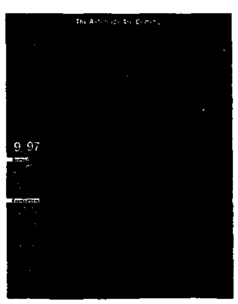
NATURAL HISTORY

September 1997 Volume 106 Number 8

Cover: A remnant of the Grand Canyon's volcanic past, Vulcan's Throne, a 600-foot cinder cone, sits atop cascades of ancient lava. Story on page 34.
Photograph by Adriel Heisey; Photographers/Aspen



sion of the Upper Paleolithic, however—with its cave paintings and sophisticated tool kits—the rate of change accelerated greatly. All modern cultures are thus rich in artifacts that have evolved over time. No chimpanzee culture is.)

Much imitation in human culture is accompanied by explicit instruction. Chimpanzees do not appear to actively try to teach one another how to do things, or at least not often. In more than a decade of fieldwork in the Tai Forest of Africa's Ivory Coast, primatologist Christophe Boesch, of the Zoological Institute of the University of Basel, reported only two clear examples of teaching in chimpanzees, both involving mothers and juvenile offspring learning how to open nuts with a rock.

Every human parent, in contrast, has experienced the frustration of trying to teach a child to do something "right"—whether tying shoes, following a recipe, or speaking properly—and all children have been equally frustrated at being so ordered about, often objecting that their creativity is being squashed. The common parental response, "Once you know how to do it right, *then* you can do it your way," may be more significant than we generally realize. Exact imitation reinforced by explicit instruction may be close to the heart of what makes human culture what it is: the collective creation of countless individuals over many generations, each attempting much of the time to do exactly what everyone else is doing.

Learning Under the Influence

By Bennett G. Galef, Jr.

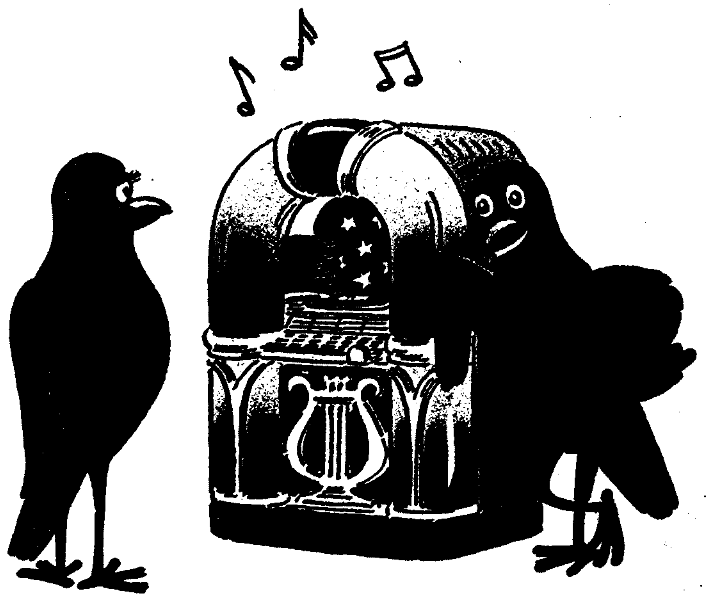
Image by Alexis Rockman

Some years ago, German applied ecologist Fritz Steiniger tried to reduce the cost of rodent control by placing large amounts of poisoned bait in rat-infested areas in Berlin. He hoped that such relatively permanent baiting stations would both eliminate resident populations of Norway rats and prevent immigrant rats from moving into the empty territories, thereby saving a great deal of effort and money.

Steiniger failed, and the rat colonies flourished (after an initial, short-term reduction in rat numbers) for two reasons. First, despite Steiniger's best efforts, a few members of each rat colony almost always managed to survive their first contact with the poisoned bait. They sampled a small amount, fell ill for a while, recovered, and then never touched the bait again. Second, and even more unfortunate for Steiniger, young rats raised by poison-bait survivors never so much as tasted the bait left for them. They had apparently learned from their companions what to eat and what to avoid, although just how was unknown.

