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5/02

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NATURAL HISTORY

MAY 2002 VOLUME 111 NUMBER 4

FEATURES

COVER Close-up of a garden dahlia reveals the blossom's distinct pattern, shaped by genes.
STORY BEGINS ON PAGE 48
PHOTOGRAPH BY EARL HARPER ECOSTOCK

DEPARTMENTS

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UP FRONT

Transformations

Mary, Mary, quite contrary,
How does your garden grow?
—Anonymous

One of the wonderful things about the nature movies of the 1950s, such as Disney's *The Vanishing Prairie* and *The Living Desert,* was the pioneering use of time-lapse cinematography, which enabled the viewer to observe an otherwise imperceptible organic process, such as the opening of a flower. In real life and in real time, we watch a child develop—or a potted plant or a puppy—yet never really perceive the growth process itself, much less the internal mechanisms that direct it.

It's not just change in size that is hard to grasp; it is the transformation involved. Seed to plant, boy to man, girl to woman, tadpole to frog, caterpillar to butterfly, bud to blossom—these common transitions drive even the most unspiritual types among us to utter words like "mystery" and "miracle." The mechanisms of evolutionary transformation—large-scale changes from species to species—are even harder for us to fathom.


DAVID LIEBMAN
Snapdragons

In writing about a particular gene that influences snapdragon symmetry, plant geneticist Enrico Coen ("The Making of a Blossom," page 48) gives us a glimpse of growth and development at a level that until quite recently has been invisible not only to the uneducated eye but even to the eye of the scientist. As groups of genes activate in sequence, a flower constructs itself. To understand this is to better appreciate how one type of flower might have evolved from another. "It is not organisms themselves that change," writes Coen, "but the way they develop."—*Ellen Goldensohn*

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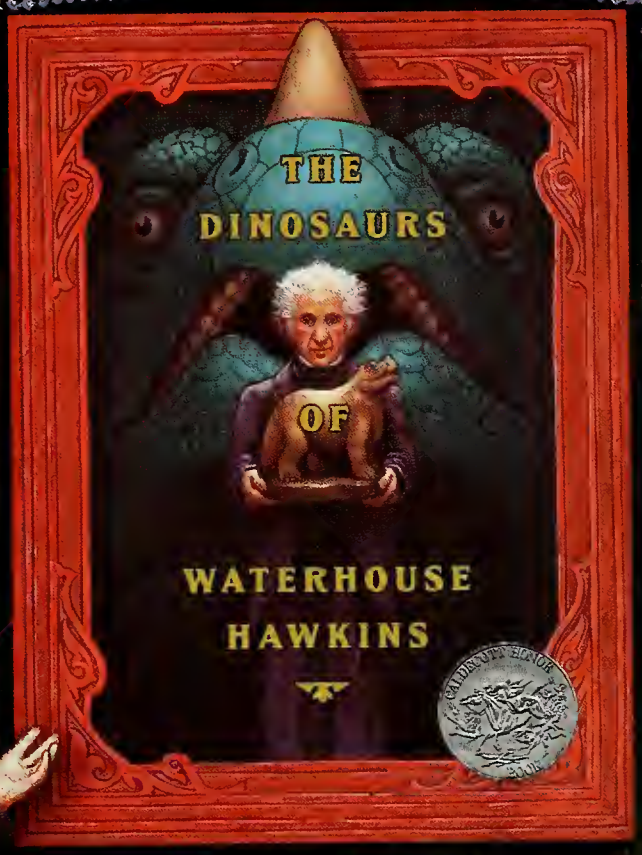
CAN YOU FATHOM A TIME WHEN ALMOST NO ONE KNEW WHAT A DINOSAUR LOOKED LIKE?



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LETTERS

A Home Run

I've enjoyed every issue of *Natural History* since my grandfather first gave me a subscription over fifty years ago. This morning, I began casually skimming "Baseball's Reliquary" (3/02). About halfway through, I slammed the magazine down and exclaimed out loud, "How does this writer think he can get away with such a blatant imitation of Stephen Jay Gould? I flipped back to the title page, laughed out loud, and wrote my first letter to the editor! Thanks for bringing Gould back to your pages.

David B. Harris
North Adams, Massachusetts

Blue Sky

In describing the origin of the blue light we see when looking at the sky on a clear day, Philip Ball, in "Seeing Red . . . and Yellow . . . and Green . . . and" (3/02), states that "rays from the sun are scattered by atmospheric dust."

The blue color of the sky actually arises from the scattering of sunlight by molecules of air (mostly nitrogen and oxygen), which are smaller than the wavelength of the light, not from dust particles, which are likely to be much larger.

Why doesn't the air all around us appear blue? In a relatively dense medium, such as the air on the surface of the earth, the sidewise scattering of blue light cancels out. However, at high altitudes, where air is less dense, fluctuations in density allow the sidewise scattering to escape without cancellation.

Karl A. Hartman
Kingston, Rhode Island

PHILIP BALL REPLIES: I am grateful to the correspondents who pointed this out. I was aware that molecules in the atmosphere also contribute to the light scattering that makes the sky blue and that they act through a different mechanism (Rayleigh scattering) than does dust (Mie scattering). However, I did not realize that scattering by molecules is predominant. Had I known, I would have recognized that the streamlining of the concepts in the article had led to an oversimplification.

ID vs. Evolution

By providing an opportunity for Jonathan Wells, Michael J. Behe, and William A. Dembski to write about "intelligent design" (Special Report: "Intelligent Design?" 4/02), you gave them exactly what they desired: publicity in a mainstream scientific forum (though not a peer-reviewed journal, of course). Wells, Dembski, and Behe are not practicing science when they advocate the "intelligent design" position. They are practicing pseudoscience. These advocates should be ostracized by the scientific community, just as we would ostracize someone who claims to be researching the natural behavior of wood nymphs and faeries.

James G. Acker
via e-mail

What were you thinking? I am not at all against conducting debates for the general public in neutral forums about ID and creationism; but to bolster Wells's, Dembski's, and Behe's already overblown publicity by publishing their views in *Natural History* is akin to debating astrology in *Astronomy*. I assume the next "debate" in your magazine will be entitled, "Is Natural Supernatural?" Darwin forbid.

Barry F. Seidman
Boonton, New Jersey

Thank you for publishing your feature on "intelligent design." The proponents of ID are not as obviously foolish or fraudulent as astrologers or creationists, but rather are far more sophisticated and insidious. You have done your readers a service by exposing them for what they really are.

However, I was disappointed in Ian Tattersall's "Endpaper" essay, "Science Versus Religion? No Contest." The author, perhaps out of a desire to make science seem less threatening, tries to make the case that scientific and religious thinking aren't in conflict, that "religions seek ultimate truth" while science would never "claim to be doing anything like the same thing."

Religious thinkers are right to fear science, because the understanding it produces demands that we give up the illusions of purpose and meaning and instead celebrate—after 4.5 billion years of evolution—how completely insignificant we are. If that's not an "ultimate truth," what is?

Gerry Bishop
Vienna, Virginia

Many highly educated professionals not only lack skills in inductive and deductive reasoning but also fail to understand the fundamental distinction between science and religion.

Ian Tattersall hits the nail right on the head when he states, "Science and religion deal in totally different forms of knowledge." As a biologist and an educator, as well as a believer in a divine creator, I am confident in the theories of my profession and inspired by my spiritual faith. I thank God for his grace to me and for the human icons of natural history such as Charles Darwin, who provides humankind with workable explanations of the world around us and a window into the glory of creation.

Gary Noel Ross
Baton Rouge, Louisiana

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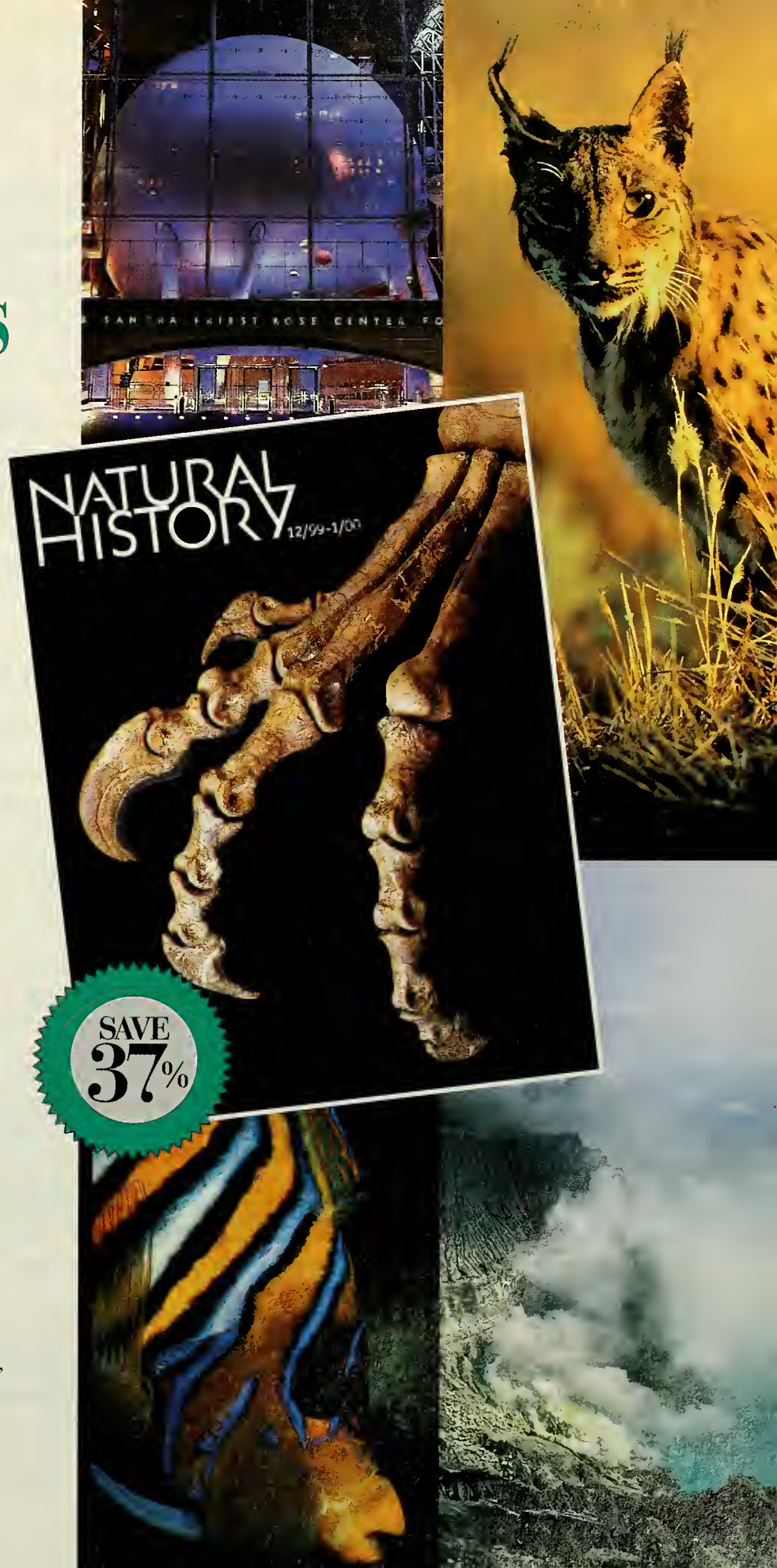

CONTRIBUTORS

Enrico Coen ("The Making of a Blossom," page 48) leads a research group in the Department of Cell and Developmental Biology at the John Innes Centre in Norwich, England. With other members of his lab, he is working to unravel the genetics behind many aspects of flower development and morphology. Pictures of mutant snapdragons can be found at www.jic.bbsrc.ac.uk/STAFF/enrico-coen/index.htm. Coen writes about the evolution of development—of living organisms and other kinds of made objects (from furniture to fine art)—in *The Art of Genes: How Organisms Make Themselves* (Oxford University Press, 1999). A believer in practicing what he preaches, Coen likes to paint, especially portraits, and is fascinated by how each step in the process of painting affects the next.

Born and raised in Idaho, **Laurel Thatcher Ulrich** ("An American Fantasy," page 56) moved to New England after graduating from the University of Utah in 1960, eventually earning a Ph.D. in history at the University of New Hampshire. Ulrich teaches at Harvard University and likes to "piece together the past from the fragments that have survived," particularly with regard to New England social history. This fascination is revealed in her books: *Good Wives: Image and Reality in the Lives of Women in Northern New England, 1650–1750* (Vintage Books, 1984); *A Midwife's Tale: The Life of Martha Ballard Based on Her Diary 1785–1812* (Knopf, 1990), for which she won the Pulitzer Prize for History in 1991; and *The Age of Homespun* (Knopf, 2001), from which this article is adapted.

Richard S. Ostfeld ("Little Loggers Make a Big Difference," page 64) has spent the past ten years trying to unravel the ecological consequences of fluctuations in small-mammal populations. A researcher at the Institute for Ecosystem Studies in Millbrook, New York, he is also an avid gardener and notes that—unlike voles, the subject of this article—woodchucks, cottontails, and deer, the main herbivores in his garden, "tend to nibble on plants without killing them." For more on small mammals, Ostfeld, left, suggests *Do Lemmings Commit Suicide? Beautiful Hypotheses and Ugly Facts,* by Dennis Chitty (Oxford University Press, 1996). A botanist studying voles, **Keith Clay,** director of Indiana University Bloomington's Plant Science Program, describes his work as going "in the opposite direction of reductionism" and says that "Darwin's famous description of how the amount of red clover in the British landscape was related to the number of spinsters in the area serves as a warning to those in search of simple answers" (the spinsters owned cats that ate the mice that attacked the hives of bumblebees that pollinated red clover).

Born in Istanbul, **Mustafa Türker Erşen** ("Parallel Brides," page 72) started out by studying city planning but switched to communication sciences because "being on the road was more interesting." For his master's thesis he wrote about youth subcultures, in part to explore "why modern culture is alienating, pushing some people to create an underground." A writer and editor for Turkey's *Atlas Geographic Magazine* and its companion publications, Erşen originally joined photographer **Şebnem Eraş** in researching the custom of *berdel* marriage for an article that appeared in *Atlas*. Born in Ankara, Eraş has studied law and is now working toward a master's degree in legal anthropology. Her thesis explores the *berdel* marriage custom as a traditional form of law. "Photography is not just a profession for me," she says, "it's a means to understand people and society."

British wildlife documentary filmmaker **Mark Payne-Gill** ("The Natural Moment," page 94) was inspired to take up his art at the age of twelve after watching David Attenborough's nature specials on television. He has since included still photography in his repertoire. His image of an African bullfrog won him a runner-up spot in last year's BG Wildlife Photographer of the Year competition. Enduring the 95°F heat of "a classic African day," Payne-Gill snapped the shot with an Olympus OM2n. Afterward, when he moved nearer the animal, Payne-Gill reports with delight, the tenacious bullfrog leaped three feet out of the water and landed at his feet.

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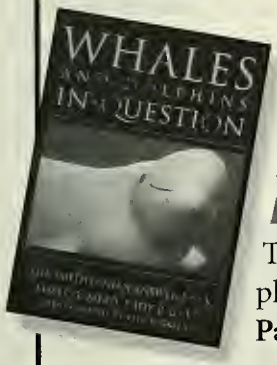

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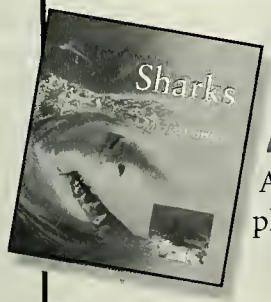

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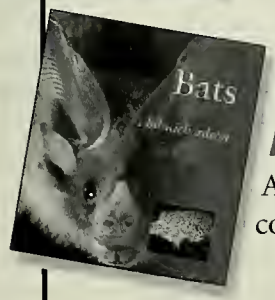

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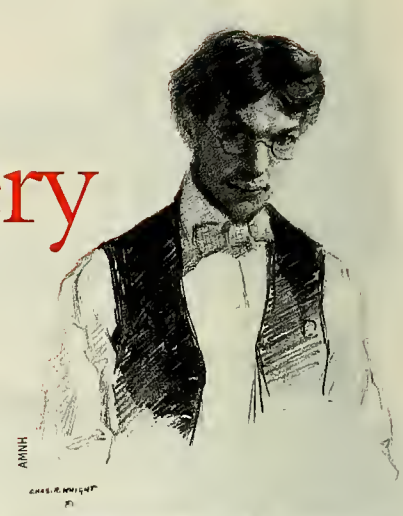
AT THE MUSEUM

A Mammoth Mystery

Was accuracy sacrificed to romance in the Museum's mural of Font-de-Gaume?

By Joyce Cloughly and Ian Tattersall



Charles Knight, self-portrait ca. 1915

Charles R. Knight is best known for his large-scale paintings of dinosaurs and extinct mammals, some of which are on display in the American Museum of Natural History's fourth-floor Hall of Vertebrate Origins. Recently, the Museum unveiled a restored Knight mural with a human theme. *Cro-Magnon Artists of Southern France,* which he completed in 1920, depicts a group of Ice Age artists decorating the walls of a cave with a frieze of woolly mammoths perhaps some 14,000 years ago.

This painting, which originally hung in the Museum's Hall of the Age of Man, marvelously captures the atmosphere of the limestone cave of Font-de-Gaume, located in southwestern France near the village of Les Eyzies, on the Vézère River. But Knight had never seen the cave's paintings, and vertebrate paleontologist and the Museum's then president, Henry Fairfield Osborn, wanted the artist to get the details right. So he consulted with the great French archaeologist Abbé Henri Breuil, who dominated scholarship of Ice Age cave art during the first half of the twentieth century. In a letter to Osborn dated January 1919, the Abbé responded to several questions posed by Osborn concerning a preliminary sketch Knight had made in 1914. Among other things, Osborn wanted to know if the cave artists could be shown using reindeer shoulder-blades as palettes for their pigments and holding simple stone lamps that burned animal fat. The Abbé's answer to both these questions was yes, but he expressed reservations about portraying clothed figures in a cave. A few animal-skin garments appeared anyway, possibly as a nod to 1920s sensibilities.

The enigma of the mural, however, lies not in the accoutrements of the Cro-Magnon artists themselves but rather in the subject matter they are painting. In Knight's 1914 sketch, published the following year in Osborn's book *Men of the Old Stone Age: Their Environment, Life, and Art,* the artists were shown in the act of creating the frieze of bison for which the cave of Font-de-Gaume is justly renowned. But in Knight's final mural, they are shown depicting a parade of woolly mammoths. In 1912, before the mural project got under way, Osborn had visited Font-de-Gaume in the company of the Abbé and had admired the powerful, if faded, polychrome images of bison there. On the wall opposite the most famous bison group are other bison paintings with some images of mammoths engraved on top of them. Since these mammoths are extremely

hard to see, it is rather odd that they became the subject of the final mural, intended to represent Font-de-Gaume.

Perhaps part of the answer is that Osborn was entranced by the idea of Ice Age men as hunters of woolly mammoths—creatures on which he was, moreover, an expert. Perhaps he felt that mammoths were a worthier subject for Ice Age artists than were mere bison, which would have been a fairly humdrum choice for an American audience. After all, until relatively recently, buffalo had teemed on the central plains of the United States, whereas woolly mammoths, here as in Europe (where bison are somewhat more exotic), are more suggestive of the distant Ice Age past.

In a monograph on the cave published in 1910, the Abbé had acknowledged the superimposition of the most striking Font-de-Gaume mammoths on preexisting images of bison. And Osborn had also acknowledged this in an article of his own, published in *The American Museum Journal* (the precursor of *Natural History*) in December 1912. Yet in Knight's mural, the cave is being freshly painted with mammoths, with no traces of bison underneath. We suspect that Knight himself was somewhat taken aback when, in the company of the Abbé, he finally visited Font-de-Gaume in person some seven years after completing the mural. For in 1939 he created another picture, depicting a scene similar to his Font-de-Gaume mural, but in this one a Cro-Magnon artist is shown superimposing a mammoth over a previously painted frieze of bison.

Whatever the case, Knight came away with vivid impressions when he finally saw the cave. In his 1949 book, *Prehistoric Man: The Great Adventurer,* he wrote that the mammoths "were to me intensely romantic," for he pictured the artists breaking off their work to see "the actual living specimens of the great brutes . . . an inspiration for a personality now buried forever in the mists of time." He pronounced himself "awed and slightly shaken [by his] glimpse into that long-past world of life."

Despite the mystery of the mammoths, Knight's mural has worn well. The best part of a century later, we still cannot quarrel with most of its details. The scapula palettes, the simple stone lamps illuminating the cave walls, the man grinding pigments on a rock at the far left, the dramatic chiaroscuro of the lighted human figures set against the dark cave walls: all of this accurately and magically evokes the ambience of the cavern and the concentration of the artists within it, caught in the creative process. Whether or not the clothing is at all accurate—something we will never know for sure—this painting is still about as close as we will ever come to re-creating the lives of those long-vanished but gifted ancestors.

Joyce Cloughly is a senior principal preparator in the Museum's exhibition department. Ian Tattersall is a curator in the anthropology department.

Charles Knight's Portrait of Abbé Henri Breuil

The summer of 1927 was to be a memorable one for the author and his family because of a unique invitation . . . to some of the better-known caves in France and Spain, where drawings, paintings, and sculptured forms of animals, made by a race of prehistoric men, were to be seen in all their pristine freshness and excellence of execution. . . .

Our mentor and guide in this truly romantic adventure was to be the Abbé Henri Breuil, celebrated savant from the Collège de France and world expert on the art and general culture of prehistoric man. It was our good fortune to be thus associated with one of the very ablest men on this subject. An eminent scientist with a genial and interesting personality, he had previously visited all the caves which we were to examine and had faithfully copied many of the drawings and paintings they contained. . . .

It was in this romantic atmosphere [Les Eyzies, France] that we first met the Abbé Breuil, a short, dark, almost bald man with brilliant full eyes, an ingratiating smile, and an informal but courtly manner. Although a priest, he was not dressed in clerical garb, but wore a somewhat dilapidated suit of khaki clothes, the trousers tucked into leather leggins, and a pair of stout muddy shoes. He was a man of great cultivation, a keen and mischievous host, and a veritable mine of knowledge on many subjects. . . .

We were to lose no time in our explorations of the caves; the Abbé had arranged all that. Never have I known a more restless, dynamic personality than he proved to be, a sort of caged scientific lion pacing to and fro when balked or thwarted in any way, and a most persistent and energetic worker. . . .

[At our first stop, Font-de-Gaume,] in his broken yet fluent English, the Abbé pointed out with his cane the special outlines of the mammoths superimposed upon earlier drawings of bison, horses, and reindeer. We listened carefully—it was an engrossing talk on prehistory.

From Prehistoric Man: The Great Adventurer, *by Charles R. Knight. Copyright © 1949 by Charles R. Knight and published by Appleton-Century-Crofts, Inc.*

MUSEUM EVENTS IN MAY

"BASEBALL AS AMERICA"

Theater 5/5: "Tale of 2Cities: An American Joyride on Multiple Tracks." Playwright and actor Heather Woodbury's one-woman show of her "living novel" about Mexican Americans and the Brooklyn Dodgers. Linder Theater, 2:00 P.M.

Film 5/1: *In Whose Honor?* Director, Jay Rosenstein. A Spokane Indian challenges a University of Illinois mascot. Linder Theater, 2:00 P.M.

Panel discussion 5/12: "Indigenous Peoples' Images in Sports and Media." Charlene Teters, National Coalition Against Racism in Sports and Media; Gary Brouse, Interfaith Center for Corporate Responsibility; Dennis Banks, American Indian Movement. Linder Theater, 3:15 P.M.

Film 5/16: *61** Director, Billy Crystal. The battle to be home-run champion. Screening and discussion with Ross Greenburg, president of HBO Sports. Kaufmann Theater, 7:00 P.M.

Film and music 5/18: *Dodgers Sym-phony.* Filmmaker Pegi Vail, former band member Armand Soriano, longtime band member Louie Dallojacono. Bring a musical instrument and get in free. Kaufmann Theater, 2:00 P.M.

AMNH BOOK CLUB

Monthly meeting 5/19: *The Botany of Desire: A Plant's-Eye View of the World,* by Michael Pollan. Details at (212) 769-5200. Portrait Room, 3:00–4:30 P.M.

REVOLUTIONIZING MEDICINE IN THE 21ST CENTURY

Lecture 5/7: "After Anthrax: Bioterrorism in America." Anthony Fauci, National Institute of Allergy and Infectious Diseases.

Lecture 5/14: "Infectious Diseases of New York State." Barry Hartman, Weill Medical College of Cornell University.

Lecture 5/21: "Bioterrorism." Joshua Lederberg, Rockefeller University.

These lectures held at Caspary Auditorium, Rockefeller University, 1230 York Avenue at 66th Street, 7:00 P.M.

INSIDE AND OUTSIDE THE MUSEUM

Walking tour 5/4: "Inwood Hill Park." Botanist William Schiller. Meet at Calder Lab. 10:30 A.M.–3:00 P.M.

Workshop 5/4: "Dioramas and Fabric Companions." Craft artist Lauri Faggioni. Rose Center Classroom, 3:00 P.M.

Tour 5/10 (Many Religions: One City series): "Buddhist Temples." Karen Kane, AMNH. Meet at Calder Lab. 9:30 A.M.–2:00 P.M.

University Without Walls 5/9–5/23 (telephone course, three Thursdays): "The Archaeology of Early Humans" (Hall of Human Biology and Evolution). Berna Villiers, Highlights Tour guide, Natural Science Center volunteer. 11:00 A.M. Advance registration required. For more information, call DOROT at (212) 769-2850 or toll-free at (877) 819-9147.

