Letter from the Desk of David Challinor
March 2005

Years ago when the southwest corner of Connecticut was still rural, a farmer near our house unsuccessfully tried to cull a large crow population that was foraging on his germinating corn. He would sneak out before dawn with his shotgun when he heard them in his field, but despite the crepuscular light, the crows either discerned the gun or understood what he was up to and fled. However, whenever he was unarmed, the crows ignored him. I recall this incident because it was a childhood confirmation that crows are really smart. This perception has existed for centuries and Aesop, the fabulous fabulist, featured crows in more than a dozen of his stories in the sixth century BC.

Aesop's fable most relevant to this month's topic—corvid intelligence—relates how a thirsty crow tries to drink from a narrow pitcher. The water level was below reach so the bird dropped pebbles one by one into the pitcher until the water level was accessible to him. Now 2500 years later, I wonder whether Aesop actually witnessed this corvid behavior or heard of it from someone who did. What is remarkable is that the behavior of this ancient Greek crow is comparable to what scientists have recently observed when studying avian intelligence as it relates to behavior.

A major breakthrough in these studies occurred when it became evident that traditional theory of brain evolution as espoused by Ludwig Edinger, a neurobiologist and the leading comparative anatomist of a hundred years ago, was wrong. He believed that brains evolved in a straight line with invertebrates at the low end and progressed "upwards" through fish, reptiles, birds, to mammals, with humans at the top. His approach is no longer accepted. Readers of these letters may remember my account of the Zoo's female octopus (an invertebrate) that mastered the technique of opening a screw-top jar to eat the shrimp or crab enclosed therein. She solved a problem as complex as any mastered by a primate. Neurobiologists now understand that bird brains, although constructed differently from that of mammals, nonetheless function as elegantly as any mammal's brain. In fact, in proportion to body size, a crow's brain is as large as a chimpanzee's.

In mammals, the lower third of our brains consists of groups of neurons, whereas the upper two thirds—the neo-cortex—is made up of flat cells, six cell layers thick. The top part generates our rational or intellectual activity, whereas the bottom third controls our instinctive reactions—such as extending an arm to soften a fall or jerking away a hand when touching something hot. In human evolution the six cell-layered sheet on the top of the brain spread to such an extent that the only way the scull-confined brain could contain its increased area was for it to become convoluted, i.e. with many folds and crevices.

The tops of bird brains are smooth, not folded, and until recently were thought to consist of cells grouped in clusters similar to the lower part of mammal brains, and thus would make all bird behavior merely instinctive. We know now this is not the case, but the exact neural pathways are still unclear. It seems, however, that the large area of cell clusters in the cerebrum or top part of a bird's brain performs the same function as the flat cell layers in a mammal's brain. In a bird the neural interaction between the upper cell clusters and the brain cells in the lower part of its brain can produce such complex behavior as tool use and learned song repertoires that vary within species as dialects do within human languages. What seems to have happened is an example of convergent evolution of intelligence where two differing forms of brain structure eventually lead to almost equivalent brain power.

A few astonishing examples of avian behavior may illustrate my point. Aesop's crow may have learned its "pebble routine" by watching its parents or other crows just as blue tits, a European chickadee somewhat larger than ours, learned to open milk bottles in England in the days when milk was delivered daily to doorsteps. To distinguish between what is learned and what is figured out individually, Alex Kacelnik and colleagues at Oxford designed an elegant experiment (*Nature*, vol.433, p.121). They raised four New Caledonian crows (*Corvus moneduloides*) from eggs so that when hatched the three males and one female never saw an adult crow. When fledged at about two months, they put a male and the female in an aviary well-stocked with plants, twigs, dead tree limbs, etc. The other two males were housed in separate, similar aviaries out of sight of each other. The researchers hid food in wood crevices and other crannies from where it could only be reached by using a twig. Scientists entered the enclosure of the crow pair and demonstrated to the watching birds how to extract food with a twig. The other two isolated males received no such instruction. The results: the pair successfully used twigs to gain food in 68 and 72 days from hatching and the uninstructed in 63 and 79 days. In other words, within this small sample of four birds, tool use instruction did not speed up the process. Would the two "instructed" birds have had better results if other birds, rather than humans, had done the teaching? We don't know, but probably not.

