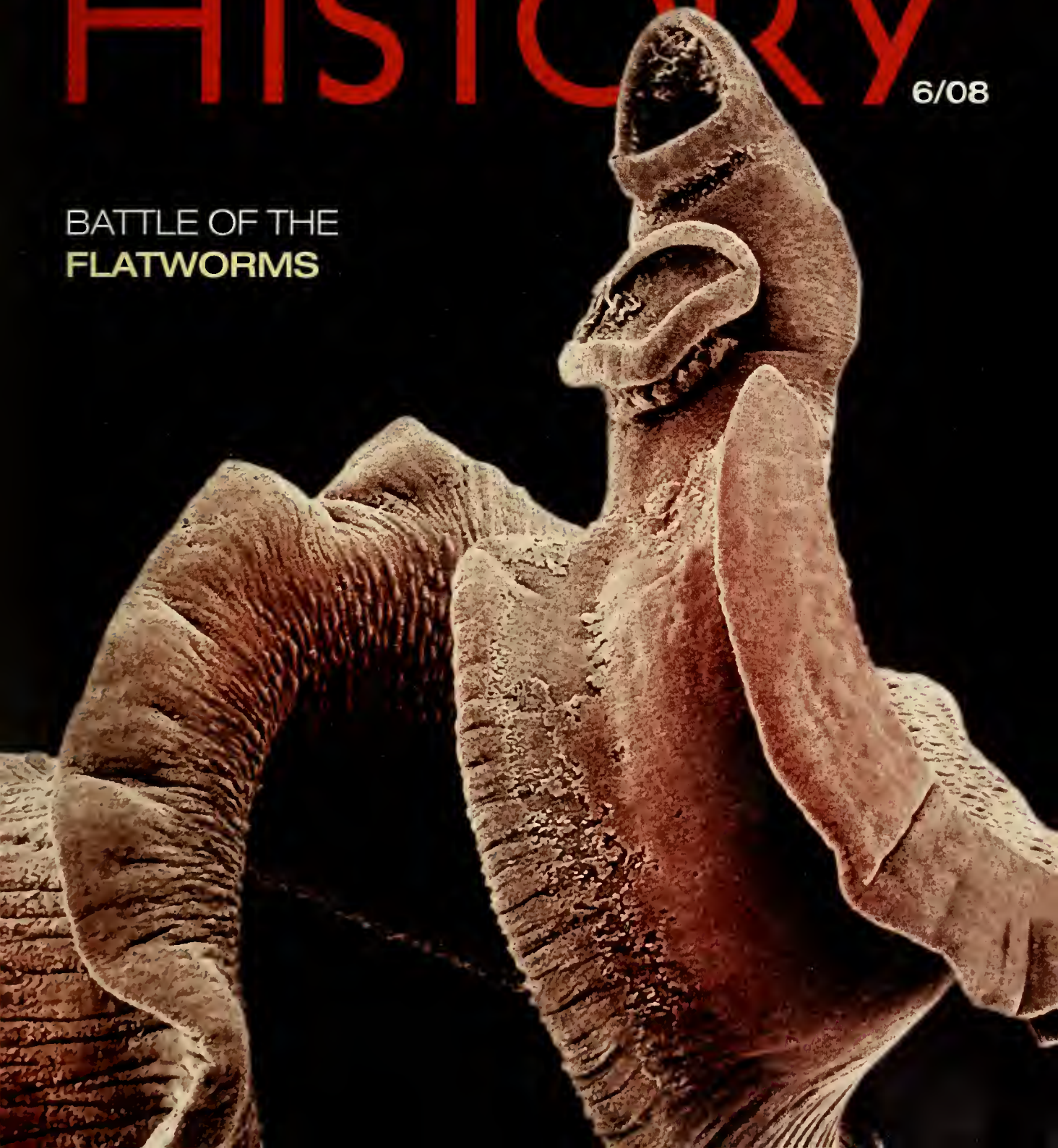
NATURAL HISTORY

6/08

BATTLE OF THE
FLATWORMS



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FEATURES

COVER STORY
22 **SEX AND THE SINGLE SCHISTOSOME**
Once thought to pair for life, some infective flatworms often lose their mates in battle.
PATRICK J. SKELLY

28 **BURMESE MOTORCYCLE DIARIES**
Following the trail of an adventurous scientist to its—and his—end
JAMIE JAMES

DEPARTMENTS

2 **THE NATURAL MOMENT**
Hot Tubs
Anup and Manoj Shah

6 **nature.net**
Butterfly Effect
Robert Anderson

6 **WORD EXCHANGE**

10 **SAMPLINGS**
News from Nature

17 **LIFE ZONE**
Chromosomagnon Man
Olivia Judson

34 **BOOKSHELF**
Laurence A. Marschall

36 **SKYLOG**
Joe Rao

44 **AT THE MUSEUM**

48 **ENDPAPER**
Scents and Sensibility
Walker Thomas

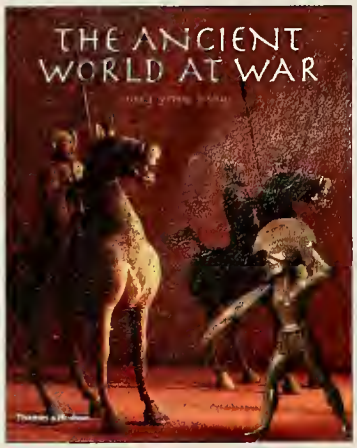
ON THE COVER: *A male schistosome,* Schistosoma mansoni *(magnified 120×).* SCANNING ELECTRON MICROGRAPH BY BRIAN SULLIVAN

THE NATURAL MOMENT

HOT TUBS

Photograph by Anup and Manoj Shah

A new look at ancient history...



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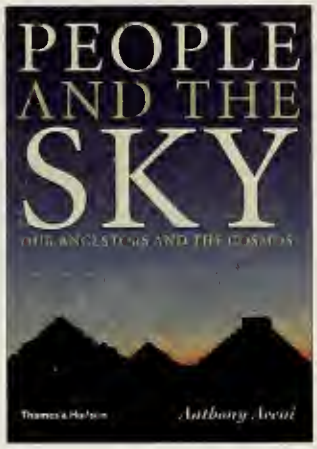

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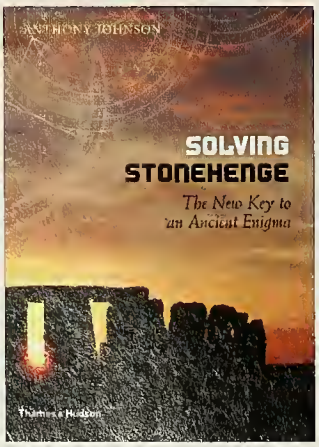

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THE NATURAL EXPLANATION BY ERIN ESPELIE

ANUP AND MANOJ SHAH

Taking a bath inside the Ngoro-ngoro Crater during Tanzania's hot dry season is far from a private affair. Quarters are close, particularly for resident hippopotamuses, which converge on a lone watering hole. They use the crowded setting as an opportunity to get frisky and do some courting. (Sure enough, most hippo births follow in eight months—a gestation period that dovetails with the arrival of the rains and fresh grass.)

Observing one particular courtship in Ngorongoro, photographers Anup and Manoj Shah—brothers who tag-team on their photo shoots with a wide-angle lens and a telephoto lens—compiled a veritable *Kama Sutra* of positions. As a prelude, the male followed the female into the water. Once there the couple clashed their jaws repeatedly, nuzzled, wheeze-honked, and craned their stumpy necks. Eventually they submerged most of their bodies in the water to mate, said the Shahs, who watched from the safety of their 4WD vehicle.

Let me count the reasons why the common hippopotamus (*Hippopotamus amphibius*) might be better appreciated from a distance.

Consider first that male hippos can fatten up to more than three tons. That pulverizing weight might be less fearsome if it guaranteed lethargy. But no, the titanic creatures can outsprint any human runner on land, and they often maul or kill the people they overtake. In such situations, the hippos are usually on the defensive. Territorial to the teeth, male hippos will fight each other, urinate, and defecate in efforts to defend their space—even flapping their tails in a windshield-wiper fashion to spray fresh feces farther.

If the "dung-showering," as it's called, fails to convince anyone to steer clear, think about this: hippos, though usually herbivores, can turn to cannibalism in crowded settings—an act that may drive outbreaks of anthrax among herds. Also, the creatures ooze an oily red substance (containing particles that may prevent sunburn).

Yet if you're a cattle egret (*Bubulcus ibis*), a front-row seat on the bank of the watering hole would be a prime spot for snapping up insects disturbed by a hippopotamian ruckus.

Anup and **Manoj Shah** were born in Kenya to Indian parents and grew up visiting nearby Nairobi National Park. After receiving several university degrees in England, they developed an interest in wildlife photography and returned to Kenya. Together they have published many books, their most recent being *African Odyssey: 365 Days* (Abrams, 2007). Visit www.shahimages.com for more of their photographs.

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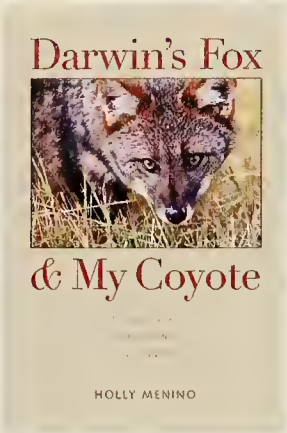

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Why science alone can't win the race to save wild animals

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—**Elizabeth Marshall Thomas, author of *The Hidden Life of Dogs* and *The Old Way: A Story of the First People***

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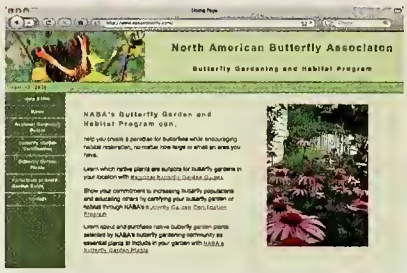

SEVERAL YEARS AGO, my son and I found ourselves in a veritable swarm of medium-size, orange-and-black butterflies with white spots on their wing tips. They weren't flitting from flower to flower; they were fluttering by, twenty or more a minute, with a definite sense of direction. Back home, I turned to the Web site of the North American Butterfly Association (www.naba.org) and learned (via their "Butterfly Questions and Answers" section) that we had witnessed a migrating stream of painted ladies, the most cosmopolitan of butterfly species, found on all continents except Antarctica. For my guide to this and other Lepidoptera-related sites, please visit the magazine online (www.naturalhistorymag.com).

ROBERT ANDERSON is a freelance science writer who lives in Los Angeles.

WORD EXCHANGE

Around Our Necks

In "Around Their Necks" [4/08], Tui De Roy and Mark Jones call attention to both the beauty and the plight of albatrosses. Effective albatross conservation requires managing resources while taking into account the surrounding ecosystem—an approach known as "ecosystem-based management." Three initiatives are already in place that illustrate this approach to albatross management. In 2003, BirdLife International compiled a global tracking database; in 2004 the Agreement on the Conservation of Albatrosses and Petrels encour-

Continued on page 38

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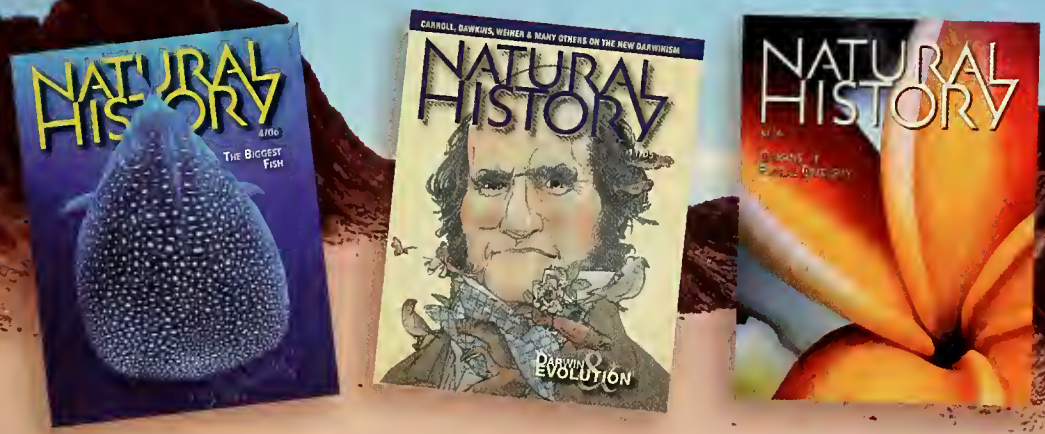

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NATURAL HISTORY

Mixed Greens, Extra Large

In the dinosaurs' day, the plant kingdom was ruled by primitive greenery that biologists have presumed to be only marginally digestible, and thus a poor energy source for herbivores. How could such scanty fare support colossal vegetarian dinosaurs, such as sauropods, which weighed up to seventy tons and were the largest creatures ever to walk the Earth? Sauropods would have needed to eat such massive quantities of vegetation that it would have been difficult for any ecosystem to support a sustainable population of them.

Now Jürgen Hummel at the University of Bonn in Germany and several colleagues have shown that the ancient veggie diet was more nourishing than previously thought. Using test tubes full of digestive microbes from sheep to simulate sauropod stomachs, the team tested the digestibility and energy content of eighty-six plant species—the nearest living relatives of ones the dinos probably ate.

Many of the prehistoric plants, particularly horsetails, ginkgos, certain conifers, and ferns, yielded energy sufficient to support the enormous sauropods. Cycads, tree ferns, and a subset of conifers, on the other hand, would have made poor meals.

That probably didn't put the dinos off, though: they couldn't afford to be picky eaters with such bulky bodies to sustain. Hummel says a balanced mix of greens was the foundation of their supersize success—not such bad advice for people, either. (*Proceedings of the Royal Society B*) —*Lydia Bell*

Flat-tailed house gecko

Turn Tail

For a long time, biologists thought a main function of geckos' tails was to store fat, but a new study gives that couch-potato image a makeover. In fact, the tail plays an active role in the gecko's amazing ability to climb—for which their sticky feet usually get all the credit—as well as to fall safely.

