Winter 1980

Birdman: [Dr. Peter Marler]

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THE ROCKEFELLER UNIVERSITY

RESEARCH PROFILES

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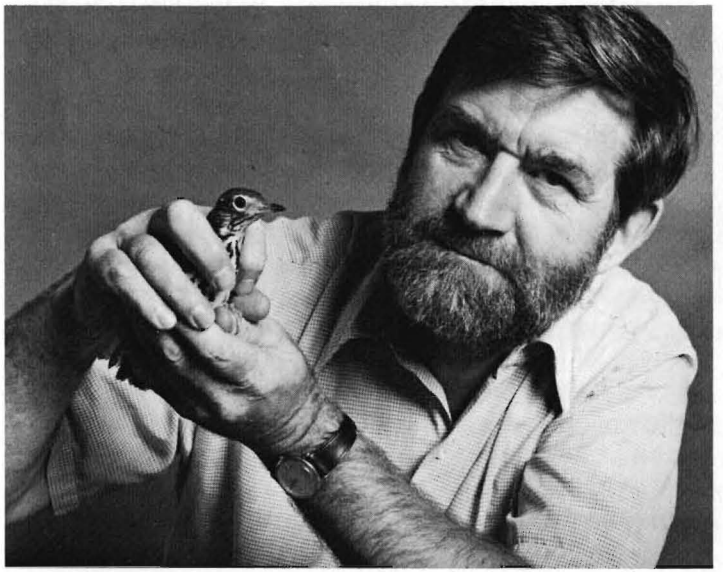
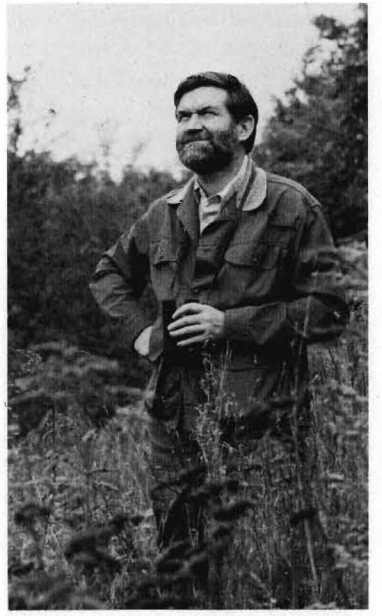
Birdman

"What is so exciting to me about ethology," says Professor Peter Marler, "is that on the one hand it broaches behavioral problems complex enough to begin to give an inkling of the really deep issues, the ones that cognitive psychologists and philosophers worry about and, on the other hand, it's in touch with the machinery of the body—the physiology."

Dr. Marler's base is The Rockefeller University's Field Research Center in Millbrook, New York, headquarters for a diverse program of investigations in ethology, the study of animal behavior — what he calls the area of zoology where "biology and psychology converge." At Millbrook, researchers ask questions about everything from bird migration to monkey alarm calls to bat "radar" to the "dances" of bees. His own particular interest is in social and communication systems, which he has studied extensively in birds and primates. But his curiosity has ranged broadly. In the words of one of his colleagues, "Peter is a supreme synthesizer." His book, *Mechanisms of Animal Behavior*, coauthored with William J. Hamilton III, was one of the first texts in the field.

His major research goal has been the elucidation of learning in birds. For, as his work has helped to establish, most songbirds and a few other birds, such as parrots and hummingbirds—like human beings and apparently unlike any other animals studied thus far—do *learn* their language. That is, they must hear and memorize the distinctive songs of their own species during a particular stage of their physical development in order to be able to reproduce them. The calls and sounds of other animals may convey very specific messages,





At Millbrook, Dr. Marler (left) with hand-reared wood thrush and (above) in the field.

Dr. Marler using electronic sound analyzer for bird songs.

Jungle fowl chicks (see page 5).

as some recent research in Dr. Marler's lab is showing, but they appear to involve little or no selective learning. Birds also make instinctive calls, but these are different, in role and development, from their songs.

