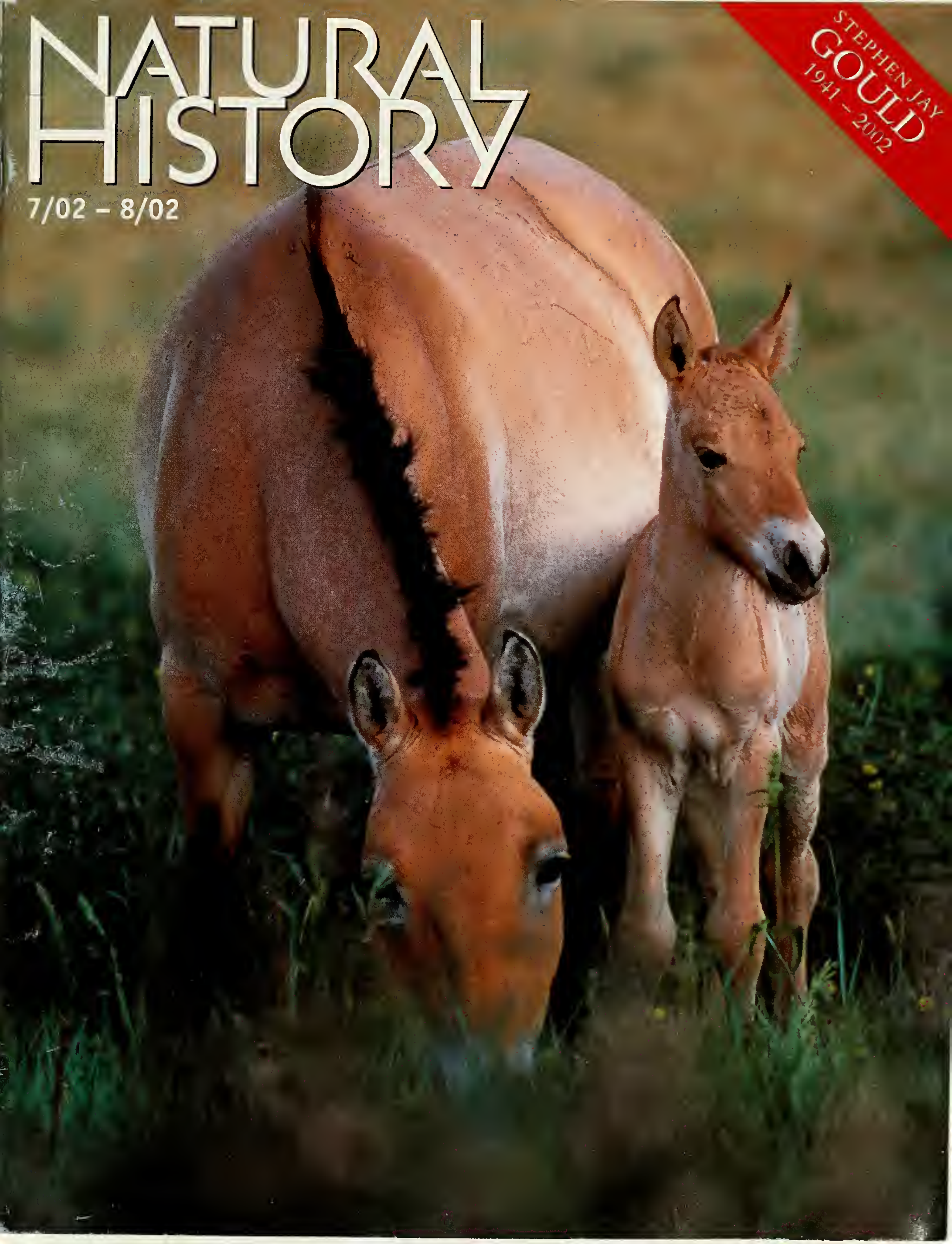