Workshop 5/9: "Biodiversity at the Museum and Beyond." Jay Holmes, Discovery Room Coordinator. Room 319, 7:00–8:30 P.M.

Field trip 5/11 (Black Rock Forest, 60 miles north of New York City): "Biodiversity at the Museum and Beyond." Jay Holmes. 10:00 A.M.–3:00 P.M.

Walking tour 5/11: "Blue Heron Park, Staten Island." Botanist William Schiller. Meet at park. 10:30 A.M.–3:00 P.M.

Walking tour 5/18 (Bensonhurst, Brooklyn): "Landscaping Our Ethnic Neighborhoods." Art historian Joseph Inguanti. Room 319, 2:00–3:30 P.M. For information about tours, workshops, and field trips, call (212) 769-5200.

Conference 5/30–6/1: "Assembling the Tree of Life: Science, Relevance, and Challenges." Advances in genomics and their implications for evolution, disease, and biodiversity. Co-sponsored by AMNH and Yale University.

KOREAN DRUMMING

Workshop 5/19: "Hannuri: South Korean Drumming." Musician Won, Il. Kaufmann Theater, 11:00 A.M.

Performance 5/19: "Hannuri, One World." Korean court music and dance, *p'ansori* (Korean opera), *changgu* (hourglass drum), and classic *Salp'uri* (ritual music to drive out evil spirits). Kaufmann Theater, 3:00 P.M.

ASTRONOMY

Planetarium courses: 5/1–5/29 (four sessions): "Stars, Constellations, and Legends." 5/4 (Saturday): "Life Beyond Earth." 5/7–6/4 (five Tuesdays): "Astrophotography."

Lecture 5/6 (Frontiers in Astrophysics series): "The Pangs of Star Birth." Grace Wolf-Chase, University of Chicago. Space Theater, Hayden Planetarium, 7:30 P.M.

Lecture 5/27 (Distinguished Authors in Astronomy series): "Children of the Stars: Our Origin, Evolution, and Destiny." Daniel Altschuler, Arecibo Observatory. Space Theater, Hayden Planetarium, 7:30 P.M.

June's Celestial Highlights 5/28: Joe Rao, meteorologist and *Natural History* columnist. Space Theater, 6:30–7:30 P.M.

Planetarium information: (212) 769-5200 or www.amnh.org/hayden/

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Artist-in-residence program 5/18–6/1: "Baseball and Playing Indian." On-site installation art. Charlene Teters, National Coalition on Racism in Sports and the Media, Minneapolis, and the Institute of American Indian Arts in Santa Fe, New Mexico. Leonhardt People Center.

The American Museum of Natural History is located at Central Park West and 79th Street in New York City. For listings of events, exhibitions, and hours, call (212) 769-5100 or visit the Museum's Web site at www.amnh.org.

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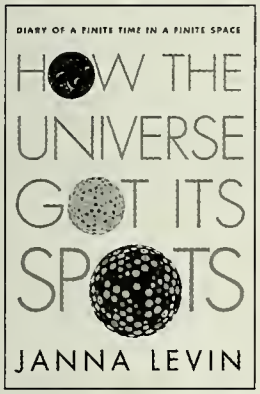

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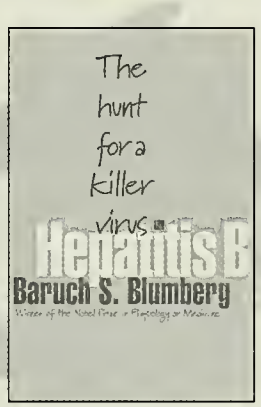

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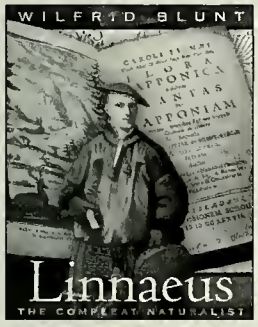

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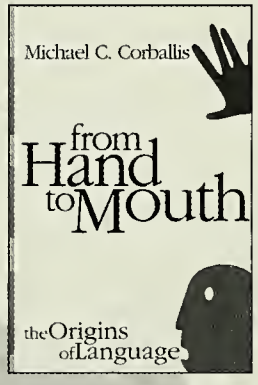

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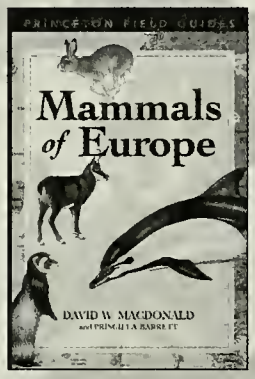

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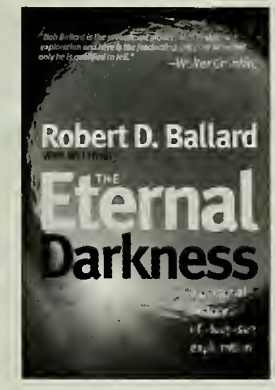

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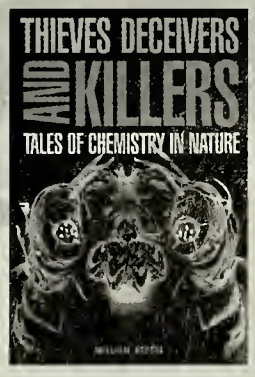

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SAMPLINGS

By Stéphan Reebs

CRETACEOUS MOTHER For more than a hundred years, the Municipal Museum of Natural History in Trieste, Italy, has housed the fossil of a six-foot-long *Carsosaurus marchesetti* (a marine lizard from the Cretaceous) that clearly shows the teeth and bones of at least four smaller animals within it. These remains were long thought to belong to prey consumed by the lizard 100 million years ago. But after taking a closer look, Michael W. Caldwell, of the University of Alberta, and Michael S. Y. Lee, of the University of Queensland, say that those extra bones came from embryos and that *Carsosaurus* must have been viviparous—giving birth to live young rather than laying eggs.

The scientists base their claim on several observations. The creatures in question are evenly spaced and their spines are curved, typical of the position and posture of embryos in present-day viviparous lizards. Also, their heads point forward (that is, toward the front end of the *Carsosaurus*); this orientation, often found in the embryos of aquatic live-bearers, allows tailfirst delivery and thus reduces the risk of drowning. Had the small animals been prey, they would most likely have been eaten headfirst (the heads would then point backward) and could not have curled up into a ball. Further suggesting viviparity are the putative embryos' large size and advanced stage of development, together with the absence of eggshell fragments. One of the embryos is located within the pelvic area of the adult, a hint that the mother may have died while giving birth.

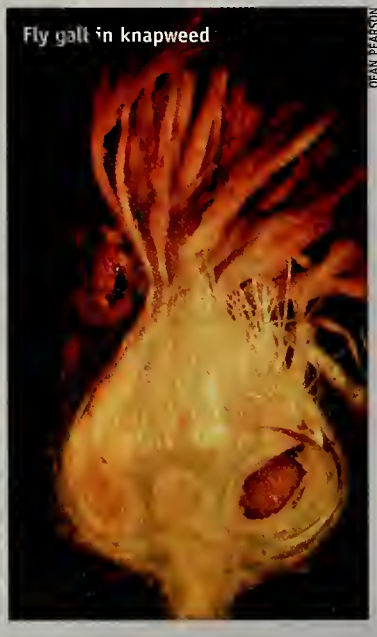
If Caldwell and Lee are right, this would be the first fossil record of viviparity in reptiles (other than the highly aquatic ichthyosaur). Most paleontologists think that *Carsosaurus* could move around both on land and in water. The evolution of viviparity, which frees the mother from having to deposit eggs on land, and the tailfirst birth of the young imply that *Carsosaurus* was well on its way to a more fully aquatic lifestyle. ("Live Birth in Cretaceous Marine Lizards *[Mosasauroids]*," *Proceedings of the Royal Society of London* B 268, 2001)

RECORDED BY ROV TIBURON 2001 MBARI

This alien-looking creature is a newly described species of squid that lives near the seafloor at great depths. Crew members of submersibles have observed specimens eight times since 1988, in all major oceans, but they haven't captured any. Each of the squid's ten appendages (eight tentacles and two arms) bears suckers. At the bends in the appendages is a long but somewhat retractable filament whose function scientists do not know and on which no suckers are visible. When the animal flees, it tows these long filaments awkwardly behind. ("Worldwide Observations of Remarkable Deep-Sea Squids," *Science* 294, December 21, 2001)

To see the squid, go to www.naturalhistory.com

DOUBLE AGENT The spotted knapweed *(Centaurea maculosa)* is a European invader that, over the last hundred years, has spread throughout the pastures and rangeland of western North America, often outcompeting native species. (It landed on the West Coast in the 1890s, probably carried in a shipment of alfalfa seed or in soil used as ballast). To combat it, agricultural agencies began to introduce gall flies of the genus *Urophora* in the 1970s. The flies' larvae build galls within the flower buds and steal some of the plant's energy, leading to a reduction in the number of seeds that develop.



Fly gall in knapweed

DEAN PEARSON

It turns out, however, that the deer mouse views these larvae as yummy snacks and, while foraging for them, may accidentally ingest whole knapweed seeds. Since the seeds can survive passage through the mouse's digestive system, the little mammal may contribute to knapweed's dispersal. Seeds may travel even farther if an owl catches the mouse and then, at the end of its meal, regurgitates the seeds along with undigested bones. Working in Montana, USDA Forest Service biologists Dean E. Pearson and Yvette K. Ortega examined four regurgitated great horned owl pellets and discovered deer mouse remains along with 102 knapweed seeds. Only one of these seeds germinated when planted. While this germination rate may seem low, it still means that one pellet in four had the potential to contribute to the spread of knapweed.

As Pearson and Ortega point out, this unexpected seed-dispersal pathway begins, ironically, with the very biological control agent brought in to curtail knapweed's spread. Gall flies may still be worthy allies in the fight against knapweed, but they provide one more example of an important fact: once introduced, species become part of large ecological webs, with possibly unforeseen consequences. ("Evidence of an Indirect Dispersal Pathway for Spotted Knapweed, *Centaurea maculosa*, Seeds via Deer Mice, *Peromyscus maniculatus*, and Great Horned Owls, *Bubo virginianus*," *Canadian Field-Naturalist* 115, 2001)

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ATSUSHI SAKURAI; NATURE PRODUCTION

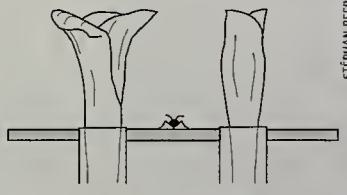
FISH IN THE FAST LANE Love can sweep you off your feet (or fins), but for one species of freshwater fish, being swept away is the last thing an amorous male would want.

Rhinogobius is a small goby that lives in streams and rivers in Japan. During the reproductive season, the male builds a nest by clearing a space underneath a stone in a shallow area known as a riffle. Then he moves to deeper pools and tries, through energetic displays, to convince females to come spawn inside his nest. Two researchers at Osaka City University, Daisuke Takahashi and Masanori Kohda, have found that females are attracted to males that display in stronger currents within the pools. Not necessarily the biggest in absolute terms, these successful males are nevertheless rather heavy relative to their length.

According to Takahashi and Kohda, a female may use a male's performance in a fast current as an indication of his physical condition and his energy reserves. These are important, because after a female chooses a male and lays her eggs in his nest, she departs, leaving the male to guard the eggs, a task to which he devotes himself assiduously for two weeks. With no time for foraging, males sometimes cannibalize some of the eggs under their care. Healthy males with abundant energy reserves may be less likely to succumb to temptation, which may explain the females' preference. ("Females of a Stream Goby Choose Mates That Court in Fast Water Currents," *Behaviour* 138, 2001)

FLARED WELCOME Some flower shapes that are particularly good at forcing insect pollinators into contact with pollen have a downside: they also let in nectar thieves, such as ants that do not transfer pollen and may even munch on the flower's ovary. One wildflower faced with this dilemma is the skypilot, *Polemonium viscosum*.

Working at a site in Colorado's Rocky Mountains, Candace Galen and Jessica Cuba, of the University of Missouri, noted the flared shape of skypilot flowers growing on the alpine tundra, where bumblebees are the main pollinators and nectar-stealing ants are rare. Flowers were slightly more tubular at the timberline, where ants are more abundant. To investigate the reason for this difference, the researchers first exaggerated the tubular form of some flowers by gluing the edges of petals together. To control for the possible repellent effects of the glue, Galen and Cuba also placed drops of it on the remaining flared flowers (on the back of the petals, where it did not change the blossoms' shape). Then they waited to see which shape—hypertubular or flared—was more attractive to bumblebees and ants. They inferred the bees' preference from pollination rates in the field but tested the ants' preference more directly, on a makeshift platform.


STÉPHAN REEBS

Setup for an ant choice test

The results were clear: both bumblebees and ants favored the flared flowers by a twofold margin. The biologists also found more damage to the ovaries of flowers that were naturally more flared. Predation by ants may have driven the evolution of flowers with a more tubular shape, counterbalancing the pressure for flaring caused by bumblebees and explaining the less open shape in areas where ants are more numerous. ("Down the Tube: Pollinators, Predators, and the Evolution of Flower Shape in the Alpine Skypilot, *Polemonium viscosum*," *Evolution* 55:10, 2001)

DIGESTIVE MOVE For a snake, there's no such thing as eating piecemeal: it gobbles its prey whole. But a complete carcass sitting in the snake's stomach may slow it down, and the prey may even start to decompose before being fully digested. So it would be advantageous for a snake with a full stomach to speed digestion by raising its body temperature. And according to observations by Gabriel Blouin-Demers and Patrick J. Weatherhead, of Carleton University in Canada, snakes do that by judiciously choosing where they go to digest their meal.

The researchers placed recently killed chipmunks, mice, and voles in the shady interior of a forest and also along its edges, which get more sun and thus afford more opportunities for warming up. Free-living black rat snakes that fed on rodents along the forest edges tended to stay put after eating, whereas snakes that ate


Black rat snake swallowing a mouse
TOM DRAKEFIELD; BRUCE COLEMAN INC.

in the interior often moved out to the edges afterward. Individuals that had dined were seen basking more often than those that hadn't, and surgically implanted temperature-sensitive radio transmitters reported higher body temperatures in fed than in unfed snakes. Back in the laboratory, captive black rat snakes confirmed these field observations. Offered the opportunity, these snakes, too, liked to repair to a warm spot after a good meal. ("An Experimental Test of the Link Between Foraging, Habitat Selection and Thermoregulation in Black Rat Snakes *Elaphe obsoleta obsoleta*," *Journal of Animal Ecology* 70, 2001)

Stéphan Reebs is a professor of biology at the Université de Moncton in New Brunswick, Canada. He is the author of Fish Behavior in the Aquarium and in the Wild, *recently published by Cornell University Press.*

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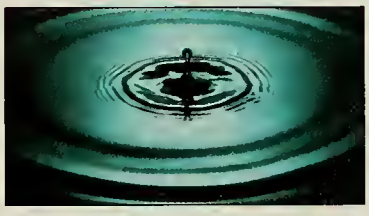

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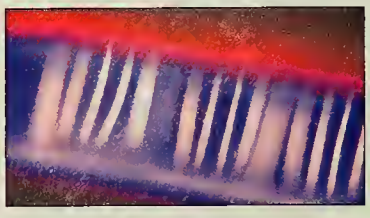

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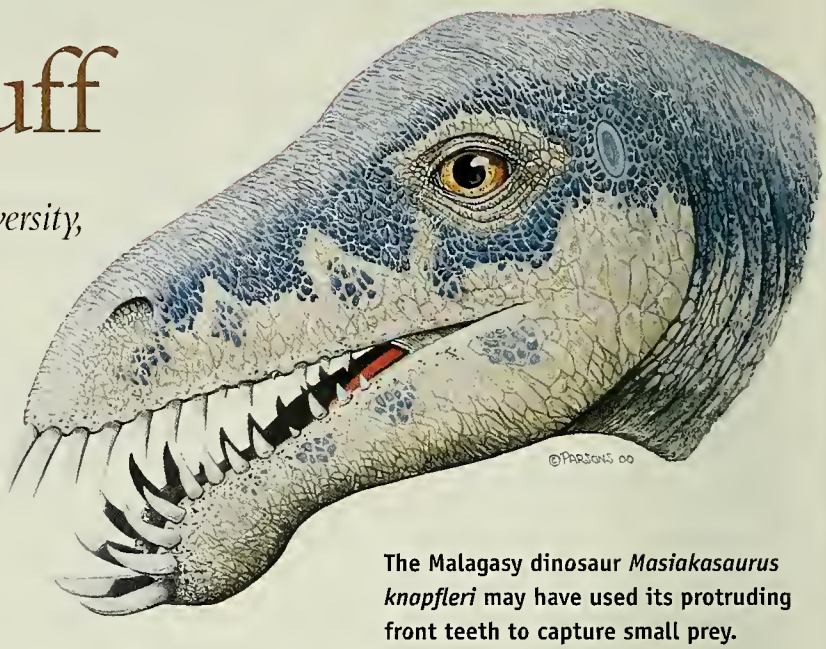
FINDINGS

The Bite Stuff

An old jaw provides clues to ancient diversity, ecology, and geography.

By Scott D. Sampson



The Malagasy dinosaur *Masiakasaurus knapfleri* may have used its protruding front teeth to capture small prey.

ILLUSTRATIONS BY BILL PARSONS

In 1995 during a paleontology field season in Madagascar, a large island off the east coast of Africa, my good friend and fellow expedition member Cathy Forster unearthed part of a strange fossil jaw. Even at first glance, the shape of the four-inch-long bone and the linear arrangement of tooth sockets told us that this was a dentary, or tooth-bearing portion of a lower jaw. Yet the socket for the missing frontmost tooth, instead of being directed upward, pointed forward, suggesting that this tooth had been oriented almost horizontally. The next few sockets on either side were also inclined forward, though at successively lesser angles. At the back of the jaw, the preserved teeth were bladelike and serrated, whereas the single preserved front tooth was long and conical, with a hooked tip. Thus, we knew from the start that the owner of the ancient jaw was an odd little beast with protruding teeth.

The fossil quarry that produced this specimen is one of the richest and most important in Madagascar. The sediments and bones are of Late Cretaceous age, about 70 million years old, from a time several million years before the demise of the dinosaurs. Because we were unsure what kind of animal the bone—which we affectionately called "weird jaw"—might belong to, we informally consulted colleagues after returning home. To our request for a "best guess," we received responses ranging from dinosaur to crocodile to bird to pterosaur, or flying reptile. Only after comparing the dentary with that of *Majungatholus,* a theropod (bipedal carnivorous dinosaur) found in the same deposits in Madagascar, were we convinced that the weird jaw, too, once formed part of the weaponry of a predatory dinosaur.

However, it was not until 1999 that we were able to bring the identity of this animal into sharper focus. While working at the same quarry, we found a concentration of small theropod fossils: vertebrae, various limb bones, and a few skull parts, including three more weird jaws. We uncovered multiple examples of many of the bones, which belonged to several individuals, all of the same buck-toothed species. By piecing together the fragile fossils, Cathy and I, together with our colleague Matt Carrano, reconstructed almost half of the total skeleton and were able to get a pretty good idea of the size and shape of this new species. Our Mesozoic meat eater was a lightweight, as dinosaurs go. It had a body length of five to six feet, most of which was neck and tail, and would have weighed approximately eighty pounds, roughly as much as a German shepherd. Now all we needed was a suitable name.

Paleontologists and biologists have the honor of giving a two-word name, or binomial, to any new species they formally describe in the scientific literature, and the rules for naming are relatively few. For the first part of the name, we combined the Malagasy word for "vicious," *masiaka,* and the Greek for "lizard," *sauros.* *Masiakasaurus* seemed an appropriate moniker for a dinosaur with a putative dietary preference for flesh.

The second part of the name came about more through serendipity than science. Life in the field is rather spartan, so it's always a good idea to bring along a few comforts from home, including music. During our 1999 season, whenever we played the

rock music of Mark Knopfler and his group Dire Straits, crew members seemed to uncover more *Masiakasaurus* bones. The converse appeared true also: no Dire Straits, no bones. So in a nonstandard but, we thought, fitting gesture, we followed Cathy's suggestion and named the carnivore after our musical talisman. The beast was officially dubbed *Masiakasaurus knopfleri:* the vicious dinosaur of Knopfler.

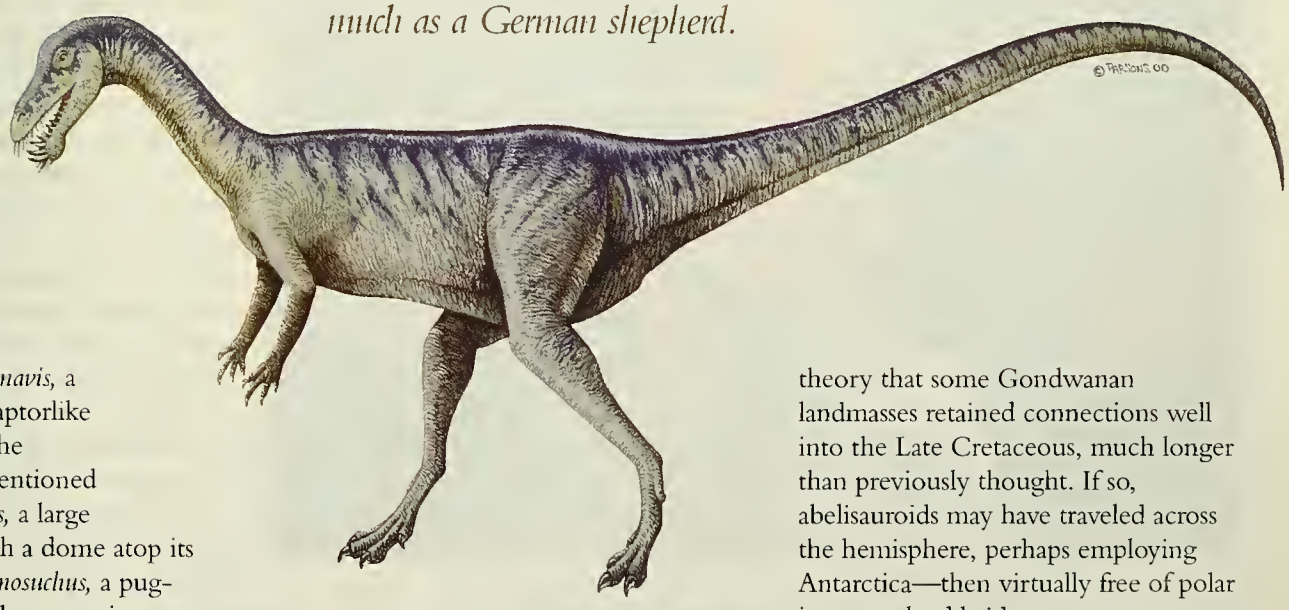
Our team, led by David Krause, of SUNY Stony Brook, has been working in Madagascar since 1993, and *Masiakasaurus* is not the only bizarre animal we've found. Others include *Rahonavis,* a bird with a raptorlike sickle claw; the previously mentioned *Majungatholus,* a large theropod with a dome atop its head; and *Simosuchus,* a pug-nosed, possibly vegetarian crocodile. So far, no other dinosaur from anywhere in the world exhibits specialized jaws and teeth like those of *Masiakasaurus,* which makes one wonder what this animal did for a living. A few species of modern mammals may provide an analogue. Some small mammals—various shrews, for example—possess a similar dental setup, with long, conical, forward-projecting teeth up front. In virtually all these mammals, the front teeth are used for grasping and piercing prey—mainly insects. *Masiakasaurus* may have employed the same kind of strategy, capturing and manipulating prey with its slanted front teeth. Prey candidates include insects, fish, lizards, snakes, and mammals. Following the initial attack, the bladelike rear teeth may have been used to tear and slice the victim into bite-sized chunks.

Both of the Malagasy theropods from our site are members of an enigmatic group called abelisauroids, known almost entirely from the Southern Hemisphere. Through our research, Matt, Cathy, and I have found that *Masiakasaurus* shares a number of specialized features with predatory dinosaurs from India and Argentina. This discovery indicates that toward the end of the dinosaurs' reign, small-bodied theropods were spreading throughout much of the Southern Hemisphere. This southern radiation parallels the spread of small theropods such as the dromaeosaurids, or "raptors," through the Northern Hemisphere during the same time period.

Larger abelisauroids were also distributed widely across the Southern Hemisphere, on landmasses that once made up the great southern supercontinent of Gondwana, including Madagascar, India, and South America. By the end of the Cretaceous, shifts of the earth's crust had long since begun to break Gondwana into continent-sized masses, which were then carried toward their present geographical positions. But the wide distribution of abelisauroids, both large and small, is consistent with a recently proposed theory that some Gondwanan landmasses retained connections well into the Late Cretaceous, much longer than previously thought. If so, abelisauroids may have traveled across the hemisphere, perhaps employing Antarctica—then virtually free of polar ice—as a land bridge.

So it turned out that our weird jaw had quite a tale to tell, one with global implications. The little prehistoric predator also demonstrates that we have yet to plumb the depths of dinosaur diversity. Undoubtedly, many new and bizarre discoveries still wait to be unearthed, and we look forward to our next trip to Madagascar.

