fly under water, and eiders and scoters keep their wings partially expanded for paddling and steering while propelling themselves primarily with their feet. Many marine birds, including guillemots, auks, cormorants, shearwaters, and diving-petrels, use their relatively short, muscular wings for propulsion when submerged.

Indeed, a group of birds that could represent what penguin ancestors were like at the time of transition from air to water was common around the *World Discoverer* in the vicinity of South Georgia Island. Both Common and Georgian diving-petrels burst in groups from the sea, buzzing away on rapidly beating wings. The wing loadings of these small (8-10 inch long) birds are high, and they appear to be almost struggling to stay aloft, often taking advantage of the ground effect. They fly well under water; in fact, they often fly *through* waves rather than over them. One can easily imagine proto-penguins with similar capabilities increasing in size and gradually leaving the aerial life altogether—as some day the diving-petrels could.

If they do, selection will probably cause them to emulate penguins and lose some other adaptations to aerial flight, such as light, hollow bones and long feathers on the wings. Selection has adapted birds beautifully for moving through air. The basic skeletal design is rigid and light, designed to allow the bird to be supported entirely by either its fore or hind limbs and possessing a deep, solid sternum (breast bone) for anchoring the powerful wing muscles. The lungs and circulatory system are highly efficient to provide the flow of oxygen required to power flight. Reproductive organs are internal (where they can create no drag) and weight is saved most of the year by having these organs only become large and functional during the breeding season.

During our Antarctic trip, we often saw, in the vicinity of penguins and diving-petrels, what are virtually the symbols of commitment to aerial life—albatrosses. There were thousands of Black-browed Albatrosses in the vicinity of the Falkland Islands, and we saw a fair number of Royal and Gray-headed albatrosses as well. Wandering Albatrosses often followed the ship, and we saw them courting and breeding on South Georgia, where Light-mantled Sooty Albatrosses were also nesting. Wanderers are long-lived; they spend most of their lives airborne and return to land only to nest. Breeding birds may cover over 9000 miles on a single foraging trip, up to 550 miles a day, and millions of miles over a lifetime of circling the Southern Ocean.

Selection has provided them with long, narrow wings (wings with a high aspect ratio) that increase gliding distance. Because the tips are proportionately small, the drag-creating vortices, caused by air curling over the wingtips into the low pressure area above the wing, are also reduced in size. The albatrosses take expert advantage of the lift created by updrafts on the windward side of waves; using this and (to a lesser degree) the gradient of increasing wind speed with altitude, they soared seemingly effortlessly in the wake of the *World Discoverer.* They are very large birds, so even with wingspreads exceeding 11 feet, they have very high wing loadings.

Albatrosses are thought to have wings near the limit of what natural selection can "design," given the strength of the structural material (bone) available. Their long wings would be useless for propulsion under water, and the option of evolving into a penguinlike niche seems as closed for them as it appears open for their fellow tubenoses, the diving-petrels. Albatrosses are as unlikely to become submarine as King Penguins are to return to flying.

If some diving-petrels should follow the penguins and become fully marine, many of their aerial adaptations will remain beneficial, from their rigid skeletons and powerful wing muscles to their efficient oxygen distribution. But selection would doubtless further modify them, at least molding wings and feathers more exactly to the demands of the thicker medium. Perhaps it would also concentrate the eye's focusing apparatus in the lens (rather than depending on help from corneal curvature) to provide the sharpest possible underwater vision. It might cause an insulating fat layer to evolve, as it has in penguins, and penguinlike modifications of the respiratory system to permit longer, deeper diving.

One can speculate further, but the basic point is that all organisms, from petrels and penguins to protozoa, plants, and people, are being continually adapted to their environments by natural selection. That does not mean that adaptation is usually perfect. Extinction is, after all, a common response to environmental change, and the frequency of back problems in human beings shows that adaptation to an upright posture is hardly "optimal." Neither does it mean that all imaginable evolutionary changes are possible. When you are birding, remember that evolution will not be finished until the last organism is extinct. The process is continual, even though it often proceeds at a very stately pace. Understanding how it has shaped birds can add a great deal to your enjoyment of them.

—*Paul R. Ehrlich is Bing Professor of Population Studies at Stanford University and co-author of* The Birder's Handbook, Birds in Jeopardy, *and* Healing the Planet.