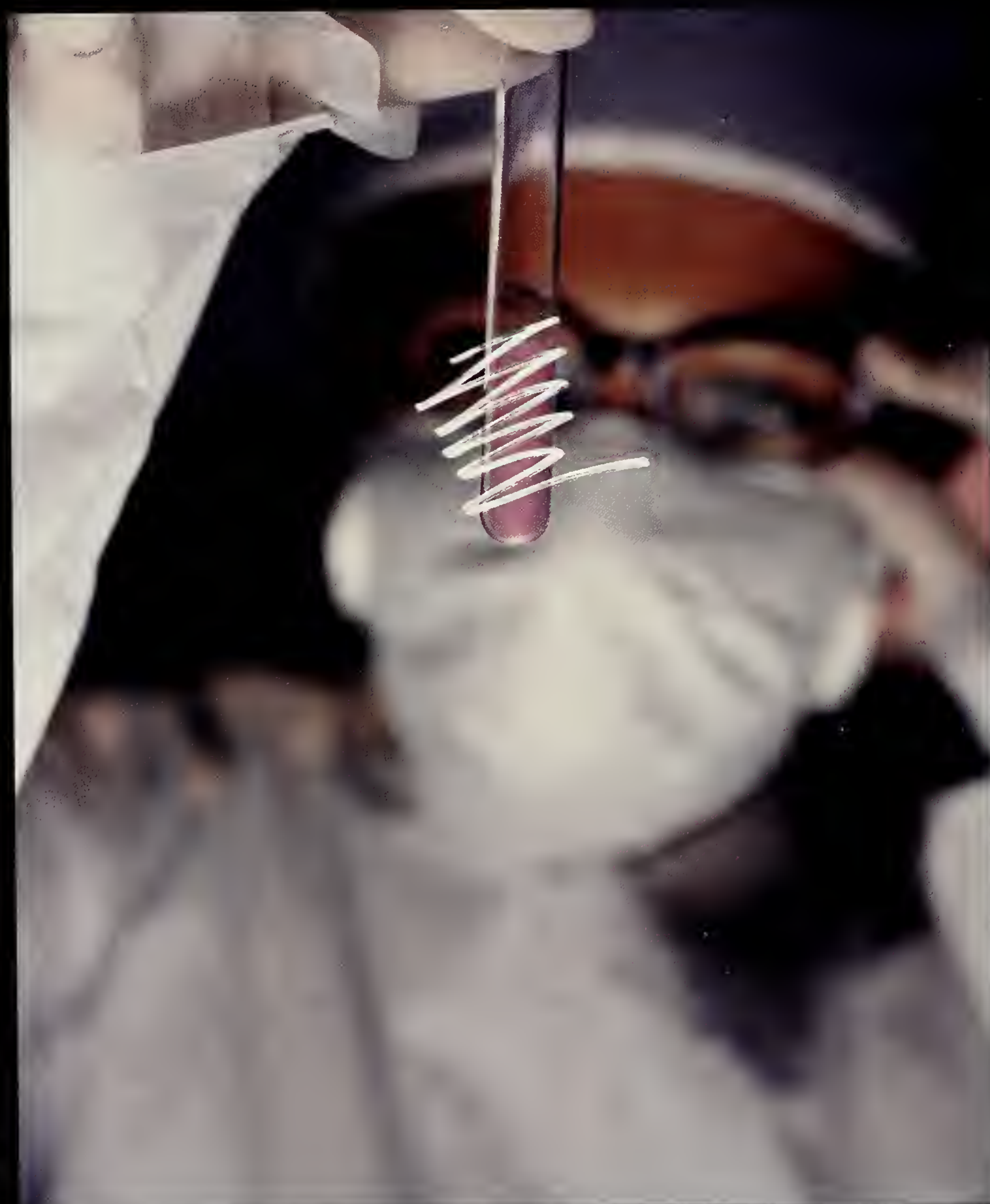
NATURAL HISTORY