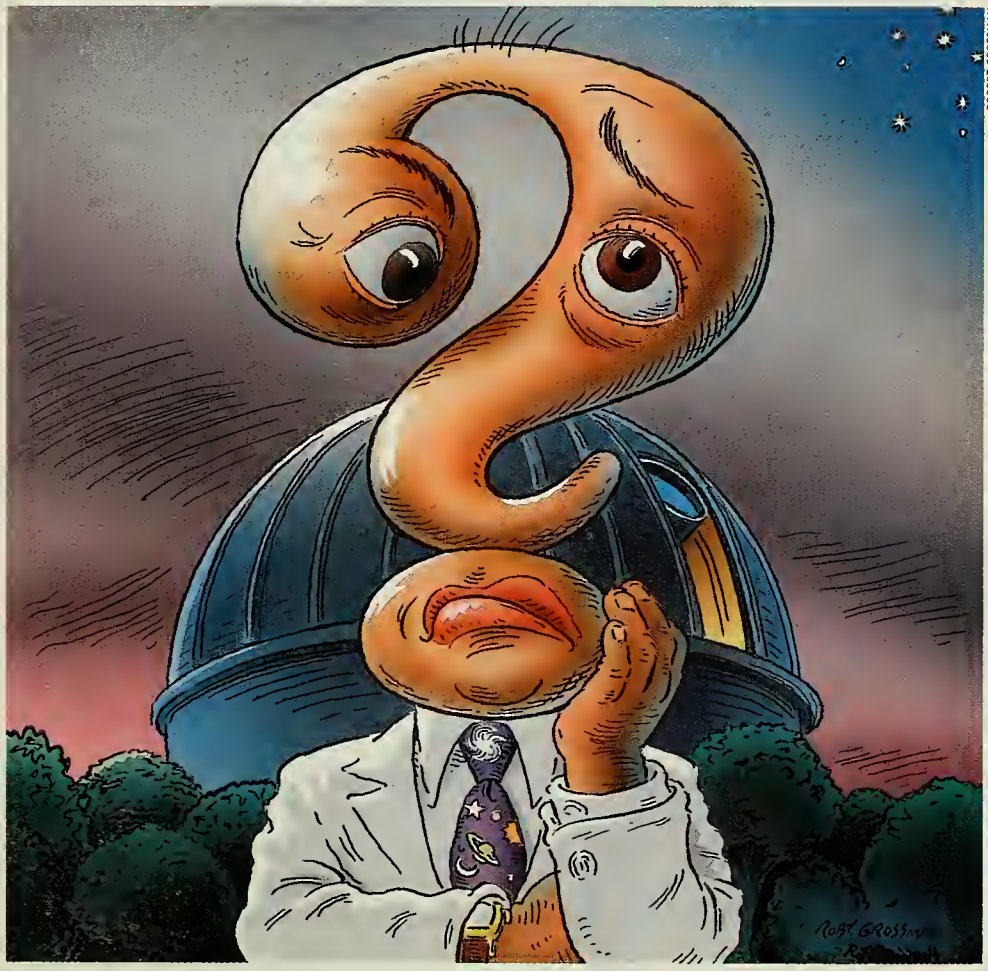
A lightweight as dinosaurs go, the little beast was five to six feet long, tail included, and would have weighed roughly as much as a German shepherd.



Scott D. Sampson is curator of vertebrate paleontology at the Utah Museum of Natural History and assistant professor of geology and geophysics, University of Utah.

UNIVERSE

On Being Baffled



Stop the presses! To scientists, the universe is a source of endless puzzlement.

By Neil deGrasse Tyson

Maybe it's the need to attract and keep readers. Maybe the public just likes to hear about those rare occasions when scientists are clueless. Is that why science reporters can't file an article about the universe without describing some of the astrophysicists they interview as being "baffled" by the latest research headlines?

Scientific bafflement so intrigues journalists that, in what may have been a first for media coverage of science, an August 1999 front-page story in the *New York Times* reported on a mysterious object in the universe whose spectrum could not be classified. Top astrophysicists were stumped. In spite of the high quality of the data (obtained from the enormous Keck telescope), the object didn't fit into any known category of planet, star, or galaxy. It was as though a biologist had sequenced the genome of some newly discovered organism and still couldn't classify it as plant or animal. Because of this fundamental ignorance, the article contained no analysis and no conclusions.

In this particular case, the object was eventually identified as an odd quasar, but not before millions of readers had been exposed to some ignorant astrophysicists saying, "I dunno what it is." This type of reporting is rampant, and it grossly misrepresents our state of knowledge at the frontier. It's not that some astrophysicists are occasionally baffled, it's that *all* astrophysicists are baffled *daily*. Scientists cannot claim to be at the research frontier unless one thing or another baffles them.

Bafflement drives discovery, but it will occasionally lead you to make errors. The late Princeton astrophysicist Martin Schwarzschild, who pioneered the study of stellar evolution, would always tell his graduate students, "The day you stop making mistakes is the day you will stop making discoveries." A widely repeated colloquial version of Schwarzschild's refrain is "Research is what you're doing when you don't know what you're doing."

Even Isaac Newton, who formulated some of history's most successful theories of the universe, remained candidly baffled. In his later years, he said of himself:

> *I do not know what I appear to the world; but to myself I seem to have*

been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

Richard Feynman, the celebrated twentieth-century physicist, made a similarly humble observation when he compared figuring out the laws of physics to observing a chess match when you know nothing about the game. Worse yet, you only get to peek at the game in progress every now and then. Starting with these handicaps, your task is to deduce the rules of the game. You may eventually notice that bishops stay on a single color, that pawns don't move very fast, or that the queen is feared by other pieces. But how about late in the game, when only a few pieces are left? Suppose you come back and find one of the pawns missing and the previously captured queen resurrected in its place? Try to figure that one out.

Not all scientists are as deeply baffled as astrophysicists are. This could mean that we are stupider than other breeds of scientists, but probably not. A more likely explanation is that astrophysical bafflement flows from the staggering size and complexity of the cosmos. By this measure, astrophysics has much in common with neurology: neurologists will assert without hesitation that what they do not know about the human brain vastly exceeds what they do know. This is why so many popular books on the universe and on human consciousness are published annually—nobody's got it right yet. One might also include meteorologists in the ignorance club. With so much going on in Earth's atmosphere that can affect the weather, it's a wonder meteorologists predict anything accurately. The weather people on the local news are the only reporters on the program who are expected to predict the future. They try hard to get it right, but in the end, all they can do is quantify their ignorance with statements like "50 percent chance of rain."

I wonder if the more profoundly baffled you have been in your life, the more open your mind becomes to new ideas. During an appearance on PBS's *Charlie Rose Show,* I was pitted against a well-known biologist to discuss and evaluate the evidence for extraterrestrial life as revealed in the nooks and crannies of the now-famous Martian meteorite ALH 84001. This potato-shaped, potato-sized interplanetary traveler was thrust off the Martian surface by the impact of a massive, fast-moving meteor—rather like the fate of loose Cheerios as they get thrust off a bed when you jump up and down on the mattress. The Martian meteorite then traveled through interplanetary space for a hundred million years, crashed into Antarctica, stayed buried in ice for an additional 13,000 years, and was finally recovered in 1984.

With so much going on in Earth's atmosphere, it's a wonder meteorologists predict anything accurately.

The original 1996 research paper on the possibility of life in the meteorite was written by David McKay, of NASA's Johnson Space Center, and several colleagues. In it, they offered a string of circumstantial evidence for Mars having once harbored life. The authors were quick to admit that each item, taken alone, could be explained by nonbiogenic processes. But taken together, they made a strong case. One of McKay's most intriguing, although scientifically empty, pieces of evidence was a simple photograph of part of the rock, taken through a high-resolution microscope. It showed a teeny-weeny worm-looking thing, less than one-tenth the size of a filamentous bacterium. I was (and still am) quite enthusiastic about these findings. But my co-panelist was argumentatively skeptical. After he had chanted Carl Sagan's mantra "extraordinary claims require extraordinary evidence" a few times, he declared that the wormy thing could not possibly be life because there was no evidence of a cell wall and because it was much too small to be life.

Excuse me?

I could not imagine a more closed-minded statement. Last I checked, the conversation was about Martian life, not about the Earth life he had grown accustomed to studying in his laboratory. Was I being irresponsibly open-minded? It is perfectly possible to be so open minded that important mental faculties spill out, the way they do in hypo-skeptical people who are prone to believing reports of flying saucers and alien abductions. How could my brain be wired so differently from that of the biologist? He and I both went to college, then to graduate school. We got our Ph.D.'s in our respective fields and are each formally trained in the methods and tools of science.

Perhaps we needn't look far for the answer.

Both publicly and among themselves, biologists celebrate the diversity of life on Earth as they admire the marvelous variations wrought by natural selection. At the end of the day, you never hear them confess that they work with a limited scientific sample. A sample of one. Life on Earth.

I'd bet almost anything that life from another planet, if formed independently from life on Earth, would differ more from any species of Earth life than any two species of Earth life differ from each other. By contrast, the objects, classification schemes, and data sets of the astrophysicist are drawn from the entire universe. For this simple reason, new data routinely force astrophysicists to think outside the proverbial box. And sometimes our whole bodies get shoved there.

We could go back to ancient times for examples, but that's unnecessary. The twentieth century will do just fine.

Just when we thought it was safe to look up at a clockwork universe and bask in the deterministic laws of classical physics, Max Planck, Werner Heisenberg, and others had to go and discover quantum mechanics, demonstrating that on the smallest scales, the workings of the universe are inherently *non*deterministic.

Just when we thought it was safe to talk about the stars as comprising the extent of the known cosmos, Edwin Hubble had to go and discover that all the spiral fuzzy things in the night sky were external galaxies—veritable "island universes" adrift far beyond the extent of the Milky Way's stars.

Just when we thought we had the size and shape of our presumably eternal cosmos figured out, Edwin Hubble went on to discover that the universe was expanding, and that there were galaxies visible as far as the largest telescopes could see. One consequence of this discovery was that the cosmos had a beginning that could yield to astrophysical inquiry. This was an unthinkable notion to all previous generations of scientists.

Just when we thought we knew all sources of gravity in the cosmos, Caltech astrophysicist Fritz Zwicky discovered dark matter—a substance that wields 90 percent of all the gravity of the universe but emits no light and has no known interactions with ordinary matter. The stuff is still a mystery. Zwicky also identified and characterized a class of objects in the universe called supernovas—exploding stars that emit the energy equivalent of 100 billion suns.

Just when we thought we had the universe figured out, Edwin Hubble discovered that it was expanding.

Not long after we figured out the ways and means of supernova explosions, somebody discovered bursts of gamma rays at the edge of the cosmos that momentarily outshine all the energy-emitting objects of the rest of the universe combined. On the brink of running out of superlatives, some have referred to gamma-ray bursts as hypernovae.

And just as we were growing accustomed to living in ignorance of dark matter's true nature, two research groups working independently, one led by UC Berkeley astrophysicist Saul Perlmutter and one by Harvard astrophysicist Robert Kirshner, discovered that things are worse than we thought: the universe is not just expanding, it's accelerating. Evidence indicates a mysterious pressure within the vacuum of space that acts in the opposite direction of gravity, and this pressure is more of an enigma than dark matter is.

These are, of course, just a sampling of the countless mind-bending and brain-boggling phenomena that have kept astrophysicists busy for the past hundred years. I could end the list here,

but I would be remiss if I did not include the discovery of neutron stars, which pack a mass rivaling that of the Sun within a ball that measures barely a dozen miles across. To achieve this density at home, just cram a herd of 50 million elephants into a thimble.

No doubt about it. My mind is wired differently from that of a biologist, and so our different reactions to the evidence for life in the Mars meteorite were understandable, if not entirely expected.

Lest I leave you with the impression that the behavior of research scientists is indistinguishable from that of freshly beheaded chickens running aimlessly around a coop, you should know that the body of knowledge about which scientists are no longer baffled is impressive. It forms most of the contents of introductory college textbooks and constitutes the modern consensus of how the world works. Because these ideas are so well understood, they no longer stimulate much research—or confusion.

I once moderated a panel discussion on "theories of everything"—those wishful attempts to explain, under one conceptual umbrella, all the forces of nature. On the stage were five distinguished, well-known physicists. Midway through the debate, I nearly had to break up a fight between two of them when one looked as if he was ready to throw a punch. That's okay. I didn't mind. The lesson here is, if you ever see scientists engaged in a heated debate, they are arguing because they are *all* baffled. These particular physicists were arguing at the frontier of knowledge, and they were sparring over the merits and shortcomings of string theory, not about whether Earth orbits the Sun, whether the heart pumps blood to the brain, or whether clouds make rain.

Astrophysicist Neil deGrasse Tyson is the Frederick P. Rose Director of New York City's Hayden Planetarium and a visiting research scientist at Princeton University.

CELESTIAL EVENTS

The New Black

What happens to science when facts meet fashion?

By Richard Panek

Forget about your parachute. What color is your universe?

Turquoise, it turned out. Maybe you saw the picture of it on the front page of the *New York Times,* or read about it in one of the newspapers that picked up the Associated Press account, or heard about it on National Public Radio, or watched it on CNN, or browsed it on space.com or Salon.com. If so, you might be interested to know that all those mentions (and many, many others) originated early one afternoon at the January 2002 American Astronomical Society meeting in Washington, D.C., when a NASA press officer walked into a media room and announced that a release arriving later that day would have serious "Joe Six-Pack" appeal.

Apparently it did, judging from its widespread dissemination. But was a turquoise universe news? And if not, did it really deserve such extensive coverage, along with the implicit credibility that such coverage conveys? As a science writer, I had my doubts, but they paled beside those of an actual scientist. The morning after the story broke, an astronomer friend e-mailed me his opinion of it: "How about all this hullabaloo about the 'color of the universe'? It's an awful story." *How so?* I wrote back. This succinct criticism was his response: "No actual scientist cares (except out of curiosity) what the integrated, or average, color of the universe is—it gives the public the wrong idea about what astronomy is, what we do, and what types of questions we try to answer in our work."

Bingo. But then I realized that this story actually *can* give the public the right idea—maybe not about what astronomy is, but at least about how science and science journalism work. Scientists sometimes generate press releases to get publicity, because publicity helps attract future funding. And media outlets sometimes report the content of a press release not because it's newsworthy but because it's colorful—literally, in this instance. The press release even included a Sherwin-Williams-like swatch in the center of the first page.

This is not in any way to impute questionable motives to the two Johns Hopkins University astronomers who collaborated on this particular project. They themselves acknowledged in the press release that they were simply having "a bit of fun." Nor is this to suggest that the study was utterly lacking in scientific value or wasn't the result of a rigorous accumulation of data. The astronomers arrived at their quite specific result (for "computer buffs," they said, "the RGB [red/green/blue] values are 0.269, 0.388, 0.342") by combining visible-light radiation from more than 200,000 galaxies. The original purpose of their investigation was to test models of the rates of star formation throughout the history of the universe; the turquoise tint, they reported, reflects the relative numbers of old red stars and young blue stars in the present era. (For more on stellar hues, see "Colors of the Cosmos," March 2002.)

Neither is this to imply that media outlets shouldn't ever run soft science news. Scientists, reporters, editors, readers, and viewers alike clearly respond to this kind of story. It captures the imagination. In this case, the story invited us to think about how the universe would appear if we could see it from the outside. Never mind that the wavelengths perceived by the naked eye represent the radiation from at most a few percent of what's actually in the universe. (Some matter radiates at non-optical wavelengths, but most of the universe is dark matter, which doesn't radiate at any wavelengths at all.) And never mind that introducing the postulate that the universe has an "outside" probably adds more conceptual complications than it eases. The fact is, the idea of looking at the universe in its entirety does serve a scientifically salutary purpose: it challenges the common, if outdated, conception of the cosmos as being too vast to comprehend and supports the more contemporary view of it as an understandable whole—indeed, as a system that changes over time.

And this is not to say that every commentator greeted this report with the seemingly requisite respect. As the Web version of Comedy Central's *Daily Show* reported, "The researchers say that the mere fact that such a thing can be analyzed indicates the universe has aged to the point where it has completely eliminated the phenomenon known as 'anything better to do.'"

Finally, this isn't even to say that the information is correct or that science journalists would be able to make that judgment. Two months after the initial pronouncement on the color of the universe, the researchers reported that, due to a software glitch, the result isn't turquoise after all. It's . . . beige, a color that probably would have as much chance of making the front page as an equivocating story about a rock from

Mars containing something that might be life (or might not), or about a bright object next to a certain star that could be a planet (but might well be a background star), to name just two examples of astronomy news from the past few years that turned out to be not nearly so exciting or important as their initial treatment made them seem.

So what *am* I saying? A thought that every nondelusional scientist and just about all science writers share, but one that may surprise readers or viewers who regard science as the objective pursuit of all truth: collaboration between scientists wanting publicity and media outlets willing to provide it does help determine what research goes forward, which in turn determines what data are produced, which in turn ultimately determine our conception of the universe.

As for my parachute, I'm not sure what color it is or even whether I actually need one. This column marks the final appearance of "Celestial Events" in *Natural History,* but I'll be landing not far away, as a feature writer for the magazine. If I may, though, I'd like to offer one last piece of advice. When you come across science news, consider the source, consider the outlet, and remember: we're only human.

Richard Panek's next book, The Invisible Century: Einstein, Freud, and Our Search for Hidden Universes, *will be published in 2003 by Viking.*

THE SKY IN MAY

By Joe Rao

A "celestial summit meeting." Belgian astronomer Jean Meeus has called the appearance of three planets within a circle 5° or less in diameter a "planetary trio." In early May, just such a trio is readily visible low in the west-northwestern sky for about two hours after sunset. The three planets—dazzling, silvery **Venus** (magnitude -3.9), medium-bright **Saturn** (+0.1), and dim, orange **Mars** (+1.6) appear within a 5° circle from May 3 to May 10. On the 6th, they fit into the smallest circle (2.7°). Separate planetary conjunctions also occur during this interval: between Mars and Saturn (2.2° apart on the 4th), Venus and Saturn (2.4° apart on the 7th), and Venus and Mars (just 0.3° apart on the 10th). All of this takes place in central Taurus, just north of the orange first-magnitude star Aldebaran and the Hyades star cluster. Amazingly, a fourth planet—**Mercury**—is not far away. Having passed just south of the Pleiades on April 29, Mercury arrives on May 4 at 21° east of the Sun, a very favorable elongation, and sits roughly 8° below and to the right of the planetary trio on May 6, shining at magnitude +0.8. Lastly, a skinny crescent Moon—the icing on this cosmic cake—passes through the same part of the sky on the evenings of the 13th and 14th.

Thereafter, Mercury slides into invisibility, overwhelmed by the bright evening twilight. Venus and Mars continue to plod eastward. Both pass from Taurus into Gemini—Venus on the 20th and Mars on the 28th. Toward the end of May, both planets approach Jupiter.

RON MILLER

The celestial summit as it appears May 7

Jupiter is the only one of the five bright planets visible to the naked eye that is not involved in the extraordinary clustering of celestial bodies mentioned above. Nonetheless, it shines brilliantly this month at magnitude -1.9 in the middle of the constellation Gemini, well up in the western sky at dusk. The planet sets at approximately 12:30 A.M. local daylight time at the start of May and at about 11:00 P.M. by month's end. The Moon sweeps past Jupiter at midmonth: on the evening of the 15th it's well below and to the right of Jupiter, and by the next night it has moved well above and to the left of the planet. During the final week of May, Venus draws noticeably closer to Jupiter.

The Moon wanes to last quarter on May 4 at 3:16 A.M. and is new on the 12th at 6:45 A.M. First quarter is on May 19 at 3:42 P.M., and the Moon waxes full on the 26th at 7:51 A.M.

A penumbral lunar eclipse is visible on May 26 over nearly all of the Pacific Ocean, including Hawaii, Australia, and New Zealand. The event is rather uninspiring, however. Even at its darkest phase, which occurs at 2:04 A.M. local time in Hawaii, the Moon's lower limb will appear only very slightly shaded by Earth's faint outer shadow.

Unless otherwise noted, all times are given in Eastern Daylight Time.

NATURALIST AT LARGE

Desire Under the Figs

An Amazonian bird's unusual diet results in an even more unusual mating system.

By Peter T. Sherman

GUNTER ZIESLER; PETER ARNOLD, INC.

The white-winged trumpeter spends its days foraging on the forest floor. It flies up into the trees only to nest, roost, and escape from predators.

Thump! It sounded as though something the size of a baseball had hit the ground about thirty feet away from me. I scanned the layer of dead leaves covering the rainforest floor but saw nothing. The group of white-winged trumpeters that I was observing reacted immediately to the sound, running over to the point of impact while giving the loud, squawking alarm call these birds generally reserve for ground-dwelling predators.

Thump! Something else hit the ground close to where the first object had fallen. The seven members of the trumpeter group were working themselves into a frenzy, giving repeated alarms and fluffing out their feathers so that they would appear larger and more threatening than their normal chicken-sized selves. Unable to see what was going on, I was feeling frustrated and a little bit on edge. I knew from twelve months of following trumpeters through the rainforests of Manu National Park, in southeastern Peru, that their usual response to danger (which generally comes in the form of an ocelot or a jaguar) is to fly up into the safety of the trees. These birds were behaving very strangely.

Thump! This time my eyes went straight to the spot where something had just hit the ground. Nothing. I walked closer, and as I did so, the trumpeters faced off against me, fanning their wings over their backs, raising their necks with heads cocked for attack, and giving a hair-raising call that was a cross between a growl and a scream and that meant "stand back." It dawned on me that the trumpeters—

normally indifferent to my presence—had been directing their alarm calls at me, and I finally saw why: sitting on the ground behind the protective guard of adults sat a stunned brown ball of well-camouflaged fluff. After about thirty seconds of blinking and periodic head-shaking, the trumpeter chick stood up and shakily stumbled off, adults packed closely around it. This chick and its two siblings had stepped boldly forth from the protective confines of a nesting cavity in a tree—where they had hatched the previous day—and plummeted forty feet to the ground, entering the outside world with a bang.

These free-falling chicks were the products of an extremely rare mating system known as cooperative polyandry, which involves several males (in the case of the trumpeters, usually three—one dominant individual and two unrelated subordinate males) that all mate with the group's single breeding female. The males then stick around to help out with incubation and, once the chicks leave the nest, to provide them with food for several months and protect them from predators such as boa constrictors and ocelots.

A typical trumpeter group also contains several other members: the group's sexually immature offspring, which help raise their new brothers and sisters, as well as an unrelated adult female, which doesn't. Monogamy is the rule for the majority of bird species (though members of a pair often "cheat" on each other), so what led to the evolution of cooperative polyandry in white-winged trumpeters? Looking for the answer to that question involved consideration of a number of factors in the lives of these birds, including the unusual ecological role they play in the forest, the need for young trumpeters to leave home when they reach adulthood, and the advantages of having comrades to protect the home turf from invaders.

Three males mate with the top female and then stick around to help raise the chicks.

PETER T. SHERMAN

Trumpeters take a midmorning break from searching for fruit. To protect their food supply, groups of about seven birds defend huge territories, averaging more than 175 acres.

If you spent all day beneath a fig or other fruiting tree in the Amazonian rainforest, craning your neck to look up into the canopy, you would likely see a round-the-clock procession of toucans, guans, capuchin monkeys, squirrel monkeys, and many other mammals and birds moving through the branches fifty to a hundred feet above the ground and feasting on soft, fleshy tropical fruit. Once they have eaten their fill in one tree, these animals move on to others, eventually either regurgitating the seeds or releasing them undigested in their feces (which then may serve as fertilizer for the germinating seeds).

The tree benefits only if its seeds are thus dispersed. But many fruits end up on the forest floor uneaten. Monkeys, the kings of sloppy eating, often grab up handfuls of fruit, sample a few, and throw the rest to the ground. What happens to the seeds of these fruits? Few species of birds and mammals include fallen fruit in their diet, and almost all that do, grind it up and digest the seeds right along with the pulp. Any uneaten fruits will have been bruised by the fall and quickly rendered inedible by bacteria and fungi. The few seeds that survive these animal and microbial assaults may germinate where they land but will be quite literally overshadowed by the parent tree, reducing the odds of their survival.

This is where the trumpeters come in. Alone among ground-dwelling creatures attracted to fruiting trees, trumpeters disperse—rather than consume and destroy—the seeds in the fruits they eat. As the fruit passes through their digestive tract, the muscular gizzard massages it until the pulp

separates from the seeds, leaving them naked, intact, and—once they have been excreted—ready for germination.

White-winged trumpeters get 90 percent of their calories from the pulp of fallen fruit. During Peru's rainy season (which lasts from November through April), such food is plentiful, but for the other six months of the year, fruiting trees are few and far between. To ensure a supply during this type in their territory, checking to see whether any ripe fruit has begun to fall.

At first glance, a trumpeter territory might seem large enough to allow the adult group members to pair off, spread out, and breed monogamously. In fact, however, during the dry season a territory produces barely enough fruit to sustain the resident group. If a territory were carved into smaller pieces, there would not be enough food for one breeds, such as the Florida scrub jay, the young may remain in their parents' territory as adults while waiting for a breeding position to open up nearby. Not so the white-winged trumpeters, which take off as soon as they reach sexual maturity (at two years of age). In this species, the individual that seeks its reproductive fortune away from home is far more likely to succeed than the one that waits for a breeding vacancy in

White-winged trumpeters get 90 percent of their calories from fruit pulp.

PETER T. SHERMAN

A group's second-ranked male feeds a chick. Subordinate males feed the young more than other group members do.

leaner period, each group defends a year-round territory that is huge for such a modest-sized bird: usually more than 175 acres. Even more impressive than the size of trumpeter territories is the memory these birds have for the fruiting schedules of the hundreds of trees that grow there. As fruit production wanes in one species, the trumpeters switch their attention to the next species due to bear fruit, traveling directly from one tree to another until they have visited all the trees of that breeding pair, let alone for several. Faced with this reality, a territory's dominant pair shows no tolerance for other pairs. Any subordinate pairs found trying to breed in the dominant birds' territory are attacked and chased off. In one extreme instance that occurred during my study, when an intruding pair did succeed in producing young in another group's territory, the residents killed the newly hatched chick.