Ardian Jusufi, his graduate advisor Robert J. Full, and two colleagues, all at the University of California, Berkeley, videotaped flat-tailed house geckos ascending a vertical wall. The team observed that when the lizards' front feet hit a slippery patch and lost their grip, the animals instantly tapped their tails to the wall to keep from pitching backwards. If a tap wasn't enough, they pressed their tails against the wall, like kickstands. Tailless individuals had much less success traversing the slick spot than intact animals. (Geckos can jettison their tails when snagged by a predator.)

The researchers also observed gecko tail action in the air: they either dropped the lizards from an upside-down position, or set them afloat in a wind tunnel. By actively rotating their tails, turned-over geckos took just one-tenth of a second to roll right side up—the fastest air-righting response ever reported for an animal without wings. Again, intact geckos outperformed tailless ones.

After self-righting, the geckos calmly glided belly first in a typical skydiving posture, moving their tails to control their direction and angle of descent into a safe landing. Fat storage, my tail! (*PNAS*)

—*Stephen Reeds*

PHOTO: NEIL ZIEMBA, COURTESY OF THE MUSEUM

Wily Coyotes

Coyotes in and around Yellowstone National Park are adjusting to life with new neighbors. Reintroduced wolves produce a steady supply of large carcasses—elk, deer, and such—but they won't hesitate to attack a coyote that ventures too close to the vittles. So the coyotes have had to figure out how to maximize the benefits and minimize the risks associated with their stronger canine cousins.

Todd C. Atwood and his then graduate adviser at Utah State University in Logan, Eric M. Gese of the USDA's National Wildlife Research Center, spent three winters observing the behavior and interactions of coyotes and wolves near carcasses. A wolf pack had moved into their study area, a remote wilderness close to Yellowstone that was already home to twelve packs of coyotes.

The coyotes, the researchers found, had developed risk-management techniques to limit confrontations with wolves. The alpha couple in each coyote pack took the lead in approaching carcasses. Ever vigilant, they only laid into a carcass when the coast seemed clear of wolves. As their reward for assuming the risk, they got the best, most energy-rich morsels. When the alphas had satisfied themselves, the rest of the pack scrambled to devour the leftovers, confident they could do so safely.

Occasionally, alpha coyotes, accompanied by their pack, were even able to drive a smaller group of wolves away from a carcass. Such incidents involved intimidation displays and sometimes even contact, but never appeared to result in injury. Coyotes, it seems, have learned to pick their battles with wolves wisely. (*Animal Behaviour*)

—*Harvey Leifert*

Coyotes feed on an elk carcass in Yellowstone National Park.

CHARLES MAUZY/CORBIS

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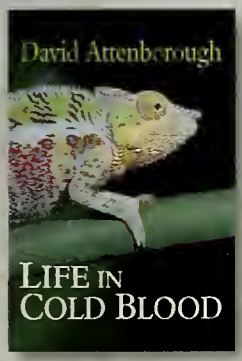

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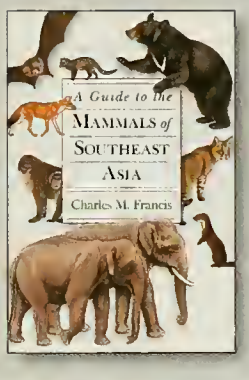

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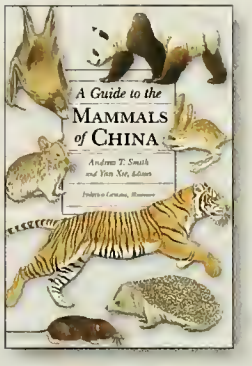

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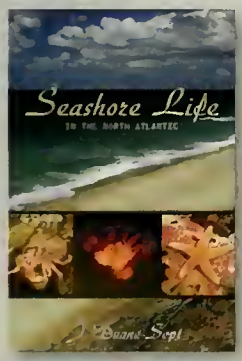

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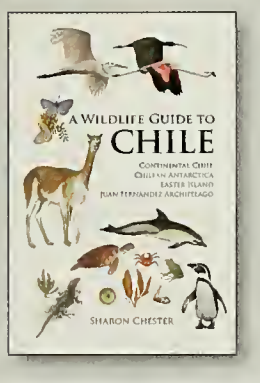

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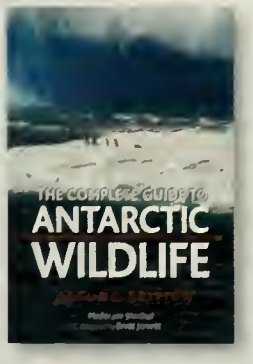

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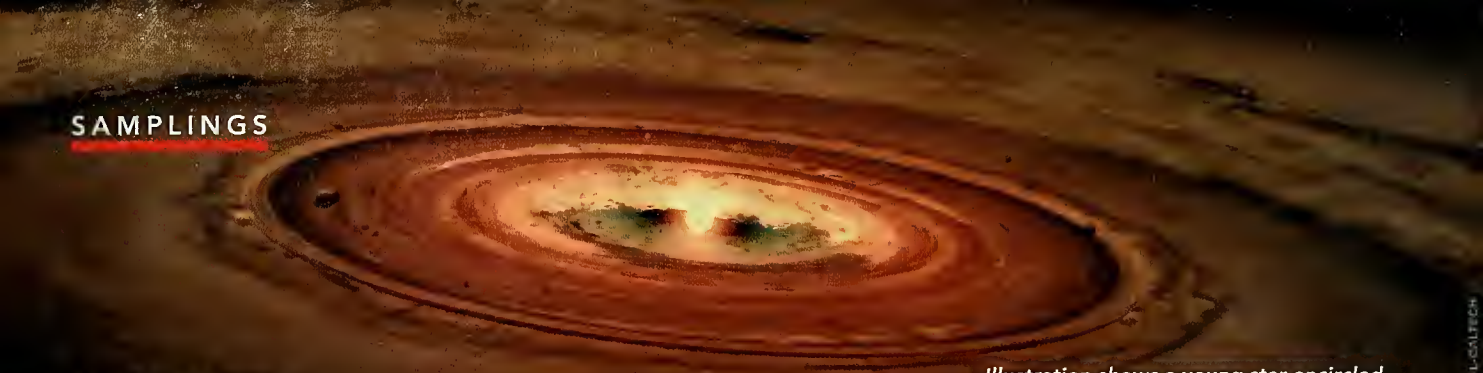

Illustration shows a young star encircled by a disk of gas and dust.

In the Zone

Water and simple organic molecules, including some thought to be essential to the origin of life, have turned up in a disk of gas and dust whirling around the young star AA Tauri, 450 light-years from Earth. Similar molecules have been found circling other stars before, but never at such an auspicious distance from the parent star: for the first time, astronomers found them in the zone where planets typically form. Thus AA Tauri could provide a glimpse of what our own solar system was like in its infancy.

The telltale signs of the faraway molecules came from detailed infrared emissions measured by the Spitzer Space Telescope. John S. Carr of the Naval Research Laboratory in Washington, D.C., and Joan R. Najita of the National Optical Astronomy Observatory in Tucson were able to tease out the emission signatures of water and the organic molecules hydrogen cyanide, acetylene, and carbon dioxide.

Carr and Najita say the relative abundance of the gaseous molecules suggests that they were synthesized within the disk itself, rather than falling in from interstellar space, where they are also known to form. If such prebiotic molecules do indeed form more readily in planet-building zones than previously thought, life on our home planet may be a little less anomalous than many Earthlings assume. (*Science*) —*S.R.*

Sand-dollar larva, left, and larval clone, above, magnified 80×

Time to Split

Sand dollars are a beachcomber's bread and butter. Their abundance may stem, at least in part, from a curious ability of their larvae: they can split themselves into two in an act of asexual cloning. The larvae tend to divide in times of plenty—extra food enables the small clones to quickly regain normal size—and also, a new study shows, in times of danger.

At the University of Washington's laboratories in Friday Harbor, Dawn Vaughn and her graduate advisor Richard R. Strathmann exposed sand-dollar larvae to fish mucus, and found that as many as 40 percent went into cloning mode. By contrast, none of the larvae in an unexposed control group did.

Vaughn and Strathmann think the larvae clone themselves when they detect signs of predators, such as fish—not so much to increase their numbers as to reduce their size. Many fish are visual hunters and may overlook the tiny larval clones; after fission, they're barely one-fiftieth of an inch long, about half their original size.

If so, cloning is a remarkable way for sand-dollar larvae to achieve what many prey animals can only do by cowering: make themselves as small as possible. (*Science*) —*S.R.*

DAWN VAUGHN

Swimming the Walk

Predators hunting randomly spaced prey should not themselves move randomly. That's the advice of many biologists, anyhow, to foragers needing an efficient search strategy. Instead, they recommend the "Lévy walk," which involves alternating clusters of short moves with much larger jumps—a pattern formulated by the late French mathematician Paul Pierre Lévy. Alas, evidence that predators actually walk the walk has so far been equivocal.

Now the theory has been bolstered by a new study from David W. Sims of the Marine Biological Association in Plymouth, England, and colleagues. Reasoning that Lévy walks, often conceived as a series of horizontal moves, could also apply to aquatic predators hunting for prey at various depths, Sims's team attached depth recorders to the bodies of thirty-one marine foragers from seven species. The data revealed that basking sharks, bigeye tuna, Atlantic cod, leatherback turtles, and Magellanic penguins swim up and down in the water column according to a Lévy pattern. Two other species—small-spotted catsharks and southern elephant seals—do not.

An analysis of how swarms of krill and zooplankton change depth through time, combined with computer simulations of the movements and distributions of predators and prey, also confirmed that "Lévy dives" beat purely random searches.

Although five adult basking sharks followed a Lévy pattern, one juvenile that the team tracked for seven months did not, so Sims thinks Lévy searches may be learned. (*Nature*) —*S.R.*

DAN BURTON / ALAMY

Basking shark

Clockwise starting top left: Prince Edward Island, Cabot Trail: Cape Breton, Louisburg Lighthouse, Whale Watching, Halifax Waterfront

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SAMPLINGS

Stuck in the Red

The leaves of pitcher plants form deadly, watery traps for insects, which beef up the verdant carnivores' nutrient supply. The traps, or pitchers, often sport red streaks or entirely red exteriors that contrast sharply with background greenery and probably serve to lure in insects. Indeed, the redder the pitcher, the more insects it catches, according to several studies.

But redder pitchers also happen to bear more nectaries, an additional temptation. Can an eye-catching red color alone bait bugs, without the lure of a sticky-sweet last meal?

To find out, H. Martin Schaefer of the University of Freiburg in Germany and Graeme D. Ruxton of the University of Glasgow in Scotland devised a simple experiment. They painted the traps of twenty *Nepenthes* pitcher plants either entirely red or entirely green, then set the plants out near ponds.

After a few days, the red pitchers had caught twice as many insects as the green ones. Apparently, as the two scientists write, the pitchers really do "roll out the red carpet" for insects.

That might explain why red is common in most carnivorous plant species—though why they're not all red remains an open question. (*Biology Letters*) —*S.R.*

Insect trap of a Nepenthes pitcher plant

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THE WARMING EARTH

Uprooted

Forests in Vermont's Green Mountains transition abruptly from a heat-loving mix of sugar maple, American beech, and yellow birch on the lower slopes to a cold-adapted mix of red spruce, balsam fir, and paper birch higher up. A new study shows that the altitude of that transition zone rose as much as 400 feet between 1962 and 2005—right in sync with a hike of 2 Fahrenheit degrees in the area's mean annual temperature.

Brian Beckage of the University of Vermont in Burlington and five colleagues documented those changes with aerial photographs, satellite imagery, and on-site measurements. That cold-loving vegetation should retreat up mountain slopes as the climate warms is hardly unexpected. But the researchers were surprised that such a marked shift occurred within just forty years—less than the natural life span of many trees.

For one forest type to replace another, living trees must die. The resulting vacancy in the canopy allows saplings below to fight it out for supremacy. Although a 2-degree temperature change would undoubtedly influence the results of the sapling competition, it's unlikely by itself to have killed off the mature trees first. For that, Beckage's team suspects the acid rain that's been falling since the 1960s.

The Green Mountains are hardly unique in suffering the one-two punch of acid rain and climate change, the team says; the same thing is probably happening elsewhere. They also warn that air pollution and tree disease could similarly accelerate the effect of climate change in driving trees up the mountains. (*PNAS*) —*S.R.*

Carbon Sootprint

The burning of biomass, such as wood or dung, and of certain fossil fuels releases particulate black carbon, or soot. Until now, soot has been considered a minor player in most climate models, but a new analysis suggests it's actually the second most important cause of global warming, right after another problematic combustion byproduct, carbon dioxide (CO_2).