This sort of "social learning" takes place among laboratory rats as well, enabling researchers to investigate the process more closely. Some learning apparently starts before weaning: given a choice, juvenile rats prefer foods their mother ate during lactation. As a result, when rat pups make the switch from mother's milk to solid food, they prefer to eat foods with the same flavors they imbibed while nursing.

Even when fully weaned, a young rat still turns to adults in its search for food. A weanling may snatch food directly from its



mother's mouth or approach another adult, crawl under its belly, emerge between its front legs just under the chin, and start feeding on whatever the generally unprotesting adult is eating. Hungry young rats also find food by following scent trails laid down by adults. Another helpful habit of the adults is urinating and defecating where they eat; pups find such soiled locations attractive dining spots.

Adult Norway rats also appear to choose food largely on the basis of what their companions are eating. They normally find cayenne pepper unpalatable, for example, but after spending time with other rats that have been trained to eat pepper-flavored food, they overcome their reluctance and begin eating it too. In fact, they often come to prefer pepper-flavored to unadulterated food. Similarly, a rat that has learned to avoid a food that made it sick will begin to eat the food again when placed in the company of rats that have no such unhappy association.

The expression on a rat's face during these kinds of experiments suggests that interacting with other rats affects not just what it is willing to eat but also its very perception of the food's palatability. Offered food it likes, a rat eats with what we in the business of watching rats call a "yummy" face. Given a food that tastes bad or makes it sick, it reacts very differently, turning down both corners of its gaping mouth—a clear sign of disgust. If, however, this same rat is put with other rats that recently ate the offensive food, it no longer makes the "disgust" face.

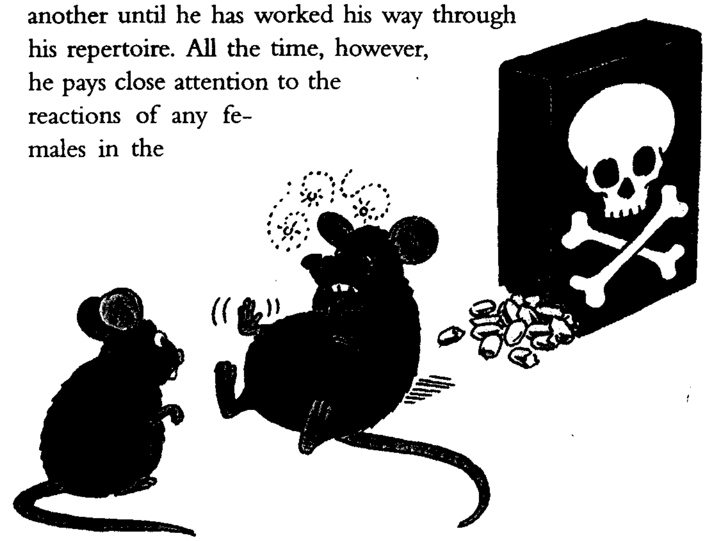
We now know that a crucial key to one rat's influence over another's eating habits is its breath. In the course of normal digestion, a rat's gastrointestinal tract produces sulfur compounds. For one rat to develop a taste for food eaten by another, it has to simultaneously smell the food—generally from bits of food clinging to the other rat's fur and whiskers—and sulfur compounds on the rat's breath.

Many mammals learn where and what to eat from others of their kind (the list includes mice, gerbils, rabbits, cats, goats, sheep, bats, hyenas, naked mole rats, and a variety of monkeys and apes). In some species, social interaction also plays a role in learning *how* to eat. In the pine forests of Israel, roof rats fill an ecological niche occupied by squirrels elsewhere in the world. These rats feed on the seeds concealed beneath the scales of pine cones. To get at the seeds, an experienced rat first strips scales from the base of the cone, then—following the spiral of scales that leads to the cone's apex—pulls off one scale after another, eating each seed as it is revealed.

Joseph Terkel and his students at the University of Tel Aviv have shown that only rats reared by adults proficient at stripping pine cones become adept themselves. No active teaching is involved; young rats learn by taking partly opened cones from adult rats (or from human experimenters working with a pair of pliers) and finishing the job.

