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Abstract: Two articles about the cheetah:
"The evidence suggests" - that cheetahs are remarkably inbred. A series of studies has shown that all cheetahs, both captive and wild, are nearly identical genetically.
"Cheetahs have fewer" genetic resources with which to fight disease. And that can have devastating effects, as a 1982 epidemic at an Oregon safari park illustrated.

Under a deep blue sky, two Maasai men walk along a grassy ridge in Kenya's Maasai Mara. They are small figures in this vast prairie landscape, but they are so intimidatingly visible in their red blankets that the zebra and wildebeest that dot the hillsides raise plumes of dust racing to get out of the way. It could be a scene from Eden, human and animal in a single frame of golden light, as if each were cut from the cloth of legend, each with uncomplicated character and meaning. There is none of the glare and fume of modern life to blind one to the other.

From the high grass a cheetah stares out at the men. Small-headed, long-legged, hunch-shouldered, it has the aimless look of a creature without appointments. Unlike lions, which look menacing and complete, cheetahs seem careless and unfinished, like youths without thoughts of age or consequence. We tend to think of most mammals as simplified people. But another view is rattling its way up a hill just outside the nearby game reserve. Three Land Rovers have just clattered up to a Maasai *manyatta*, a corral of branches thrown up around a half-circle of low mud huts, which is home to an extended family and its cows. Pieter Kat and Joseph Owino of the National Museum of Kenya, Peter Arctander of the University of Copenhagen, and Kathy Alexander, a graduate student in veterinary medicine from the University of California at Davis, get out of the vehicles. The women of the *manyatta*, thinking them tourists from the game lodges, have formed a line and are beginning to sing when Kat explains to the headman that he is here to bleed the village's cats.

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The dancing stops. The headman, dressed in shorts, a red *kikoi* thrown over a secondhand sport jacket, and sky-blue plastic shoes, crosses his legs, leans back on his walking stick, and tries to look serious in the face of this very strange request. He has identified these foreigners as doctors. But who, in the dust and hoofbeat of Eden, can say what a scientist has in mind? "We have lots of cats," he allows.

The domesticated cats live in the piled branches that form the walls of the *manyatta* and go out into the bush to hunt snakes and lizards and rodents. They are, perhaps as a consequence of evolution, tough, fast, and mean. Alexander, the veterinary student, wrestles to get a good grip on the back of one's neck, but it twists, bites her thumb, squirms free, and bounds away into the bush. The women and children of the *manyatta* give chase. Dust rises everywhere. Children scream. Women laugh. The headman leans on his walking stick, glumly clinging to his dignity as village decorum unravels around him.

Three cats are flushed from the walls before one is caught and held down by two of the scientists while Alexander draws a blood sample. The cat meows angrily. Its eyes are wide, its mouth agape, its claws lavishly extended. At the sight of the blood filling the syringe, the Maasai fall silent. The cat is released, and as it slinks away Alexander stands up and asks the headman, "Have you any more cats?"

The house cat is a newcomer to Maasailand. Fifty years ago the Maasai were nomads, moving their cattle from water source to water source, from grazed pasture to green grass. Today they dig wells and deepen springs, and webbed cattle trails coalesce into dusty depressions around these water holes. Their *manyattas* remain more or less fixed in the landscape. Patches of maize even grow around some. The Maasai have begun to acquire the baggage of towns. Now they keep cats.

But it is not house cats that the scientists are studying. It is cheetahs. House cats carry diseases that cheetahs have not yet experienced, scientists believe. By looking into the blood of cats, the researchers hope to discover what diseases might be moving into the cheetah population. The blood will be screened for feline infectious peritonitis, feline leukemia virus, panleukopenia, feline immunodeficiency virus, and other diseases.

What's in the blood may also be in the genes. All domestic cats carry in their chromosomes the DNA of at least two invading retroviruses, which splice into the cats' DNA and get passed on in their genes. And the researchers know that bits of DNA from an immunodeficiency virus found in domestic cats are also present in the cheetahs of nearby Serengeti National Park.