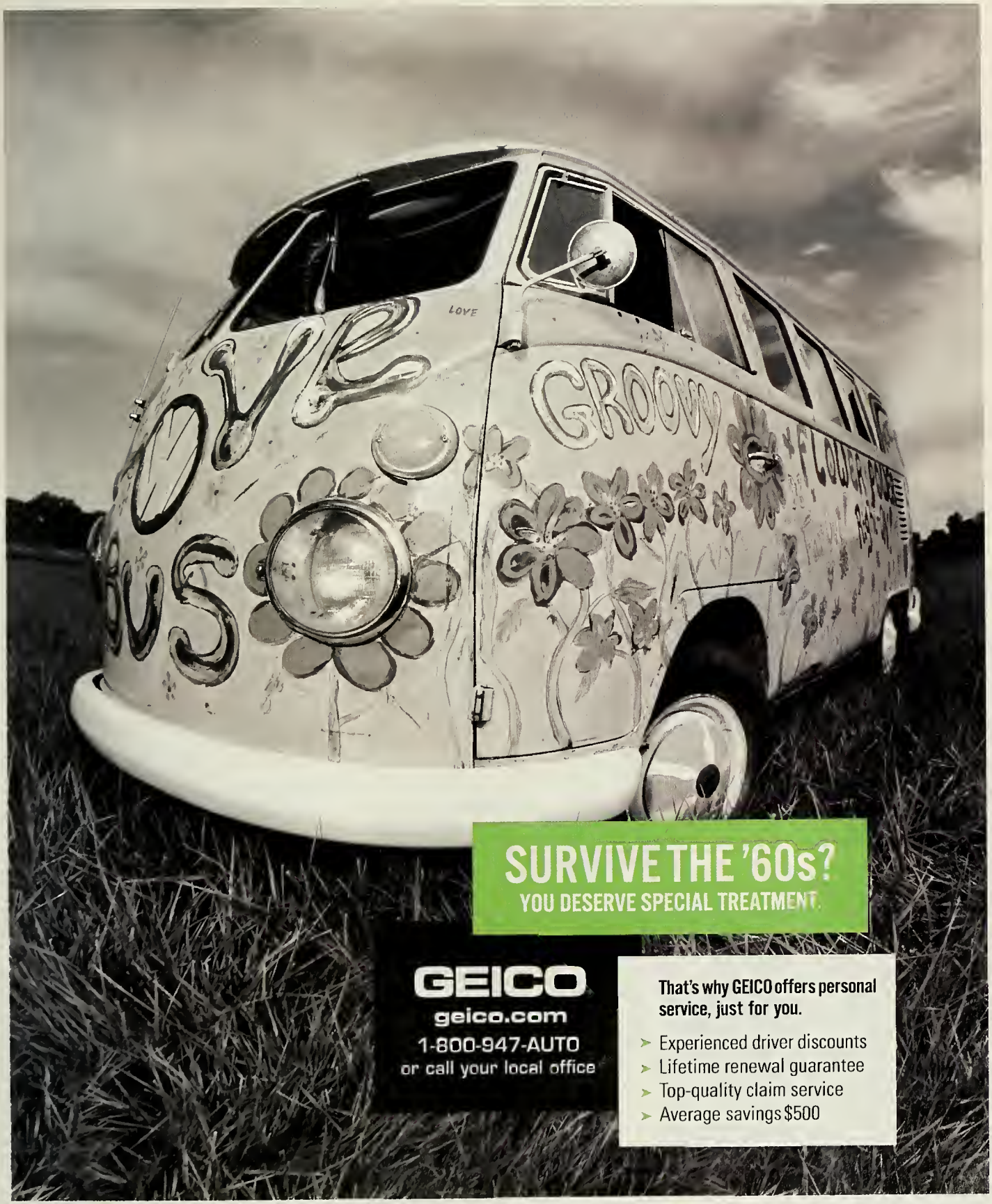
Veerabhadran Ramanathan of the Scripps Institution of Oceanography in La Jolla, California, and Gregory Carmichael of the University of Iowa in Iowa City reached that conclusion by precisely accounting for the altitudes at which soot accumulates in the atmosphere and for how other aerosols amplify its warming powers. (Airborne soot warms the atmosphere by absorbing sunlight; settled soot darkens snow and ice, increasing sunlight absorption by the ground.)

The scientists estimate that soot has probably caused about half the observed melting of Himalayan glaciers. And, they say, the decreased sunlight hitting the ocean results in less evaporation and thus less rainfall in certain areas. The good news is that soot, unlike CO_2, remains airborne for just a few weeks, though Ramanathan estimates that it would take ten to fifteen years for climate patterns to recover following soot reductions.

In the last fifty years, soot emissions have risen dramatically in developing countries of Asia, Africa, and South America. Ramanathan is leading a project to measure the environmental and health effects of building biogas plants and providing smoke-free cookers to some 4,000 households in India, where sooty, dung-fired cooking now prevails. (*Nature Geoscience*) —*Brendan Borrell*

Green Mountains, Vermont

BRIAN BECKAGE



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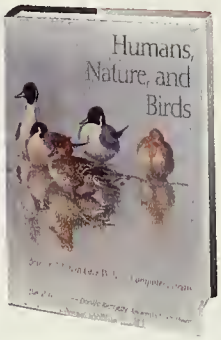

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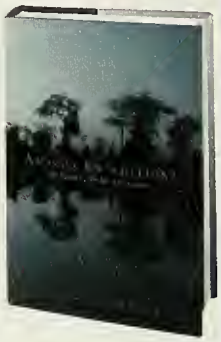

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LIFE ZONE BY OLIVIA JUDSON

Chromosomagnon Man

What's a chromosome or two among friends?

In 1921, the American zoologist Theophilus S. Painter reported that humans have forty-eight chromosomes. That was a big upwards revision: at the time, most people thought the correct number was twenty-four, and previous counts had been as low as sixteen (the same as onions). Painter was the first to analyze material taken from fresh human cells and prepared before deterioration and necrosis could cause the chromosomes to clump. The cells came from the testicles of castrated inmates of the Texas State Insane Asylum (that was at a time when medical ethics were in their infancy). Painter's number was rapidly accepted as reliable. In fact, it wasn't: humans have forty-six chromosomes. Yet for more than thirty years, everybody who examined human chromosomes again said they saw forty-eight, or figured they had counted wrong.

When I first heard the story, I thought it ludicrous. How could everyone have miscounted for so long? Was it the power of suggestion—you expect to see forty-eight, so you do? But then I looked at a photograph of the early data, and I understood the reason for the mistake: the chromosomes were piled one on top of the other, and it was hard to see where one ended and another began. The technology simply wasn't good enough to ensure an accurate count until the mid-1950s.

Nonetheless, the way we suddenly "lost" two chromosomes neatly mirrors an evolutionary tale. For chromosome numbers evolve, and at some point after the human lineage split off from the one that gave rise to chimpanzees, our chromosome number dropped from forty-eight to forty-six. Chimpanzees, and our more distant cousins the gorillas, still have forty-eight.

Chromosomes are essentially long strings of DNA. They contain protein-coding genes, regulatory genes, so-called junk DNA, and special structures such as telomeres (which prevent the ends of the chromosomes from unraveling) and centromeres (handles for moving chromosomes around during cell division). But why do we have chromosomes at all? Why not string all our DNA together into one gigantic chain? That's what lots of bacteria do: they have a single, circular chromosome, which lacks many of the features that ours have. But eukaryotes—organisms such as animals, fungi, algae, and plants—keep their DNA in a cell nucleus and break it up into multiple, linear chromosomes.

There are at least a couple of reasons for this. First, a bacterium has only one parent; in order to reproduce, it just splits into two. Eukaryotes generally have two parents, so the minimum chromosome number would, in any case, be two. I've only heard of two animals with only two—a roundworm called *Parascaris equorum* that lives in the guts of horses, and an Australian ant, *Myrmecia pilosula*. Second, eukaryotic genomes tend to be much bigger than bacterial genomes. It's probably easier for the cellular machinery to manipulate sets of smaller chromosomes than one colossal one, which would likely be prone to breaking.

Human chromosomes normally come in pairs, one in each pair inherited from the mother, the other from the father. They are numbered 1 through 22 if they come from a matching pair; and then there are the mismatched "sex" chromosomes, labeled X and Y. Many other species have a comparable arrangement, but

not all. In some spiders, for instance, females have three different pairs of X chromosomes and males have three X's but no Y chromosomes at all—so females end up with three more chromosomes than males do.

You might imagine that it matters in some obvious way how many chromosomes a species has—that the more complex the organism or the bigger its genome, for example, the greater the tally of chromosomes. Yet birds have tiny genomes strung out over many more chromosomes than ours, and a species of fern with a relatively simple genetic array has hundreds of chromosomes. Moreover, while some groups show little evolution in chromosome numbers, others vary immensely. Of the hundreds of dragonfly species that have had their chromosomes counted, for instance, almost all have twenty-six; yet species in one genus of blue butterflies, *Agrodiaetus*, can have as few as twenty or as many as 268. And doubling of all or part of the genome, leading to a sudden large jump in chromosome numbers, has been a common occurrence in plant evolution.

If you were to select 20,000 people at random and count their chromosomes, you'd find that most—but not all—of them have forty-six. Owing to an accident of cell division, for instance, people with Down syndrome usually have forty-seven chromosomes, having inherited three copies of chromosome 21. Similarly, people with Turner syndrome typically have forty-five, because they are missing one of the sex chromosomes.

Others have an unusual number for a different reason—two of their chromosomes have gotten stuck together, end-to-end. In those cases, however, individuals typically have the right total amount of genetic information, so they look and act just like everyone else.

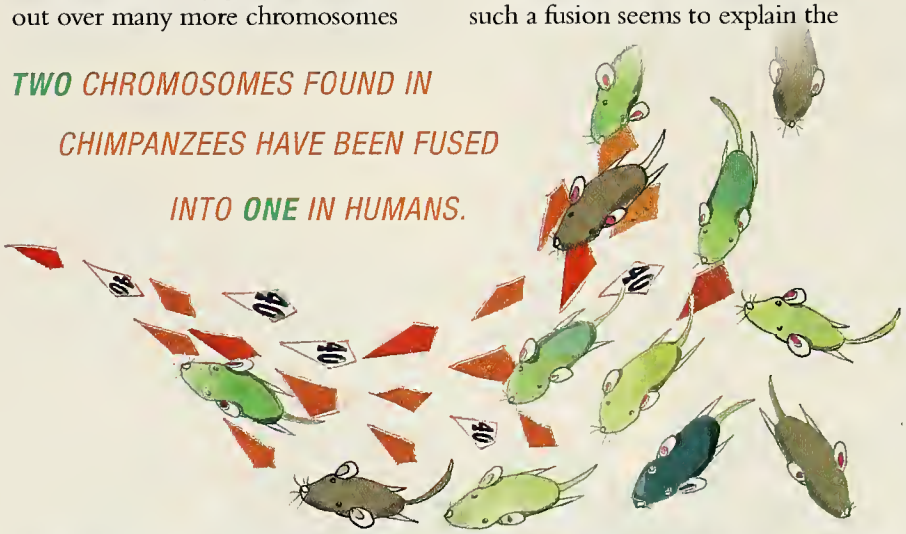
Interestingly, the establishment of such a fusion seems to explain the difference in chromosome numbers between humans and chimpanzees. Sometime after our ancestors diverged from those of chimpanzees—an event that happened about 6 million years ago—two of our chromosomes of medium size got stuck together to make one much larger chromosome. It's the one we call chromosome 2. We know this happened, because if you compare chimpanzee and gorilla chromosomes with the human set, you can see that two of the great apes' chromosomes correspond to our single one. (And when I say you can see the equivalence, I mean it literally: when stained with dye, each chromosome has a characteristic pattern of bands owing to particular aspects of its structure, such as gene density.) What's more, in the middle of our chromosome 2 there are DNA sequences that normally occur only at telomeres—at the chromosome ends. That they occur in the middle of this one is a genetic relict of the ancient fusion.

End-to-end fusions most commonly occur between chromosomes whose centromeres are near their tips. In laboratory mice, which are strains of the western European house mouse (*Mus domesticus*), the usual chromosome number is forty, and all the chromosomes have centromeres near the ends. If you look at wild strains of *M. domesticus*, however, you can find more than a hundred different combinations of chromosomal pairs that have been fused together (only chromosome 19 and the two sex chromosomes seem to have escaped the juggling). In fact, the small island of Madeira, in the Atlantic Ocean, is home to six groups of mice, each with a different set of fusions.

In humans today, about one person in a thousand is born with a fusion—one copy of chromosome 13, say, has gotten stuck to a copy of chromosome 14—giving that person forty-five chromosomes instead of forty-six. For such a fusion (or its opposite, a fission) to spread through a population and become established depends on a number of factors. One is the cost of having the fusion. Most people with a fusion appear normal, yet reproduction can be difficult. When there's an odd number of chromosomes, weird things can happen during meiosis—the process of manufacturing eggs and sperm. At the least, chromosomal irregularities in some of the eggs or sperm could reduce fertility.

Problems of this kind may explain why some groups—the dragonflies come to mind—have been so generally unchanging in chromosome number. My guess is that it's not so much that their chromosome structure is exceedingly stable, but rather that any changes are too costly to spread. In many other groups, however, fusions don't appear to spell reproductive disaster. In the house musk shrew (*Suncus murinus*), for example, some individuals have five fewer chromosomes owing to fusion events, yet they turn out to be no worse at reproducing than the rest of their spe-

TWO CHROMOSOMES FOUND IN CHIMPANZEES HAVE BEEN FUSED INTO ONE IN HUMANS.



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cies. House mice can have as many as three fusions and still have no problems mating with regular mice with forty chromosomes. As the number of differences increases, though, the mice do have problems in reproducing.

The size of a population will also affect the chance of a fusion event propagating. In a small population, evolutionary changes can sometimes become established even if they are costly. One way this can happen is through a passive process known as genetic drift. The easiest way to understand this is to think of a game of chance. If you roll a die 100,000 times, you'd expect to see each side come up about the same number of times. (Otherwise you'd suspect that the die was loaded!) If you only roll it a few times, though, you might get all sixes, just by chance. Genetic drift works the same way. If one person with a fusion lived in a small population—and early human populations are thought to have been tiny—and happened to have scads of children, who also had large families, then that fusion could have gotten a foothold in the population and spread quickly.

The die can be loaded, instead, by a process known as "meiotic drive." In some cases, as reproductive cells are being formed during meiosis, a fused chromosome may have a higher chance of being included in a reproductive cell, and thus passed on to the next generation. Here's how it happens in the case of a human egg. When a female is still a developing fetus, a "precursor cell" in her ovary doubles its chromosomes, making ninety-two. The cell then divides, making two cells with 46 chromosomes. Years later, after the female reaches puberty, one of the two daughter cells divides into two cells, each receiving twenty-three. Only one of those two cells will become an egg. So of the ninety-two original chromosomes, three-quarters get thrown away in the form of small cells called polar bodies. Although it isn't known how or why, fused chromosomes seem prone to ending up in the cell that will become the egg more often than they end up in the polar bodies.

There is some evidence that meiotic drive is acting in humans who experience fusions now, suggesting it may have played a role in how we ended up with forty-six chromosomes, in contrast with our close ape cousins. But we don't know whether the process acted similarly in the past.

In principle, a change in chromosome number could be a selective advantage in and of itself. When eggs and sperm are formed, the chromosomes in each matching pair do a genetic shuffle, known as recombination, which creates new combinations of genes and thus increases the variability in offspring. Changing the sizes of

chromosomes could affect that process, and thus be subject to natural selection. However, I don't know of any examples where chromosome number per se has been demonstrated to be under strong selection.

In any case, somewhere along the line you'd expect an odd number of chromosomes to settle down into an even number. Say a fusion happens so that an individual inherits forty-seven chromosomes—a set of twenty-four from the mother and twenty-three from the father. As that individual reproduces, some of the offspring will also have forty-seven. Once "forty-sevens" begin mating with each other, then some of their offspring will end up with forty-six chromosomes.