Almost 100 years ago, it was noted that groups of birds of the same species living at some distance from one another sang slightly different songs, much as people speaking the same language will develop local dialects. The observers, according to Dr. Marler, understood the implications of the existence of bird dialects—that some element of learning had to be involved—but the idea was not pursued scientifically.

FROM BOTANY TO BIRD DIALECTS

Dr. Marler began speculating about bird dialects thirty years ago, while conducting field work for his doctoral thesis in botany in the Lake District of England, an area that abounds in chaffinches, a species with very distinct local dialects. Shortly after, while making studies of vegetation in the Azores, he had a chance to compare chaffinch dialects there with those of the English birds. He had, in fact, taken the job mainly for that purpose. The young botanist was really a birdman at heart.

"I fell in love with birds when I was a child. The family used to go for rambles in the woods and fields near the town where we lived, just outside of London. I think I was about eight when I announced to my parents that I was going to be an ornithologist." However, as the son of a toolmaker, depending on scholarships to advance his education, he doubted anyone would "actually pay me to look at birds." Since he enjoyed all forms of nature study—he founded the Slough Natural History Society when he was fifteen—he decided on botany after working summers at an agricultural station during his high school years. He earned his B.S. and Ph.D. at the University of London.

Around the time he was doing his thesis work (and listening to chaffinches), a conference was held at Cambridge University on the new science of ethology, enthusiasm for which had been spreading from the Continent, spurred by the brilliant research of Konrad Lorenz and Nikolaas Tinbergen, who were among the conference participants. As Dr. Marler explains: "There had always been a lot of interest among zoologists in the study of animal behavior but it didn't really cohere as a science until, in the 1930s and '40s, Lorenz, particularly, began relating his encyclopedic knowledge of animal behavior to his training in psychology, fitting behavior into its evolutionary history, so to speak. His work was a revelation to biologists and that meeting was a revelation to me. I wanted to read everything I could about ethology. When I found out that practically all the literature was in German, I learned German."

A little later, while he was working for The Nature Conservancy, his interest in birds came to the attention of W.H. Thorpe, one of the pioneers of English ethology and host of the 1950 Cambridge conference. Thorpe was just then embarking on studies of song learning in chaffinches, and he arranged for Dr. Marler to join him at Cambridge University.

"My first discovery when I got there," Marler recalls, "was that Cambridge didn't recognize degrees from the University of London, so in order to become a respectable member of the community I decided I had better get a Cambridge degree and I'd better get it in zoology if I was really going to make this radical shift in my career." He earned his second doctoral degree and remained for two years as a research fellow at Jesus College—"a proper Cambridge don."

As in so many fields of modern science, research in ethology has been aided enormously by developments in technology. Dr. Marler remembers the days when he transcribed by hand, in musical notation, the songs of birds he had recorded with a cumbersome wire recorder.

"One of the most exciting things about being at Cambridge was that Bill Thorpe was among the first people to get a sound spectrograph." The sound spectrograph conveys