In some other group-living species in which only the dominant pair its backyard. Dispersing females have a long, hard road ahead of them. When they try to join a new group, the dominant male and female repeatedly chase them off.

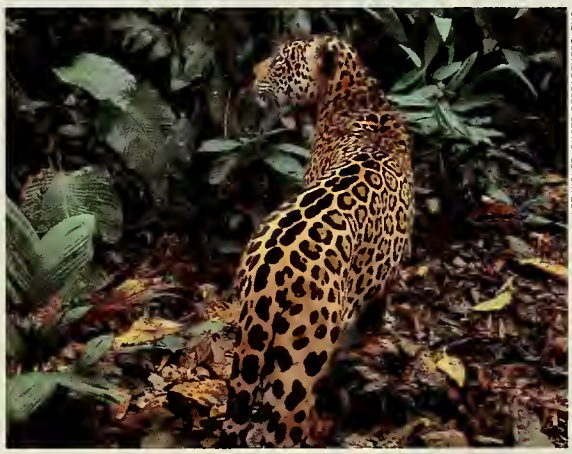
Typically, females wander from territory to territory, finally gaining admittance to a group that has no subordinate female. Even then, they may face years of harassment by the other adults in the group. The payoff for these subordinate females is very slow in coming, but eventually many of

those that persevere are rewarded. During my study, the breeding females in three groups disappeared and were immediately replaced by each group's subordinate female. (All three cases involved an incubating female that disappeared at night, most likely killed by a snake.) By the next day, the adult males in all three groups had switched from chasing away the subordinate female to mating with her.

In contrast to the treatment their sisters receive, young males have an easier time gaining acceptance into new groups. Rather than chasing them, the dominant male often actively befriends new males by feeding them fruit and grooming them. And when the mating season rolls around, the breeding female actively solicits all of the group's adult males, including newcomers (although subordinates have to be sneaky about it, waiting for a moment when the dominant male is not paying close attention).

Why the difference? It is easy to understand the reason a breeding female would have no objection to a male seeking admittance to her group: any male with which she mates will help raise her chicks. Subordinate females, by contrast, having no chance of producing young of their own, contribute little chick-rearing help. But what explains the dominant male's relatively relaxed attitude toward new males? Even though the subordinate males' assistance with chick-rearing is a bonus, it is not essential to the chicks' survival. And with other males around, the dominant male risks letting others sire the chicks (of which the usual number born each year is three).

The answer, it seems, is that the dominant male needs help defending the group's large territory, without which the chicks would have little chance of growing up to be strong, healthy adults. Because there are far more adults in the trumpeter population than there are suitable-sized territories available to accommodate them, neighboring groups constantly challenge each other's territorial boundaries. And during breeding season,



ART WOLFE; PHOTO RESEARCHERS, INC.

Easy prey for a jaguar, above, or an ocelot, trumpeter chicks are protected by all group members.

PETER T. SHERMAN

Breeding female in nesting cavity

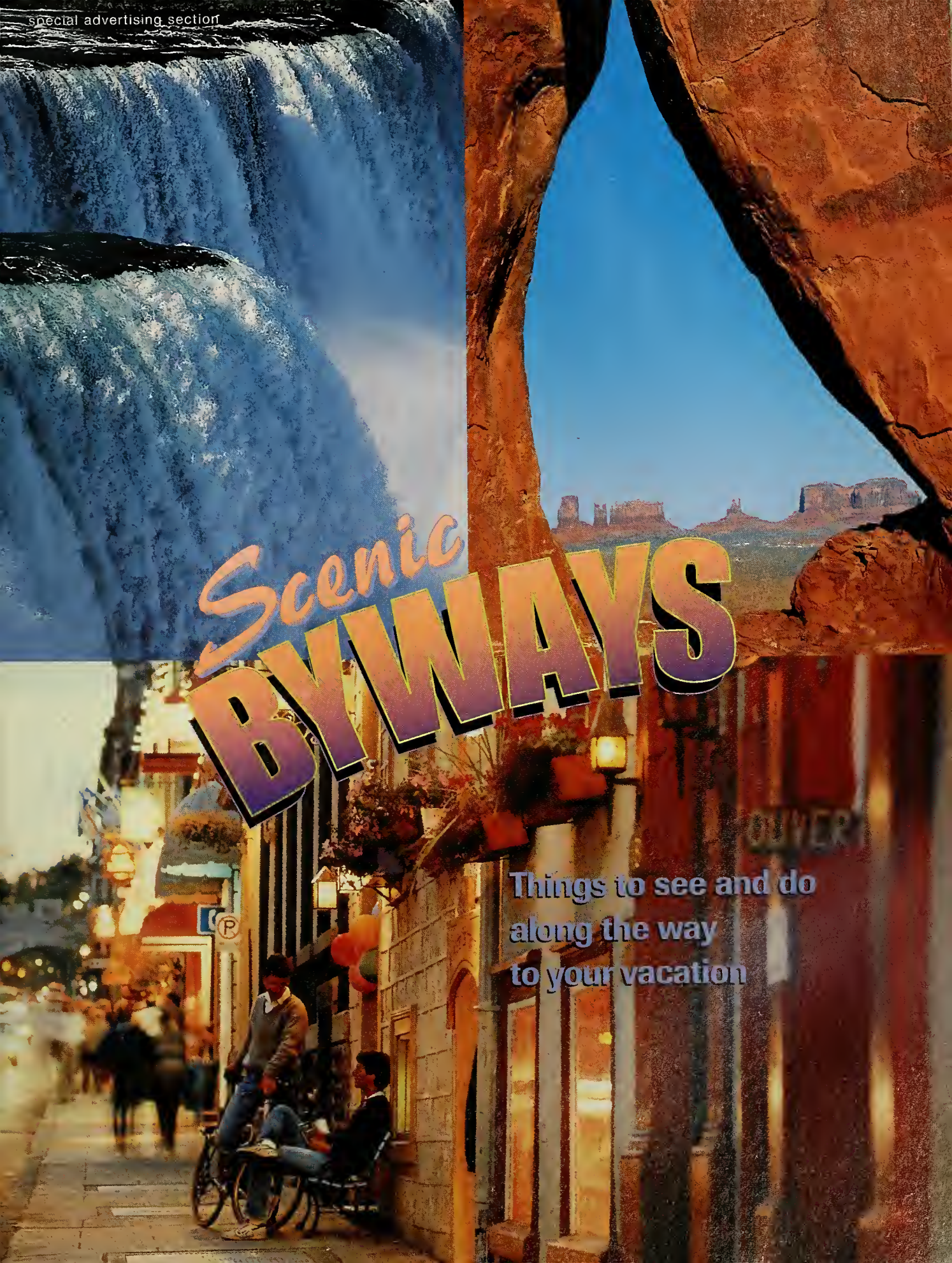
temporary groups of two to three subordinate trumpeters sometimes try to move into an already occupied space, forming a permanent group and dividing the territory if they are successful, disbanding if they are not. These invaders keep quiet and attempt to steer clear of the resident group, but if they are discovered, a fight ensues.

During territorial disputes, adult males (which weigh about 10 percent more than adult females) fight adult males in the opposing group, females fight females, and offspring focus their aggression on juveniles. Resident birds give the loud, trumpetlike territorial call for which the species is named and dash through the forest chasing intruders. If the dispute is not rapidly resolved, the battle may escalate, with males sparring like fighting cocks, jumping into the air, flapping their wings, and pecking at each other. A dominant male that tries to take on an intruding group single-handedly will likely lose the fight; over time his territory will shrink until it becomes too small to provide its residents with a year-round supply of food. For male trumpeters living in the land of fallen fruit, sharing a mate is not just an option, it is the key to survival and successful reproduction.

Peter T. Sherman is an assistant professor in the Department of Biology at Transylvania University in Lexington, Kentucky.

PETER T. SHERMAN

A two-week-old trumpeter. Until they fly at six weeks of age, chicks roost alone, close to the ground.



Scenic BYWAYS

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along the way
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Hopewell Rocks, Bay of Fundy

Photos: Tourism New Brunswick

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Kouchibouguac National Park

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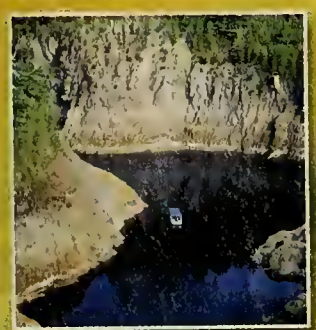

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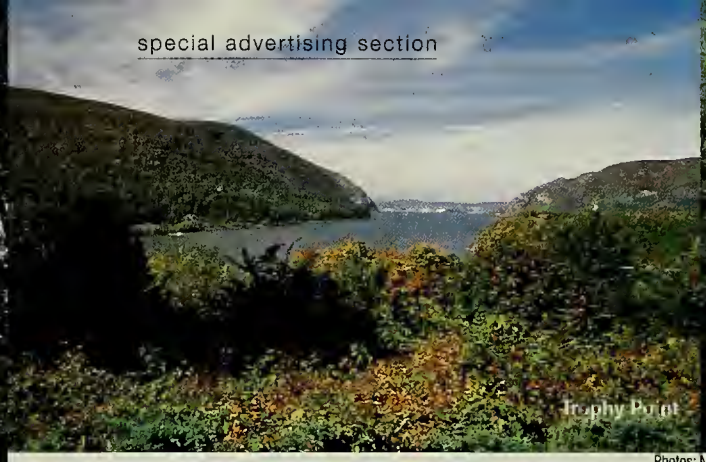
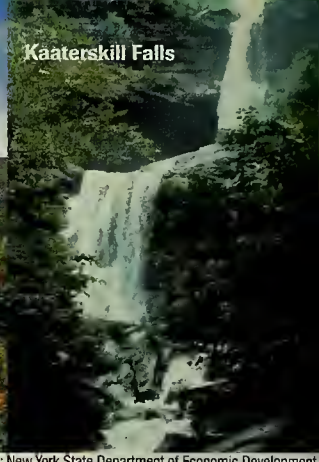

Trophy Point


Kaaterskill Falls

Photos: New York State Department of Economic Development

NEW YORK STATE

The Empire State offers art and history along its highways and byways.

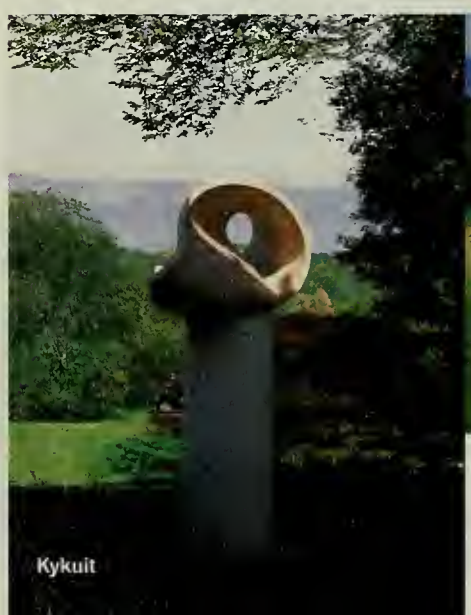
A favorite vacation spot in New York State (800-call-nys; www.iloveny.com) is the Hudson Valley Region, just a short drive from New York City. The Hudson, one of the first rivers that explorers encountered in the New World, is famous for its natural beauty, which once inspired a group of nineteenth-century painters known as the Hudson River School.

Begin your journey in the town of Hudson, home to the **Olana State Historic Site** (518-828-0135; www.nysparks.state.ny.us/hist), the estate of Frederic Church, a leading member of the Hudson River School. Begun in 1870, Church's Persian-style estate took two years to build and four years to decorate. Visitors can tour the home and the 250 acres surrounding it from April through October.

Continue your exploration of the Hudson River School at the **Frances Lehman Loeb Art Center** (845-437-5237; www.fllac.vassar.edu) on the campus of Vassar College in Poughkeepsie. Here you may view more than forty works of art by the Hudson River School painters Albert Bierstadt, Frederic Church, Thomas Cole, Jasper Cropsey, Asher Durand, and George Inness.

If twentieth-century art is more to your liking, visit the **Storm King Art Center** (845-534-3115; www.stormking.org), where major pieces of post-1945 sculpture are displayed in an extraordinary, natural setting. Works include 120 large sculptures by such artists as Calder, Moore, Nevelson, Noguchi, and Smith. A winding, scenic drive up Storm King Highway, just off Route 218, leads to the museum and its 500 acres.

Kykuit (914-631-8200; www.hudsonvalley.org), home to four generations of the Rockefeller family, also showcases an exceptional collection of twentieth-century sculpture set in lush formal gardens with stone terraces and fountains. Now a historic site of the National Trust, Kykuit overlooks the Hudson River. The house is full of artistic treasures collected by the family throughout the years, including paintings, fine furniture, and Chinese ceramics, and the barn has horse-drawn vehicles as well as classic automobiles.


Kykuit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QUÉBEC CITY

Photo: Yves Tessier, Tessima

Sidewalk café in Old Québec

Although it's only 438 miles north of New York City, and less than 400 miles from Boston, **Québec City** (418) 522-3511; www.quebecregion.com) is known for its European charm.

Founded in 1608 by Samuel de Champlain, Québec is a lively city of winding streets and quaint town squares. This walled city—the only fortified city in North America—is surrounded by the Laurentian Mountains and overlooks the Saint Lawrence River. One of the city's favorite attractions is Old Québec, where you may wander through streets lined with boutiques and cafés or take a horse-drawn carriage ride past stately homes. Stop for a view of the river from the cliffside boardwalk. Just outside Old Québec is **La Citadelle** (418-694-2815; www.lacitadelle.qc.ca), a nineteenth-century fortification and national historic site. Learn about the city's history at the **Place-Royale Interpretation Centre** (418-646-3167), the site of the first permanent settlement in New France.

After touring the city, stop by a bistro for a traditional meal, or take in the innovative offerings of Québec's new generation of gourmet chefs. Typical Québec cuisine takes its inspiration from the hearty country dishes that have been handed down from generation to generation.

Although Québec is rich in architectural and historical attractions, it's just minutes away from the great outdoors. Take advantage of the mountains, lakes, rivers, and protected wilderness areas that are just outside the city.

In the heart of the city, visit the **Plains of Abraham**, an immense park where you can walk, mountain bike, picnic, or roller-blade. At **Montmorency Falls Park**, also within city limits, visit a waterfall nearly 100 feet higher than Niagara. The park is bordered by trails and features a cable car to the top, a panoramic stairway, and a suspension bridge.

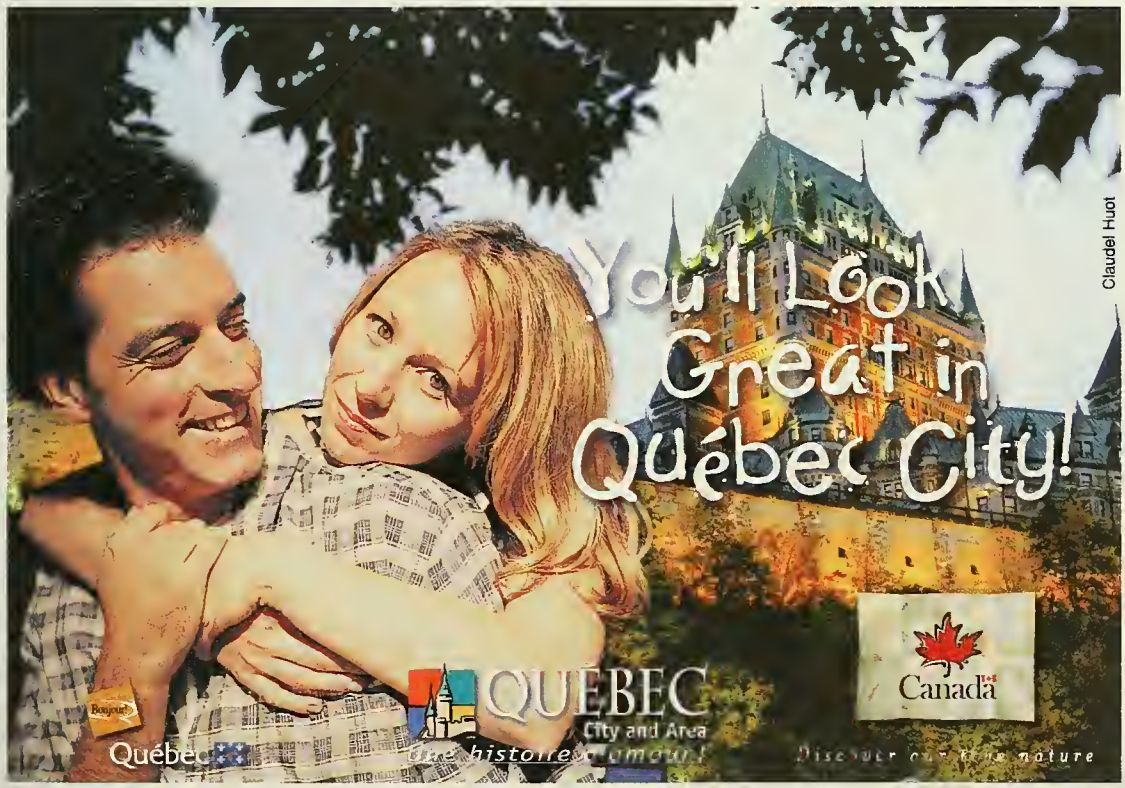
When entering Canada, and to get back in to the United States, U.S. citizens and permanent residents will need to show proof of citizenship, such as a birth certificate and a photo ID.

Saint-Denis Avenue, Old Québec

Photo: Yves Tessier, Tessima

Photo: Luc-Antoine Couturier

Greater snow geese at Cap Tourmente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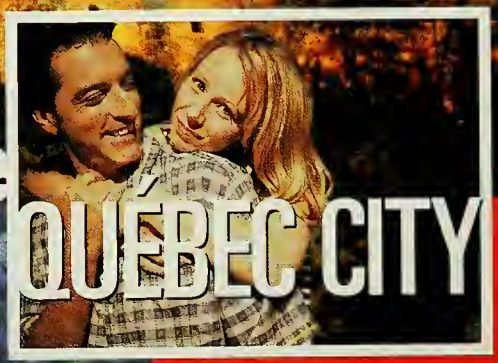

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COLONIAL WILLIAMSBURG

America's favorite restored village is celebrating its seventy-fifth anniversary.

Take a step back in time when you visit **Colonial Williamsburg** (800-history; www.history.org). Located midway between Richmond and Norfolk, Virginia (take I-63 to exit 238), this historic village has changed little from the time of our founding fathers.

Williamsburg, the capital of the colony of Virginia from 1699 to 1780, was restored and rebuilt as accurately as possible in the 1920s. It is now the country's largest outdoor history museum and its largest-scale restoration project. Existing foundations were kept intact, and period-appropriate materials decorate more than five hundred restored and reconstructed buildings and houses. Even the animals are true to the eighteenth century—they are based on breeds that were common in Colonial Williamsburg at that time.

Clustered around a one-mile stretch of Duke of Gloucester Street, Colonial Williamsburg brings to life the ideas and dreams of both the famous and the everyday people who once populated this American colony. Throughout the village, you will find hundreds of people representing actual citizens from eighteenth-century Williamsburg, whether greeting guests at the local taverns, making bread at the bakery, stoking the fire outside a tenant house, or judging the accused in the courts.

No two trips to Colonial Williamsburg are ever alike. Special military reenactments, seasonal programs, new exhibits, theatrical presentations, concerts, and an occasional eighteenth-century wedding or funeral ensure that each visit will be a new and different experience.

2002 marks the seventy-fifth anniversary of Colonial Williamsburg, and extended hours and special anniversary celebrations make this an especially great time to visit. Throughout the year, the entire village will set the clock to 1774, the eve of the American Revolution.

As many visitors know from their history, the Boston Tea Party, in December of 1773, prompted Parliament to pass several harsh measures to punish the colonists for their rebellion. By 1774, Virginia was taking the lead as the colonies began to organize and formulate a unified response to British rule.

When you visit Colonial Williamsburg this year, you can listen in as "colonists" discuss British taxes, religious freedom, the Boston Tea Party, and the radical notion of separation from England.

From May 11 through September 15, Colonial Williamsburg is offering a **Williamsburg Flex Package**, which includes nightly accommodations (there is a three-night minimum) as well as a Williamsburg Flex Vacation Pass. The pass admits you to Colonial Williamsburg, **Jamestown Settlement** (where it's still 1607), **Yorktown Victory Center** (a living history museum celebrating the final battle of the American Revolution), and, for a change of pace, **Busch Gardens** and **Water Country USA**.

Sea shells. Stuffed animals. The birth of a democracy.

What will your children bring home from vacation this year?

What will they remember? The men in their wigs. The ladies in their gowns. The blacksmiths. The candlestick makers. The balladeers. The fifes and drums.

And while they won't find any thrill rides here, they will find an understanding of what America is. And how it came to be.

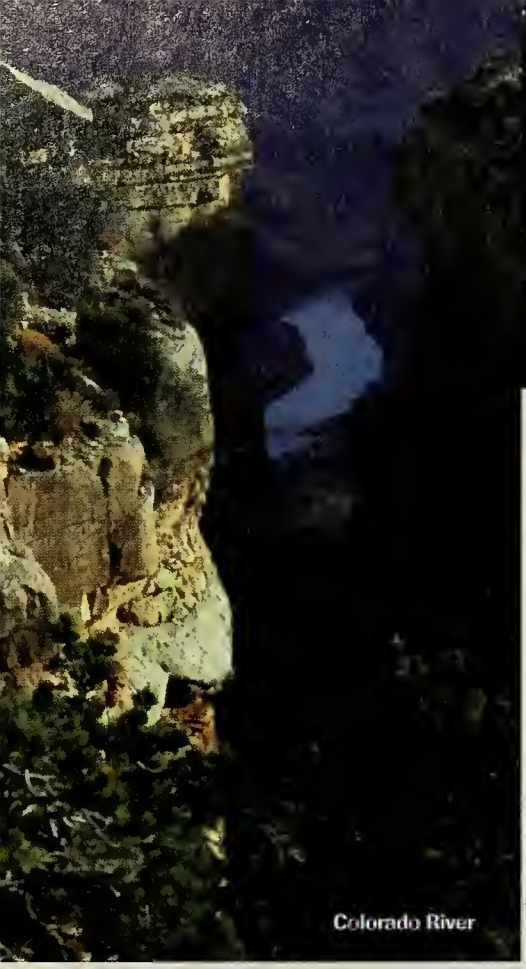
Truly, there is so much to see and do. A parade here. A concert there. A carriage ride. Toys from another time.

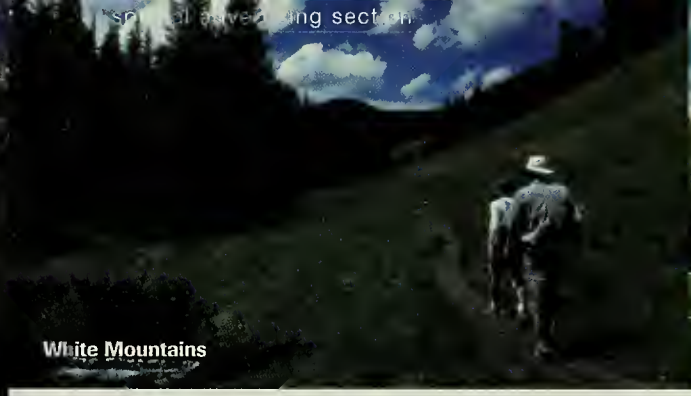
All of which begs the question. Why not spend your vacation escaping to another time?

For more information, call 1-800-280-8039 or visit us online at www.colonialwilliamsburg.com

Colonial Williamsburg

WILLIAMSBURG, VIRGINIA





Photos: Arizona Office of Tourism

ARIZONA

In the **Grand Canyon State** (602-230-7733; www.arizonaguide.com), twenty-two scenic byways, parkways, and historic and scenic roads take visitors to a variety of natural and cultural sites off the beaten track.

In northern Arizona, two scenic roads transport you deep into the Navajo reservation. Along **Kayenta-Monument Valley Scenic Road**, stop at the **Monument Valley Navajo Tribal Park** on the Colorado Plateau. The park shows off some of the most striking landscapes of sandstone buttes, mesas, and spires in the entire Southwest. While driving along the **Diné Tah (Among the People) Scenic Road**, visitors have the opportunity to explore Navajo culture. Learn about the early basket makers and the tribal people who currently live in the area at the **Canyon de Chelly National Monument**.

In southern Arizona, the **Patagonia-Sonoita Scenic Road** leads to a number of preserves and parks that are perfect for a picnic, hike, or bird watching. Trace the paths of the Spanish priests, whose influence in southern Arizona is older than the European settlements of the East Coast. Stop at the **Mission San Xavier del Bac**, established in 1691, which still serves the Tohono O'odham, or "people of the desert." **Tumacácori National Historical Park** is the site of one of the oldest missions in the Southwest, and **Tubac Presidio State Historic Park** features remnants of Arizona's first European settlement. At the binational town of **Nogales**, on the Mexican border, you can buy traditional Mexican wares.

To find out more about what to see and do along Arizona's scenic byways, order **Travel Arizona: The Scenic Byways** (800-543-5432; www.arizonahighways.com).


