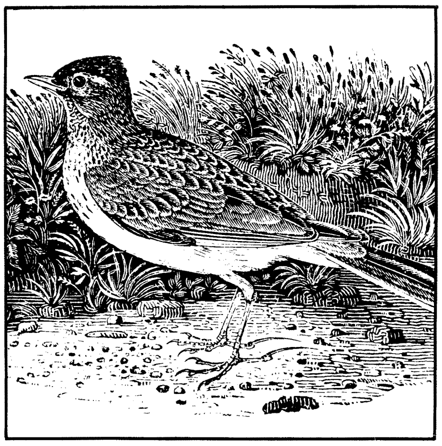
Sounding Out Birdsongs

Both genes and complex learning behavior are involved

BY JOAN AREHART-TREICHEL

Anyone who lingers in nature for some length of time can't help being struck by the diversity of sounds that birds make—the joyful notes of the cardinal heralding spring; the sweet, solitary tones of the thrush in deep summer; the mockingbird talking itself to sleep, the fuss of the chickadee when its young are threatened.

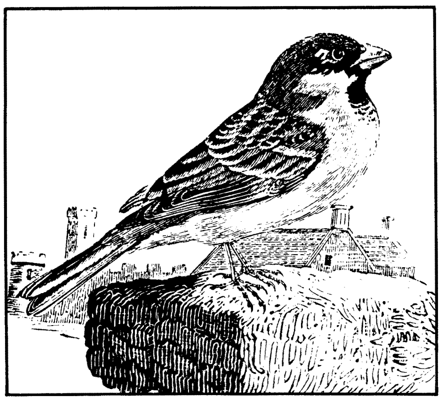
It's far from chance that birds make this diversity of sounds, scientists have found in recent years. First off, birdcalls are not the same as birdsongs. Calls tend to be produced in the presence of an enemy. Songs, on the other hand, tend to be used by birds to proclaim their



identities, mark their territories and to communicate with their mates and their own species.

How songbirds come to make their calls is not known. But their ability may be intrinsic, as it is in the chicken. Masakazu Konishi, an ethologist at the California Institute of Technology in Pasadena, studied seven of the chicken's 28 different calls in normal and deaf roosters. The deaf birds, he found, can produce normal vocalizations, showing that the chicken inherits its ability to make calls, that learning through auditory signals is apparently not involved.

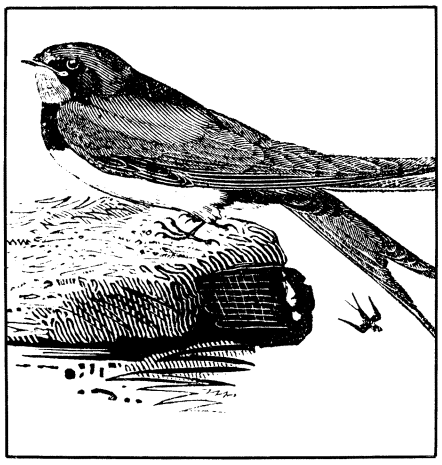
In contrast, the way birds come to sing, just as the way children come to talk, is a highly complex neural and behavioral phenomenon, ethologists and neurobiologists are discovering. Birds must learn to sing; they must hear a song model and reproduce it. Their learning depends on their being able to hear themselves prac-



tice against either a song model inherent in their brains or against a song model in the environment which is like that of their own species. Some birds must hear a correct model during a critical time in their lives. Sex hormones are also involved.

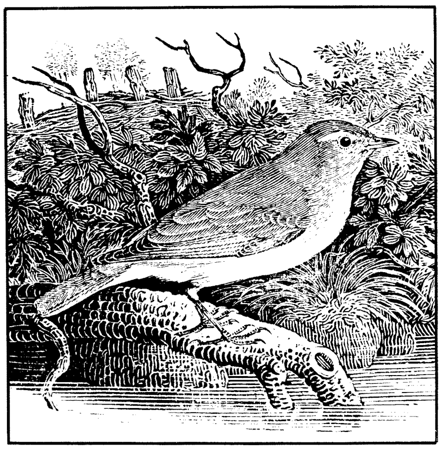
For instance, James Mulligan of Saint Louis University and Donald Kroodsma of Rockefeller University in Millbrook, N.Y., raised baby song sparrows with canaries. The song sparrows learned to sing, and the songs they sang were mostly, although not entirely, song sparrow songs—none of the songs were canary songs. This finding suggested that the song sparrows learned to sing according to an intrinsic song template in their brains.