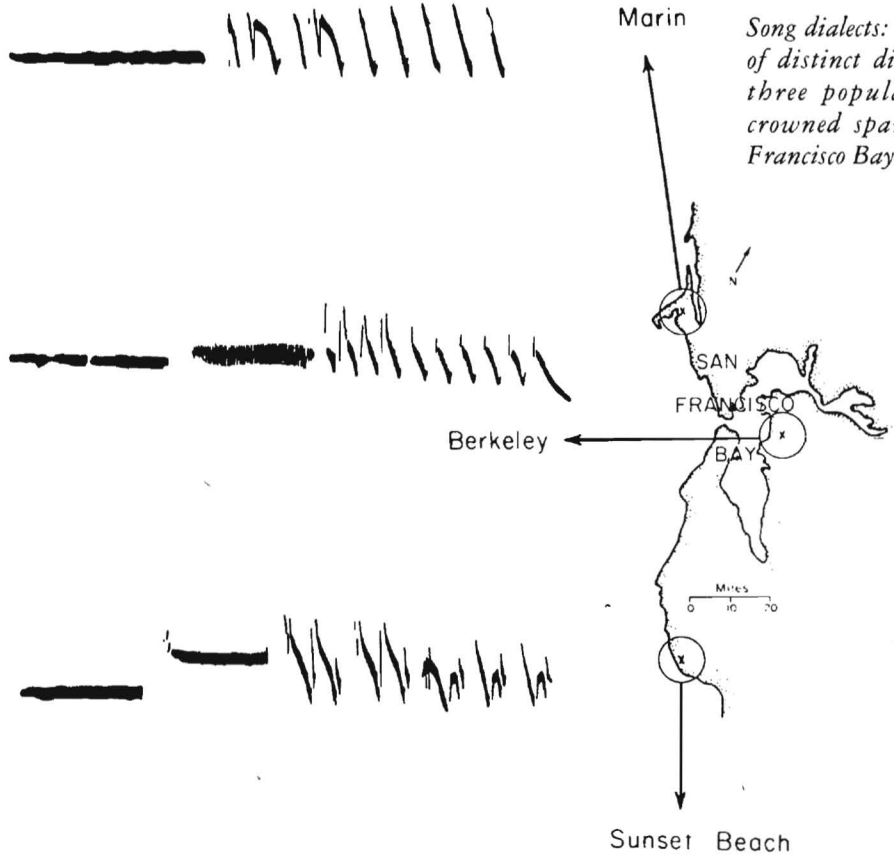
visually the exact pattern of sound sequences. Comparisons of sonograms, or "voiceprints," is one of the most important tools for studying animal signals, just as lightweight, sensitive tape recorders and versatile, lightweight cameras have enlarged the scope of field observations, and computers have made possible the fast, accurate programming and analysis of data. In Dr. Marler's work, computers have become uniquely valuable for producing synthetic birdsong.

"CHAFFINCH OF THE WEST"

The seminal work at the Thorpe laboratory was the first scientific confirmation that song learning does indeed occur. It set the stage for varied lines of research, many of which were developed by Dr. Marler and his students at the University of California at Berkeley, where he accepted an appointment in 1957. Working mostly with the white-crowned sparrow—his "chaffinch of the West"—he went on to demonstrate that young birds reared in soundproof chambers, isolated from the songs of their kind, developed abnormal songs. Other birds, also raised in isolation but exposed to recorded songs of their own species, subsequently developed normal song. By varying the age at which the birds heard the songs, the investigators found that there were constraints on when learning would take place and normal song would develop: a period in early adolescence, from about ten to fifty days of age, proved to be critical. In nature, developing birds hear the songs of many species. In the laboratory, birds exposed to recorded songs of different species selected and learned only their own song, as in the wild. When exposed only to the song of a foreign species, they developed abnormal song, like that of the birds reared in isolation.

"A logical question to ask next," says Dr. Marler, "was what role is played by the bird's ability to hear its own voice." Mark Konishi, one of Dr. Marler's Berkeley students and now a professor at CalTech, found that when mature birds, already in full possession of their songs, were deafened, it had no effect on their singing ability. In young birds, deafened in that period of delay between first hearing their species song and reproducing it, a totally abnormal song developed.

"Mark's work," explains Dr. Marler, "offered some of the first scientific evidence that a great deal of the programming of songs involves the ear. It implied the existence of sensory mechanisms such that the bird is genetically programmed to



Song dialects: Sound spectrograms of distinct dialects developed in three populations of white-crowned sparrows in the San Francisco Bay area.

match its own voice to a preferred pattern of song. It's a very nice example of the interplay of innate influences and effects of the environment in the development of learning."

As the findings grew, investigators wondered whether this kind of behavior could be found in animals other than birds and humans. Because primates are closest to man on the evolutionary ladder, Dr. Marler went to the Budongo Forest in Uganda to see if he could find evidence of vocal learning in monkeys. In the summer of 1967, he continued this line of investigation in Africa with chimpanzees. He did not find what he was looking for, but one of his Berkeley graduate students, Thomas Struhsaker, made some intriguing observations about monkey calls that formed the basis for further research (described later) at The Rockefeller.