7/02 – 8/02

STEPHEN JAY GOULD
1941 – 2002






Half a millennium ago, this road
connected the Old World to the New.
Come to think of it, it still does.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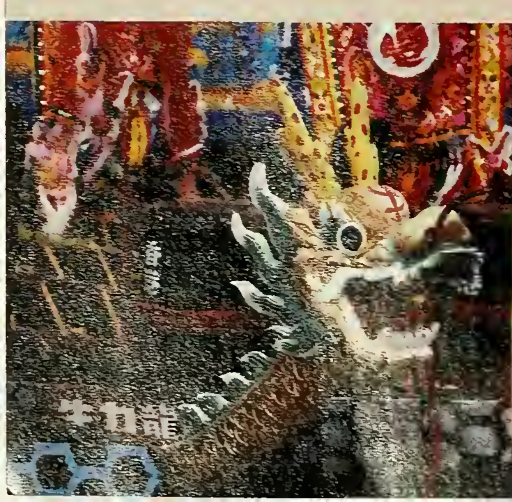
HONG KONG
The Experience of a Lifetime

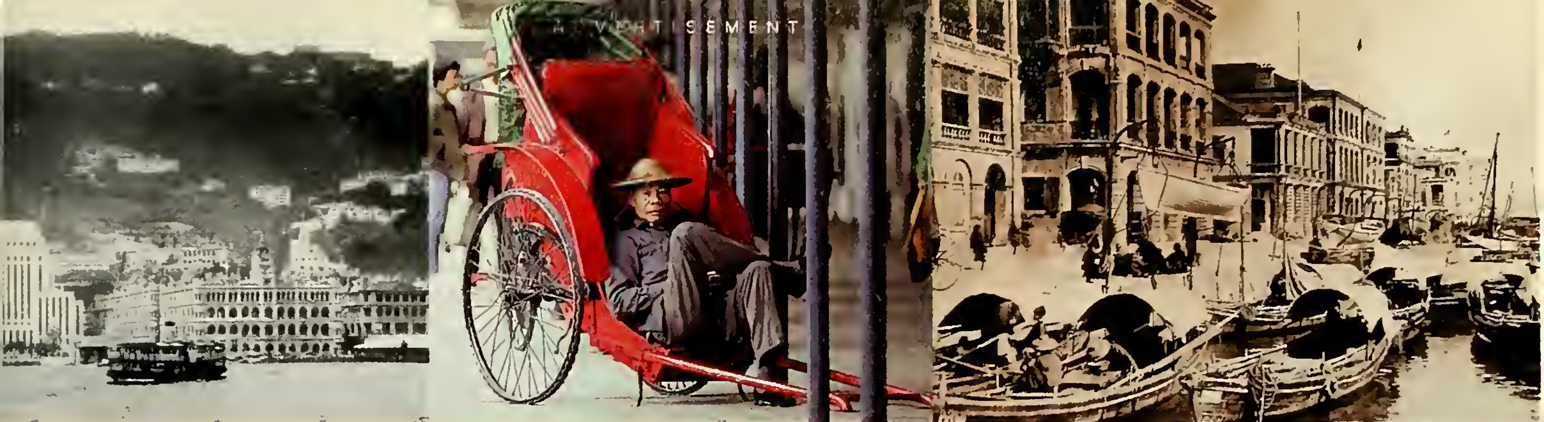
ITS FLAG HAS CHANGED from the crossed blue-and-red stripes of Great Britain's Union Jack to the *bauhinia*, a five-petaled, magenta native flower, a symbol, at once gentle yet historic, of Hong Kong's unruffled transition from colony to autonomous enclave of China. An enormous change, to be sure, yet this glistening, unique amalgam of East meeting West remains seamless, a dynamic, fetching city-state that offers to those who visit her a panorama of its Qing Dynasty-Victorian England history, the comforts of hotels with few equals, the finest Chinese kitchen extant, and a matchless collection of modish boutiques.