One intriguing question is whether the difference in chromosome numbers between us humans and our ape cousins had anything to do with why our lineages diverged. In principle, there are a couple of reasons why it might have. If individuals with different chromosome numbers mate, they might experience lower fertility, or their children could be sickly or infertile. That could happen if the cellular machinery bungles the handling of chromosomes as a result of the unequal numbers. Alternatively, subtle cues might enable individuals to gravitate to potential mates that share the same number of chromosomes. Intriguingly, some western European house mice react more aggressively to mice with a different number of chromosomes, though it is not clear whether this actually affects their choice of mates. Either way, a change in chromosome number could lead to a divergence until two populations no longer interbreed, making them separate species.

As far as I know, there is no way to tell exactly when the human lineage was downsized to forty-six chromosomes. My guess is that the change was not an important step on our path to becoming human, just something that spread in the human population after our ancestors parted ways with those of chimpanzees.

I doubt that, even now, the different chromosomal count alone would be an obstacle to human-chimpanzee hybridization. Rather, I think it would be the many other small changes and inversions and rearrangements that have accumulated in our two genomes. Mammals typically lose the ability to hybridize after about 6 million years of independent evolution, so at best we're on the cusp. In another 6 million years, if both lineages survive, each may be due for a chromosome recount. Perhaps by then the chimpanzees will have produced their own Theophilus S. Painter.

Olivia Judson, a research fellow in the Division of Biology at Imperial College London, is the author of Dr. Tatiana's Sex Advice to All Creation: The Definitive Guide to the Evolutionary Biology of Sex *(Owl Books, 2003).*

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[1] WHO/UNICEF, 2004 data
[2] *FORTUNE*, March 2008
[3] *Ethisphere™ Magazine*, April 2007

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SEX AND THE SINGLE SCHISTOSOME

ONCE THOUGHT TO PAIR FOR LIFE, INFECTIVE FLATWORMS MAY LOSE THEIR MATES IN BATTLE.

BY PATRICK J. SKELLY

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Opposite page: Adult male schistosome reveals the large suction cup underneath his "head" that he uses to anchor himself against blood flow and shinny through veins inside a host (image magnified 200x). Above: Oil painting by Charles-Théodore Frère, circa 1850, entitled "Along the Nile at Gyzeh." For millennia the Nile River has served as a primary site of schistosome infection for millions of Egyptians.

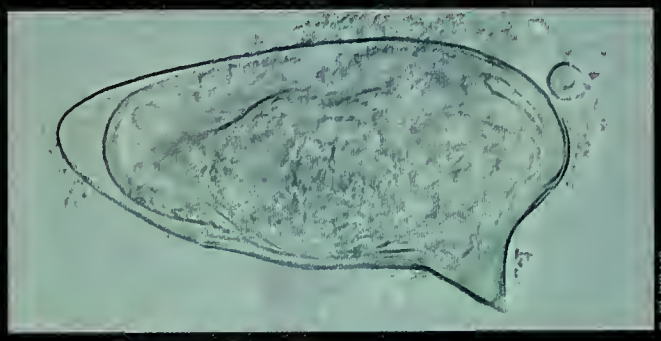
CALL ME NAÏVE, BUT I WAS A LITTLE surprised that the trip to the ancient temple of the pharaohs in Luxor, Egypt, did not require a couple of days' ride into the desert on a camel. I had visions of heat and dust and sandstorms, with the temple emerging like a mirage, magnificent in the distance. Nothing like it: the temple (magnificent indeed) sits in downtown Luxor, not far from the post office and the train station. A little farther along the road, keeping the Nile River on your left, you will find the great temple of the god Amun at Karnak. And across the river from Luxor on the west bank lies the Valley of the Kings, where, from about 1500 to 1000 B.C., Egyptians buried their pharaohs.

It was a tourist treat. But I was in Egypt for something the guidebooks warn you against—parasitic flatworms. (I was there to meet with an Egyptian pharmaceutical company to discuss development of a vaccine to ward off the worms.) Parasitologists have long known that Egyptians, ancient and modern, pharaohs and commoners, have been engaged in an ongoing battle with small, primitive worms called schistosomes, which inhabit tropical freshwater such as the Nile. Although it may look inviting on a hot day, such water often harbors tiny, tadpole-like forms that can latch onto your skin, burrow inside, and stake a claim. Of the twenty-one species of *Schistosoma* currently recognized, five infect humans. Livestock and wildlife also contract disease from such worms. For instance, *Schistosoma japonicum* can infect humans, cattle, and other mammals; *S. margrebowiei* and *S. leiperi* infect antelope, and *S. leiperi* has been found in zebras as well; *S. edwardiense* and the imaginatively named *S. hippopotami* both infect the hippopotamus.

Many millions of Egyptians are infected today with schistosomes. In their time, the pharaohs too were infected. Schistosome eggs have been detected in royal mummies thousands of years old. In addition, X-ray examination of mummies has revealed the pathological calcifications typical of schistosome infection, and worm proteins have been identified in rehydrated ancient tissue. If they have prevailed across time, schistosomes have also been undaunted by space: they are endemic in rural and suburban areas of seventy-four countries in Africa, Asia, and Latin America (where they first arrived in the bodies of slaves). Globally, about one in thirty people has them living in his or her bloodstream right now.

ONCE THEY GET INSIDE YOU, schistosomes are remarkably persistent. A German medical journal, *Deutsche Medizinische Wochenschrift,* had a report in its May 2005 issue entitled, "Surprising findings in the colon 15 years after a holiday in Africa." The patient, a sixty-five-year-old woman who went to the hospital with abdominal discomfort learned she had schistosome eggs in her intestine. She had picked up schistosomes at some point during two stays in Mwanza, Tanzania, fifteen and seventeen years earlier—and the same worms had remained in her body ever since. As most everyone does, she likely became infected by venturing into contaminated water.

Schistosomes start off as eggs—expelled into water by their human hosts via urine or feces—and hatch into free-swimming microscopic *miracidia,* which penetrate the tissues of certain freshwater snails and replicate there, developing into microscopic forms called *cercariae* that are



G. W. WILLIS

GHESE KRAUTZ-PETERSEN

PATRICK J. SKELLY

capable of infecting a new human host. The cercariae have powerful thrashing tails, but no teeth or hooks with which to latch on to human skin [*see top photograph on opposite page*]. Instead, they more or less throw up their sticky secretions onto your skin. That vomit—the beachhead that allows for infection—makes it difficult to wash them off and gives the parasites time to probe your surface, searching for the edges where the scales of your skin overlap. In fact, since their mucus swells in water, this probably lifts some of the scales to allow the parasites to gain purchase and squeeze underneath your skin. Released enzymes help degrade the barrier, and within a few minutes they are in, beneath your epidermis. Mission accomplished.

Once inside the subdermal tissues, the parasites jettison their tails and further outfit themselves for a new environment. No longer in fresh water, they alter their entire physiology and biochemistry: they shed their old surface coats and synthesize new ones, slipping into something more comfortable, more suited to the indoors. After a few days just under the skin, the baby invaders push on, aiming to hit a blood vessel that will carry them to the lungs and, after several days of further maturation there, to the blood vessels of the liver, where males and females mature and mate. It is here that our drama unfolds.

SCHISTOSOMES ARE CLASSIFIED with the flatworms, Platyhelminthes, which are said to be the most primitive of all of the organisms that have heads. (The platyhelminth cheer: "We may be primitive, but we have heads!") Most of those flatworms are hermaphroditic, but not schistosomes—they have separate sexes. Individual male and female worms must locate each other within their host's circulatory system in order for the parasites to continue their life cycle. The adult male and female schistosomes are not only sexually distinct but visibly different-looking. Males are bulky and Schwarzeneggerian, weighing three or four times as much as the longer, slimmer females. [*See middle photograph on opposite page.*]

When schistosomes of opposite sexes meet, the male holds the slender female in a groove on his underside called the gynecophoric canal. Various observers suggest that this arrangement looks a little like "a hot dog in a bun," or, my personal favorite, "an anaconda in a canoe." Worms recovered from infected hosts are usually found paired in this manner. The groove in which the female sits looks like a cut down the male's body and is what gives the parasites their names: schistosomes, or split bodies.

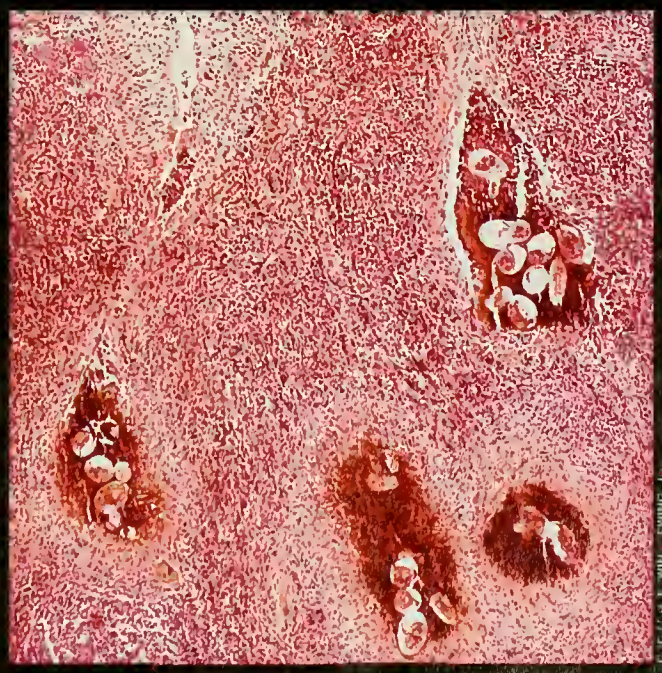
Another oddity in the sex life of most schistosome species is that female worms do not mature until they are paired with a male: single females are less than half as long as mated females. Indeed, the presence of the male schistosome is needed, not only for the female to complete her development, but also for her to maintain a mature state. If a mature, egg-laying female is separated from her male partner, she stops laying eggs and, within days, begins to

regress physically and reproductively to an immature state. If such a female finds another mate, she grows larger again and resumes normal reproductive activity. Therefore, an intimate and continuous association between the male and female worm is necessary for reproduction to occur. The slogan "A woman without a man is like a fish without a bicycle" does not apply to female schistosomes.

Even half a male worm is better than none. Cut a male schistosome in two, and each half survives in a nutrient broth and heals (but neither part regenerates to form another whole worm). In a test tube, such half males will pair with intact females. Even a quarter of a male will pair with a female! A striking result of such mixings and matchings is that the female matures only in that region of her body touching the truncated male. Exactly what the chemistry is between the sexes (or the bits of the sexes) that make pairing so crucial for female maturation has not yet been identified. However, we do know that sperm transfer is not the cue for female maturation.

The urge to pair is strong in both sexes, as shown by Vaughan R. Southgate of the Natural History Museum in London, England, and Louis-Albert Tchuem Tchuenté of the Center for Schistosomiasis and Parasitology at the University of Yaoundé in Cameroon. Indeed, much of what we know about schistosome mating is derived from the work of those investigators and their colleagues. Tchuem Tchuenté reports that "when the male has no choice at all, he will pair with another male." Homosexually paired males are seen in infections with few or no females. Such a pair consists of a large, well-developed male embracing a smaller male whose sexual maturity seems retarded.

It has long been assumed that male and female schistosomes, once they have found each other in the bloodstream, remain paired for life. Since the parasites are known to live for many years, perhaps decades, that amounts to an impressive example of monogamy. Working with collaborators at the Institute of Cell Biology in Rome, Italy, Southgate and Tchuem Tchuenté set out to see if fidelity was truly a hallmark of the worms—not an easy task. How could they track individual parasites lurking inside blood vessels? In the end, they exploited the fact that some schistosomes are susceptible to the drug hycanthone (here referred to as "S," for drug-susceptible), whereas others (referred to as "R") are resistant to the



Opposite page: A schistosome egg, released into water by an infected person (top, magnified 500×); the egg hatches into a free-swimming form, a miracidium (middle, magnified 570×), which burrows into the tissue of a freshwater snail (bottom, magnified 5×). This page: The snail hosts the parasite's development and division into cercariae, another free-swimming form (top, magnified 175×), which can find and penetrate mammalian hosts. Once inside, a cercaria loses its tail and matures into a male or female adult. Worms pair off, with the larger male enveloping the smaller female (middle, magnified 90×). Together they produce fertilized eggs; some are excreted via urine or feces, but many stay inside the host and can cause inflammation as seen in this stained tissue (bottom, magnified 45×).

drug. For their experiment, they first infected a small group of mice in the laboratory with male and female R parasites. Six weeks later, when those parasites had begun to lay eggs, they further infected the same mice with S parasites. This time, though, they introduced only male parasites.

Did the newcomers displace some of the resident males? Or did the new parasites find that there was little place for them, since the eligible females had partners? Ten weeks after the second infection, all the worms were recovered from the mice and their status (R or S) identified. Surprisingly, there were many mixed matings, that is, R females with S males. And when greater numbers of new males were introduced in such experiments, even more changes of mate were seen. So the image of an ever-faithful schistosome was shattered.

How do mate changes occur? Are resident females more attracted to the new arrivals—single studs riding a new wave of blood? Or do some of the newcomers wrest females from the males of resident pairs? Recall that schistosome males are much beefier than females. "It might be hard for the female," Southgate notes, "to get out of the grip of the male." Tchuem Tchuenté concurs and adds that it is likely that "the male is more active in the pairing process." Think of

ATLANTI E PHOTOTRAVEL/CORBIS

Children play on a bank of the Fare River, Cameroon.

battling elephant seals (which look pretty much like enormous blubbery worms): the bigger a bull seal, the better his chances of defeating potential rivals and acquiring a mate. The same sorts of battles for access to mates could be playing out right now in the blood vessels of some 250 million people on the planet.

Southgate speculates that when a part of a female is accessible outside of her male mate, another male may grab hold and eventually be able to pull the entire female into his own gynecophoric canal. Instances of "tug of war" involving one female and two males have been observed with worms in Petri dishes in the laboratory. And single female worms have even been flushed out of the veins of infected animals in association with two, presumably rival, males. Such bouts are likely, since the sex ratio of adult schistosomes recovered from naturally infected hosts is generally male biased.