American oystercatcher

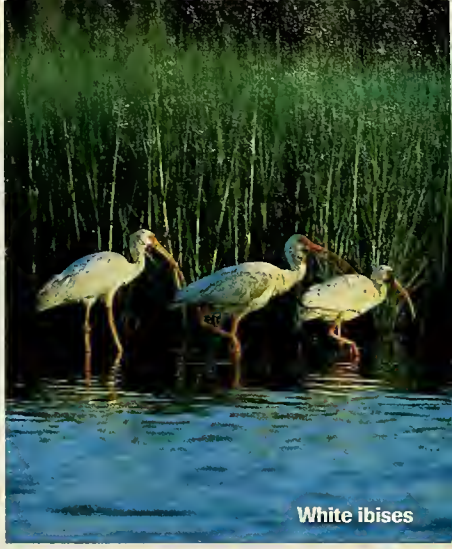
Photos: Gary Walton

PEA ISLAND
National Wildlife Refuge

Located on the north end of Hatteras Island in the Outer Banks of North Carolina, the **Pea Island National Wildlife Refuge** is a wonderful destination to witness the fall and spring bird migrations. During the sixth annual **Wings Over Water Festival** (October 15–20), you may explore this fascinating ecological setting through field trips and seminars.

Get a schedule of events and registration form at www.northeast-nc.com/wings, or call the **Outer Banks Chamber of Commerce** at 212-441-8144 to have these mailed to you.

SWIFT Binoculars


White ibises

For anyone who wants to get the most out of bird watching, perhaps while exploring the Outer Banks at the **Wings Over Water Festival**, a good field guide and fine, high-quality binoculars are "must have" items.

Swift Instruments (617-436-2960; www.swift-optics.com) has been a leader in designing and manufacturing innovative bird watching optics since 1926. Swift has just introduced a new all-weather/waterproof roof prism binocular that is perfect for bird watching. The new 8.5X.44mm model **828 Swift Audubon**® offers world-class optical performance in a light, strong magnesium body.

This binocular features precise focusing that won't go out of adjustment and phase-coated lenses for crisp, high definition viewing, with enhanced contrast in low light situations. The binocular's body is rubber clad for a sure grip and as a cushion against shocks. Both compact and lightweight, the Swift Audubon is comfortable to hold while on a long hike or a short jaunt.

Remember that birds move quickly, so when you're out in the field, observe the bird first and then consult your field guide. Look through your binoculars and make note of the bird's color, size, shape, and wing and head markings. Once you have a binocular you can depend on, the rest is easy.

Photo: Keith Whittington

Loggerhead turtle tracks leading to a nest

LITTLE ST. SIMONS ISLAND

Just off the Georgia coast, **Little St. Simons Island** (888-733-5774; www.littlestsimonsisland.com) is halfway between Savannah, Georgia, and Jacksonville, Florida. Leave your car behind and be prepared to fall under St. Simon's spell.

Late May marks a very special time on the island—the start of the nesting season for loggerhead sea turtles. From the end of May to mid-July, naturalists from the Loggerhead Sea Turtle Monitoring and Protection Program lead guests on **Sea Turtle Night Hikes** to view adult loggerheads emerge from the ocean and deposit their eggs on the beach.

Return to the island from mid-July through the end of September to watch the hatchlings as they make their way to the sea.

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The Making of a Blossom

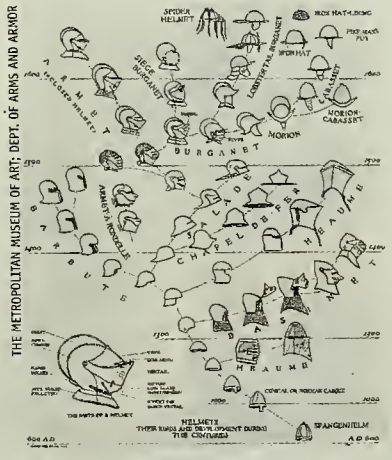
By Enrico Coen

A flower's evolutionary past may be read in the genes that influence its development.

The lower petals of a *Salvia* blossom are shaped quite differently from its upper petals. Flowers of this type provide a landing platform for flies and bees. Scientists believe that this kind of blossom probably evolved from a radially symmetrical ancestor millions of years ago, during the period when insects were becoming increasingly important pollinators.


DAN SUZIO

Bashford Dean had two passions in life. One was studying the development and evolution of fishes, which led to his becoming a professor at Columbia University in 1891 and a curator at the American Museum of Natural History in 1903. The other was a fascination with arms and armor that was first roused in early childhood, when Dean saw a beautiful European helmet in the house of a family friend. He was so taken with the helmet that he sat with it on the porch, where he studied it inside and out for a long time. Dean's interest in armor grew over the years, and in 1906 he became honorary curator of arms and armor at New York's Metropolitan Museum of Art. Eventually he retired from active duty as a scientist and a teacher and devoted himself to making the Met's collection of arms and armor one of the finest in the world.



THE METROPOLITAN MUSEUM OF ART; DEPT. OF ARMS AND ARMOR

Bashford Dean's branching diagram of helmet "evolution" resembles charts illustrating relationships of species. At the bottom of the chart is an ancestral, radially symmetrical helmet, like the sixth-century Ostrogoth helmet below.


THE METROPOLITAN MUSEUM OF ART, GIFT OF STEPHEN V. GRANCSAY, 1942 (42.50.1)

Dean took his biological past with him, however. Diagrams he drew depicting the evolution of armaments such as helmets and shields have much the same branching pattern often used by scientists to illustrate the evolution of fishes or flowers. One diagram of helmets (at left) shows a simple, radially symmetrical ancestral helmet at the bottom. From this primitive form, various lineages emerge; some of them lead to highly elaborate, enclosed helmets with visors or chin guards, while others lead to dead ends or revert to simpler shapes.

Such diagrams are a good way to organize objects and to show how they are related. But insofar as they give the impression that one object is transformed directly into another—that one helmet, say, is directly modified to give rise to the next in the series—they are misleading. What evolve, of course, are not the helmets themselves but the ways people make them. Bashford Dean's diagram tells a story about changes in how people fashion helmets in response to changing circumstances, materials, and traditions.

A similar principle applies to biological evolution. Although we commonly portray evolution as a branching tree or bush along which one type of organism seems to transform into another, it is not organisms themselves that change but the way they develop. During the evolution of flowers, for ex-

The way objects, whether flowers or helmets, change their shape over time can be understood only by paying attention to how they are made.

The earliest flowering plants are believed to have borne similar-shaped petals arranged around a center, as is the case with the poppy, above.

ample, blossoms of one type are not directly modified to produce blossoms of another type. What changes is the way flowers develop from seed in each generation. More precisely, changes come from the genes that influence development and that underlie the evolution of flowers, fishes, and every other complex biological structure.

But how do evolutionary biologists unravel the history of developmental change when the ancestral organisms are no longer with us? Even when we are lucky enough to have a fossil record, we get only a few snapshots, not a dynamic view of how ancient plants and animals developed in each generation.

Recently, researchers have been approaching

DAVID LIEBMAN

The upper and lower petals of snapdragons are shaped differently because a particular gene, known as *cyc*, is active only in the upper region of the developing flower bud.

this problem from a new angle: studying how genes influence diverse organisms living today and then trying to infer what happened in the past. After all, genes, the units of heredity, are what connect us with our past. This approach, sometimes called evo-devo (short for evolution of development), became possible only in the last decade or so, when advances in our knowledge of genes allowed us to compare their roles in different types of organisms. Evo-devo has already yielded many surprises, prompting biologists to think afresh about some age-old problems, such as the evolution of the eye or the relationship between mammals and insects. In my own field—the evolution and genetics of flowering plants—I have been especially intrigued by how genes determine floral symmetry.

Flowers can be broadly divided into two types according to their symmetry. Radially symmetrical flowers, such as buttercups and tulips, have a single type of petal arranged the same way all around a center. There is more than one way to cut vertically through the center of these flowers to produce two halves that are mirror images. Bilaterally symmetrical flowers, such as snapdragons and sweet peas, have distinctive upper and lower petals and are therefore asymmetric from top to bottom. There is only one way you can cut one of these flowers to divide it into two mirror-image halves.

Like Bashford Dean's helmets, flowers are thought to have been radially symmetrical at first. Bilateral flowers evolved later in response to pollinators, the lower petals often providing a platform for insects to land on. Curiously, bilateral symmetry—and thus the developmental "trick" that makes it possible—seems to have evolved numerous times, independently. How was this possible?

One of the most familiar plants with bilateral symmetry is the snapdragon *(Antirrhinum majus)*. Highly regarded as reliable and colorful members of the summer garden, snapdragons hold a different attraction for geneticists. Some of the key genes controlling flower symmetry have been identified in this plant, and one gene, called *cycloidea,* or *cyc* (from the Greek *cyclo-,* meaning circular), plays a particularly important role. With *cyc,* snapdragons produce the double-lipped blossom popular with small children, who like to squeeze the sides together to make the "dragon" open its mouth. Some snapdragons, however, produce radially symmetrical blossoms; in such mutant plants, the *cyc* gene is inactive.

A few years ago, my colleagues Da Luo and Rosemary Carpenter and I isolated the *cyc* gene. Then we began to look at when and where it first becomes active in the developing flower bud. (All of a plant's genes, of course, are present in all of its cells, but only if a gene is activated, if it turns on, can it have an effect.) We showed that in normal snapdragons, *cyc* turns on at a very early stage of flower development, when the bud is just a tiny bulge, less than one-tenth of a millimeter across. At this stage, viewed through a scanning electron microscope, the bud still appears symmetrical from the outside. But when we stained a section of the developing bud to reveal where the *cyc* gene was active and then looked through a light microscope, we saw something striking: the *cyc* gene was active only

The Indian strawberry, above left, is radially symmetrical, while the periwinkle, above right, is an example of a "left-handed" flower. Its petals are tilted like the blades of a fan turning counterclockwise; as a result, it is not symmetrical on any one plane.

in the upper part of the bud, visible as a region that stained dark blue. This early internal asymmetry in gene activity is what leads to the distinctive upper and lower petals that develop later on.

Cyc is a regulatory gene, which means it influences the activity of other genes. Regulatory genes produce particular types of proteins (sometimes called master proteins) that are able to bind to other genes and switch them on or off. In the snapdragon, *cyc* influences a specific set of genes in the upper part of the bud, leading the upper petals to develop characteristics that differ from those of the lower petals.

How could this be? We can gain some insight into this question by thinking about how certain letters of the Latin alphabet are used in the English language. Some words contain letters that aren't pronounced when we speak. The letter *k,* for example, is silent in the word "knight." The *k* is not useless, however; in written text, it distinguishes "knight" from "night"—words with very different meanings. Similarly, a pattern of gene activity may not always manifest itself in the most obvious way in an organism. In *Arabidopsis,* for example, the asymmetric pattern of *cyc* activity is there in the early bud but is of no consequence to the symmetry of the mature flower that develops from it. This is probably because the genes that respond to *cyc* in *Arabidopsis* are different from those that get switched on or off by *cyc* activity in snapdragons. Rather than influencing the way the petals grow, these genes might have to do with orienting the flower or with ensuring that the petals develop in regular positions. Researchers in various laboratories are currently working to pin down *cyc*'s role in *Arabidopsis*.

Some of the key genes regulating the development of flower symmetry have been identified in Antirrhinum majus, *the snapdragon.*

What happens in plants such as buttercups, in which radially symmetrical flowers are the norm? In these cases the upper and lower petals look the same, so you might think there would be no gene like *cyc* present. Right? Wrong. In 2001, scientists sequenced the genome of a plant named *Arabidopsis thaliana.* Bearing tiny, white, radially symmetrical flowers, this small member of the mustard family is the workhorse of gene research in plants. A computer scan of all this genome-sequencing information revealed that among its 25,000 or so genes, *Arabidopsis* has one that is, in fact, very similar to *cyc.* The real surprise came when my colleague Pilar Cubas, working at the Universidad Autónoma de Madrid, discovered that the *cyc* gene was active in *Arabidopsis* only in the upper part of developing flower buds—just as we had found for the snapdragon.

Even without revealing just what that role may be, however, the *cyc* research to date has provided an important clue as to why bilateral asymmetry in flowers has evolved so many times. Since the asymmetric pattern of *cyc* activity is found in both snapdragons and *Arabidopsis,* it was presumably also pre-

ANDREW DAVIES; JOHN INNES CENTRE

Above: A snapdragon with a functional *cyc* gene will develop the typical double-lipped blossom (left). In a mutant snapdragon (right) with similar petals radiating around the center, *cyc* is inactive. Opposite: This dahlia blossom contains two types of flowers. The eight pink rays belong to eight bilaterally symmetrical flowers, whose structure cannot be fully seen without dissecting the blossom.

sent in their most recent common ancestor, a plant that would have lived about 100 million years ago. This ancestral plant probably had radially symmetrical flowers, and thus, as in *Arabidopsis,* the *cyc* gene must have had a different role to play. Whatever its role, the asymmetric pattern of *cyc* activity meant that, in terms of gene activity, the ancestor's flowers were already asymmetric from top to bottom. This may have made it relatively easy for differences between upper and lower petals to evolve numerous times in the descendants of the ancestral plant, through minor modifications in *cyc* or in the genes that respond to *cyc.*

Much of what seems novel in an organism's appearance stems from ancient patterns of gene activity manifesting themselves in new ways.

The key point here is that much of what seems novel in the appearance of an organism stems from ancient patterns of gene activity manifesting themselves in new ways, rather than from the invention of something completely new. And we do not have to go back millions of years to find evidence of the importance of changes involving regulatory genes. A more recent example is the domestication of maize (corn) by the prehistoric peoples of Mexico. The maize we cultivate today has one main stem, from which grow large cobs with lots of accessible, nutritious seeds (the kernels). Teosinte—maize's nearest living wild relative—looks very different; it is a highly branched plant with relatively small cobs, each of which bears a few seeds that have a hard, inedible covering.

About ten years ago, John Doebley, then at the University of Minnesota, and colleagues, building on earlier work by George Wells Beadle, showed that changes in as few as five genes could convert teosinte into a useful food plant like maize. Recently, Doebley's group went on to isolate one of these genes. Called *teosinte-branched,* or *tb1,* this gene is largely responsible for the difference in branching patterns between maize and teosinte. As might have been expected from the appearance of the plant, *tb1* was found to be most active in the developing side buds. Quite unexpectedly, however, the DNA sequence of *tb1* turned out to be very similar to that of the *cyc* gene of *Antirrhinum,* and like *cyc, tb1* seems to be a regulatory gene.

In the process of domesticating maize, the ancient peoples of Mexico seem to have chosen a plant with a mutant form of the *tb1* gene that was particularly effective at preventing side buds from developing into long branches. They were unwittingly playing with regulatory genes, much as may have happened naturally in the evolution of bilateral symmetry. And the evolution of maize has another parallel with that of floral asymmetry: both enabled plants to establish new associations with animals—humans in one instance, insects in the other. By studying these genes, we are revealing not only the history of changes in plant development but also something of the habits and predilections of the animals that interacted with them.

During one of Bashford Dean's trips to Europe, he came across an ancient box in the corner of an attic in Dijon, France. The box had belonged to an armor maker some 600 years earlier and contained parts of unfinished gauntlets. Dean remembered: "It gave me a curious feeling to take in my hands these ancient objects which seemed only yesterday to have been put in the box by their maker. I had the strong impression that if I should go through the old door near by, I would by some 'Alice in Wonderland' wizardry, pass into the sixteenth century and find in the next room a veritable armorer at his table by the low window."

The study of genes can also help transport us into the past to contemplate previous acts of making. But as with all cases of imaginary time travel, the fascination does not lie simply with re-creating the past, for the past is intrinsically no more or less interesting than the present. Rather, the deepest satisfaction comes from viewing the past through the eyes of the present and contemplating how they are related through time. □

EARL HARPER; ECOSTOCK

Myths about rural life are as old as the Greek eclogues and as modern as America gave us the Age of Homespun, an ideological haven from the more

An American Fantasy

The Age of Homespun wasn't born in Litchfield, Connecticut, but it was christened there on August 14, 1851, the second day of the county centennial. Like much of rural New England, Litchfield County had been in decline for almost a generation, its population siphoned off by new industrial cities farther east and by more fertile states and territories to the west. But under the watchful eye of the Litchfield Village Improvement Society, the town was discovering a new dignity through history.

At 10:00 A.M. on the centennial's first day, a procession led by a military band moved out from Mansion House in the center of town. Behind the band marched Connecticut's governor, the general of the state militia, various local officials, and the male citizens at large. Women stood on the sidelines or hastened to a big tent set up on the common.

A reporter for the *New York Observer* estimated that as many as 5,000 people gathered in the tent on opening day. The assembled crowd listened to speeches emphasizing Litchfield's progress from a backwater town to a center of education, enterprise, and trade. Most speakers focused on the biographies of men deemed significant to the county's history: its military leaders and judges, its doctors and lawyers—the sorts of men, in fact, who

:he L. L. Bean catalog. Nineteenth-century :complicated realities of the country's history.

By Laurel Thatcher Ulrich

DANA SALVO; SOCIETY FOR THE PRESERVATION OF NEW ENGLAND ANTIQUITIES

There are more than 500,000 stitches in a "chimneypiece" embroidered by Eunice Bourne, daughter of a well-to-do eighteenth-century Cape Cod merchant. Only the daughters of the gentry had the leisure to embroider such elaborate scenes.

marched in the centennial parade. The speakers acknowledged the "fair daughters of Litchfield County" with a few lyrical asides. Judge Samuel Church praised the hardworking colonial wives "to whom the music of the spinning-wheel and the loom was more necessary than that of the piano and the harpsichord." Poet and wit John Pierpont also gave brief mention to the ladies, assuring them that their housekeeping talents were valued and that they, too, had been beneficiaries of progress. In a particularly enthusiastic passage, he described an exhausted colonial housewife sitting slumped beside her wheel, "a heap of cotton lying by her side," when suddenly the steam from her boiling teakettle rose, took the form of an angel, and spoke:

Woman, fear not, for thou shalt see the day,
When I, yes I, the vapor that I seem,
Of fire and water born, and baptized Steam,
Will save you all this labor

There was no hint in Pierpont's poem that, even as he spoke, 40,000 women labored in New England's textile mills. In his view, steam, not workers, produced calico.

At half past ten on the celebration's second day, the procession formed once again, with a new orator, the Reverend Mr. Horace Bushnell of Hartford, at its head. A handsome man with a large head and a shock of dark hair, slightly silvered, he was about to surprise his audience. Taking as his text Proverbs 31—the chapter describing the virtuous woman who "layeth her hands to the spindle"—Bushnell proposed that the first century of Litchfield County's history be called "the Age of Homespun." He used the craft of cloth making—a subject

BY JARED B. FLAGG (BEFORE 1850); THE WADSWORTH ATHENEUM MUSEUM OF ART. ENDOWED BY C. N. FLAGG & CO., 1850.10

LITCHFIELD HISTORICAL SOCIETY, LITCHFIELD, CT

Connecticut's Litchfield County celebrated its centennial, below, in 1851. Speaking at the celebration, Horace Bushnell, right, asserted an idealized vision of colonial household labor.

ourables, the Governors, or even of the village notables called Esquires, that mark the springs of our successes and the sources of our distinctions. These are rather effects than causes; the spinning-wheels have done a great deal more than these."

In the colonial Litchfield of Bushnell's imagination, there were neither rich nor poor, and few distinctions among neighbors. Within the family, both sexes did essential work. Fathers "climbed among these hills, with their axes, to cut away room for their cabins and for family prayers," and "mothers made coats, every year, like Hannah, for their children's bodies, and lined their memory with catechism." Bushnell celebrated both the anonymity and the dignity of those he considered the true founders of Litchfield County. "Who they are by name we cannot tell—no matter who they are—we should be none the wiser if we could name them, they themselves none the more honourable. Enough that they are the King Lemuels and Queens of Homespun, out of whom we draw our royal lineage." Bushnell's allusions linked Litchfield's pioneers to ancient textile traditions and Old Testament piety: Hannah was the mother of the prophet Samuel; King Lemuel was the assumed author of Proverbs 31.

Bushnell's vision was part myth, part history. Much of what he said was based on his own memories. He had grown up in a cloth-making family. His mother had spun and woven flax and wool; his father had operated a wool-carding mill and a shop for pressing and dyeing homespun cloth. When Bushnell described people wearing coats made from "sheep individually remembered," he was surely talking about his own childhood. His description of young "Queens of the spindle" agree-

In colonial America, making cloth at home complemented rather than replaced foreign imports. Those who could avoid it, did.

that had been mere miscellany in the judge's discourse and an object of humor and pathos in Pierpont's poem—to challenge conventional ideas about history.

The causes of a nation's greatness, Bushnell argued, had never been recorded and perhaps never could be, certainly never in the deeds of famous men. He told his audience not to go into burying grounds looking for tall monuments to important people. "It is not the starred epitaphs of the Doctors of Divinity, the Generals, the Judges, the Honing to "join works" in cooperative spinning, "enlivening their talk by the rival buzz of their wheels," was based on recollections of gatherings he had himself witnessed. His descriptions can be corroborated in hundreds of historical records. In Bushnell's childhood, cloth making really was a cooperative enterprise, a neighborly as well as a household activity, and women were at the center of production.

But the system Bushnell remembered was neither as old nor as innocent as he portrayed it. The colonists who came from East Anglia to New Eng-

CONNECTICUT HISTORICAL SOCIETY, HARTFORD, CT

In colonial New England, embroidered bed rugs were a perfect example of the union of industry and refinement. In the late 1700s, using homespun, home-dyed yarn, and a design she may have drawn herself, Betty Foot of Colchester, Connecticut, embroidered the covering at left in preparation for her marriage. Foot was a teacher with a small income of her own and was the daughter of a prosperous farmer, but she still spent much of her time engaged in household chores, including a daily regimen of carding, dyeing, sewing, and knitting.

land in the 1630s left behind a sophisticated manufacturing economy in which men, not women, did the weaving. In the New World, weaving became first a marginal enterprise and then, as it lost commercial value, a domestic occupation. English weavers had been apprentice-trained male artisans; their colonial successors were women and girls who produced simple fabrics for household use. Making cloth at home was a way to complement rather than replace foreign imports, and those who could avoid it, did.

Politics changed the meaning of household production. In the 1760s, Britain's effort to tax the colonies provoked boycotts of British manufactured goods, and once-anonymous spinning gatherings became front-page news. "I presume there never was a Time when, or a Place where, the Spinning-wheel could more influence the Affairs of Men, than at present, in this and the neighboring colonies," exclaimed one writer. A concern with the political meaning of women's work continued in the early republic as Jeffersonians and Hamiltonians debated the virtues of commercial manufacturing and as new agricultural fairs began to display

SUZANNE BROWN ANDERSON

Patty Sessions began her linen sampler, right, as a Maine schoolgirl but put it aside when she married. She finished it nearly forty years later, in 1848, after moving to Salt Lake Valley with one of the earliest companies of Mormon pioneers. By then, her husband had taken a second, younger wife. The sampler's idyllic imagery, with its portrayal of a couple standing side by side surrounded by fruit trees, is at odds with the facts of Sessions's own difficult life. Two years after arriving in the Salt Lake area, her husband died, leaving her to care for the younger wife and the children.

dians for possession of the land. As trees fell, displaced tribes moved north, allying with the French in the Anglo-French wars that ravaged northern New England throughout the colonial period. The English conquered North America with spinning wheels as well as with guns. In a fractious frontier world, early settlers' willingness to stay put, cultivate flax, pasture sheep, and establish sons and daughters on new farms was as essential to English victory as was the raising of armies. Long after the end of these wars, New England's farmers were turning up Indian bones with their plows.

For people caught in the march of mechanization, antique scraps of cloth evoked a world that seemed simpler and more authentic.

women's work. In addition to tallying the nation's inhabitants, the federal census of 1810 counted the spinning wheels, looms, and yards of cloth in its rural households. In the period leading up to the War of 1812, political leaders revived the rhetoric of revolution. A Massachusetts writer publishing under the pseudonym Dorothy Distaff insisted that America needn't go "cap in hand" to England, because the women of New England would "pledge our spinning-wheels (of ten times more value than all the wheels within wheels at Washington)" to produce all the cloth the nation needed.

Household production soared in this period, not because women were willing to work harder but because water-powered carding mills, such as the one operated by Horace Bushnell's father, had taken over the arduous task of preparing wool for hand spinning and because home weavers could now supplement their hand-spun yarn with factory-spun cotton. Bushnell was right, then, in emphasizing the importance of household production in early Litchfield, but wrong in imagining a pristine colonial society untouched by change.

He also ignored the dark underside of his region's history. The Litchfield fathers who carved out farms with their axes also fought American In-

From the beginning, cloth making was also implicated in the expansion of New World slavery. The ships that carried New England lumber and fish to the West Indies brought back cotton as well as sugar. Both of these products were dependent on the labor of slaves bought in Africa and sold in the Caribbean. As early as the middle of the seventeenth century, the colonists were spinning West Indian cotton. By the 1760s, 70 percent of the cotton shipped to mainland North America from the Caribbean was slated for the New England market. Most of this cotton was spun and woven by household weavers. There never was a time when the residents of New England were disconnected from the larger Atlantic economy.