Hong Kong is exhilarating. A visitor cannot help but be plunged into history: gaslights and 100-step market streets; temples redolent with incense; Queen Victoria in bronze, enthroned in a public park; sing-song Cantonese opera in the nighttime Temple Street Market; and the Noon Day Gun blasting its signal every day.

Remnants of the old walled city remain, and you may sit on Sung Wong Rock, once the visiting throne of the Sung Dynasty emperor. In the Yuen Po Street Bird Market, join the old men drinking tea in the company of their exotic birds. Take a ride on a double-decked tram clattering ten miles east to west along a 98-year-old rail route from the Western District, full of aromatic dried food shops, through teeming Wanchai and Causeway Bay, past the Happy Valley racecourse. Or cross Victoria Harbor on a snub-nosed Star Ferry, with "star" names such as Guiding, Evening, Rising, and Twinkling—the way Hong Kongers have commuted since 1898. Ferry over to Hong Kong's other islands, to the 70-foot-high sitting Buddha on Lan Tau, and to Peng Chau, once the refuge of South China Sea pirates.

A few rickshaws still remain at the ferry slips in Central, and the Peak Tram, the way up to Hong Kong's steep Victoria Peak, runs as smoothly as it has since 1888. People come to Hong Kong lured by its promise of the latest ready-to-wear from Paris and Milan; for pearls and jades, some to be found in the morning bazaar of the Jade Market; and for afternoons among the Ming Dynasty porcelains and heavy old blackwood furniture along Hollywood Road. They come evenings a small way up the peak to the pubs and jazz of Lan Kwai Fong, Hong Kong's Soho, its Greenwich Village. They come to eat dim sum and roasted duck, bowls of noodles, and fish just pulled from the sea.





Photos: Hong Kong Tourist Association

Just as satisfying, however, is Hong Kong as history, old and new. Its Museum of Art, on the Kowloon waterfront, regularly displays antique calligraphy and historic ink paintings on silk. The Hong Kong Museum of History, farther into Kowloon, and the new Heritage Museum, in the New Territories, boast dioramas and exhibits from 6,000-year-old Neolithic pottery shards to Qing Dynasty embroideries. Learn about Hong Kong's history, from the early fishing tribes—the Punti, Hoklo, the seafaring Yueh, and the Tanka—to its 150 colonial years of Taipans and foreign traders and its relationship to revolutionary China.

In such small restorations as the Tai Fu Tai scholar's residence, the Sam Tung Uk walled village, a rolling stock Railroad Museum, and in the Sheung Yiu Folk Museum, so much of old Hong Kong endures. In the Taoist monastery of Ching Chung Koon, visit with the monks and their gardens of miniature trees and eat vegetables with them.

To be in Hong Kong at any time of the year is to be in the midst of a festival. The Lunar New Year occurs each January or February, and Victoria Harbor is alight with great explosions of fireworks. Fifteen days later the Lantern Festival is celebrated and all of the city is illuminated with glowing ornate paper lanterns. April brings the Bun Festival to the nearby island of Cheung Chau, with its 50-foot-high pyramids of steamed buns offered to hungry mythological ghosts. In May, foods and prayers are offered to Tin Hau, the goddess of fishermen, and the following month the brightly decorated Dragon Boats are oared swiftly in races through Hong Kong's waters. Mid-autumn brings more lanterns and mounds of sweet paste-filled moon cakes.

Hong Kong is home to *feng shui*, the belief in the efficacy of properly located winds and waters. It is a place to perhaps meet with an herbalist who will analyze your pulse and your forehead and prescribe foods and herbs to restore your interior balance. Visit City Hall on the weekend and you will see newly married couples by the score, the brides often in their glittering red traditional gowns, their heads adorned with spangles.