SCHISTOSOME MALES AND FEMALES

first rendezvous in the large veins of the liver, but they do not stay there. Couples make their way into the small blood vessels around the intestines, in the case of four human species (*Schistosoma intercalatum, S. mansoni, S. japonicum,* and *S. mekongi*), or to the blood vessels around the bladder (*S. haematobium*). To reach those vessels directly from the blood vessels of the liver, the worm pairs must hunker down and migrate *against* the flow of blood, using their suckers to pull themselves along the vessel walls. (The male most certainly works hard to haul his partner, but it is not known whether the female uses her suckers to assist in the journey as well.)

Once the intestinal species have situated themselves in blood vessels near the host's intestine, the female lays eggs, which begin to degrade the intestinal wall and to move through it into the gut itself. Host bowel movements then pass the eggs out into the environment with the feces. Schistosomes residing in the blood vessels around the bladder release eggs that pass into the bladder, where they are voided with urine. Before they are excreted, however, those eggs can severely damage tissues; and worse yet, not all the eggs make it out of your body. As many as half of the hundreds of eggs laid by each female worm every day get swept away by blood and dispersed elsewhere in the body. Many of the eggs end up trapped in other tissues, such as the liver.

The pathological problems caused by all of the roaming eggs are collectively called schistosomiasis, or bilharzia (after Theodor Bilharz, a German physician who discovered the parasite in Cairo in 1851). Infected people can experience fever, chills, abdominal pain, bloody diarrhea (or bloody urine), liver and spleen enlargement, and other uncomfortable symptoms. The World Health Organization puts the mortality due to schistosome infection in sub-Saharan Africa alone at over a quarter of a million people per year.

POPULATIONS OF INFECTED humans represent large battlefields not only for the competition between male schistosomes, but also for competition among different species of schistosomes. Take the town of Loum, Cameroon, for instance. In the late 1960s more than half of the children in Loum were infected with a human intestinal species *S. intercalatum*, and no one was infected with the human bladder schistosome, *S. haematobium*. Nowadays, however, *S. intercalatum* is nowhere to be found in Loum, and *S. haematobium*, first observed in Loum in the early 1970s, has effectively replaced it.

Although individuals of the two species are comparable in size, it turns out that in experimentally infected animals *S. haematobium* is good at displacing *S. intercalatum* and is, remarkably, even better at taking *S. intercalatum* females away from their same-species male partners. In other words, changes of mate can occur even in mixed infections with different schistosome species. Those worm battles could have important consequences for the spread of the different kinds of schistosomiasis around the world.

My laboratory, in conjunction with Jeffrey D. Peterson and his group at VisEn Medical, Inc., in Woburn, Massachusetts, is developing methods to find and monitor live schistosomes within living hosts. We are hoping to observe the natural movement and distribution of the parasites, including identifying sites where mates of different species may be switching partners. Moreover, we are working to exploit the bonanza of schistosome genome sequence information now available. A large proportion of the worms' genes appear to be unique to schistosomes, and we hope to understand how these contribute to the extraordinary biology of the parasites. The aim is to use the information gleaned to devise better control strategies.

Currently the drug praziquantel is widely used to kill adult schistosomes. However, drug-cured people often get reinfected, so a vaccine is needed. Molecules on the schistosome's body surface are perhaps the best targets for vaccines, since they are presumably exposed to attack by host immune cells, and my laboratory is working to understand the makeup of this schistosome skin. Several research groups, such as that led by Alex Loukas at the Queensland Institute for Medical Research and Akram Da'dara and Donald Harn at the Harvard School of Public Health, have tested schistosome surface molecules in vaccine trials in animals, with encouraging results.

Fears that schistosomes will develop resistance to praziquantel have also prompted the search for new schistosome-killing compounds. Several promising candidates have surfaced, including a group of chemicals called oxadiazoles identified in March of 2008 by a research group at Illinois State University in Normal, led by David L. Williams. Such advances show promise that people in Africa and around the world will someday be able to break the schistosomes' hold. But for now, as they have for millennia, the worms are holding on to their human hosts as jealously as they do to their mates.

DAVID SCHARF/PETER ARNOLD

Dimorphic adults: a diminutive female schistosome sticks her head out of her partner's gynecophoric canal—a trough on the underside of his body (magnified 120×). But she might not stay there for long if an unpaired male comes along and "tug of worm" ensues.

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BURMESE Motorcycle DIARIES

Following the trail of an adventurous scientist to its—and his—end

BY JAMIE JAMES

JOE LEMONNIER

Like mystics and soldiers of fortune, field biologists are fond of exotic, far-flung places. It's partly scientific: the study of wildlife requires wilderness. Yet sometimes there's an irrational, almost addictive edge to the attachment. Joe Slowinski, a curator of herpetology at the California Academy of Sciences, had such a bond with Myanmar—or Burma, as much of the world still calls that Southeast Asian nation, preferring tradition over a name foisted on it by a military regime. Burma is about as far from San Francisco as it's possible to be flung. In eleven trips beginning in 1997, Slowinski led expeditions throughout the country. To biologists, he is probably best known for his identification, with herpetologist Wolfgang Wüster of Bangor University in Wales, of the first new species of cobra to be described since 1922: *Naja mandalayensis,* the Burmese spitting cobra. Slowinski also cofounded, with the Smithsonian Institution's George R. Zug, the Myanmar Herpetological Survey, one of the country's few stable scientific institutions.

Late in the summer of 2001, Slowinski led an expedition into Burma's extreme north, in the foothills of the Himalayas near the frontier with China, to conduct the first large-scale survey of the region's life-forms. On September 12, while the world was reeling from the attacks on America, Slowinski died from the bite of a many-banded krait, *Bungarus multicinctus,* the deadliest land serpent in Asia. He was only thirty-eight. It was a tragic loss to science and an exemplary tale of grace under pressure. A few hours after the bite, when Slowinski could no longer breathe on his own, his colleagues began

Khun Kyaw, one of the young motorcyclists from Putao who accompanied the author, negotiates the suspension bridge at Rat Baw (in background), the village where herpetologist Joe Slowinski died in 2001.

JAMIE JAMES

mouth-to-mouth respiration. They kept him alive that way for more than twenty-four hours, waiting for a helicopter rescue mission that came too late.

In January 2005, I began researching a biography of Slowinski with a journey of my own, tracing the route of his expedition from Putao, a small district capital in the north of Burma, to the village of Rat Baw, about thirty miles from the Chinese border, where he died. It was my fourth visit to Burma in twelve years, but the first time I ventured beyond areas ordinarily open to tourists.

I began in Yangon, the nation's capital, also known as Rangoon. The decrepit airport terminal was typical of the dilapidated infrastructure I saw everywhere, the ravages of more than four decades of dictatorial military rule. Also evident was the watchful eye of the junta. Posted on the way into the city were scarlet signs proclaiming in Burmese and English: "Oppose those relying on external elements acting as stooges holding negative views" and "Oppose foreign nationals interfering in the internal affairs of the State."

My first call in the capital was at the Forest Ministry, whose primary mission seems to be to look the other way while foreign loggers clear-cut Burma's ancient hardwood forests. On the other hand, the ministry's Nature and Wildlife Conservation Division, which sponsored most of Slowinski's field expeditions, makes a valiant effort to protect what remains of the nation's natural heritage. I met the division's director, U Khin Maung Zaw, a courtly, soft-spoken zoologist, in a dim office lined with glass-doored cabinets full of scholarly books and old maps. He and Slowinski had been friends; in fact, in 1998 Slowinski had named a new species of wolf snake after him, *Lycodon zawi*.

Zaw was still sorrowful about Slowinski's death. He was glad I was writing a book about his old friend, but there was a limit to what he could do. The area I wanted to visit had been a site of active resistance by guerilla groups until the mid-1990s, and the presence of foreigners there is restricted. I had only managed to obtain a ten-day pass to Putao and environs. A guide was also assigned to accompany me—a tall, serious, bespectacled man of twenty-seven named Lynn Htut Oo, who continually reminded me of the importance of giving him a big tip.

Our flight north was slightly terrifying, aboard an

ancient commuter plane that looked ready for the scrap heap. When we skittered to a landing in Putao, I found myself in the middle of a broad plain encircled by distant blue mountains, the southeastern edge of the Himalayas. Concealed by the closer peaks, to my north lay Hkakabo Razi, at 19,294 feet the highest peak in Southeast Asia, which had been Slowinski's destination.

While Slowinski's expedition was the first full-scale international scientific venture to the region, a few intrepid Western scientists had preceded him. As recently as 1997, Alan Rabinowitz, the director of science and exploration for the Wildlife Conservation Society, in New York City, had made a quick trip through the area, discovering a new species of deer, the diminutive leaf muntjac, which is the smallest member of the deer family. Shortly before Slowinski's expedition, Rabinowitz had helped the Forest Ministry establish a national park around Hkakabo Razi [*see "The Price of Salt," by Alan Rabinowitz, September 2000*].

With the aid of my government guide, I immediately set about organizing an expedition to Rat Baw. The village lies in a rugged area that is home to hill tribes that came from around Tibet hundreds of years ago. Known collectively to outsiders as the Kachin, they call themselves by the names of their tribal groups, among them the Jingpaw, Rawang, and Lisu. To my dismay, I found only one person willing to take me there. At the only decent restaurant in Putao, a town of 10,000, I met with Yosep Kokae, an experienced guide who had served on Slowinski's expedition. He said he would help me, but he couldn't find porters on such short notice.

Then the restaurant's owner, a tall, dignified Kachin woman, told me that her son and his friends might be willing to take me to Rat Baw on their motorcycles. Her son, Khun Kyaw, a strapping, self-confident twenty-two-year-old, recruited two friends, making a party of six with me, my government guide, and Yosep Kokae. It wasn't ideal, roaring through the wilderness on cheap Chinese motorbikes, but I had no alternative. Just as we were about to depart, the local constabulary decided that we must have another official minder on the expedition, so we were assigned a timid twenty-year-old policeman, whom Khun Kyaw and the others treated with open contempt.

It was a cool, misty morning when we set off, seven men on six bikes, laden with bottled water and freshly killed chickens. On the outskirts of town we passed several Protestant churches, simple bamboo structures with wooden crosses surmounting their flimsy entrance gates. Burma is overwhelmingly Buddhist, but most of the people around here follow Christianity. The earliest known missionary to the Kachin was Eugenio Kincaid,

JAMIE JAMES, FAR LEFT
ROYAL GEOGRAPHICAL SOCIETY, LEFT

The forests in the valleys around Rat Baw "partake of the character of tropical rain forest." So wrote the botanist Frank Kingdon-Ward (above, photographed in China), who traveled to Burma ten times from 1914 to 1956, bringing back showy species that became staples of English gardens.

a Baptist preacher from Wethersfield, Connecticut, who paddled a small boat loaded with bibles and religious tracts some 400 miles up the Irrawaddy from Mandalay in 1837.

A few miles out of town, we crossed a fine iron suspension bridge spanning a northern tributary of the Irrawaddy. Elephants were stacking freshly felled trees on the riverbank, awaiting a barge from Myitkyina, the capital of Kachin State, to collect them. It was the last evidence of logging activity I would see on the trip.

A good paved road led to the village of Machanbaw, the last outpost of relative civilization; after that, the trail became narrow and overgrown, climbing steadily to an elevation of 2,000 feet. Although it lies north of the Tropic of Cancer, the forest here has a distinctly subtropical character, with towering dipterocarps, Chinese coffin trees, flowering magnolias, fragrant screw pines, and many fruit trees, including rambutan, mangosteen, and banana, all wrapped in thick ropes of lianas and other climbers. The British botanist Frank Kingdon-Ward described the terrain in his account of a collecting expedition in 1953: "Here the forest is richer and denser—not only does frost never enter into these deep sheltered valleys, but throughout the winter they are steeped in mist till nearly midday, and so partake of the character of tropical rain forest."

Kingdon-Ward was the hardest-working and most productive of the foreign scientists who preceded Slowinski in the region. In ten epic journeys to Burma from 1914 to 1956, he collected dozens of plant species new to science, and brought back hundreds of varieties of begonias, poppies, rhododendrons, and other showy flowering plants, which became staples of English gardens. His vivid, often witty journals of those expeditions were popular reading for British Sunday gardeners.

We made our first camp at a village called Htanga. It was wretchedly poor, malaria was rampant, and the people were obviously not getting enough to eat. Yet the inhabitants were wonderfully hospitable, giving us the best house in town, a rickety bamboo structure on stilts with a thatched roof. For dinner, Yosep Kokae made "bachelor's chicken," a mild, savory curry served with tiny fried potatoes, the size of garbanzo beans, which had a delicious, nutty flavor. Later, a few children sneaked up to see us. They were fascinated by my battery-powered lantern; one little boy blew on the light bulb as if it were a flame or ember, trying to make it glow more brightly.

We awoke to a misty morning. Yosep Kokae was already busy cooking fried rice with chilies. Breakfast began with pomelo, the fruit of *Citrus maxima*. One of the volleyball-size fruits—the largest of the citrus fruits—fed us all. Its mild grapefruit tang was sharpened with a dash of salt. My bowl had a fried egg on top, the only one, laid overnight by the hen that lived on the back porch. One of the bikes wouldn't start, so we abandoned it there, along with our useless police escort.

After we had been an hour on the road, our surroundings took on a wilder aspect, so I told the guys to break for a few hours. I went ahead on foot and was soon surrounded by dense forest. I saw a hornbill swoop overhead, a reliable harbinger of wilderness; farther along I heard a pair of gibbons serenading each other. The most thriving forms of wildlife I observed, however, were the leeches. The morning mist gave them a congenial environment in low-hanging foliage. Kingdon-Ward wrote after an expedition to Putao District in 1937, "It was rather horrible to see the hordes of famished leeches advancing immediately one entered the jungle. It is almost indecent how they smell their victim and sway their way towards him, the foliage shivering to their regular movements."

By midday the weather had cleared, and the landscape displayed an exquisite, rugged beauty—high rock cliffs with waterfalls plunging a hundred feet or more, soaring trees, ferns with fronds five to ten feet long, stands of many varieties of bamboo, and treelike rhododendrons. I passed some boys catching tiny fish in a creek with conical, thorn-lined traps. Where a tree had fallen across the trail, I sat to wait for my escort. In a shady recess by

Local children wait for a river ferry near Rat Baw.

a small creek I found a black orchid—a rare flower, but not as beautiful as its name.