But all this seemed forgotten by the time Horace Bushnell gave his speech at the Litchfield centennial. As redbrick factories, railroads, and non-English immigrants transformed the nation, the mystique of homespun spread. For a people caught in the march of mechanization, antique tools and scraps of old fabric evoked a world that seemed simpler and more authentic than the one they knew. Old things validated the claims of those who considered themselves the true heirs to New England's history. During the Civil War, antique spin-

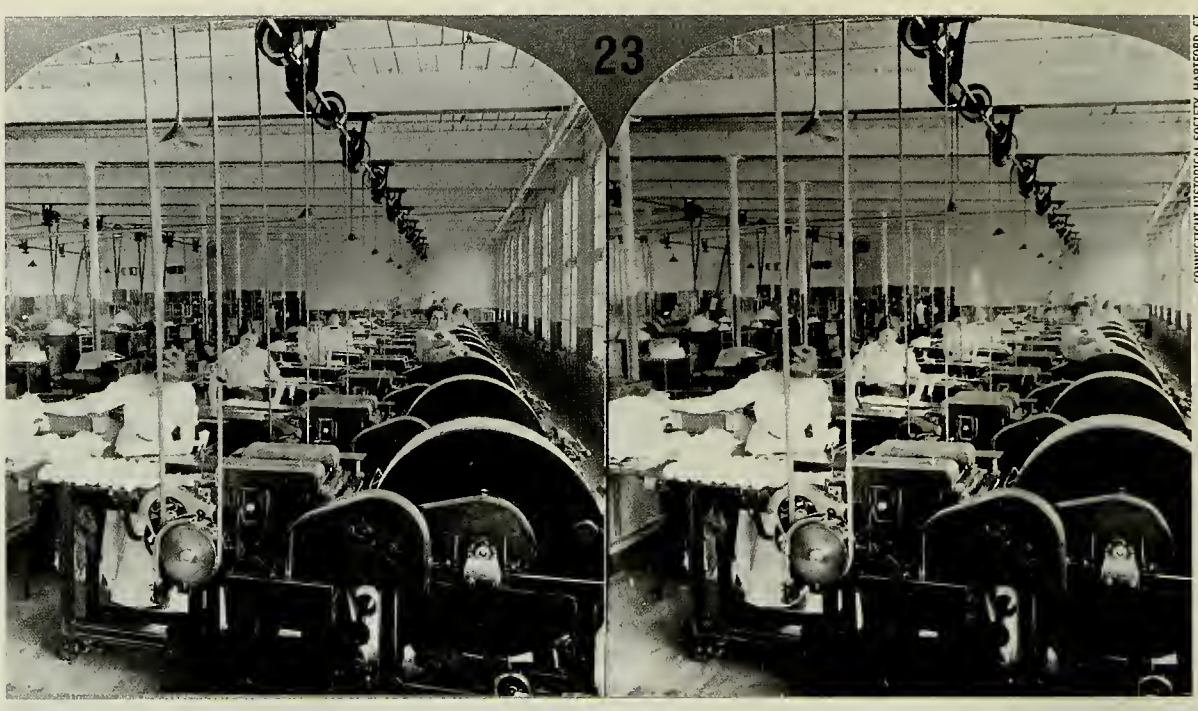
ning wheels appeared in fund-raising fairs from New York City to Saint Louis. A "New England kitchen," complete with demonstrations of carding and spinning, was a popular feature at the Philadelphia Centennial Exposition of 1876 and at the World's Columbian Exposition of 1893, held in Chicago. By the end of the century, spinning wheels could be found in the newly restored house of George Washington at Mount Vernon and in the mansion of a Montana mining magnate, at the headquarters of the Sequoia Chapter of the Daughters of the American Revolution in San Francisco and at Hull House in Chicago.

To secure their connection to the colonial past, Americans rummaged through attics and old trunks, labeling hundreds of objects ostensibly made by colonial grandmothers—sheets, pillowcases, tablecloths, napkins, towels, quilts, blankets, grain bags, handkerchiefs, aprons, coverlets, and more. The mystique of homespun attracted social reformers as well as conservatives, academic artists such as Thomas Eakins as well as popular illustrators. (Eakins's sister even took spinning lessons so she could model for him. In 1881 he featured her in two watercolors, *Spinning* and *Home-spun*.) Antiquarians, novelists, interior designers, settlement-house workers, museum curators, social theorists,

HILLEL BURGER, PEABODY MUSEUM, HARVARD UNIVERSITY

BURT GLINN, MAGNUM PHOTOS

Indian baskets were as much a part of colonial households as were spinning wheels, but few collectors paid much attention to them until the late nineteenth century. A wall pocket, left, made by Maliseet basket maker Agathe Athanase for the 1893 World's Columbian Exposition in Chicago, commemorated the skill of early basket makers. It included, in addition to various compartments, forty-five tiny baskets and twenty ash-splint flowers. Below left: Handmade objects continue to have a strong appeal, often providing a comforting sense of connection to an imagined simpler, and perhaps safer, past. AIDS quilts on display in Washington, D.C., in 1996 drew large crowds.



CONNECTICUT HISTORICAL SOCIETY, HARTFORD, CT

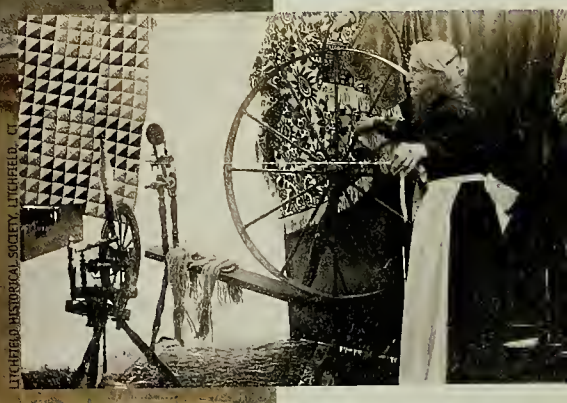
This 1910 image of a textile factory in South Manchester, Connecticut, was meant to be viewed through a stereoscope. From the mid-nineteenth century on, cloth making by women was more likely to take place in a factory than at home. At the same time, the popularity of homespun articles grew, partly as a response to the increasing mechanization of the workplace.

During the late nineteenth century, the mystique of homespun attracted artists, writers, designers, and social activists of all stripes.

architects, genealogists, entrepreneurs, journalists, political conservatives, and radicals joined in the frantic pursuit of the lost relics of colonial households. The mythology of household production gave something to everyone. For sentimentalists, spinning and weaving represented the centrality of home and family; for evolutionists, the triumph of civilization over savagery; for craft revivalists, the harmony of labor and art; for feminists, women's untapped productive power; for antimodernists, the virtues of a bygone age.

When Horace Bushnell selected Proverbs 31 as his text, he was connecting his memories of Litchfield to an ancient and enduring tradition. Hovering around Bushnell's sermon were the echoes of the aristocratic pastoral. Privileged people in many centuries have imagined the pleasures without the muck and labor of country living. Pastoral celebrations of homespun were a convention in English and continental aristocratic painting and poetry. A hundred years before Bushnell gave his speech, New England girls were embroidering frolicking lambs and winsome shepherdesses on needlework pictures and samplers. In America, however, politics transformed pastoral affectation into a vision of a democratic republic sustained by rural virtue. The rhetoric of the American Revolution and of the War of 1812 emphasized household production both because it was an essential part of the nation's economy and because images of industrious, self-sacrificing, patriotic women softened the often harsh realities of political conflict, economic uncertainty, and war.

The vision lives with us still. Inherited ideals of rural life survive in children's books, craft shows, and the names of suburban streets. The Age of Homespun haunts public discourse in debates over family farms, anxieties about the deterioration of family values, and invocations of lost community. When AIDS activists organize a national quilting bee, when evangelical writers celebrate home schooling, when the First Lady proclaims that it takes a village to raise a child—they are all creating new versions of the American pastoral. The mythology of homespun persists because it is adaptable to so many political persuasions and also because it allows us to forget that greed and war have been a part of U.S. history. Horace Bushnell was surely correct when he argued that ordinary people make history through the smallest acts of everyday life. But people make history not only in the work they do and the paths they follow; they also make history through the things they choose to remember. □



Left: Famed Philadelphia artist Thomas Eakins's 1881 watercolor *Homespun* depicts a bygone age. The painter had his sister take spinning lessons so that her pose would seem more authentic.
Below: Forty years later, at Litchfield town's bicentennial, a woman dressed in colonial garb gave a spinning demonstration.

The tastes of two small rodents—the meadow vole and the white-footed mouse—can determine what trees grow in a forest. ***By Richard S. Ostfeld***

Little Loggers Make a Big Difference

A hundred years ago in the northeastern United States, farms covered one-half to three-quarters of what is today forested land. But working the thin, rocky soils of the Northeast was a marginal existence, and after the opening of the Erie Canal in 1825, farming shifted to the more fertile ground of the Ohio River Valley and the Midwest. Since then, northeastern woods have been regrowing—creating new habitats for forest wildlife, satisfying a human yearning for unmediated natural beauty, and possibly even helping to reduce global warming (young trees have enormous potential to remove carbon dioxide, the primary greenhouse gas, from the atmosphere by capturing the carbon in their burgeoning tissues).

But while some tracts of abandoned farmland became overgrown with woody plants in only a few years, others resisted colonization by trees for decades, and scientists eventually began to wonder what accounted for the difference. The wind would have blown in myriad seeds from the maples, pines, ashes, and other trees bordering all of these "old fields"; were quick-growing grasses outcompeting tree seedlings by creating too much shade and appropriating the available water and nitrogen? Two plant ecologists in upstate New York tried to test this supposition in the 1980s by planting seedlings in areas dense with grasses as well as in areas dominated by taller, slower-growing herbs such as goldenrod—only to have some mysterious nocturnal visitors clip the seedlings, killing them and ruining the experiment. A bit of detective work revealed the unexpected culprits: meadow voles *(Microtus pennsylvanicus)*, small herbivorous rodents that are ubiquitous in North American old fields. The ecologists promptly fenced out the pesky saboteurs and resumed their investigation of plant competition.

Voles are common denizens of virtually every habitat (other than dry desert) in the temperate, boreal, and arctic zones of the Northern Hemisphere. Of the roughly 120 species of voles worldwide, about a dozen are notorious for their boom-and-bust population fluctuations; one of these is the meadow vole. But unlike the populations of some of their more famous relatives (more famous to ecologists, at least), whose population fluctuations follow a regular, three-year cycle, some meadow vole populations irrupt sporadically and others almost always stay high or low. Biologists interested in the radical population swings of voles and their close relatives, the lemmings, have focused almost exclusively on why such fluctuations occur rather than on what the wider impact is. Hearing of the devastation of the researchers' experimental tree seedlings by marauding rodents, my plant ecologist colleague Charles Canham and I decided to investigate whether the fluctuations in vole populations might be important in determining when and whether tree seedlings are able to invade old fields: we wondered whether trees can establish themselves only when the voles go bust. If so, it could be that the old fields that resist tree invasion for decades are those in which the vole populations are chronically high,

DWIGHT R. KUHN

Red maple seedlings, opposite, are inviting targets for a hungry meadow vole like the one below. Several weeks old, this rodent has most likely already reached maturity.

and those that get overgrown quickly are able to do so because their vole populations crash frequently.

Canham and I established nine enclosures in a grassy field on the grounds of the Institute of Ecosystem Studies in Millbrook, New York. We chose a typical northeastern hayfield—habitat that's wonderful for voles but also likely to get rapidly overgrown if left unmown. The enclosures were each about a third of an acre, and wire-mesh fencing more than three feet high kept all but the most intrepid voles from moving between them. For two years we kept track of the populations every other week by livetrapping and marking each individual with a numbered ear tag. Within each enclosure, we kept the vole population at one of three density levels: about 400, 175, and 80 voles per hectare. We chose such distinct levels to match what happens naturally. To maintain these vole densities over the course of the experiment, we had to keep removing individuals from the lower-density enclosures. (We released these animals in another field about a mile away. Some voles, we learned, can navigate their way home from this distance—even wading through streams, crossing paved roads, and scaling fences to get there.)

Inside the enclosures we planted small seedlings of several tree species that commonly colonize old fields in the eastern United States, Quebec, and Ontario, and we monitored their fates for up to a year. In that time, the densest vole populations eliminated about 95 percent of seedlings, whereas medium- and low-density populations killed about 80 and 65 percent, respectively. The voles, it turned out, preferred red maple, white ash, and tree-of-heaven seedlings and turned up their noses at those of white pine and red oak. Such high levels of destruction, combined with such clear food preferences, suggest that these animals control the species composition of regrowing forests.

Were the voles searching for food—or managing their habitat by keeping woody plants out of the grassy fields?

VIRGINIA P. WEINLAND; PHOTO RESEARCHERS, INC.

TOM MCHUGH; PHOTO RESEARCHERS, INC.

Home and away: The entryway to a meadow vole's nest, right. "Runways" dug by voles, below, leave a lasting impression on their grassland habitat.

Seedlings killed by voles are easy to identify: the stems are clipped near ground level, leaving tiny, diagonally cut stumps. We were puzzled to find that about a third of the clippings went uneaten and were left to rot. Were the voles not searching for food but instead managing their habitat by keeping woody plants from invading the grassy fields that voles prefer? After all, other animals appear to engineer their environment for their own future benefit—beavers create wet meadows by damming streams, elephants aid grasses by destroying savanna trees. But individual beavers and elephants live long enough to benefit from the work, so the evolutionary rewards plausibly outweigh the costs. A vole lives no more than a year, and it is hard to

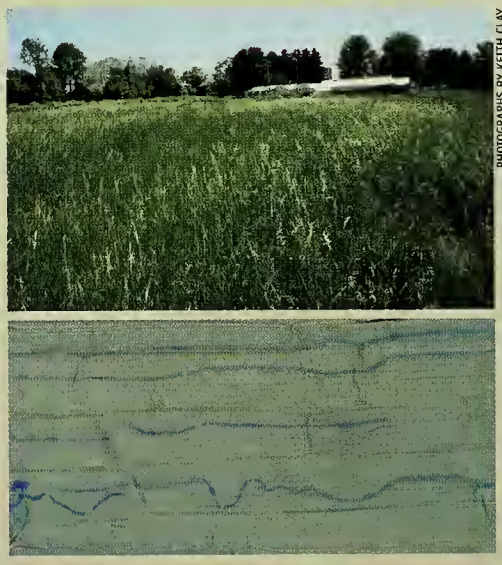
The Fescue, the Fungus, and the Prairie Vole

The prairie vole *(Microtus ochrogaster)*—a close relative of the meadow vole and one of North America's most prolific mammals—lives in the grasslands of the central United States, building elaborate paths and fibrous nests under the elfin canopy. Tall fescue, a vigorous Old World grass introduced to the New more than a century ago, now reigns over much of this region. Farmers and others planted it widely in the Midwest and Southeast, where it invaded natural communities and displaced native species. Its success results in part from its beneficial relationship with a fungal endophyte—a symbiont living within the plant—that was discovered and quickly forgotten in New Zealand in the 1940s and then redescribed by Charles W. Bacon and colleagues at the USDA's Agricultural Research Service and the University of Georgia in the mid-1970s. They found the fungus after noting that cows grazing on tall fescue were prone to infertility and spontaneous abortion; the endophyte produces toxic alkaloids that sicken and thus discourage grazers, allowing the grass to grow unmolested (see "Trespassers Will Be Poisoned," September 1989).

In 1994, aided by a small army of undergraduates, researcher Jennifer Holah and I planted a series of plots at Indiana University with either infected or uninfected tall fescue to determine how the endophyte affects competition between the grass and other plants. Compared with the plots planted with fungus-free grass, the plots containing the endophyte had fewer different plant species, and tall fescue accounted for a higher proportion of the individual plants. However, we didn't know why.

For some time, I had been noting dead patches of tall fescue in my research plots. I thought they were succumbing to disease, so I decided to show them to a colleague. To my surprise, the whole mass of dead leaves lifted cleanly off the ground. The grass had been cut near ground level as if with a machete. My colleague, Gary Fortier, of Delaware Valley College, quickly recognized this as the work of voles. I was also puzzled by the toothpicklike segments of grass stems littering our plots, until another small-mammal ecologist explained: Voles like to eat the succulent, nutritious tips of leaves, not the tough bases, but getting hold of leaves twenty inches off the ground requires some effort for a creature that's only two inches high. To feed, a vole bites a stem off at the bottom, pulls it downward, bites off a piece and discards it, pulls the stem down farther, bites off another piece, and so on, until the good parts are within reach. Like the cartoon carrots pulled down into Bugs Bunny's burrow, the grass is eaten from the bottom up.

Although, as a botanist, I have tended to discount mammals as minor components of most plant communities, my research team expanded our study to look at how tall fescue's endophyte might affect vole populations. In the first year, vole density started out low and increased quickly. We found a significantly higher proportion of male voles in endophyte-infected plots than in uninfected ones, suggesting that female voles were avoiding the infected fescue. In the second year of our study, as the population became denser, the ratio between males and females in infected areas evened. Perhaps increasing competition for food and territory had forced females into less desirable habitat. Females in infected plots were older and bigger when they began to reproduce than were their counterparts in uninfected plots; ingesting the fungus seemed to delay puberty.



PHOTOGRAPHS BY KEITH CLAY

Tall fescue grass, top, and the fungus within it, below

When vegetation is lush and prairie vole populations are small, little prevents the voles from increasing rapidly. But as their numbers rise, so does competition for the best food plants or, indeed, for any plants whatsoever. Though the voles prefer uninfected tall fescue, they do eat other grasses while trying to avoid the infected plants. In our infected plots, the proportion of tall fescue plants rose as the vole population—and hence the consumption of other grasses—increased. The opposite occurred in uninfected plots. Voles, then, are unwitting accomplices in tall fescue's competitive strategy: the fungus redirects the rodents' appetite toward other plants, sparing its host the cost of being eaten and also eliminating the competition.—*Keith Clay*

S. T. A. PICKETT/BUELL-SMALL SUCCESSION STUDY; I. E. S.

S. T. A. PICKETT/BUELL-SMALL SUCCESSION STUDY; I. E. S.

Good vole habitat, the field above has been clear for about a year and is dominated by plants such as mustard and foxtail grass. The "field" at right, after twenty-eight years of regrowing, has been overrun by red maple.

imagine an individual vole reaping much benefit from killing a several-inch-tall seedling that is years away from shading out grasses and eliminating vole habitat. Only if the voles' descendants, several generations later, lived in the same area could there be an evolutionary benefit from clipping seedlings, and the propensity of the voles' offspring to disperse makes that unlikely. Perhaps, we speculated, voles constantly explore potential new foods, and the few surviving seedlings belonged to species that proved bad tasting.

If noxious taste might protect seedlings, what else would have the same effect? Canham and I tried our best to think like meadow voles. We knew that various hawks, owls, snakes, and mammals prey on the voles and that these rodents have a number of adaptations to compensate for their popularity as food. One is reproductive—females reach sexual maturity at three to four weeks of age and become sexually receptive within a day of giving birth. One litter of approximately four to five young is suckled while the next brood is gestating. Other adaptations include selecting safe haunts and being discreet. It's easy for vole aficionados to impress the uninitiated by predicting which spots in a field are best for finding voles: simply parting the tallest, densest patches of grass will more than likely reveal vole feces, as well as small piles of grass clippings characteristic of vole activity (see "The Fescue, the Fungus, and the Prairie Vole," page 67) and narrow "runways." In shorter, sparser vegetation or near the bare dirt around woodchuck or gopher mounds, such signs will be rare. Canham and I planted seedlings down the middle of small clearings that were intended to simulate woodchuck mounds or other disturbances; in keeping with our expectations, the voles almost never touched these seedlings, even when their populations were quite dense. Lingering in the open, it seems, is not worth the risk of being killed by a sharp-eyed predator, especially an aerial one.

Tall grass is no perfect refuge, however. Mammalian carnivores such as weasels and foxes catch voles by chasing or pouncing and are probably just as dangerous in dense cover as in sparse. Perhaps, I thought, mammalian predators indirectly protect tree seedlings in all habitats—not just in clearings—by trimming the vole populations or at least scaring them into inactivity. My colleague Jyrki Pusenius and I got the idea of tricking the voles into perceiving that they were in danger. We created an audiotape with the sounds of a weasel calling and a weasel catching a vole. With speakers wired to a van parked on the study site, we played the tape every night for two weeks inside some of the enclosures while we monitored the fate of seedlings. To our amazement, voles clipped more seedlings in enclosures where they heard taped weasel sounds than in those where no tapes were played. The same thing happened when we placed a caged weasel inside one enclosure. And neither the feces of bobcats nor the urine of foxes, coyotes, and bobcats discouraged voles from attack-

ing seedlings. The smells of these predators had no more effect than the odor of dilute vinegar. Only when these carnivores actually *eat* voles do they become accidental allies of the little trees.

Most of the trees that invade old fields have fairly large seeds that don't fall far from the parent plant. Even maple and ash seeds, with their helicopter-like samaras, may float only a few dozen yards on the wind, while larger seeds, such as acorns, beechnuts, and hickory nuts, drop like stones. (Exceptions do exist: tiny, winged aspen and birch seeds may float thousands of yards, and cherry and red cedar seeds are swallowed by fruit-eating birds and defecated at some distant spot.) Because of this modest dispersal distance, the invasion of old fields by trees usually proceeds most rapidly near forest edges, where the influx of seeds can be tremendous. Several colleagues and I therefore decided to establish our next generation of experiments at the boundary between forests and fields. Two students, Robert Manson and Jaclyn Schnurr, had already demonstrated that the ubiquitous white-footed mouse is a seed predator extraordinaire, and we thought that mice and voles might provide a one-two punch that could undermine tree colonization of old fields. While meadow voles rarely leave grassy fields to enter forests, white-footed mice are generalists, preferring forests but frequenting old fields as well.

Tall grass is no perfect refuge for voles. Weasels and foxes, which hunt by pouncing and chasing, can catch voles anywhere.

DAVID LIEBMAN

The white-footed mouse, left, and the meadow vole, below, reproduce frequently and prolifically, adaptations that helps keep them a step ahead of their many predators.

DWIGHT R. KUHN

This time, our enclosures extended five and a half yards into the forest and thirty-eight yards into the field. Each enclosure had three walls and was open on the forest side. We suspected that the voles would treat the forest edge like a fourth wall but that the mice would freely enter the old fields. Again we created vole populations of differing density levels. As before, attack rates on tree seedlings correlated well with vole density. However, we found that wherever vole density was high, mouse density was low, and wherever we kept voles scarce, mice thrived. We don't know exactly how voles deter mice, but we suspect that voles, which are twice the size of mice and about ten times as pugnacious, may attack and chase any mice they encounter. Whatever the mechanism, the result was that enclosures with a high vole density had low seedling survival but high seed survival, whereas those with a low vole density had good seedling but poor seed survival.

A crucial twist is that not only do voles eat seedlings while mice eat seeds, but voles and mice have different food preferences. Mice avoid the smaller and less protein-rich seeds of maples, ashes, and trees-of-heaven but devour the larger, more nutritious seeds of pines and oaks. Pines and oaks, then, should invade old fields dominated by voles (assuming that parent trees reside somewhere nearby), and maples and ashes should colonize old fields dominated by mice. But since few, if any, long-term records are available to tell us which types of old fields each animal inhabits, testing this expectation is difficult.

A weasel, below, indirectly protects seeds and seedlings only when it catches and kills rodents. Death from above: An American kestrel, opposite, swoops down on a vole.

STOUFFER PROD./ANIMALS ANIMALS

However, because we maintained the high and low vole population levels within our three-walled enclosures for about four years, we were able to observe which species of rodent had the stronger net impact on tree invasion. Manson surveyed all the experimental plots and found very few naturally occurring seedlings where voles were abundant and

When mice dominate a field, pines and oaks can't grow there; voles prevent maples and ashes from colonizing.

mice were scarce. On the other hand, many more natural seedlings flourished where voles were kept rare and mice were plentiful. It makes sense that, as seedling predators, voles have a greater impact on tree regeneration than do seed-eating mice. Any individual forest tree can produce tens of thousands of seeds (or more) in any given autumn, and even if the mice consume 95 percent of those seeds, a healthy number of seedlings could survive. On the other hand, after everything else that may kill seeds—fungi, bacteria, insects, birds, mice, infertility—has had its way, far fewer seedlings than seeds will be present. So a dense vole population that kills almost every tree seedling can strongly inhibit the regrowth of forests.