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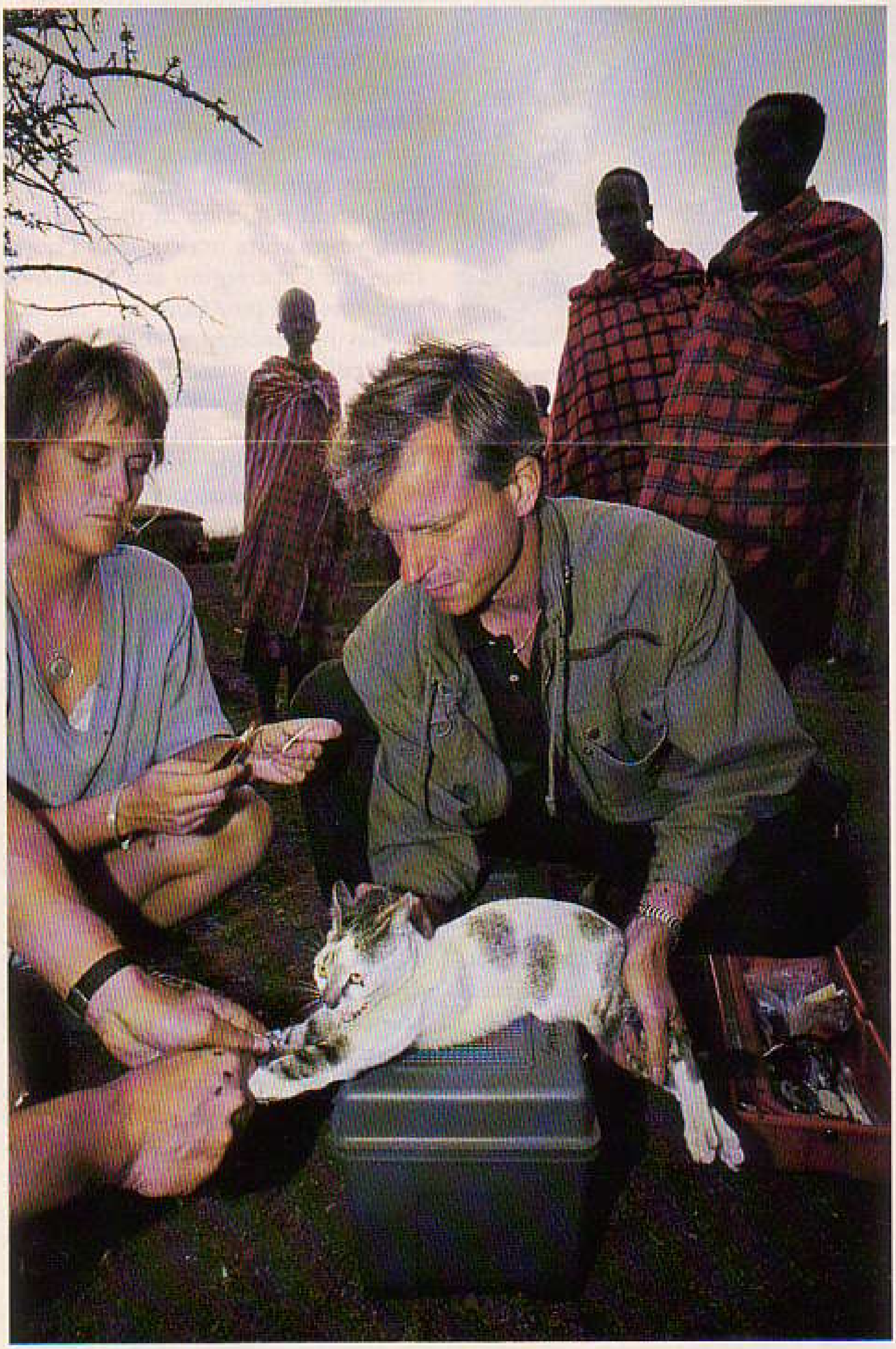
These scientists see the cheetah not as an unfinished human but as a gene pool. A number of researchers have arrived at the same view after experiencing difficulty breeding cheetahs in zoos. While cheetahs have been kept in zoos and as hunting animals for hundreds of years, there was only one recorded captive birth until this century. Akbar, a 16th-century Mogul emperor in India, reportedly kept 9,000 cheetahs. Virtually all were captured in the wild; only one ever bore a cub in captivity.