In the wild, adult New Caledonian crows sever long narrow pandanus (pandanus or screwpine is a stilt-rooted palm native to Southeast Asia) leaves and split them to keep the sharply serrated outside edge intact. The split leaves are cut again in roughly 8" lengths for bill-controlled tools to hook small insects from cracks or to swish rapidly through leaf litter to impale other prey. Within the range of these crows, separate populations shape and use leaf tools differently, just as separate chimpanzee troops in Africa use different tools (sticks or rocks) to crack hard-shelled palm nuts. When the four lab-raised crows were initially presented with pandanus leaves, all four modified them so they could be used as tools, but only one of the isolated males successfully used the leaf tool it had made. Its achievement indicates that tool-making ability among these crows is at least partly inherited and not dependent on learning through social contacts.

Evidence is accumulating quickly on the inherent talent of tool-using birds and mammals and, therefore, research is now focusing on why and how such traits evolve. Corvids and great apes both share rather elaborate social hierarchies within their respective communities. Those of the latter have been, and still are being welldocumented by the protégées (and their successors) of the late Louis S.B. Leakey (1903-72). Emphasis on similar avian behavior, however, is more recent and is well-reflected in a recent review by two scientists at Cambridge University; Emery, N.J., N.S. Clayton, "The Mentality of Crows: Convergent Evolution of Intelligence in Corvids and Apes" Sci.306:1903-07 (Dec. 2004).

The authors summarize current thinking that intelligence may have primarily evolved to handle social information rather than to find answers to physical challenges. For example, to prosper or even survive in primate or corvid communities, the individual must know which fellow members they are related to or allied with in order to know whom to trust. Reaching this level of social knowledge could lead them to reason about a new situation. Such an ability could, therefore, lead to tool fabrication and use. One lab-raised crow evidently reasoned that, based on past experience with twigs it used to hook otherwise inaccessible food, a certain length of flexible wire (heretofore novel to her) could be made into a tool to hook food vertically from a container inside a plastic tube.

An understanding of time and space is evident in the skill with which Clark's nutcracker (a corvid) caches seed for later consumption and, not only remembers cache locations, but will even relocate a cache if it perceives that another nutcracker saw the cacheing and thus might steal it. Flexibility and imagination are two other qualities being investigated and shown to be evident in corvid behavior. Captive scrub jays cached crickets and peanuts. They soon learned that crickets deteriorated more quickly than peanuts and cricket caches had to be eaten more quickly than peanuts. For me, an example of corvid imagination that matches the well-known one of chimpanzees stacking boxes to reach overhead bananas is the case of the hand-raised ravens. In their aviary, meat was dangled from a string attached to a perching bar. Other strings held stones. All ravens successfully retrieved the meat by reaching down with their bills, pulling up the string and securing the loop with their feet. This exercise was repeated several times until the meat was reachable. Some ravens figured out the procedure the first time they tried and did not resort to trial and error learning.

What these experiments have shown is that convergent evolution of cognition or understanding is evident in apes and corvids but lies not in their respective brains, which have quite different structures. This is important as it shows that avian intelligence or cognition can evolve without having a brain with a prefrontal cortex as possessed by primates. Intelligence still requires a big brain relative to body size, and the forebrain of corvids is definitely bigger than that of other birds (with the exception of some parrots). By concentrating on this fascinating family of birds, scientists can learn facets of the evolution of human intelligence. Let us credit Aesop and his contemporaries for recognizing the braininess of crows so long ago or, as we would say today, "crows are brainiacs."

David Challinor
Phone: 202-673-4705
Fax: 202-673-4686
E-mail: ChallinorD@aol.com