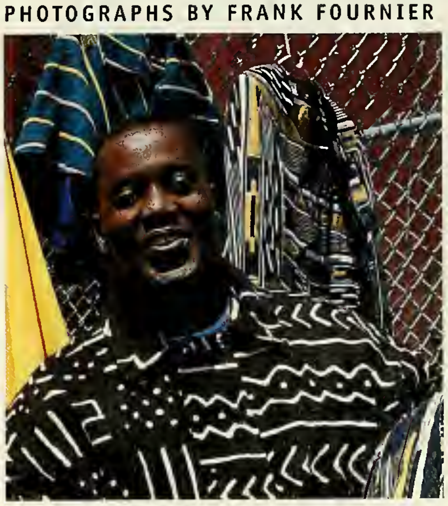
Universal amity, foods that excite the palate, the stimulation of history and the presence of the past, touches of the exotic, continual festivals, all within exuberant urban beauty. Visit Hong Kong for an experience of a lifetime.

The MEET THE PEOPLE program allows you to meet with English-speaking specialists each day of the week who will initiate you into the many aspects of Hong Kong that casual visitors miss.There is no need to book ahead for these visits with specialists, whose expertise ranges from Tin Hau, tai chi, Chinese tea, and traditional medicine to the city's contemporary art and antiques scene. For more information on Hong Kong, visit **www.DiscoverHongKong.com** or call 1-800-282-4582.

NATURAL HISTORY

JULY - AUGUST 2002 VOLUME 111 NUMBER 6

FEATURES

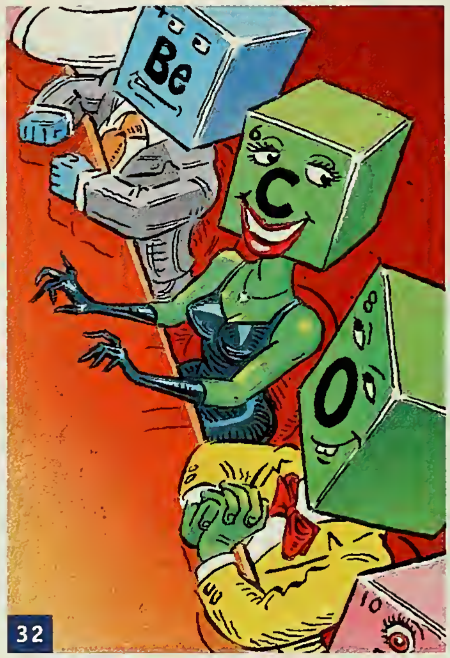


COVER
Wild Przewalski's horses in Mongolia's Hustai National Park

STORY BEGINS ON PAGE 56

PHOTOGRAPH BY FRANS LANTING

D E P A R T M E N T S



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UP FRONT

This View of Steve

I write this editorial on the day after the untimely death of *Natural History*'s longtime columnist Stephen Jay Gould. Phone calls and e-mails of condolence have been coming in to the magazine all day. Most are from readers who never met Steve or his family but were driven to express their sense of loss to the magazine, which to them was his home base. Like us, they feel they have lost a friend. (One miracle of reading is that it can allow you to develop a great affection for the mind of someone you've never met.)

Steve wrote 300 consecutive essays for this magazine between 1974 and 2001. He did not write drafts; the essays sprang fully formed from the Gouldian brain, like Athena from the forehead of Zeus. His was a strong, capacious mind. "This View of Life," his column, introduced a generation to the brilliance of Charles Darwin—and to Steve's take on evolution as a process that has tinkered with available materials and proceeded in nonlinear, nonprogressive fashion to create the gorgeous, variegated tapestry that is (and was) life on Earth.

Over the years, readers were exposed not only to this interpretation of Darwin's view of life but to Steve's own view. As an historian of science who habitually scrutinized original texts, he was an acute analyst and debunker of what are called received ideas. And as a man who was spiritually close to his family's immigrant roots, he understood the way pseudoscientific ideas can harm people who may not be in a position to defend themselves. Both traits led him to look with a particularly skeptical eye at scientific justifications for racism and other forms of prejudice.