The second known captive birth came in 1956 at the Philadelphia Zoo. After that, there was something of a rush to bring cheetahs to America—385 of the 470 cheetahs known to have been brought to the United States arrived after 1956. Nearly all of those were born in the wild. The Endangered Species Act of 1973 led to a ban on importation two years later and put new emphasis on captive breeding. But fewer than half the zoos that have tried to breed cheetahs have succeeded. In 1987 only 52 individuals, less than 15 percent of the American cheetah population, had bred successfully. By 1987 two-thirds of all the cheetahs in American zoos were descended from 10 individuals.

All of this suggested that cheetahs were remarkably inbred. And indeed, a series of studies has shown that all cheetahs, even in the wild, are just about genetically identical.

During the 1980s Stephen O'Brien of the National Cancer Institute and others did genetic studies of cheetahs. In one study of 200 DNA sequences of 55 cheetahs, they found less than 1 percent variation among individuals. Humans in comparable studies vary in 32 percent of the gene sites, cats in 21 percent, lions in 12 percent,



In a Maasai village in Kenya, researcher Kathy Alexander (left) of the University of California and geneticist Pieter Kat of the National Museum of Kenya take blood samples from a domesticated cat.

ocelots in 20 percent. Of 250 species studied for genetic variation in natural populations, the average variability is about 36 percent. Researchers say cheetahs show the kind of variability that one would expect of mice after 10 to 20 generations of brother-sister matings.

The most genetic variability ought to be found in the DNA sequences that control immunities to disease. Viruses evolve as much as 1 million times faster than the genes of host animals. Mammals devote large numbers of genes to the coding of anti-

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gens, which detect and reject foreign proteins and thus protect the animals from disease. Each individual has different immunities, which is why most mammals will quickly reject skin grafts from other individuals, even of the same species. O'Brien exchanged skin grafts among seven pairs of cheetahs, and none of the grafts were rejected. Grafts from domestic cats to cheetahs were invariably rejected. The experiment showed that unrelated cheetahs had nearly identical immune systems.

Further studies showed that cheetahs have one-tenth the sperm count of domestic cats. And while 29 percent of the sperm of domestic cats show morphological abnormalities such as bent tails and malformed heads, 71 percent of cheetah sperm cells show such abnormalities. Similar rates of abnormality occur in inbred mice and livestock.

Perhaps 100,000 years ago, there were at least four species of cheetah, and they inhabited most of the northern hemisphere and Africa. As recently as 20,000 years ago, cheetahs ranged over North America. All but one species vanished during the Pleistocene extinction. That event probably reduced the modern cheetah to a number of small, isolated populations that went on to become separate subspecies. Science now recognizes an east African subspecies and a south African subspecies. The south African subspecies, which shows less variation than the east African subspecies, apparently suffered its own population reduction in the 19th century, when white settlers spread north from the Cape region and eliminated predators and prey from their farms.

Having undergone these population collapses, cheetahs have fewer genetic resources with which to fight disease. And that can have devastating effects. In June 1982 an epidemic of feline infectious peritonitis hit a successful cheetah breeding program at the Wildlife Safari Park in Oregon. The disease, first identified in 1966, is fatal in about 1 percent of domestic cats. But it killed 60 percent of the park's 42 cheetahs and infected the rest. The park's lions were exposed, but none even showed symptoms.

Plagues such as this have often burned through wild populations. In the 1960s rinderpest decimated the wildebeest herds of east Africa. In 1952 a new strain of myxoma virus caused a vast rabbit plague in Australia. In 1984 an epidemic of canine distemper in Wyoming reduced the known population of black-footed ferrets to 18 individuals.

As wildlife is crowded into smaller and smaller islands of habitat and gene pools shrink, the threat of disease will grow. O'Brien observes that there are now about 50 separate populations of giant panda surviving in China. About half of those are so small that inbreeding is likely, and as each loses genetic variety it will be more vulnerable to disease. Some effort will have to be made to carry genes across the developed land that separates populations.

Biologists are just beginning to look into the genetics of wild species. For example, Peter Arctander is working on a joint project of the University of Copenhagen and the National Museum of Kenya to take DNA samples from hartebeest, wildebeest, waterbuck, Grant's gazelle, buffalo, and impala. By taking tissue samples from 30 of each in Maasai Mara and like samples from populations in other parts of east Africa, and then reading select sequences of DNA in those samples, he hopes to determine how closely related different populations are.