Social learning is not limited to feeding or, for that matter, to mammals. Animals can also learn fear from one another. Monkeys reared in captivity are not afraid of snakes until they witness the fearful grimacing and vocalizing of wild-reared monkeys responding to one. Like monkeys, some birds can learn to identify potential predators by listening to their more knowledgeable fellows. In the laboratory, European blackbirds were shown an unfamiliar object (a bleach bottle) while they listened to an audio tape of a wild-caught blackbird giving an alarm call in the presence of an owl. The listening birds soon came to respond to bleach bottles as though they were dangerous; birds watching their reaction soon came to fear the bottles as well.

When it comes to finding a mate, social learning comes in several guises. Female guppies and female quail save time and energy by copying the mating choices of other females. A good way for a male to attract females is to be seen courting one. For male cowbirds, attracting females is more complicated. A male cowbird may know some five or six different songs, and outside the breeding season, he normally sings these songs one after another until he has worked his way through his repertoire. All the time, however, he pays close attention to the reactions of any females in the



vicinity. If a female responds to any particular song with the gesture he is watching for—a rapid sideways movement of one of her wings—he then repeats that song several times in succession. When the breeding season comes around, these are the songs that the male sings most often and, most importantly, the songs that prove most seductive to the females in his area.

It has been said that the wise learn from personal experience, while the happy learn from the experiences of others. If this is true, then there are plenty of animals best described as both happy and wise.

Better Learning Through Chemistry

A chemical compound essential to the normal development of the young brain, nerve growth factor—commonly known as NGF—has been studied intensively. Now NGF has also been found to play a role in learning throughout life. NGF causes neurons to sprout axons and dendrites, the threadlike appendages with which neurons transmit and receive messages. When it is blocked in laboratory rats, as in the experiments of Federico Bermúdez-Rationi, of the Universidad Nacional Autónoma de México, the animals are unable to associate certain tastes with feeling sick. (Many learning experiments with rats involve taste aversion tests, partly because they are easy to observe and partly because learning what foods to eat and what to avoid is vital to a rat's survival in the wild.)

NGF may also help reverse damage associated with aging, such as forgetfulness. Charlotte Granholm, of the University of Colorado, has found that as rats get older, certain neurons in the forebrain atrophy and die, affecting the animals' memory and their ability to make and use mental maps. "Spritzing" the neurons of these aging rats with NGF fully restores their spatial "smarts," enabling the rodents once again to perform well in mazes and other tests. It is not simply a case of the more, the better, however: in older rats that have shown no signs of decline, an extra application of NGF actually harms the animals' performance.

Another compound involved in learning and memory is CamKII (calcium-calmodulin-dependent kinase). Eric Kandel and his colleagues at Columbia University investigated the gene that produces CamKII and found that laboratory mice genetically engineered to produce unusually high levels of CamKII in the hippocampus performed poorly on spatial tests but did fine on tests of fear conditioning (that is, they came to fear a tone that was paired with shock). Tests with other mice—this time, engineered to have high levels of CamKII in the amygdala (a part of the brain associated with emotion)—produced the opposite results. Thus, CamKII is important to learning in both parts of the brain but acts independently in each. This sort of specific information makes possible more precise genetic analysis of cognitive processes than had been possible before.—*Catharine Rankin*

Inattention Must Be Paid

By Catharine Rankin

Nearly half of all people hospitalized with mental disorders suffer from schizophrenia, a condition characterized by disturbed moods, delusions, disordered thoughts, or catatonia. This frightening disorder may result in part from a breakdown in one of the most basic forms of learning: filtering out irrelevant information in the environment and in the mind itself.

Very early in life, we have to learn how not to pay attention to such things as the feeling of our clothes on our body, the street noises around us, and the sound of our own breathing. A number of studies have shown how hard this can be for schizophrenics. In one experiment, Mark Geyer and David Braff, of the University of California at San Diego, repeatedly exposed participants—some schizophrenic, some (the controls) not—to a loud tone. At first, all the participants blinked their eyes strongly every time they heard the noise—a natural "startle response." After three blocks of twelve trials, the controls grew used to the sound, while most of those with schizophrenia had a much more difficult time, still blinking hard at the end of the experiment.

Learning to ignore a stimulus that goes on for an extended time or, like the tone, is repeated frequently without anything