Stephen Jay Gould at a minor-league baseball stadium in Savannah, Georgia, 1993

Some of his most powerful essays treated this theme. In Steve's memory, we reprint on the pages immediately following this editorial his 1984 essay "Carrie Buck's Daughter." To me, it exemplifies Steve's beautiful mind, because in it we see the public citizen, the historian in pursuit of the truth, and the compassionate human being.—*Ellen Goldensohn*

For remembrances of Stephen Jay Gould, and to read his last essay in the series "This View of Life," go to www.naturalhistory.com.

NATURAL HISTORY

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THIS VIEW OF LIFE

Carrie Buck's Daughter

A popular, quasi-scientific idea can be a powerful tool for injustice.

By Stephen Jay Gould

The Lord really put it on the line in his preface to that prototype of all prescription, the Ten Commandments:

> *for I, the Lord thy God, am a jealous God, visiting the iniquity of the fathers upon the children unto the third and fourth generation of them that hate me (Exod. 20:5).*

The terror of this statement lies in its patent unfairness—its promise to punish guiltless offspring for the misdeeds of their distant forebears.

A different form of guilt by genealogical association attempts to remove this stigma of injustice by denying a cherished premise of Western thought—human free will. If offspring are tainted not simply by the deeds of their parents but by a material form of evil transferred directly by biological inheritance, then "the iniquity of the fathers" becomes a signal or warning for probable misbehavior of their sons. Thus Plato, while denying that children should suffer directly for the crimes of their parents, nonetheless defended the banishment of a man whose father, grandfather, and great-grandfather had all been condemned to death.

It is, perhaps, merely coincidental that both Jehovah and Plato chose three generations as their criterion for establishing different forms of guilt by association. Yet we have a strong folk, or vernacular, tradition for viewing triple occurrences as minimal evidence of regularity. We are told that bad things come in threes. Two may be an accidental association: three is a pattern. Perhaps, then, we should not wonder that our own century's most famous pronouncement of blood guilt employed the same criterion—Oliver Wendell Holmes's defense of compulsory sterilization in Virginia (Supreme Court decision of 1927 in *Buck v. Bell*): "three generations of imbeciles are enough."

Restrictions upon immigration, with national quotas set to discriminate against those deemed mentally unfit by early versions of IQ testing, marked the greatest triumph of the American eugenics movement—the flawed hereditarian doctrine, so popular earlier in our century and by no means extinct today (see my column on Singapore's "great marriage debate," May 1984), that attempted to "improve" our human stock by preventing the propagation of those deemed biologically unfit and encouraging procreation among the supposedly worthy. But the movement to enact and enforce laws for compulsory "eugenic" sterilization had an impact and success scarcely less pronounced. If we could debar the shiftless and the stupid from our shores, we might also prevent the propagation of those similarly afflicted but already here.

TO THE READER

Natural History mourns the passing, on May 20, of Stephen Jay Gould, who wrote 300 essays under the rubric "This View of Life" between 1974 and 2001. Through him, our readers came to know not only Charles Darwin, but a panoply of major and minor actors in the history of evolutionary biology. The essay reprinted here, "Carrie Buck's Daughter," has a very different cast of characters, but it is also a quintessentially Gouldian piece of historical detective work. It originally appeared in the July 1984 issue of the magazine.

The movement for compulsory sterilization began in earnest during the 1890s, abetted by two major factors—the rise of eugenics as an influential political movement and the perfection of safe and simple operations (vasectomy for men and salpingectomy, the cutting and tying of Fallopian tubes, for women) to replace castration and other obvious mutilation. Indiana passed the first sterilization act based on eugenic principles in 1907 (a few states had previously mandated castration as a punitive measure for certain sexual crimes, although such laws were rarely enforced and usually overturned by judicial review). Like so many others to follow, it provided for sterilization of afflicted people residing in the state's "care," either as inmates of mental hospitals and homes for the feebleminded or as inhabitants of prisons. Sterilization could be imposed upon those judged insane, idiotic, imbecilic, or moronic, and upon convicted rapists or criminals when recommended by a board of experts.