Knowing the genetic distance between subspecies or between populations may help to prevent catastrophic errors. Arctander recalls the sad history of the steenbok, a mountain goat that has several distinct populations, including one in Czechoslovakia's Tatra Mountains and one on Egypt's Mount Sinai. As hunting and habitat loss reduced the European population, replacement individuals were introduced from Mount Sinai, and the replacement animals quickly became dominant in the population. But the Mount Sinai steenbok gave birth in February, when European mountains were locked in snow and ice, and the offspring died from the biting cold. Because human managers didn't understand the genetics of the species, the steenbok vanished from the region.

Genetic analysis shows that even animals that graze the same pasture may be very different. Says Kat of the National Museum of Kenya, "We took wildebeest and said, 'Here is an animal that, because it can travel large distances, shouldn't be that much different genetically.' But what we found is that the wildebeest on this side of the Rift Valley are as different from the wildebeest on the Nairobi side as different species of deer." The wildebeest that migrate north from the Serengeti plains give birth in January and February, while the wildebeest that migrate west from the Loita Hills calve in April. Both come together in Maasai Mara in July. If the migration and calving patterns are inherited, what would happen if the populations interbred? Would the Serengeti wildebeest give birth late, when there was little grass left to eat in the Serengeti?

WHAT SHOULD BE THE ground rules for saving wild species? Should we prefer the extinction of a species to the human hubris of acting as the agent of change?

Genetic studies promise to broaden our view of creation. Says Kat, "We're finding the concept of a species is much more complicated than was thought five to ten years ago. . . . What we're finding with genetic studies is that the populations are in fact more divided. Instead of this one single-species concept, we see that genetic variability is distributed in a very patchy way."

The tide of animal extinction urges us to focus less on the symbolic lives of creatures and more on the arrangement of base pairs of nucleic acids into the DNA that designs the species. But this change challenges our traditional view of animals.

For one thing, the law by which we protect wild species is based on a cultural view that assumes species are rigidly defined. Under the Endangered Species Act, hybrids between wild species or subspecies or even wild populations cannot be protected. But that restriction may defeat the goal of protecting genetic resources. For example, the dusky seaside sparrow became extinct in 1987. The last individual was bred in captivity to closely related Scott's seaside sparrows. But under the law the crossbred descendants cannot be released. So while we possess perhaps 90 percent of the dusky seaside sparrow's genes, they cannot be returned to nature.

That prohibition raises a related question. What good is a gene apart from the setting that shaped it? Some desert lizards, for example, cannot reproduce without exposure to ultraviolet light. An emerald moth in Arizona lays eggs on oak catkins, and the larvae look like oak catkins; later in the year, the same moths lay eggs on oak-leaf stems, and the larvae look like leaf stems. Can we conserve genes apart from the things that trigger their expression? Where does the gene leave off and the environment begin? Are genes the way a species survives? Or are they part of the way an entire landscape organizes itself?

The genetic view also raises questions about what we may or may not do to save wild species. If cheetahs prove to be in trouble in Maasai Mara, should we crossbreed south African and east African cheetahs in the wild in an effort to increase their genetic resources? Since genetic characteristics are linked, that might introduce into the east African subspecies genes that doom it the way the steenbok was doomed. But should we introduce by recombinant DNA technology a single gene borrowed from another species, say a gene from a lion that gives resistance to feline infectious peritonitis? Purists would say no, that's interfering with the natural gene flow. Others would say it's no less desirable than introducing a gene into humans to protect them from, say, an inherited susceptibility to sickle-cell anemia. And gene pools in nature are constantly changing. Should we prefer extinction of an entire species to the human hubris of acting as the agent of change?

The real difficulty may be that we are a visual species, and that like the Maasai headman, most of us find the abstract quantum of genes and habitat strange and confusing. Most of us prefer the golden light of Eden, and the hope that a common language and character beckon to us from within other skins. We continue to think in story and symbol. But we must think through the skin, into the delicate strands of DNA, and through them, back to sun, soil, and water. Evolution rests on more than pictures. ❧