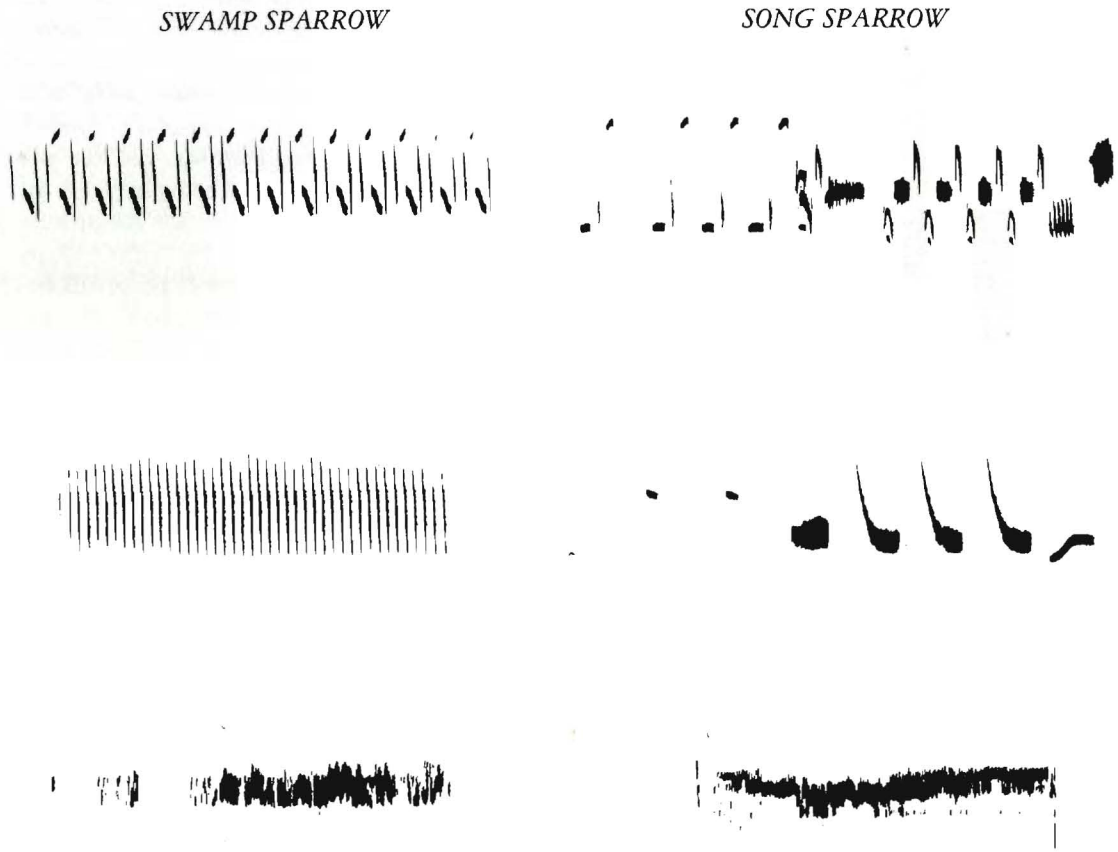
Why only birds and man? "We just don't know," says Dr. Marler. "But, with any luck, we will learn from the birds where in the brain to look for the answers."

MILLBROOK

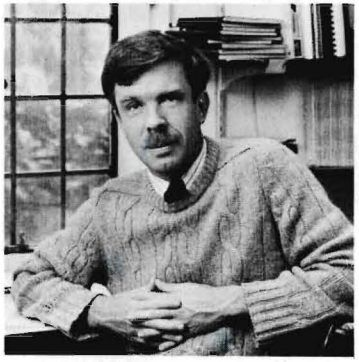
In 1965, The Rockefeller University initiated a broad program of behavioral research that brought together a distinguished faculty of ethologists, psychologists, and neurobiologists. Dr. Marler joined the program the following year. The Millbrook center, about ninety minutes north of New York City, opened in 1972, making it possible for lab and field work to be united in a country setting.