On the other hand, Peter Marler of Rockefeller University in Millbrook raised baby white-crown sparrows in soundproof rooms and studied their songs. In isolation the birds developed very different songs from the songs in the natural environment, suggesting that they needed to learn from a song model in the environment. Marler



then exposed baby white-crown sparrows to songs of other species; the birds couldn't learn them. So obviously, the model of another species wouldn't do. Finally Marler put the baby white-crown sparrows in the presence of songs recorded from their own species, and the fledglings imprinted them. These results showed that the white-crown sparrow learns to sing by hearing songs of its own species from the environment, and by developing a corresponding song model in its brain to which it then matches its own singing.

But does the song model have to be



identical to that of its own species? Konishi is currently trying to find out by exposing several baby white-crown sparrows to a computer rendition of their species' song.

Songbirds can learn to sing only during a critical period of their lives, Marler and other researchers have shown. For white-crown sparrows, it is between two and seven weeks after hatching. For some other species, it is several months.

The nerve pathways involved in birdsong imprinting are just starting to be elucidated. Auditory nerves are definitely implicated. When Konishi deafened baby white-crown sparrows, the birds produced only noises. It was as if the birds could not register their own voices with their intrinsic template. Canaries also learn their songs by reference to auditory information, Marler has found. During this development period they pass through a subsong stage that can be likened to infant's babbling in early speech efforts.

Once young birds' auditory nerves discern an incoming song, the information is processed in their brains. Exactly where the processing occurs has not yet been pinpointed. But it may well be in the left hemisphere of the brain. Specific nerves in the left hemisphere play a dominant role in the control of song, according to the findings of Fernando Nottebohm and his colleagues at Rockefeller University in Millbrook.

In their earlier experiments they cut either the left or the right hypoglossus nerve in young canaries, chaffinches and white-crown sparrows. The hypoglossus nerve innervates the birds' organ of sound production. Cutting the left hypoglossus nerve led to severe song deficits. The birds' songs were barely audible and poorly structured. Cutting the right nerve, however, had a much less devastating effect on song.

"Thus, it is possible to speak of the left hemispheric dominance for vocal control," Nottebohm reported at the annual Society for Neuroscience meeting last fall. "Intriguingly, the left hemisphere in people is also usually dominant for language-related tasks and in particular for speech."

In their more recent experiments, Nottebohm and his colleagues used a combination of behavioral and anatomical techniques to show which higher brain centers are involved in birdsong control. Again, this control took place more in the left hemisphere of the brain than in the right hemisphere, specifically in several areas of the left forebrain (telencephalon)—the caudal hyperstriatum ventrale and the archistriatum. Neurons in this latter brain center in turn connect with the thalamus, midbrain, reticular formation, medulla and—most notably—the hypoglossus nerve, which innervates birds' song organ.

Nottebohm and his co-workers summarize these findings in the JOURNAL OF COMPARATIVE NEUROLOGY (165:457, 1976). In that paper they also predict: "In time it might be possible to characterize brain areas specialized for the storage of auditory and motor song memories."

As if the nerves involved in birdsong learning weren't elegant enough, sex hormones also enter the picture. With the exceptions of a few species, female songbirds usually don't sing. But when Konishi injected the male hormone testosterone into some young female birds, they did learn to sing. Exactly how the hormones assist birdsong is not known, but the hormones may act on nerves in the brain that process birdsong information. Some of the nerve centers involved in birdsong learning—the caudal hyperstriatum ventrale, pars caudale and hypoglossal nucleus—absorb male hormones. This finding comes from Arthur Arnold, still another Rockefeller University researcher. ☐