By the 1930s, more than thirty states had passed similar laws, often with an expanded list of so-called hereditary defects, including alcoholism and drug addiction in some states, and even blindness and deafness in others. It must be said that these laws were continually challenged and rarely


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enforced in most states; only California and Virginia applied them zealously. By January 1935, some 20,000 forced "eugenic" sterilizations had been performed in the United States, nearly half in California.

No organization crusaded more vociferously and successfully for these laws than the Eugenics Record Office, the semiofficial arm and repository of data for the eugenics movement in America. Harry Laughlin, superintendent of the Eugenics Record Office, dedicated most of his career to a tireless campaign of writing and lobbying for eugenic sterilization. He hoped, thereby, to eliminate in two generations the genes of what he called the "submerged tenth"—"the most worthless one-tenth of our present population." He proposed a "model sterilization law" in 1922, designed

> *to prevent the procreation of persons socially inadequate from defective inheritance, by authorizing and providing for eugenical sterilization of certain potential parents carrying degenerate hereditary qualities.*

This model bill became the prototype for most laws passed in America, although few states cast their net as widely as Laughlin advised. (Laughlin's categories encompassed "blind, including those with seriously impaired vision; deaf, including those with seriously impaired hearing; and dependent, including orphans, ne'er-do-wells, the homeless, tramps, and paupers.") Laughlin's suggestions were better heeded in Nazi Germany, where his model act served as a basis for the infamous and stringently enforced *Erbgesundheitsrecht,* leading by the eve of World War II to the sterilization of some 375,000 people, most for "congenital feeblemindedness," but including nearly 4,000 for blindness and deafness.

The campaign for forced eugenic sterilization in America reached its climax and height of respectability in 1927, when the Supreme Court, by an 8–1 vote, upheld the Virginia sterilization bill in the case of *Buck v. Bell.* Oliver Wendell Holmes, then in his mid-eighties and the most celebrated jurist in America, wrote the majority opinion with his customary verve and power of style. It included the notorious paragraph, with its chilling tag line, cited ever since as the quintessential statement of eugenic principles. Remembering with pride his own distant experiences as an infantryman in the Civil War, Holmes wrote:

> *We have seen more than once that the public welfare may call upon the best citizens for their lives. It would be strange if it could not call upon those who already sap the strength of the state for these lesser sacrifices. . . . It is better for all the world, if instead of waiting to execute degenerate offspring for crime, or to let them starve for their imbecility, society can prevent those who are manifestly unfit from continuing their kind. The principle that sustains compulsory vaccination is broad enough to cover cutting the Fallopian tubes. Three generations of imbeciles are enough.*

Who, then, were the famous "three generations of imbeciles," and why should they still compel our interest?

When the state of Virginia passed its compulsory sterilization law in 1924, Carrie Buck, an eighteen-year-old white woman, was an involuntary resident at the State Colony for Epileptics and Feeble-Minded. As the first person selected for sterilization under the new act, Carrie Buck became the focus for a constitutional challenge launched, in part, by conservative Virginia Christians who held, according to eugenical "modernists," antiquated views about individual preferences and "benevolent" state power. (Simplistic political labels do not apply in this case, and rarely do in general. We usually regard eugenics as a conservative movement and its most vocal critics as members of the left. This alignment has generally held in our own decade. But eugenics, touted in its day as the latest in scientific modernism, attracted many liberals and numbered among its most vociferous critics groups often labeled as reactionary and antiscientific. If any political lesson emerges from these shifting allegiances, we might consider the true inalienability of certain human rights.)