There are three major groups at Millbrook. One, led by Professor Donald Griffin, conducts studies of bird orientation and migration; of the mechanisms of "echolocation," a term coined by Dr. Griffin for the radarlike system by which bats locate their prey; and of the ways honeybees orient their direction according to patterns of light polarization.

Closely related to the research of Dr. Marler's group is the work of Professor Fernando Nottebohm, a former student of Marler's at Berkeley and a Rockefeller colleague for the past thirteen years. Dr. Nottebohm has greatly expanded under-



Compared at top are sound spectrograms of two normal sparrow songs. Songs in middle are from two male sparrows reared in isolation with no chance to hear their normal species songs. Shown at bottom are songs of two deaf sparrows. Most species differences are lost in deaf birds.



Dr. Nottebohm.

standing of the physiological and biochemical mechanisms of learning: what Dr. Marler calls the "machinery." He has identified those brain areas in birds that are involved in vocal control and has discovered major differences in the structure of male and female brains in those areas. Because only male birds sing, these finding have now led him to pursue research on the role of sex hormones in vocal learning. He has also demonstrated the dominance of the left hemisphere of the brain in vocal production, the first nonhuman example of hemispheric dominance.

The Millbrook station bustles with life. Birds and small animals can be heard and seen in the bushes, the trees, the sky. Dr. Griffin's bats roost in the eaves of one of the Center's English country-style buildings. There are birds in outdoor cages and in the aviary designed and built by the members of the Center. The bird nursery is the Marler home in nearby Staatsburg, New York, where Mrs. Judith Marler does most of the rearing by hand. "During the summer months, the birds dominate our lives," a condition which the three Marler children "tolerate," according to their father. This past summer they raised swamp sparrows, song sparrows and some thrushes. These last, musicians without peer, are for a new series of experiments by Postdoctoral Fellow Carl Whitney.

"In our early work," says Dr. Marler, "we usually chose birds with relatively simple songs so that we could cope with the details without being overwhelmed. As we have made progress, we feel we can deal with more complicated situations. Thrushes are among the finest songsters in the world. They have a number of interesting characteristics, including the ability to produce different notes simultaneously with the two sides of their sound-producing organ."

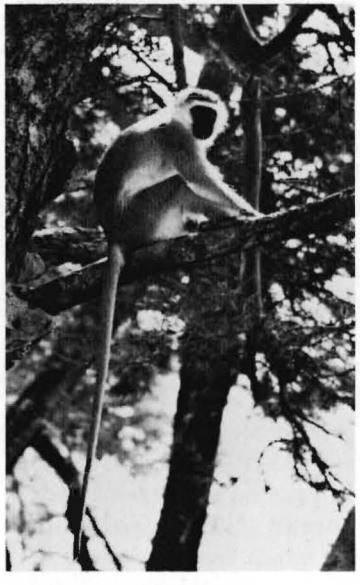
Why are the songs of some birds more complicated than those of other birds? "We don't know for sure," says Dr. Marler, "but one reason is probably the varying role song plays in their biology. It looks as though you tend to get simple songs when the main function is territorial defense. In other birds, the attraction and stimulation of the mate seem to be more important functions, and there is some evidence that when the balance has shifted in favor of sexual stimulation the songs get more elaborate. Dr. Donald Kroodsma of our group did some experiments in which he found that female canaries that hear complex songs build nests sooner, make them larger, and lay more eggs. Some experiments by Dr. Ken Yasukawa with redwing blackbirds seem to show that females, given a choice, will prefer to mate with a male having a larger song repertoire."