At dusk, just as a light rain began to fall, we reached Rat Baw, tucked into a valley between two high ridges that vanished into swirling clouds. Home to forty-eight families, the village has a rustic, Tolkienesque charm: bamboo fences crisscross the gentle hillside, ruling off neat vegetable patches; the low roofs of the houses, thatched with fan-palm leaves, blend imperceptibly with the surrounding secondary forest. A dirt path curves back toward the river, leading to the schoolhouse, a solid frame building with a tin roof. It was here Joe Slowinski died.

We pitched our tents in the main classroom. After dinner the schoolmaster, Joseph Tawng Wa, invited me to his house behind the school, just as he had Slowinski in 2001. His house was almost in ruins, with gaping holes in the floor and roof. Wild spearmint grew all around, covering the mild funk of cow dung. A grave, placid man with two gold incisors, Wa wore a Norwegian ski sweater against the damp cold. He had lost three of his five children to malaria. He opened a bottle of homemade rum and we talked about our lives. He told me he loved America, and showed me a laminated portrait of Bill Clinton he carried in his wallet.

Recalling the death of Slowinski, Wa said, "We were so sad, sir. The lady teachers all wept. The men teachers were also very sad." He was upset that Slowinski had refused to take *mashaw-tsi,* the local herbal cure for snakebite. He claimed that no one in Rat Baw ever died of snakebites, thanks to the plant's miraculous curative power. Kingdon-Ward was the first to identify the herbal remedy as a species of the genus *Euonymus.* At that time a Kachin elder controlled the market for the precious herb. "This cheerful old rogue," wrote Kingdon-Ward, "claimed a monopoly not only in purveying *mashaw-tsi*—at a price—to the public, but even in the occurrence of the plant, which he maintained grew *only* in the jungle near his village." (Later in Putao, I bought a sprig in the market for a few cents.)

In the morning, Wa told me, "You are very fortunate to find me here." After six years as schoolmaster in Rat Baw, he had been offered a new job, and was leaving for good just four days later.

My rush to get to Rat Baw and back before my permit expired was soon revealed to be pointless. In Putao I learned that my flight to Yangon had been cancelled indefinitely. So I was stranded there with a trio of British birdwatchers, staying in an unheated guesthouse next door to a karaoke club that catered to very drunk loggers. The birders told me that they had sighted the Burmese bushlark, hooded treepie, white-browed nuthatch, white-throated babbler, and several species of bulbul. They held out little hope for the pink-headed duck, *Rhodonessa caryophyllacea,* a legendary waterfowl with a head as pink as bubble gum. It is almost certainly extinct; the last reported sighting was in 1966.

A week later, an airlift was organized for us, serendipitously scheduled for the morning after Putao's annual festival. This country fair consisted mainly of dart-throwing gambling games, booths selling beer and fried snacks, and karaoke. The chief attraction was a performance by an inept rock band, Claptonian noodling laid over a thumping pop rhythm of bass and drums. Yosep Kokae was there with his wife; Khun Kyaw and his compadres were flirting with the girls, boasting about their adventure. Perhaps 500 people milled about watching the show. Outside Burma it might have been accounted a pretty poor festival, but after my trip to Rat Baw it seemed like a jubilant saturnalia.

A writer of both fiction and nonfiction, **Jamie James** (above, in the red jacket) grew up in Texas and lived in New York City for many years before settling in Indonesia nine years ago. His book about Joe Slowinski, *The Snake Charmer: A Life and Death in Pursuit of Knowledge,* is being published by Hyperion this month. Previous books he has authored include *The Music of the Spheres: Music, Science, and the Natural Order of the Universe* (Springer, 1993).

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BOOKSHELF BY LAURENCE A. MARSCHALL

What Bugged the Dinosaurs?

Insects, Disease, and Death in the Cretaceous

by George Poinar Jr. & Roberta Poinar
Princeton University Press,
2008; $29.95

Since only a few scraps of fossilized dinosaur skin have ever been found, we can't be sure that tyrannosaurs were bothered by mosquito bites or triceratops suffered head lice. Yet George and Roberta Poinar, paleozoologists at Oregon State University in Corvallis who specialize in smaller forms of life, are convinced that dinosaurs waged a constant battle against tiny parasites and pests—a battle from which, to judge by the dino-to-insect ratio today, the insects ultimately emerged victorious.

The circumstantial evidence is compelling. That insects were on the scene with dinosaurs is indisputable: there is a rich record of insects and other invertebrates beautifully preserved in nuggets of golden amber to prove it. The variety of species thus preserved could hardly be a representative sample of life in the Cretaceous. It takes an extraordinary set of circumstances—including unusually bad luck—for a creature to get stuck in tree sap. Yet more than 490 families of insects have already been identified in amber (compared with 762 known worldwide today), including ticks, mites, sand flies, biting midges, blackflies, mosquitoes, and horseflies—and, of course, cockroaches.

The Poinars' second line of circumstantial evidence is the behavior of insects today, which clearly enjoy as close a relation to reptiles and to birds (the descendants of the dinosaurs) as they do to mammals. As mammals ourselves, of course, we are most acutely aware of annoyances such as fleabites and of pestilences as grave as mosquito-borne yellow fever and malaria. With the spread of West Nile Virus, we've lately learned how troublesome mosquitoes can be to birds. But it's still surprising to learn about insects attacking creatures that have scales: for instance, pythons are troubled by ticks, chameleons by sand flies, and Galápagos tortoises by horseflies. During the Cretaceous there would have been plenty of available targets for the ancestors of those reptile-biters, while early blackflies, the only bloodsucking insect family that today does not seem to share a taste for reptiles, could have made do with the primitive birds and mammals that were just beginning to appear on the scene.

Insects, then as now, were as necessary as they were annoying. Dinosaurs probably used them as a secondary source of food, and they clearly played an essential role in cleaning up the mess the giant creatures left behind, turning carcasses into skeletons and scarfing down vast amounts of saurian waste. The authors estimate that a herd of ten large sauropods could produce at least fifteen tons of feces every day—manna for legions of Cretaceous dung beetles.

On balance, though, the Poinars are willing to bet insects played a role in the eventual extinction of the dinosaurs. When an asteroid or small comet hit the Earth about 65 million years ago, triggering a climate change that marked the end of the Cretaceous, the dinosaurs may already have been so weakened by insect-borne disease that they had little chance of survival. Whether or not you accept the authors' ultimate conclusion, they make a strong case that the true rulers of the Cretaceous were not the big lizards that towered over the landscape, but the tiny buggers that pervaded it.

Traversa

A Solo Walk across Africa, from the Skeleton Coast to the Indian Ocean

by Fran Sandham
Duckworth Overlook,
2007; $25.00

Following, if a bit shakily, in the footsteps of Livingstone and Stanley—the great ninteeth-century explorers—English travel writer Fran Sandham set out to walk across Africa at the end of the twentieth century. The trans-Africa trip of Victorian times, known as "the Traversa," was usually undertaken to fill in uncharted regions of the map, to advance the domain of the Crown, and to save the souls of "poor benighted heathens" (in Kipling's sardonic phrase). Sandham's path, in contrast, took him mostly along well-mapped tarmac, and, he admits, was undertaken as "an extremely self-indulgent episode." But he had been fascinated by Africa since he was a young boy, and his restlessness with the routine of life in the sheltered isles of his homeland was probably not so different from the ennui that had set the Victorian explorers on their journeys. Carrying a map and an eighty-pound backpack, he arrived in Namibia one day, bummed a ride to a barren spot on the Atlantic shore, and turned his face eastward.

What follows is a journey mostly of misadventure. Experienced backpackers (which Sandham definitely was not) will find something to wince about in nearly every chapter. Sandham quickly discovers that his pack is waaay too heavy, but his solution is not to jettison most of his gear or replace it with lightweight high-tech stuff. Instead, he decides to buy a donkey to carry the load—a decision that delays his departure from the coast for many weeks and embroils him in sometimes alarming encounters with local farmers, veterinarians, and fast-talking con men.

Once on the road—without the donkey, his own beast of burden again—he walks through the desert

during the hours when most foot travelers rest in the shade, and nearly collapses from the heat. He seems to have walked the entire 3,000 miles across Africa along paved highways in sandals, which helps explain why he complains of severe blisters every inch of the way. He survives on a diet of junk food and warm beer, and suffers from constant exhaustion, occasional crises of hunger and thirst, and sporadic illnesses of various sorts, including, ultimately, malaria. By the end of the trip he's lost nearly fifty pounds, and, as he quips, "I wasn't exactly a tub of lard when I set out."

Still, you have to admire his perseverance. While other travelers whizzed by in Land Rovers and air-conditioned buses, he patiently refused to short-circuit his route by leapfrogging over the hard parts.

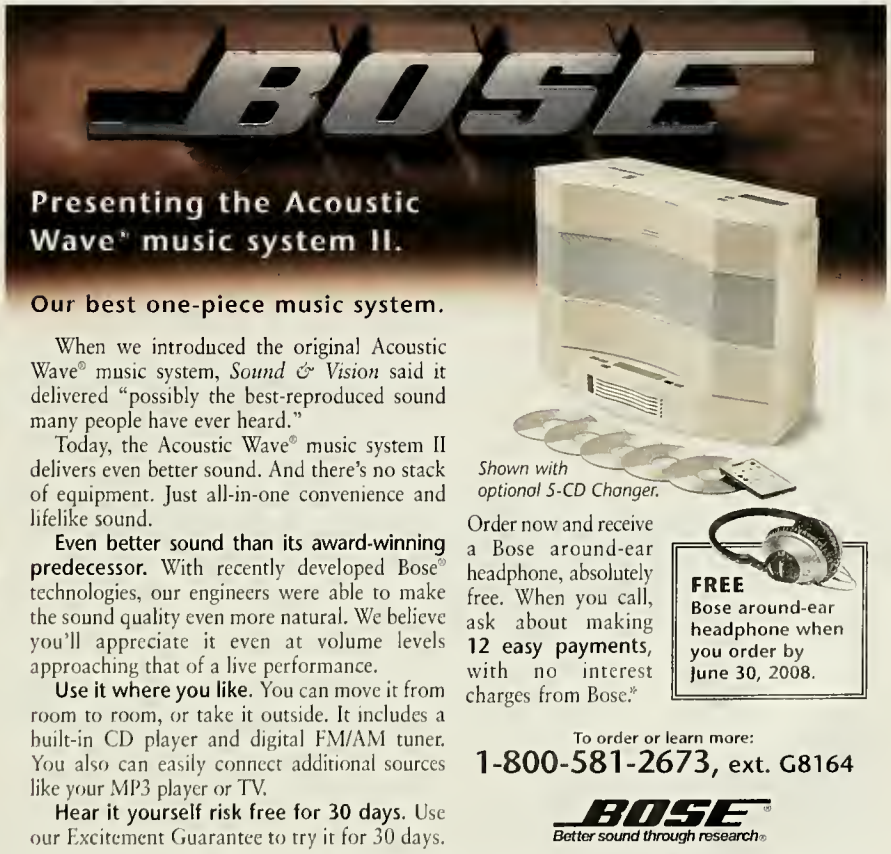
It's this persistence—even in folly—that makes *Traversa* an oddly entertaining book. What keeps you slogging along the road, turning the pages of the journal, is the voice of Sandham himself: slightly self-deprecating, somewhat bemused, and always ready to get up in the morning, slip on those damned sandals, shoulder the giant pack, and see what the day will bring.

Scientists would like to believe that our understanding of nature is based on evidence, ingenuity, and logic. That may be true in professional circles, but it is hardly the case in the arena of public opinion. Most of us have neither the time nor the training to understand the latest discoveries in particle physics, microbiology, or astronomy. Instead, what we know is what we read in magazines or see on TV—we rely on intermediaries to turn data into narrative. Thus it is the popular science writer, not the scientist, who creates the public understanding of the natural world. Edwin Hubble measured the cosmos and published his results in journals, but Carl Sagan brought "billions and billions" of galaxies into everyone's living room.

In this fascinating academic study, historian Ralph O'Connor of the University of Aberdeen in Scotland takes a close look at a similar process that took place in Britain in the first half of the nineteenth century. In 1800, the term "paleontology" had not yet entered the language, and the conventional story—even among the educated classes—was that the world had been created no more than a few thousand years previously, as recorded in the early chapters of Genesis. Fossil bones, though clearly bizarre, were regarded as remains left over from Noah's Deluge.

As new sciences of geology and taxonomy developed, however, a few gentlemen collectors and academics began to understand that the Earth was millions of years old at least, and that monstrous species of giant animals, now extinct, once roamed the planet. Such views flew in the face of long-established belief, and when first

Continued on page 36



SKYLOG BY JOE RAO

DAVID BAGLEY/ALAMY

Low tide at Staithes harbor in North Yorkshire, England

Swinging into position between the Sun and Earth, the Moon becomes new on June 3, at 3:23 P.M. eastern daylight time (EDT). Although the alignment is not within the necessary limits to grant us a solar eclipse, it will promote more pronounced high and low tides. Known as *spring* tides, these have nothing to do with the season of the year: the word "spring" refers to a tide that "springs up." The same enhancing effect occurs at full Moon, when the gravity of the Sun and Moon tug at Earth from opposite sides. In both cases, high tides and low tides are roughly 20 percent greater than average. (At first and last quarter Moon, when the Sun and Moon are least aligned, the tidal effects are dampened; these are called *neap* tides.)

The Moon's gravitational attraction causes the oceans to bulge out in the direction of the Moon. A bulge of high tide also occurs on the opposite side of the Earth, since the underlying ocean basin there is being deepened by the Moon's pull. As a result, as the Earth turns, any given region experiences two cycles of high and low tide in a twenty-four-hour period.

But there's more! Earlier in the day on June 3, at 9:00 A.M. EDT, the Moon will be at perigee, its closest orbital point to the Earth—a distance of 221,985 miles. When perigee coincides with a new Moon, approximately every one and a half years, the tides (called *proxigean* spring tides) can reach unusual highs and lows. Coastal topography, barometric pressure, wind, and other factors also affect the tidal range.

JOE RAO (hometown.aol.com/skywayinc) is a broadcast meteorologist and an associate and lecturer at the Hayden Planetarium in New York City.