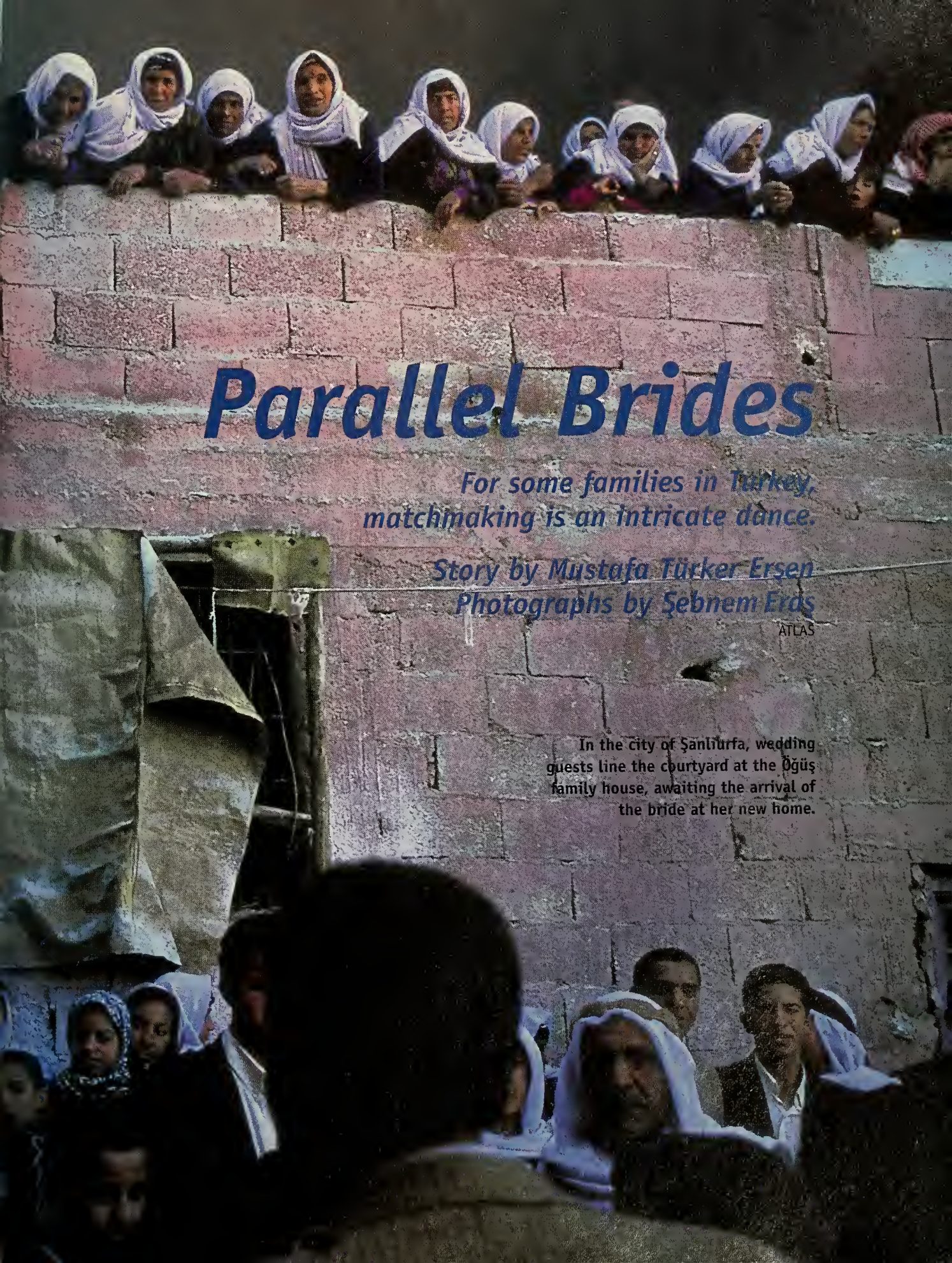
The life of the meadow vole has wider implications than I suspected the first time my cat bestowed upon me a small, brown, and very dead one. Its targeting of seedlings has prompted some utilities, as an alternative to using herbicides or machinery to control trees, to look into making their power-line corridors favorable to voles. These rodents also play a strong role in preserving attractive vistas and maintaining the open habitats favored by such other wildlife as deer, turkeys, woodcocks, and bluebirds. And meadow voles, by excluding white-footed mice from some habitats, may reduce the risk of Lyme disease, which is carried by ticks that feed off (and are infected by) these mice. Nearly omnipresent, these voracious killers of tree seedlings might even affect the global climate by delaying or preventing the expansion of woods at a time when the absorption of carbon would be very helpful. All these wider implications are nearly invisible—until you push back the tall grass and have a look. □

Parallel Brides

For some families in Turkey, matchmaking is an intricate dance.

Story by Mustafa Türker Erşen
Photographs by Şebnem Eraş

ATLAS



In the city of Şanlıurfa, wedding guests line the courtyard at the Öğüş family house, awaiting the arrival of the bride at her new home.

Villagers in southeastern Turkey fire shots, below, to celebrate the exchange of brides that will link two families in a reciprocal marriage arrangement called a *berdel*.

It is a bright Sunday in the tiny Arab village of Lower Arbit in southeastern Turkey. Cheerful melodies issue from a cassette player powered by a tractor battery. I watch as Nuri and Türkân, brother and sister, join the snaking line of the *halay* dance in front of their house, over which flies a Turkish flag. Meanwhile, a few miles away, in the village of Mengalan, a similar scene must be unfolding for Mehmet and Feride, who are also brother and sister. All four are to be wed today: Nuri to Feride, and Mehmet to Türkân.

Such a double wedding is known as a *berdel*, which in Kurdish means "in place of the one." Instead of paying the required bride-price to another family so that his son may have a bride, a father arranges to offer a bride from his own family in compensation. In Nuri's and Mehmet's cases, both fathers have a daughter of their own to offer, but if they didn't, they might have drawn upon a niece or other eligible female in the extended family. Whatever the arrangement, the actual exchange of brides is the most critical part of the process—as tricky as dropping off a ransom payment in return for a kidnap victim.

Right: Newlywed Nuri (left) stands next to his bride, Feride, whose brother Mehmet (right) has wed Nuri's sister Türkân.

Around noontime, two dust clouds appear on the horizon, both heading toward the designated rendezvous point midway between the two villages. The cars carrying the brides are approaching. Timing, as well as having an equal number of attendees, is crucial; the possibility that some slipup will cause one of the parties to cancel the deal inevitably creates a stressful atmosphere. There is only one way to overcome the tension—to be quick. The vehicles park side by side, the brides are hastily exchanged, and the cars head home to the waiting grooms. In both villages the women shout and pray when the bride arrives at her new home; that same day, an imam joins the couple in matrimony.

Instead of paying a bride-price so that his son can get married, a father offers a bride—a daughter or another eligible female in the extended family—to his prospective in-laws.

On maps of Turkey, the zone where Lower Arbit is located appears empty of inhabitants; it is a "government productivity farm," off-limits to settlement. Nevertheless, a few tiny villages cling to the rocky terrain. Electricity, schools, and other facilities are lacking, and the village residents, forbidden to grow crops on government property, must depend for their livelihood on herding sheep and other livestock. In this setting, where raising enough money for a bride-price can be difficult, a *berdel* can have practical advantages. But it is much more than an economic convenience. According to Serpil Altuntek, an anthropologist at Hacettepe

University in Ankara, "*Berdel,* cousin marriage, and similar arrangements are better viewed as part of a family's strategy to forge and maintain favorable political and economic alliances." The choice of spouse also contributes to the solidarity of the encompassing kin groups—lineage, clan, and tribe—which are the backbone of social life.

Berdel marriage is found primarily among Kurdish, Arabic, and Turkic peoples in what is now southern and southeastern Turkey. Altuntek points out that before the establishment of the Turkish republic in 1923, when new borders were drawn with Syria, Iraq, and other neighboring countries, these groups led a pastoral life that involved nomadic movements and social ties over a much wider region. Under the new national arrangements, most of the people who remained within Turkey's borders were obliged to take up a sedentary way of life, and many of their ties with distant allies were weakened or severed. "Nowadays," says Altuntek, "*berdel* and other close-kin marriages function as a means to re-create strong group ties." (Hacı Halef Varlı, a villager in Lower Arbit, tells me about his experience in the 1960s: It had been arranged for him to marry his mother's brother's daughter, who had emigrated to Syria. "We smuggled the brides over the border, to the east of Ceylanpınar," he recalls.)

The tradition of *berdel* crosses not only ethnic lines but also the urban-rural divide. When Ahmet Börek got married recently in the city of Şanlıurfa, sixty miles west of Lower Arbit, his sister married his wife's brother. "Through a *berdel* deal," I ask, "you had to marry a girl you only saw once before the wedding. Are you happy?" The twenty-three-year-old groom doesn't hesitate for a moment: "Yes," he answers. "I saw her. I liked her. In the old days, you did not even have the chance to see her."

Led by an aunt and an older sister, Feride arrives at her new home, where an imam will conduct her wedding ceremony.

A *berdel* in the city of Viranşehir. The automatic rifle carried by one guest, above, is a sign that he is an official village guard. Right: Guests at one of the paired weddings pin gifts of money on the groom.

Ahmet also observes that he had no realistic opportunity "to meet someone in a pastry shop," and adds, "If I had not accepted, my father would not have forced me to."

A go-between helped Ahmet Börek's family arrange the deal with a family from another clan, but this is not typical in *berdel* exchanges. Usually marriages are arranged within a clan, and the right to ask for a young woman as a bride traditionally goes first to the son of a brother of her father and then to the sons of other close relatives. Thus, the families are relieved of the burden of choosing. Pairings are sometimes made in childhood, so everybody knows who will be marrying whom. In any case, the elders have the final word.

From the point of view of the two couples,

however, the social arrangement can entail its own special pain. In theory and sometimes in practice, if one of the exchanged brides is divorced and sent back to her family, the other marriage will be undone. This possibility may act as a deterrent to divorce, especially as time goes by and children are born. Nevertheless, I hear stories of returned brides who subsequently wed other men but who still keep their ex-husbands' prayer beads as souvenirs, despite fearing the wrath of their new husbands should they be found out.

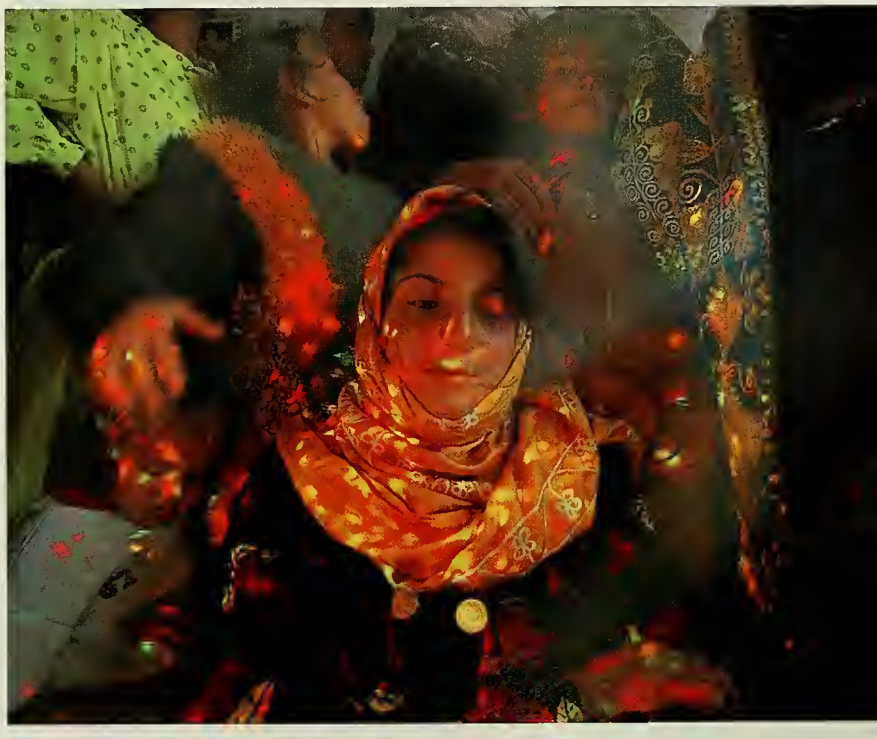
"Is it fair," I ask Ahmet, "to force a happy couple to break up their marriage because of an unhappy one?" But this is not uppermost in his mind. No matter how much he loves his wife, he tells me, he wouldn't think of letting a sister suffer in an alien home. "The brother is his sister's shadow," he says. "If not, who else does the sister have to depend upon?"

No official contract is involved, but in theory and sometimes in practice, if one of the exchanged brides is sent back home, the other marriage will be undone.

Still, there is a traditional way to keep the happy bride at home. The bridegroom may be willing to pay a bride-price to the bride's family in order to retain the right to keep her. (Even so, his own family may question this solution: "Those people did not want your sister," they might say, "so why should we keep their girl in our family?")

Most arrangements for bride-price or *berdel* bride exchange do not involve official contracts, and, particularly in rural areas, marriages may not be officially registered with the civil authorities. Under these circumstances, divorces and divorce settlements are usually a private matter. But if a dispute erupts into violence or a man is accused of harboring an underage bride (men and women may not legally marry before the age of eighteen), a case may wind up in court.

Aslan Veyseloğlu, a lawyer from Viranşehir, a small city north of Lower Arbit, gives me an example: A young couple eloped to get married. As a compensation for the loss, the young woman's family claimed a bride from the young man's family. Eventually, however, disagreements arose between the two families, and both brides were sent back. The case was taken to court. Finally, through the



Below: Celebrants at a *berdel* wedding in Viranşehir. Bottom: The *halay* dance.

Above: Veze, a bride, exits her car at the rendezvous place; in return, her family will receive Dürsün. Top: In her new home, with her trousseau, Dürsün awaits the wedding ceremony.

lawyers' assistance, the families reconciled and the brides were returned to their husbands.

The custom of *berdel* still seems secure in a vast region of Turkey. But this land—incessantly fought over in the past by Arabs, Safavids, Christian crusaders, people of all nations—is poised for change. Dams have had a positive impact on agriculture, industry, and trade. Labor is being redefined through the diversification of crops and the creation of more stable jobs. This economic awakening, in conjunction with new means of communication, is affecting education and values. Thousands of migrants from rural areas are now trying to create new lives in Şanlıurfa, which is becoming increasingly cosmopolitan. Still, even in Şanlıurfa, bride-price payments are not a thing of the past. Indeed, they start at nearly $2,000 and soar to $7,000 or more.

A pink flag flies over a house in one of Şanlıurfa's new districts, signaling that a wedding is taking place. The house belongs to sixty-year-old Kadir Yön, whose son Ahmet and daughter Veze will be part of a *berdel* marriage. Kadir, one of two chiefs of the Abuhamdan clan, sold his ancestral land about a decade ago and moved to the city. I wonder why he frets so much, why his eyes are misty. Is this simply a father's excitement, or could Kadir be feeling that the city wedding will lack the joy of a rural one? No black tents for feasts, no galloping horses in clouds of dust—not any longer.

The beat of the *dabla* drum may sound weaker in the urban setting, yet the celebration still has its special aura. Women dressed in festive outfits of velvet and silk, men in their everyday clothes and head scarves, and hundreds of children float through the streets from one wedding house to the other. In the house of the Öğüş family, with whom the *berdel* exchange is taking place, the noisy celebrants crowd into the courtyard. Both parties are close to the climax; the trousseau was sent long before, and the "henna night"—the women's evening of entertainment before the day of the wedding, when the bride has her fingers and toes freshly tinged with henna—has been celebrated already.

The moment of exchange is the most critical part of the process—as tricky as dropping off a ransom payment in return for a kidnap victim. It's best to be quick.

In the street where the Yön family lives, a long chain of men and women move to the rhythm of the *halay* dance. The dancers' faces do not reflect great joy; they

look as if they are only doing their duty. Suddenly the double-reed *zurna* and the *dabla* drum stop playing, and a wave of excitement surges through the crowd. Veze, Kadir Yön's daughter, comes out of the house and steps into the waiting car. An older brother will take her to the appointed place of exchange, where her brother Ahmet's bride, Dürsün, will be waiting.

We reach the site of the rendezvous, but there is no sign of Dürsün's car. Nobody looks worried about the delay, however, because the brides' families are close relatives. Then a convoy of several pink-flagged cars nears us, horns sounding. All of a sudden, the mood changes. The brother accompanying Veze shouts, "Back to the car! I am not giving the bride!" He is angry because it was agreed that each party would come in only one car, but here they are with a convoy! As the menfolk beg Veze's brother to keep calm, the convoy of cars passes us by, ignoring us. In a moment, everything is clear: the convoy belongs to another wedding. Soon we hear celebratory gunshots in the next neighborhood.

At last, Dürsün arrives. The two brides get out of their cars at precisely the same moment, and the exchange is made. Finally, everybody can take a deep breath and relax. And now comes the shooting of guns in the air for celebration, with a few shell cases spurting out toward me. I pick one up to keep as a souvenir. □

Dürsün, veiled, breaks a glass before entering her new home, to keep out any evil spirits.

THIS LAND

CARL KURTZ

Sedges grow in a boglike zone at Marietta Sand Prairie State Preserve.

Sands of Time

A small prairie that formed at the end of the Ice Age is an Iowa gem.

By Robert H. Mohlenbrock

I have taught several spring and autumn classes in the heart of Iowa, where the plants we studied inhabited wetlands, uplands, woods, and prairies, but when I first stepped onto the upper end of Marietta Sand Prairie, I knew I was in a unique place. This seventeen-acre state preserve, which lies seven miles northwest of Marshalltown, harbors a large and unusual selection of species.

Indian grass

GARRY BRANDENBURG

The main attraction is a sand prairie, which slopes gently down from the top of a small hill. About 12,000 years ago, when the last of the great glaciers were melting, strong winds picked up sand from the nearby Iowa River valley and blew it across the countryside. Where the sand hit elevated areas such as this hill, it created deposits as much as thirty-six feet deep. The sand in the Marietta preserve overlies an ancient soil surface so hard and dense that water cannot percolate through it. Water trapped in the sand slowly drains downhill to a small creek at the preserve's eastern end, which is about fifty feet lower than the hilltop.

Once the sand was in place, sand-tolerant species colonized it to create the prairie we see today. My first visit was in early May, when the ground was covered with delicately beautiful sand love grass, punctuated by bright yellow clusters of hoary puccoon and golden alexander. When I next visited, in September, the dominant grass had become the equally lovely prairie sandreed, above which grew other yellow-flowering species.

The sand prairie occupies the western half of the preserve, where the habitat is very dry and hot. But as the land slopes downward to the east, the impact of the afternoon sun lessens and the pure sand begins to peter out, allowing the soil to retain more moisture. Exploring this zone, I passed through a wet prairie, into which intrudes a small strip of aspen woods. I then entered a shallow, two-acre basin of extremely spongy terrain. In this boglike area, where the soil is too saturated for trees and most woody plants, a wet meadow has developed. Finally, reaching the small creek at the eastern border of the preserve, I came to a riparian woods. Perhaps the most surprising plant here was the crested fern, a species rare in Iowa.

HABITATS

Sand prairie. In May, sand love grass dominates, and the conspicuous wildflowers are hoary puccoon and golden alexander. Less conspicuous species are woolly plantain, wild four-o'clock, yellow stargrass, and false toadflax. By May, prairie pussytoes, one of the earliest bloomers, is already covered with its fuzzy fruiting heads. In September, prairie sandreed grass dominates, and prominent flowers are sawtooth sunflower, western sunflower, prairie sunflower, grass-leaved goldenrod, yellow coneflower, round-headed bush clover, white sage, rattlesnake-master, smooth beard-tongue, and horsetail milkweed. Other grasses and sedges that appear during the summer: switch-grass, little blue stem, Indian grass, Schweinitz's flatsedge.

Moist prairie. The transition into the moist prairie is heralded by scattered scouring rushes. Common species include Virginia mountain mint, perfoliate boneset, and New England aster. Here and there are small clusters

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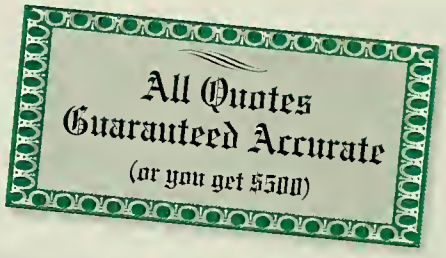

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of the shrubby meadow willow. Other wildflowers: bottle gentian, flat-topped aster, blue vervain.

Aspen woods. Quaking aspen is the dominant tree; others are roughleaf dogwood and wild black cherry. Because the aspens are crowded together, little light penetrates them, thus limiting the growth of understory species. A small grass known as white grass, which is related to the much larger rice cut-grass, is abundant. Wildflowers: bluntleaf bedstraw, woolly blue violet, cinquefoil.

Wet meadow. Early spring brings the bright yellow flowers of marsh marigold—followed, as the seasons progress, by woolly sedge, false nettle, swamp aster, water horehound, and swamp goldenrod. Marsh fern and the vinelike arrow-leaved tearthumb (with its bristles on the stem) are also common. Other wetland wildflowers: tussock sedge, a pink St.-John's-wort, giant water dock, willow herb.

Riparian community. American elm, honey locust, and box elder line the small creek, whose waters ultimately flow into the Iowa River. Prominent shrubs are swamp dogwood and elderberry. Other plants: crested fern, white turtlehead, clearwed, several species of smartweeds.

Robert H. Mohlenbrock, professor emeritus of plant biology at Southern Illinois University, Carbondale, explores the biological and geological highlights of U.S. national forests and other parklands.

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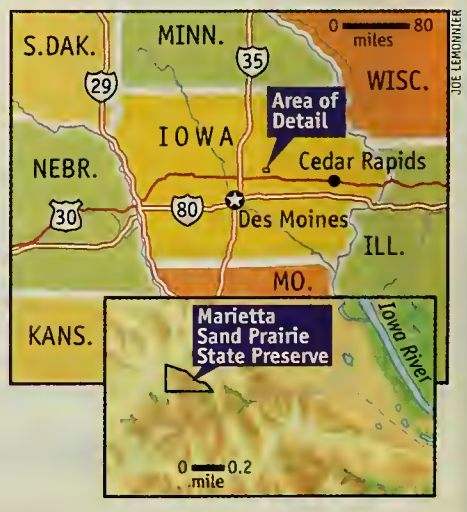
CARL KURTZ

The yellow blossoms of hoary puccoon peek out between spikes of woolly plantain. The pink blooms belong to wild four-o'clock.



JOE LEMONNIER

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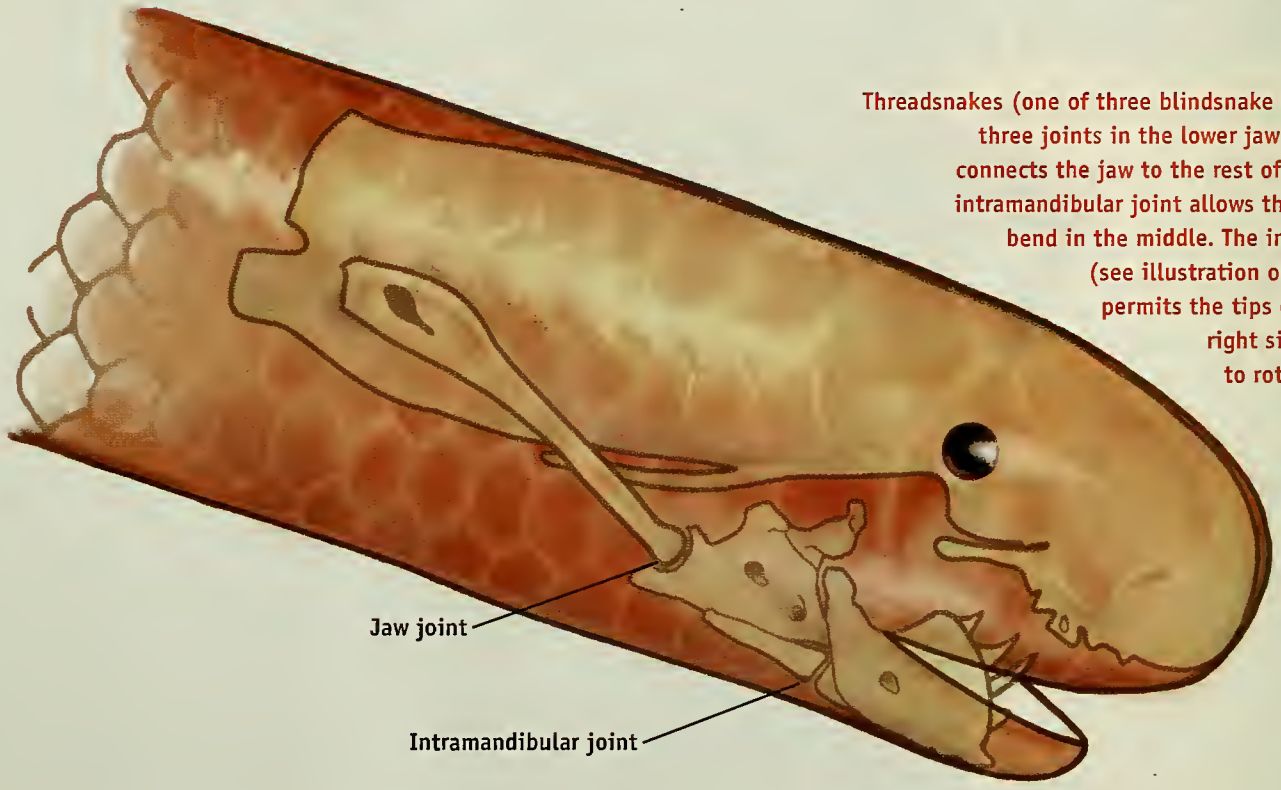
BIOMECHANICS

Fast Food Joints

Special hinges in their lower jaw enable some skinny little snakes to eat at an astonishing speed.

Story by Adam Summers ~ Illustrations by Sally J. Bensusen



Threadsnakes (one of three blindsnake families) have three joints in the lower jaw: The jaw joint connects the jaw to the rest of the skull. The intramandibular joint allows the lower jaw to bend in the middle. The interramal joint (see illustration on facing page) permits the tips of the left and right sides of the jaw to rotate relative to each other.

The eating habits of snakes have jump-started many a cocktail conversation among my (admittedly peculiar) circle of friends, and we are always fascinated by the extremes: the python that swallowed a deer, the bull snake that swallowed several lightbulbs, the odd little African snake that crushes bird eggs with special vertebral protrusions at the back of its throat and then regurgitates the shells. All these gustatory achievements are accomplished with deliberate slowness. Recent work on a group of snakes known as blindsnakes has revealed them to be eating champions of a very different sort. These snakes feed on smaller prey—the larvae, pupae, and adults of ants and termites—and they do so remarkably fast.

Found mostly in tropical and subtropical regions, blindsnakes are not well known because they are small and spend much of their lives hidden in underground burrows and foraging in ant and termite mounds. Their tiny eyes can tell light from dark, but little more. These snakes are roughly cylindrical, and if their small forked tongues didn't flick in and out, it would be hard to tell one end from the other.