A current project is to explore further how birds develop the capacity to recognize even individual members of their species. To do this, computer-synthesized songs, in which various acoustic features are systematically modified, are played to the birds. The computer is also used for physiological studies. With it, for example, Dr. Timothy DeVoogd, working with Dr. Nottebohm, is mapping the dendritic processes of neurons in the brains of birds. (Dendrites are branchlike parts of neurons, the nerve cells, along which impulses are conducted toward the cell body.) Dr. Marler's colleague, Dr. Robert Dooling, uses the computer to analyze brain waves triggered by song. There are studies probing deeper into the role of the animal's own voice in learning. For these, a number of jungle fowl are custom-fitted with headsets through which sounds, including their own, are played, to see how they respond.

In addition to learning their languages, songbirds and man share another seemingly related behavior: what is called subsong in birds is thought to be analogous to the babbling of human infants. Subsong exists only in those birds that learn their songs, Dr. Marler explains.

"It's a very intriguing illustration of that interplay between genetic instructions and learning. Here is a bird—we're using the swamp sparrow—with a very simple song; and to our astonishment it has revealed to us that it learns very much more than it will ever produce in its crystallized song. In the mid-stages of what we call plastic song, the bird shows us that it has learned all kinds of things, most of which eventually get

Vervets in the wild.



culled. The bird apparently practices what he has heard in infancy and, in the process of rehearsal, so to speak, selects out the final, mature song of its species."

A TANTALIZING OBSERVATION

Dr. Marler continues to encourage studies of other animal communication, particularly with primates. One of these studies, as mentioned earlier, began at Berkeley with Thomas Struhsaker, now a research zoologist at the New York Zoological Society and an adjunct professor at Rockefeller.

"Tucked away in Tom's thesis on vervet monkey behavior was evidence he found for an extraordinary set of alarm calls that seemed to symbolize different predators," according to Dr. Marler. Although not central to Dr. Struhsaker's work, it was a tantalizing observation. Four years ago, Doctors Robert Seyfarth and Dorothy Cheney Seyfarth joined Dr. Marler's lab and, with his collaboration, have been following it up, working in the area of Africa where Dr. Struhsaker first studied these animals.

"Despite all the attention that has been given to animal communication," says Dr. Marler, "the tendency has been to think of animal signals as just involuntary production, manifesting emotion, not meant to say any specific thing. I have always been suspicious of this simplistic picture."

Dr. Struhsaker believed that the monkeys he saw responded to calls that precisely said, for example, "snake," "eagle," "leopard," predators these animals must avoid. But, as Dr. Marler asserts, "until you do controlled experiments you can't be sure of cause and effect. You have, let's say, a troop of monkeys and an eagle appears. One of the monkeys gives a call and immediately all the other monkeys drop out of the trees. Did just one animal see the eagle and the others only hear the call? Did they all see the eagle? Did one see the eagle, call, and the others first look to the caller for cues, and then see the eagle, before responding? In other words, did the call, by itself, say 'eagle'? The answer was yes, as we found out by playing tapes of the calls when there was no predator actually present, and by filming the responses many times, under different circumstances, to be sure of what we were seeing." The Seyfarths are continuing to explore what other things vervet monkeys may say to one another.

"It is typical of our work," says Dr. Marler, "that many different kinds of experiments are needed to interpret what you have apparently observed, simply because it is so terribly difficult to get even a glimpse of what an animal mind is like, a theme that Don Griffin has dramatically reopened in his recent book on animal awareness.* As Don points out, nothing forces on you an awareness of the degree to which we rely on introspection quite so strongly as asking questions of an animal. It is then one realizes that all of the methods we normally apply to that kind of judgment, when thinking about human behavior, rest on our ability to converse.

"To me it means that we must do ethological work with an eye to discerning, ultimately, the underlying physiological mechanisms—the kind of work that Dr. Nottebohm is doing. I think that will be the major contribution of ethology in the future, at the interface between the study of behavior and the brain. These problems are tangled and arcane, but we do get a tremendous kick out of trying to solve them, one after another." □

**The Question of Animal Awareness: Evolutionary Continuity of Mental Experience.* Donald R. Griffin. Published by The Rockefeller University Press. 1976.

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