June Nights Out

3 The Moon is new at 3:23 P.M. EDT. Expect unusually high and low tides for a few days (see story above).

7 Mars sits above and to the right of the crescent Moon.

8 A fat crescent Moon forms the apex of a long, narrow triangle that points toward the right; the other two corners are Saturn and, about 3 degrees to the planet's west, the star Regulus.

10 The Moon reaches first quarter at 11:04 A.M. EDT.

16 The nearly full Moon will appear to slowly slide to the south of the bright red star Antares.

18 The Moon becomes full at 1:30 P.M. EDT.

20 At 8:00 P.M. EDT, the Sun arrives at that point where it is farthest north of the celestial equator, the projection of Earth's equator onto the heavens. With this solstice, summer officially begins in the Northern Hemisphere and winter begins in the Southern Hemisphere.

26 The Moon wanes to last quarter at 8:10 A.M. EDT.

30 Mars sits just above and to the west of Regulus, while Saturn sits about 5 degrees above and to the star's east. The trio resembles a spear point, with Saturn as the spear tip.

BOOKSHELF

Continued from page 35

proposed, they must have seemed as outlandish to most people as the belief in a 6,000-year-old Earth seems today. But by the 1850s, the bizarre had become the commonplace: Britons flocked to museums to admire the reconstructed skeletons of ichthyosaurs and pterodactyls.

What stirred up public interest in the geologic past was not just the new discovery of old bones, as O'Connor shows, but the efforts of gifted science popularizers to spin the latest research findings in ways that appealed to public sensibilities. Some were showmen, like William Bullock of London, whose museum in Piccadilly in 1814 invited the curious to view a "dragon" (an ichthyosaur). One of the most influential geologists of this era, William Buckland of Oxford University, turned the past into performance art by dashing around the classroom brandishing hyena skulls, or flapping his coattails to imitate a pterodactyl.

To reassure believers that the new geology did not pose a threat to established religious belief, many writers cloaked their accounts of ancient rocks and extinct beasts in robes of piety. Looking at the past, so their formula went, was a way of revealing God's wonders and his marvelous plan for Creation. For lovers of old books, O'Connor not only provides a close reading of great texts, but also offers lovely reproductions of illustrations from rare volumes. Yet O'Connor's book illuminates the present as well as the past: rhetorical flourishes (of a modern sort, to be sure) are still the key to effective science writing. People read Stephen Jay Gould, Oliver Sacks, or Mary Roach not because they write about facts and logic, but because, like their predecessors in the 1800s, they write so well.

LAURENCE A. MARSCHALL is W.K.T. Salm Professor of Physics at Gettysburg College in Pennsylvania, and director of Project CLEA, which produces widely used simulation software for education in astronomy.

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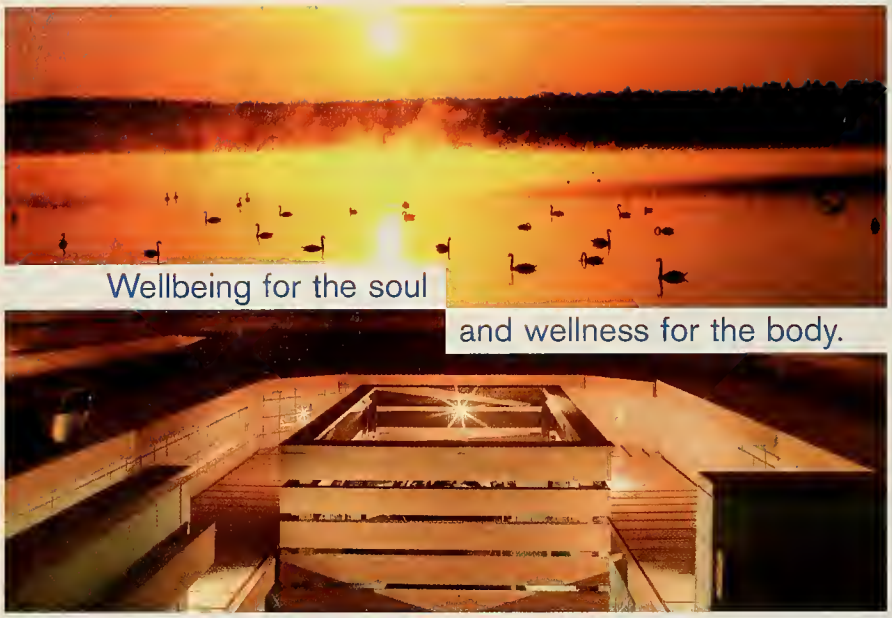

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WORD EXCHANGE

Continued from page 6

aged nations to commit to conservation goals. Most recently, in 2007, the U.S. Fish and Wildlife Service outlined a plan to monitor natural and human impacts on North Pacific albatrosses. Across the globe, resource managers are embracing large-scale and multinational conservation actions to reverse the worsening status of albatrosses.

K. David Hyrenbach
Hawaii Pacific University
Kaneohe, Hawaii

Good Vibrations

In telling the story of the new optics of invisibility, Michio Kaku ["Invisibility," 4/08] uses James Clerk Maxwell's equations as a starting point. Maxwell developed these equations in response to Michael Faraday's description of electric and magnetic force fields. A commonly forgotten piece of the story, however, is that Faraday himself knew that light was electromagnetic waves. Maxwell found the right equations, but Faraday knew they were there all along.

Felix T. Smith
San Francisco, California

MICHIO KAKU REPLIES: Indeed, Faraday understood that electric and magnetic fields can turn into each other, which is the concept behind electromagnetic waves. Unfortunately, Faraday was mathematically illiterate. (In fact, he often expressed disappointment that he could not transform his force fields into precise equations.) It was up to Maxwell to rephrase the work of Faraday into the beautiful equations that we still use today.

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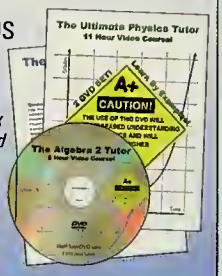

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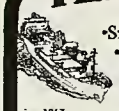

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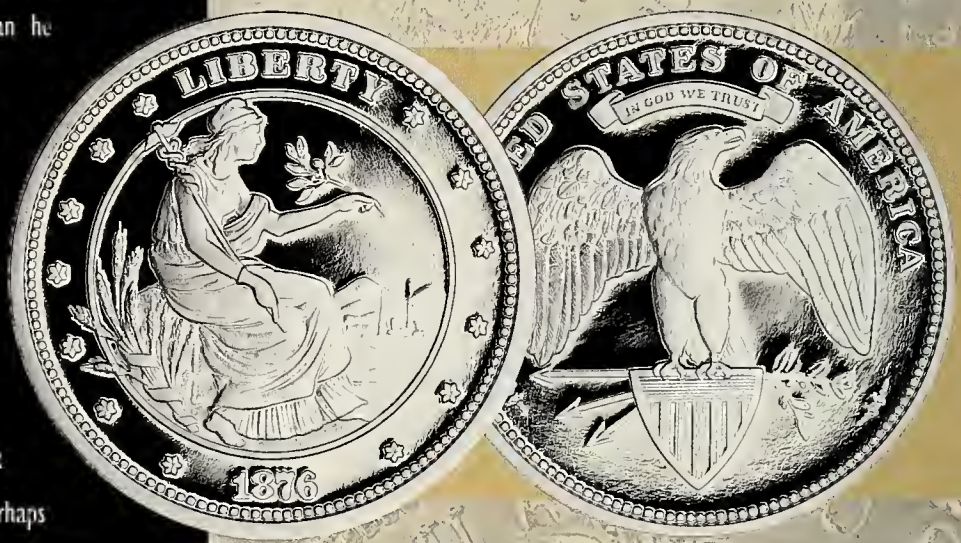

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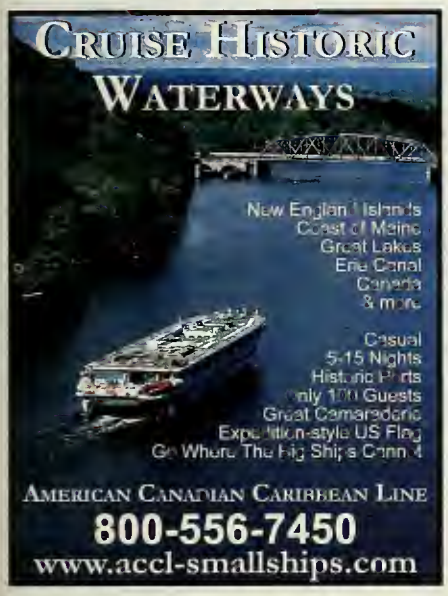

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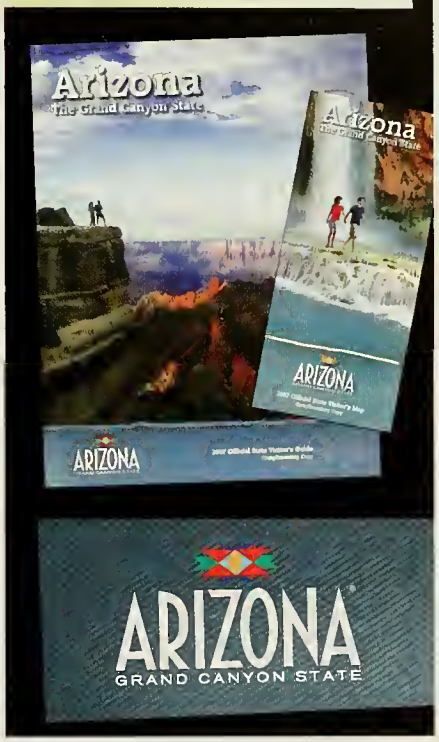

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Science in the Summer

LEFT: © AMY DAVIDSON. RIGHT: © ANDRÉ WYSS

Left: Jim Carpenter collecting in South Africa's Northern Cape province; right: John Flynn in the Andes

As summer bakes Manhattan, Museum curators head out of the city on field expeditions. Not that the climate is any less sultry in the Congo River Basin, where **Melanie Stiassny** recently found blind fish surfacing with catastrophic decompression syndrome, suggesting that they came from great depths. She'll return to investigate and map the river channel with Doppler equipment. In nearby Angola, **John Flynn** will prospect strata from near the end of the Age of Dinosaurs more than 65 million years ago for fossilized vertebrates before moving on to the Peruvian Amazon for younger specimens. Also exploring the tropics will be herpetologist **Christopher Raxworthy**. He'll travel Madagascar's unexplored eastern coast in hopes of discovering new species of chameleons and geckos.

Several scientists will journey north. Paleontologist **John Maisey** plans to survey for 375-million-year-old shark fossils on a cool, evergreen-cloaked island in the Tongass National Forest of Alaska. Maisey hopes that new specimens will help pin down the origins of jawed vertebrates. **Ross MacPhee** also moves north to search for mammoth frozen in permafrost. If a well-preserved specimen older than a quarter of a million years is found, analysis of its DNA could sort out the genetic relationships among different species of *Mammuthus*. **David Hurst Thomas** will head west and upward to 12,000 feet in Nevada where he'll remap the highest North American Indian village ever found, Alta Toquima, with modern technology. The archaeological site is so remote that access is only by horseback.

Other expeditions in the U.S include one to the Great Plains, formerly an epicontinental sea with an abundant population of ammonites, where paleontologist **Neil Landman** will travel in search of new specimens. **James Carpenter**, on the other hand, has recently discovered a new species of wasp in Southern California and plans to revisit the Algodones Dunes to confirm his discovery of this endemic insect for an upcoming publication. Refining the relationships among the hymenoptera is also the work of **Jerome Rozen**, whose Tenth International Workshop on Bees takes place at the Museum's Southwestern Research Station in Arizona. He will also sweep through Egypt and Turkey looking for nests of native bees to collect immature specimens. Finally, **Niles Eldridge** intends a short jaunt to upstate New York. He will collect trilobites, a very ancient marine arthropod from the Middle Devonian, as well as associated fossils like clams, snails, and brachiopods.

Summer research by physical scientists may take them to the outer reaches of the universe, but they won't actually travel very far. **Denton Ebel** will go to Chicago to analyze samples of Wild 2, the first solid extraterrestrial material returned to Earth since the Apollo program, to see what this comet is made of. **Ben R. Oppenheimer** continues his search for planets around distant stars at the Palomar Observatory in California with a new imaging device, Project 1640. And **Mordecai-Mark Mac Low**'s summer will be spent in Heidelberg, Germany, exploring the formation of planets and stars through computer simulations. "As an astrophysical theorist, my 'field trips' tend to be to rather more comfortable climes than some of my colleagues," he says.

Saturn: A New View

© NASA/JPL/SPACE SCIENCE INSTITUTE

This richly detailed image of Saturn and its rings was sent to Earth by the Cassini spacecraft on October 6, 2004.

IT'S DIFFICULT TO OVERSTATE the clarity and quality of the more than 50 spectacular photographs in the exhibition *Saturn: Images from the Cassini-Huygens Mission* now on view in the American Museum of Natural History's IMAX Corridor on the first floor. They are the clearest views yet recorded of the ringed planet. Sent back over half a billion miles to Earth, the up-close photographs illuminate the complex structure of Saturn's famous rings; atmospheric phenomena such as violent storms, streaming clouds, and aurorae; and the gas giant's numerous moons—the count of which has more than tripled, from 18 to 60, since *Cassini-Huygens* began its exploration.

An international collaboration of NASA, the European Space Agency, and the Italian Space Agency involving more than 200 scientists in 19 countries, the mission that yielded these images is full of firsts. Launched on October 15, 1997, *Cassini-Huygens* is the largest interplanetary spacecraft ever built. It is also the first spacecraft to explore Saturn from orbit. The *Huygens* probe—which separated from the *Cassini* orbiter on Christmas Day, 2004, and three weeks later parachuted to the surface of Titan, Saturn's largest moon—is the first to land on a world in the outer reaches of our solar system. The pictures from Titan are the first ever taken on a moon other than our own. Bigger than Mercury and Pluto, Titan is of special interest because it is one of the few moons in our solar system with its own atmosphere and the only object in our solar system other than Earth with flowing liquid on its surface, in Titan's case, liquid methane instead of water.