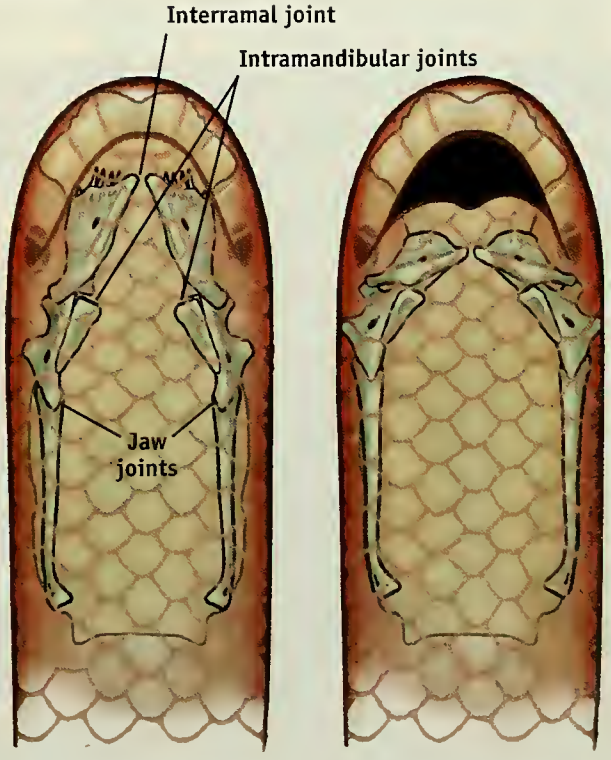
Ants and termites may be small, but they're not easy pickings. Armed with formidable tactical and chemical weapons, they will swarm an attacker. The "soldiers" of both groups have strong mandibles with which they can inflict a nasty bite. Many ants also sting, and some termites can shoot acid from their bulbous heads. To a blindsnake, an ant or termite nest is a huge, concentrated supply of food but also a serious danger, because given the chance, most colonies could rapidly kill and consume it (most blindsnakes are less than two feet long and thinner than a pencil).

To see the action, go to www.naturalhistory.com

These snakes are not entirely defenseless, however. Some blindsnakes have thick skin as well as scales so smooth that ant mandibles tend to slide right off. Others produce glandular secretions known to repel adult ants. But the snakes' best defense is simply to minimize the time spent exposed to attack. To do so, they pack in the pupae so fast that early researchers thought they must employ suction.

Most snakes use their upper jaw to move prey into their mouth, slowly "walking" first the left side and then the right side along the prey item, while their lower jaw slides along passively. Nate Kley, of the University of Massachusetts, has studied ingestion of prey in a family of blindsnakes that have teeth only in their upper jaw. While feeding, these snakes don't just move the upper jaw back and forth, they also rotate it rapidly and extend it partially out of their mouth. The upper jaw shoots in and out of the mouth up to ten times per second, one of the fastest repetitive feeding rates recorded for vertebrates. As a result, the snakes can rake in more than eighty pupae per minute.

Kley has also studied threadsnakes. This blindsnake family has teeth on the lower (rather than the upper) jaw and also an especially well-developed intramandibular hinge joint about halfway along each side of the lower jaw. This joint allows the jaw to bend in the middle, flexing back toward the gullet. (As in all snakes, the tips of the left and right sides of the jaw are connected by a flexible ligament.) A long muscle, running back from the jaw about a tenth of the snake's length, yanks the tips of the lower jaw back in less than one-sixth of a second (long muscles can shorten more quickly than short ones).



Left: When the snake is at rest, the teeth on its lower jaw (seen here from below) face forward and upward. When feeding, the snake is able—thanks to its three joints—to rapidly move the two sides of its lower jaw like swinging doors. (During the "in" swing, the teeth are not visible from below.)

Springy cartilage in the hinge joints and muscle that runs between the left and right sides of the jaw then snap the jaw back into position. Quickly repeating these jaw movements, the threadsnake ratchets the squirmy prey farther and farther down the hatch.

You can visualize the movements by holding your hands open, with the palms facing you and held at about eye level. Make sure your pinkies are touching. Then flex your wrists to bring your fingertips toward your chest. (If your fingers start to bend, try to keep them still—imagining them, if necessary, in little splints.) In this analogy, your forearms and hands are the lower jaw, your wrist joints the intramandibular hinges, and your fingers the teeth. Now picture doing that while hugging a pillow (a fat little larva), and you get an idea of what it must be like for a threadsnake to eat dinner.

Or look at it this way: to emulate the dining accomplishments of this skinny little snake, we would have to gulp down a whole ballpark frank or a large loaf of bread (depending on the species of blindsnake and the particular ant or termite). Consider Takeru Kobayashi, the world's champion hot dog eater, who ate fifty frankfurters in twelve minutes. A blindsnake could polish off a comparable meal in little more than thirty seconds, and if it continued eating for a full twelve minutes, it would consume the equivalent of more than a thousand of Nathan's finest.

Adam Summers is an assistant professor of ecology and evolutionary biology at the University of California, Irvine, and can fit a billiard ball in his mouth (asummers@uci.edu).

IN THE FIELD

Wanted: Secluded, Shady Nest, Streamside View

For a small forest bird, real estate may boost sex appeal.

By Peter J. Marchand

I followed quickly along the stream bank as the lanky figure ahead of me skillfully negotiated the undergrowth and low branches with the awkward tools of his trade. Carrying long bamboo poles over his right shoulder, with bundled mist nets hanging from them, the man looked like the classic hobo. But vagabond he was not. Bob Mulvihill is an accomplished ornithologist, and on that spring afternoon he was pursuing his newest discovery, charged with energy and anticipation.

Suddenly Bob stopped. Eyes fixed on a bird, he slowly lowered his gear to the ground with one hand while raising his binoculars with the other. In an instant the silence exploded. "Black-white-metal-black-orange," Bob shouted back to an assistant, reeling off the band colors on the bird's legs. "That's the polygynous male!" Banded the previous year, the bird had only recently returned from wintering grounds in Central America, and already it had been seen at an upstream nest. But here it was in the vicinity of a second nest, moving defensively and carrying an insect in its bill, as if it had fledglings in the immediate area.

The bird was a Louisiana waterthrush. Unusual among warblers in its preference for streams, this waterthrush is not restricted to the South, as its name might suggest, but can be found breeding throughout eastern U.S. deciduous forests. This species was thought to be strictly monogamous, as are the majority of perching birds, until Bob and his assistants at the Powdermill Biological Station in western Pennsylvania discovered the polygynous male. (Tim O'Connell, of Penn State University, made a similar observation in central Pennsylvania at the same time.) And like most such discoveries, this one was serendipitous. When the banded male was seen near a nest in what was thought to be another male's territory, Bob was immediately suspicious and began watching it closely. Within

ALVIN E. STAFFAN; PHOTO RESEARCHERS, INC.

Carrying an insect, a Louisiana waterthrush pauses at the entrance to its nest.

several days, he witnessed the bird setting up housekeeping with a second female downstream, so he and his assistants erected observation blinds near each nest. Soon they saw the male and the first female feeding young at the upstream nest, but a few days after these fledged, the same male turned up at the downstream nest to help a second female with newly hatched chicks there. Bob estimated that this male provided about 60 percent of the food for the upstream nestlings and about 25 percent for the downstream chicks.

By most counts, only about fifteen species of North American perching birds are regularly polygynous, with an equal number occasionally so. Unlike waterthrushes, most birds known to be polygynous breed in marshes, prairies, or savanna-like habitats. Red-winged and yellow-headed blackbirds are among the most familiar; males of both species maintain harems of up to eight females in prime wetland territories. In marshy habitat, boat-tailed grackles, sharp-tailed sparrows, and marsh wrens, in addition to other blackbirds, are also commonly polygynous. Grasslands and prairies support a number of polygynous species as well, including meadowlarks, bobolinks, dickcissels, lark buntings, and great-tailed grackles.

For all their apparent differences, marshes and prairies share physical characteristics that appear to favor polygynous mating systems among perching birds. In both of these treeless habitats, not only food but also good nest sites are concentrated near ground level, where the territorial males can defend them more easily. A male controlling an especially desirable territory often attracts more than one female, even though other, still-unmated males may be available in neighboring territories. In sharing a mate rather than having one all to herself, the female may sacrifice some of the male's assistance in feeding their offspring. This often results in smaller fledglings. But the trade-offs—which might include safer nest sites or more abundant food—can mean that more of the chicks survive. (In a recent study of great reed warblers in northern Europe, polygyny was common in areas of low nest predation, while males holding territories that were more at risk often went unmated.)

CHUCK WOOD

Nest surveillance takes place from a blind.

Polygyny is uncommon in forests. On rare occasions, birds such as American redstarts, hooded warblers, and black-throated blue warblers engage in polygyny. But because food, such as insect prey, is less concentrated in a forest than in a marsh (being distributed from the ground to the treetops), females and young benefit when males can give them full attention. Why, then, would a female Louisiana waterthrush on this densely wooded stream choose a partner already mated with another female and whose time would have to be divided among the young of two broods?

Watching the male at the Powdermill reserve gave me a hint at the answer. As it picked through the leaf litter for insects—its dietary staple—the bird soon worked its way down to the stream, where it hopped from rock to rock and occasionally flipped a leaf out of the water, all the while bobbing its tail. As I followed it with my binoculars, the male suddenly darted for a salamander, and then struggled with it momentarily before the amphibian broke free. Louisiana waterthrushes feed almost entirely on the ground and in eddies of flowing water, and though not often reported, salamanders, along with crustaceans and freshwater mollusks, may be among the more exotic food items of this species.

Eroded stream banks also provide prime nesting sites for the waterthrush. A short distance upstream, Bob showed me a nest only recently vacated by fledglings that he had hoped to band. On the bank about a foot above water level, the nest was tucked out of sight under an upturned root, in a pocket that had been excavated in the moist soil. Deep and cup-shaped, the nest was lined with fine root material and had many plant stems and whole leaves worked into it. It appeared as safe from discovery as any ground nest I had ever seen.

Given the species' dependence on stream banks for shelter as well as for food, the banded male might have cornered a reach of the Powdermill stream so appealing that two females were willing to share it. Although neighboring males may sing their hearts out to attract attention, it seems that real estate carries sway with female Louisiana waterthrushes when it comes to choosing a mate.

Peter J. Marchand is a research ecologist at the Catamount Institute on the north slope of Pike's Peak in Woodland Park, Colorado.

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REVIEW

A pod of orcas, Queen Charlotte Strait

ALEXANDRA MORTON

Sea Highs, Sea Lows

Despite humanity's depredations, two biologists remain hopeful about the fate of the world's oceans. By Jeff Fair

As a naturalist, I believe that what we often need in order to enhance our understanding of the natural world is to step into it and apply our own senses. I was therefore skeptical about a book by a scientist who listens to cetaceans underwater through a microphone and about another book whose author follows an albatross's breeding cycle via satellite telemetry.

I needn't have worried. *Listening to Whales,* by Alexandra Morton, is a passionate memoir by a true field biologist. Morton won me over early on with her tale of escaping the confines of her San Diego laboratory for the waters off British Columbia. Subsisting on the fieldworker's diet of fresh air, peanut butter, and coffee, she searches for the free-ranging family pod from which one of her confined orca (killer whale) subjects at Sea World was taken years before. She finds the pod—as well as a permanent connection with the natural world.

All is not perfect in these wilder waters, however. Occasionally we hear a rifle report when the orcas come into view. And Morton finds the submarine environment polluted with noise: the deafening thrum of cruise-ship engines drives her from her headphones, as do the screams of submerged "acoustic harassment devices," employed by salmon farmers to keep seals away but devastating to the whale's ultrasensitive hearing.

Listening to Whales: What the Orcas Have Taught Us, *by Alexandra Morton (Ballantine Books, 2002; $26.95)*
Eye of the Albatross: Visions of Hope and Survival, *by Carl Safina (Henry Holt, 2002; $27.50)*

Morton's text is generous with information about cetacean life in general and observations of killer-whale behavior in particular. Though she states that the interactions of mother orcas and their offspring are her deepest interest, Morton waxes most emphatic here about the species' intelligence. She offers empirical evidence of its language complexity, identifying a vocabulary of no less than sixty-two "codes"—distinct calls that carry easily across a hundred square miles of ocean.

She also offers anecdotal evidence of cetacean telepathy and acts of compassion toward humans. Once, lost in the fog and panicky in her inflatable boat, she finds herself surrounded by a familiar pod of orcas that usher her to safety. Alert to separating the "mythology" of whales from her scientific work, she nevertheless finds "profound evidence of something beyond our ability to scientifically quantify." Like the best biologists, she is unwilling to ignore what she has seen with her own eyes. Morton's sense of the orcas' intelligence leads her to risk her scientific reputation in advocacy: she sees these creatures as sentient beings subjected to continuing abuse in the sea and to the veritable torture of captivity. I'm sure Morton's willingness to speak out pleases her fellow orca biologists.

Carl Safina, founder of the National Audubon Society's Living Oceans Program and author of *Song for Blue Ocean,* donned the mantle of advocacy years ago. Now, in *Eye of the Albatross,* he surveys the Pacific by following a Laysan albatross he calls Amelia. "During their prodigious travels," writes Safina, "albatrosses cross paths with a spectacular array of creatures near the ocean surface, including other seabirds, fishes, seals, whales, sharks, sea turtles, and some extraordinary people."

His narrative begins in the Northwest Hawaiian Islands, "a series of dots and dabs in the wide sea" that extends a thousand miles west of what tourists usually think of as Hawaii. These remote islands are the breeding ground of 95 percent of Hawaii's millions of seabirds, including "some 600,000 breeding *pairs* of Laysan Albatross, and

60,000 Black-footed Albatross pairs—virtually their entire world populations." Once a satellite transmitter has been affixed to Amelia, Safina is able to follow the long vectors of her soaring junkets to gather food for her chick (one course of flight lasts twenty-nine days and covers 7,600 miles, touching the Aleutians). Because Amelia spends a large proportion of her time foraging far from her chick, Safina finds time to investigate the larger story: the plights, both historic and current, of Hawaiian monk seals, bluefin tuna, tiger sharks, sea turtles, and numerous species of seabirds, so many of them devastated by drift nets, egg gatherers, feather hunters, releases of rats and rabbits, toxins, and (most egregious) plastic litter in the sea.

Safina interweaves the natural history of marine life with vivid evocations of life in the field: lizards in the dining hall, the din and pungency of hundreds of thousands of seabirds, the sensation of donning brand-new, *frozen* underwear before setting foot on one of these protected islands (in an effort to keep alien grass seeds and other stowaways from being brought onto the islands in the wrinkles and fray of old clothing, the U.S. Fish and Wildlife Service requires that all visitors wear prefrozen brand-new, head-to-toe apparel). Safina powerfully portrays humanity's effect on ocean-dependent creatures. Perhaps his most moving scene occurs on Midway Island, a U.S. military base until 1993 and now a national wildlife refuge, where seabird nesting colonies have somehow survived despite feather hunters, rats ("e-rat-icated" as of 1997), and past efforts by the military to torch them alive with flamethrowers. Safina watches a mother albatross regurgitate clots of digested food, rich in oil, directly into her chick's gullet. Early in the feeding, however, food stops flowing, though the parent continues to retch pathetically. "Slowly, the tip . . . of a green plastic toothbrush emerges in the bird's throat." Unable to dislodge the toothbrush, she walks away from her chick.

Both Morton and Safina balance science with informed compassion, an essential stance in a world that, for lack of significant data, can overlook horrific and obvious injuries to so many organisms. And both remain hopeful. Safina retains faith in the efforts and spirit of biologists, ethical fishermen, and society itself, as well as in the resilience of wild creatures. He cites the reappearance of the "extinct" short-tailed albatross: ten individuals in 1951 on the Japanese island of Torishima, where the remaining few were believed to have been slaughtered in 1933. Morton concludes on a note of celebration: when the fish farmers' acoustic harassment devices were finally turned off, twenty-five orcas returned to Cramer Pass (her front yard), after six years of exile.

Biologist and author Jeff Fair studies loons in his laboratory under the open sky from Maine to Alaska, equipped with binoculars, field notebook, and the stub of a no. 2 pencil.

nature.net

Making the Moon

By Robert Anderson

The leading explanation for the Moon's origin is younger than the theory of plate tectonics. Often called the "giant impact theory," it did not receive much attention from scientists until the mid-1980s. Even now, I wonder how many people know that our magnificent satellite was born in a chance collision 4.5 billion years ago.

Looking up the subject on the Internet, I found a number of sites that tell the remarkable story in different ways. *NOVA*'s "To the Moon" (www.pbs.org/wgbh/nova/tothemoon/origins.html), for example, sums up competing theories. Click on "The Big Whack," and you'll find an animation showing what happens when a Mars-sized planet strikes primordial Earth. At www.xtec.es/recursos/astronom/moon/camerone.htm, Alastair G. W. Cameron, one of the originators of the "single impact hypothesis," gives a more learned account of lunar formation, and at www.lpl.arizona.edu/outreach/origin/, H. Jay Melosh shows a Mars-size protoplanet colliding with the protoearth, with each computer-simulated snapshot separated by about 400 seconds.

Perhaps my favorite find, however, is a site created by Japanese astrophysicist Eiichiro Kokubo, who has modeled the growth of the Moon from the disk of debris created by the impact (yso.mtk.nao.ac.jp/~kokubo/moon/kit/movie.html). He has some (very large) movie files, along with selected stills of the formation of a "lunar seed" through the rapid growth and accretion of particles. Kokubo's conclusion: the Moon assembled itself in about a month.

Robert Anderson is a freelance science writer living in Los Angeles.

BOOKSHELF

The Trouser People: Colonial Shadows in Modern-Day Burma, *by Andrew Marshall (Counterpoint/Perseus, 2002; $26)*
Retracing the expeditions of a Victorian adventurer in the uncharted Burmese highland, Marshall skillfully links past and present in his encounters with civilians who have bestowed the nickname "trouser people" (once used for white colonialists) on their current oppressors in Myanmar's military dictatorship.

The River's Tale: A Year on the Mekong, *by Edward A. Gargan (Knopf; 2002; $26.95)*
Gargan, who explored the Mekong's 3,000-mile course, describes the river as "a watery no-man's-land between the bright lights, the boisterous politics and the blossoming economy of Thailand and the dark impoverishment . . . of Laos."

The Fever Trail: In Search of the Cure for Malaria, *by Mark Honigsbaum (Farrar, Straus and Giroux, 2002; $26)*
In the mid-seventeenth century, Spain began to import the bitter bark of cinchona trees from Peru and Ecuador as an antidote for malaria. A hundred years later, as the disease ravaged Europe and hampered its colonial conquests, a succession of European botanist-adventurers struck out to find the plant in its remote mountain home and to bring back cuttings. Today, malaria's 300–500 million victims a year still await a cure.

Life at the Limits: Organisms in Extreme Environments, *by David A. Wharton (Cambridge University Press, 2002; $25)*
Thriving in inhospitable hydrothermal vents as well as in deserts, polar regions, hot springs, and salt lakes are organisms that have much to tell us about the mechanisms of adaptation.

The Story of Rats: Their Impact on Us, and Our Impact on Them, *by S. Anthony Barnett (Allen & Unwin, 2002; $14.95)*
"Humanity today is notorious as a destroyer of species and environments. Yet human settlements have, for more than ten millennia, enabled some species to thrive," writes zoologist Barnett. One such animal—the rat—carries more than fifty infectious diseases, as the author discusses in this historical and social study.

Synaptic Self: How Our Brains Become Who We Are, *by Joseph LeDoux (Viking, 2002; $25.95)*
Neuroscientists are now investigating the role of synapses (the tiny spaces between neurons) in electrical and chemical transmissions that are critical to integrated brain development and, therefore, to the construction of the self.

Nature's Building Blocks: An A-Z Guide to the Elements, *by John Emsley (Oxford University Press, 2002; $27.50)*
A delightful, idiosyncratic survey of the known elements, this guide also includes many nuggets of surprising information—for example, the use of fluorine (found in our bones and teeth) in the development of the nonstick frying pan.

The Wild Vegetarian, *by "Wildman" Steve Brill (The Harvard Common Press, 2002; $29.95)*
A self-styled forager offers up more than 500 recipes for "preparing and savoring wild (and not so wild) natural foods"—including such healthful concoctions as Scottish nettle pudding and chickweed bean spread.

Consider the Eel, *by Richard Schweid (University of North Carolina Press, 2002; $24.95)*
A chronicle of the freshwater eel's natural history, anthropology, and mythology seeks to shed light on this elusive and often overlooked creature.

The books mentioned are usually available in the Museum Shop, (212) 769-5150, or through www.amnh.org.

PHOTOGRAPHY

STEVE MCCURRY

Sanctuary. The Temples of Angkor, *by Steve McCurry (Phaidon, 2002; $39.95)*

EXPLORER GUIDE

THE NATURAL MOMENT

Bulldozer

Photograph by
Mark Payne-Gill

Each December and January, rainstorms drench the parched South African landscape and summon African bullfrogs *(Pyxicephalus adspersus)* from their subterranean lairs. Driven underground to protect their moist skin during the ten-month-long dry season, these paunchy amphibians emerge to spawn in newly formed puddles. Females hop away after depositing 2,000 to 4,000 fertilized eggs, which hatch after only two days. The males—exemplary fathers among amphibians—stay behind to protect the tadpoles. Besides thwarting predators, male African bullfrogs keep an eye on the sky. Summer storms are sporadic, and between rains the puddles teeming with tadpoles can evaporate under the relentless sun. In response, the paternal guardians take action. To save their broods, they dig canals between dwindling puddles and deeper pools.

Photographer Mark Payne-Gill, who captured one such excavation on the scrublands of central South Africa, watched the bullfrog "use its powerful hind legs to claw out some of the clay before turning around and bulldozing the rest of the way with its nose." The foot-long canal took five hours to complete and, says Payne-Gill, "the bullfrog's snout was quite raw when he finished." But other perils may have awaited his tadpoles: researchers have found that despite their paternal inclinations, male African bullfrogs sometimes cannibalize their young.

—Brittain Phillips

ENDPAPER

Disassembly Required

By Michael Hansell

Every time I hold the nest of a long-tailed tit *(Aegithalos caudatus)* in my hands, I am struck by its neat dome shape, the tidy little entrance hole near the top, and the soft, flexible fabric of which it is made. A few years ago, no longer satisfied with admiring the finished product, I dismantled a nest piece by piece (after the breeding season was over, of course), laid the construction materials out in rows according to type, and counted. The tally came to an astonishing 5,000 to 6,000 separate pieces of material!

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Long-tailed tit at its nest

Providing structural support for the nest was a wall made of small-leafed mosses and the fluffy silk of spider-egg cocoons. Moss and cocoon were so intimately entangled—forming a sort of natural Velcro—that an accurate count was hard to get, but I estimated more than 600 cocoons and a few hundred sprigs of moss. Covering the wall was a mosaic of about 3,000 flakes of lichen, each oriented with its pale green surface facing out and its black underside largely out of sight. Among the lichens were about 200 pieces of other light-colored materials: more spider cocoons, balls of expanded polystyrene, and fragments of newspaper. Based on the difficulty I have had detecting long-tailed tit nests in early spring, my guess is that the pale exterior helps the solid outline of the nest dissolve into the background of the still leafless woodland and thus decreases the chances of its being discovered by a predator.

The interior layer of my nest consisted of some 1,400 to 1,500 contour (body) feathers. Most of them belonged to blackbirds, wood-pigeons, and chaffinches, whose death provided a feathery windfall for the tits. Arranged so that their natural curvature followed that of the nest cavity, the soft feathers would have offered insulation against the sometimes harsh weather of early spring. (In Scotland, where I work, long-tailed tits start constructing their nests as early as March, when spring still looks a lot like winter.)

The nest of the long-tailed tit would seem to have plenty of both workmanship and effort to impress the human observer. But might our species' fascination with engineering and our respect for craftmanship put us at risk of romanticizing the building skills of a bird that weighs in at just eight grams? After all, as Niko Tinbergen, Nobel laureate and one of the founders of the modern science of animal behavior, wrote, "The most amazing thing about [the nest of the long-tailed tit] is, in my opinion, the fact that so few, so simple and so rigid movements together lead to the construction of so superb a result."

Tinbergen had a point. The beauty of Velcro fasteners, whether in a tit's nest or on a child's shoe, is indeed their simplicity. Using them requires little skill; all those hooks and loops just want to stay together. Also uncomplicated is how the outer layer of lichen flakes attaches to the nest wall: spiky projections on their dark undersides help hold the flakes in position. Even the way feathers fit the curve of the nest-cavity wall may be the result of simple shaping movements that the bird makes with its breast and feet.

And what about the building materials? We have little information on the availability of spider cocoons, but lichens and mosses are generally abundant. Collecting 1,500 feathers sounds more arduous. To find out if it really is, I put feathers at various places in a woodland near my home, about eighteen miles from Glasgow. Each feather was marked to indicate where it had been set down. Checking nest contents later, I was surprised to find that fewer than 3 percent of all nest feathers were ones I had marked and that these had been picked up fairly close to the nest—an average of 200 feet away. Clearly, the birds did not need my handouts.

There is no denying, then, that the nest of the long-tailed tit is both cheap and easy to construct. It is also good looking and extremely functional. And that's enough to impress me.

A professor at the Institute of Biomedical and Life Sciences, University of Glasgow, Michael Hansell is the author of Bird Nests and Construction Behaviour *(Cambridge University Press, 2000).*

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