The photographs are divided into four sections: Saturn the planet; Saturn's rings; Saturn's geologically active moons, including Titan and Enceladus; and Saturn's other moons. Also on display is a one-quarter scale model of the *Cassini-Huygens* spacecraft, which takes it name from the Italian-French astronomer Giovanni Cassini and the Dutch astronomer Christiaan Huygens, both of whom made significant discoveries about Saturn and its rings in the 17th century. Cassini first observed the gap between Saturn's main rings (now called the "Cassini Division") and correctly hypothesized that the rings themselves were made up of small particles. It was Huygens who verified that Saturn had detached rings and explained the phenomenon of their occasional "disappearance": we can't see them when they face Earth edge-on.

The exhibition, which runs through March 29, 2009, is curated by Denton Ebel, Associate Curator, Department of Earth and Planetary Sciences, and co-curated by Mordecai-Mark Mac Low, Curator, Department of Astrophysics, and Joseph Burns, Professor of Astronomy at Cornell University.

The presentation of Saturn: Images from the Cassini-Huygens Mission *at the American Museum of Natural History is made possible by the generosity of the Arthur Ross Foundation and the support of the Eastman Kodak Company.*

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Titan's upper atmosphere consists of a surprising number of layers of haze, as shown in this ultraviolet image colorized to look like true color.

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OPENS OCTOBER 18, 2008

GLOBAL WARMING is one of the most pressing issues of our time. Today, flowers bud earlier and summer temperatures inch higher; tomorrow's news may include drought, heavy storms, and other potentially severe effects. This new exhibition will explore the science and impact of human-induced climate change and consider working solutions to this complex problem.

At the Museum

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EXHIBITIONS

The Horse
Through January 4, 2009
This trailblazing exhibition explores the origins of the horse family, extending back more than 50 million years; examines early interactions between horses and humans that led to horse domestication; and shows how horses have, over time, changed warfare, trade, transportation, agriculture, sports, and many other facets of human life.

The Horse is organized by the American Museum of Natural History, New York (www.amnh.org), in collaboration with the Abu Dhabi Authority for Culture & Heritage; the Canadian Museum of Civilization, Gatineau-Ottawa; The Field Museum, Chicago; and the San Diego Natural History Museum.
The Horse at the American Museum of Natural History is made possible, in part, by the Eileen P. Bernard Exhibition Fund. Additional support has been provided by an anonymous donor.

© AMNH/R. MICKENS

Red Spitting Cobra

Lizards & Snakes: Alive!
Through January 5, 2009
With over 60 live lizards and snakes from five continents, *Lizards & Snakes: Alive!* introduces visitors to the remarkable adaptations of these legged and legless lizards, such as projectile tongues, deadly venom, amazing camouflage, and sometimes surprising modes of locomotion.

Lizards & Snakes: Alive! is organized by the American Museum of Natural History, New York (www.amnh.org), in collaboration with the Fernbank Museum of Natural History, Atlanta, and the San Diego Natural History Museum, with appreciation to Clyde Peeling's Reptiland.

© JIM NEIGER

The great horned owl *(Bubo virginianus)*

On Feathered Wings
Opens June 21, 2008
This photography exhibition reveals the majesty of birds in flight: the controlled chaos, the acrobatic wizardry, the mysterious aerodynamics.

Saturn: Images from the Cassini-Huygens Mission
Through March 29, 2009
See previous page.

The presentation of both *On Feathered Wings* and *Saturn* at the American Museum of Natural History is made possible by the generosity of the Arthur Ross Foundation.

Unknown Audubons: Mammals of North America
Through August 2008
The stately Audubon Gallery showcases gorgeously detailed depictions of North American mammals by John James Audubon, best known for his bird paintings.

Major funding for this exhibition has been provided by the Lila Wallace-Reader's Digest Endowment Fund.

LECTURES

SCIENCE & SOCIETY
Peace and Science in the Middle East
Thursday, 6/12, 6:30 p.m.
Uri ten Brink of the U.S. Geological Survey will discuss several multinational projects examining the geophysics of the Dead Sea valley—projects that can help promote peace in the Middle East through scientific and economic cooperation.

Copresented with IRIS/SSA Distinguished Lecture Series.

FROM THE FIELD
The Haphazard Construction of the Human Mind
Tuesday, June 24, 6:30 p.m.
Psychologist Gary Marcus, NYU Infant Language Learning Center, examines memory, belief, decision-making, language, and happiness, and argues that evolution has resulted in a clumsily cobbled together contraption that explains our more irrational thought processes. A book signing follows.

This program is supported, in part, by Natalee Lee Quay.

WORKSHOP

Understanding your DNA
Three Tuesdays, 6/17–7/1, 6:30–8:30 p.m.
(Ages 18 and up)
Written in our DNA is an unbroken record of our shared ancestry as human beings. In this hands-on workshop, participants sequence their own DNA and discuss its implications.

Public programs are made possible, in part, by the Rita and Frits Markus Fund for Public Understanding of Science.

CHILDREN AND FAMILY PROGRAMS

Identification Day
Saturday, 6/7, 12:30–3:30 p.m.
Bring your shells, rocks, insects, feathers, bones, and artifacts to our annual Identification Day! Museum scientists will attempt to identify your mysterious garage-sale finds, curios from the basement, exotic souvenirs, and flea-market discoveries.

This program is supported, in part, by Ruth A. Unterberg.

© AMNH/R. MICKENS

The Museum's scientific staff examines visitors' mysterious finds at the wildly popular annual Identification Day.

ROSE CENTER FOR EARTH AND SPACE

Sets at 6:00 and 7:30 p.m.
Friday, 6/6

Visit amnh.org for lineup.

Central Park in the Dark
Tuesday, 6/17, 7:00 p.m., followed by a nature walk
Explore the little-known world of Central Park's nocturnal wildlife with naturalist Marie Winn. Learn about the bats, owls, raccoons, spiders, crickets, and slugs that become active in the park after dark and see where the daytime creatures spend the night.

Dr. Nebula's Laboratory: Life with Lucy
Sunday, 6/29, 2:00 p.m.
Recommended for families with children ages 4 and up
In this science-theater adventure for the whole family, Scooter, Dr. Nebula's apprentice, explores what it would be like to live, work, and play with Lucy, a three-million-year-old human ancestor.

NOAO/AURA/NSF

Andromeda and our own Milky Way are on a collision course—billions of years in the future.

HAYDEN PLANETARIUM PROGRAMS

TUESDAYS IN THE DOME
Virtual Universe
Recycling the Universe
Tuesday, 6/3, 6:30 p.m.

Celestial Highlights
Summer Skies
Tuesday, 6/24, 6:30 p.m.
These programs are supported, in part, by the Sant'Angelo/Koval Family and Val and Min-Myn Schaffner.

LECTURE
Physics of the Impossible
Monday, 6/2, 7:30 p.m.
Theoretical physicist Michio Kaku considers science-fiction technology that could or could not become real, based on our current understanding of the universe.

HAYDEN PLANETARIUM SHOWS

Field Trip to the Moon
Wednesdays, 10:30 a.m. (through June; resumes in September)
Guided by a live presenter, children and adults can see a sunrise in space and orbit and land on the Moon.
Supported by a grant from NASA's Marshall Space Flight Center.

Cosmic Collisions
Journey into deep space to explore the hypersonic impacts that drive the formation of our universe. Narrated by Robert Redford.
Cosmic Collisions was developed in collaboration with the Denver Museum of Nature & Science; GOTO, Inc., Tokyo, Japan; and the Shanghai Science and Technology Museum. Made possible through the generous support of CIT.
Cosmic Collisions was created by the American Museum of Natural History with the major support and partnership of the National Aeronautics and Space Administration's Science Mission Directorate, Heliophysics Division.

IMAX MOVIES

The Museum's LeFrak Theater, with its large-format screen and plush seating, offers a viewing experience like no other. For films and showtimes, visit www.amnh.org or call 212-769-5100.

LATE NIGHT DANCE PARTY

One Step Beyond
Friday, 6/27, 9:00 p.m.–1:00 a.m.
This monthly party in the Rose Center features the biggest names in techno, electronica, hip-hop, and indie rock. Cocktails keep the party going.

INFORMATION

Call 212-769-5100 or visit www.amnh.org.

TICKETS AND REGISTRATION

Call 212-769-5200, Monday–Friday, 9:00 a.m.–5:00 p.m., or visit www.amnh.org. A service charge may apply. All programs are subject to change.

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Scents & Sensibilities

By Walker Thomas

To find me twenty years ago, you might have looked under a Mexican blue oak in the mountains of southern Arizona. From there I would often watch javelinas wander among shin dagger agave in open stretches of juniper and oak woodland. They would gnaw on the yellow flame of flowers and the spiny hearts of the agave. I'd once heard that Napoleon used pigs to test his food for poison. If a pig could eat it, the story went, the meal was deemed safe for Bonaparte. So, perhaps I could eat the agave?

But javelinas, also known as collared peccaries, are not pigs. They belong to another family of cloven-hoofed ungulates—something between pigs and hippos—that is native to the Americas. True pigs came from Asia, Europe, and Africa. If I had known some of the differences at the time, like the fact that javelinas have more complex stomachs than true pigs, I wouldn't have been so eager to try the javelinas' fare.

Since I was already supplementing my diet with what the local bears and birds eat—cactus fruit, acorns, manzanita berries—I decided to venture into the shin dagger agave. The spines stabbed my shins and ankles, leaving small spots of blood at the puncture sites, which later festered and ejected pencil-point splinters. I cut out the juicy, white pulp of one agave, and when I chewed it, I gasped. The fluid released was so caustic it burned mouth and throat. Yet it cleared my sinuses and left a pleasant sense of menthol.

With vision in the range of the legally impaired, javelinas depend upon their exceptional sense of smell. So when downwind of them in the nighttime dark, I've blundered into their midst. Their sharp, muffled grunts crackle like distant cannon fire. In the gray light, I would see their coarse fur bristle and feel my own hackles rise. Then one would snuffle, catching my scent, and send them clattering in all directions, bumping me in a blind rush to escape.

At first, javelinas all smelled vaguely like skunk to me. Herd members will rub their throats against scent glands on one another's rumps, so each member of a given herd wears a community scent. One morning near a pool shaped like a crow's foot, I smelled coffee. I looked for a shrub called Wright's silktassel or bearberry, which emits a coffeelike scent when brushed against, but I found none. I looked for a campfire—nothing. I smelled coffee several more times, always in that area, and slowly realized that I had found a coffee-scented herd. The familiar coffee scent made me more aware of nuances in the scents of other herds. I was soon able to distinguish one that bore the more skunklike scent, and another whose scent was sweeter.

One evening at dusk I came across a dead javelina on the road. I grabbed a fistful of coarse gray hair to pull the still-warm body aside and clear the way; it was heavier than I expected. I lifted it by its hindquarters, dragging the head with its long, tusklike canine teeth, behind. My shirt was pressed against its rump gland.

Ninety minutes later, in a flat stretch of prickly pear above the crow's-foot pool, I found myself surrounded by javelinas. As my miner's light moved from one pair of red-glowing eyes to the next, they stood their ground, snouts raised, nostrils flared and twitching, the fur on their backs rippling. They've caught the scent of the foreign javelina, I thought. Suddenly they rushed at me—hot flanks against my bare legs—making me sway as they came in from all sides, veered past, and turned to charge again. I feared that they'd knock me down, trample me with their sharp hooves, rip me to pieces with their long canines.

No deathblow came. They jostled me until I had retreated to the ridge that marked the edge of their territory. I stood on shaky legs as their hoofbeats faded into the lower distance. Yet now I am at ease among javelinas, knowing the quality of their attack.

Walker Thomas spent about eight years exploring the mountains of southern Arizona. He wrote of those years in "Notes from a Solitary Beast," in Tucson's City Magazine *in 1987, and about his trips to town during that time in "The Commute,"* (Outside, *1988).*

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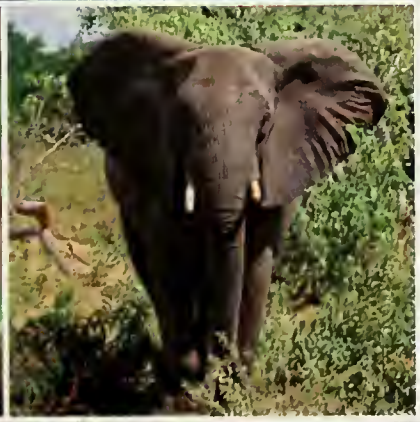

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A Family Holiday in Argentina

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Tanzania Family Safari

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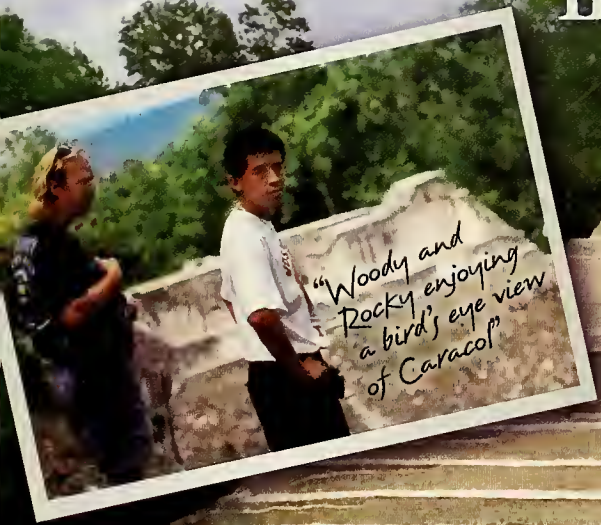
Finding a lost civilization in Belize.



"My husband Woody and I stepped out of the Chiquibul Rainforest and felt like we had just discovered a lost civilization; there in front of us stood Caracol, the largest of Belize's Maya ceremonial centers.

The temple and surrounding scenery are magnificent, with lush palm trees and orchids growing beautifully in the wild. We took a break for a moment in the cool shade of the temple and watched a green iguana bobbing its head up and down as if nodding hello. We hiked the whole area with our wonderful guide, Rocky Mai, who gave us a running commentary on the Maya in perfect English.

Belizeans are the friendliest people we've come across in our travels, and the country itself is amazing. One minute you're hiking through an untamed ecosystem, the next you're walking through the door of a plush resort with all the amenities. This is my idea of roughing it."

– Ann Bridges –

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