But why was Carrie Buck in the State Colony, and why was she selected? Oliver Wendell Holmes upheld her choice as judicious in the opening lines of his 1927 opinion:

> *Carrie Buck is a feeble-minded white woman who was committed to the State Colony. . . . She is the daughter of a feeble-minded mother in the same institution, and the mother of an illegitimate feeble-minded child.*

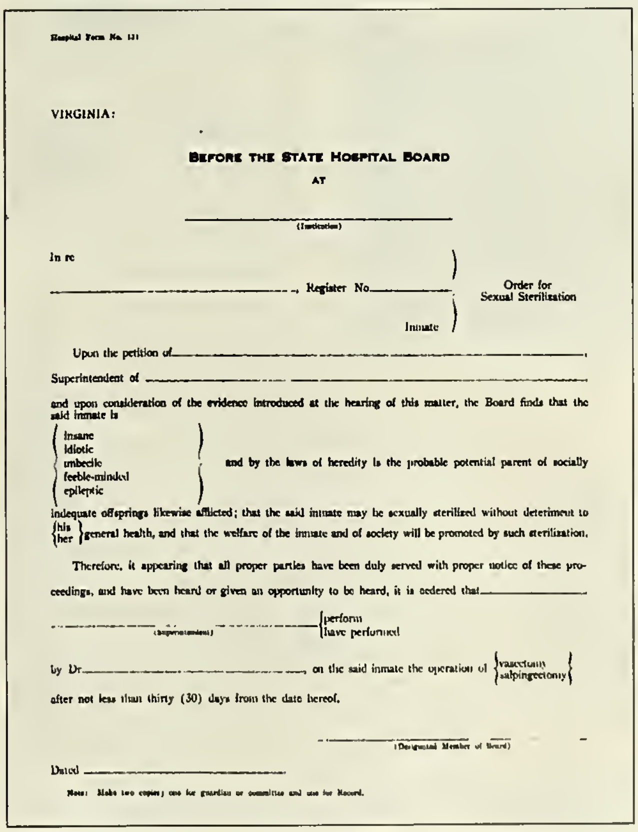
In short, inheritance stood as the crucial issue (indeed as the driving force behind all eugenics). For if measured mental deficiency arose from malnourishment, either of body or mind, and not from tainted genes, then how could sterilization be justified? If decent food, upbringing, medical care, and education might make a worthy citizen of Carrie Buck's daughter, how could the State of Virginia justify the severing of Carrie's Fallopian tubes against her will? (Some forms of mental deficiency are passed by inheritance in family line, but most are not—a scarcely surprising conclusion when we consider the thousand shocks that beset fragile humans during their lives, from difficulties in embryonic growth to traumas of birth, malnourishment, rejection, and poverty. In any case, no fair-minded person today would credit Laughlin's social criteria for the identification of hereditary deficiency—ne'er-do-wells, the homeless, tramps, and paupers—although we shall soon see that Carrie Buck was committed on these grounds.)

When Carrie Buck's case emerged as the crucial test of Virginia's law, the chief honchos of eugenics knew that the time had come to put up or shut up on the crucial issue of inheritance. Thus, the Eugenics Record Office sent Arthur H. Estabrook, their crack field-worker, to Virginia for a "scientific" study of the case. Harry Laughlin himself provided a deposition, and his brief for inheritance was presented at the local trial that affirmed Virginia's law and later worked its way to the Supreme Court as *Buck v. Bell.*

Laughlin made two major points to the court. First, that Carrie Buck and her mother, Emma Buck, were feebleminded by the Stanford-Binet test of IQ, then in its own infancy. Carrie scored a mental age of nine years, Emma of seven years and eleven months. (These figures ranked them technically as "imbeciles" by definitions of the day, hence Holmes's later choice of words. Imbeciles displayed a mental age of six to nine years; idiots performed worse, morons better, to round out the old nomenclature of mental deficiency.) Second, that most feeblemindedness is inherited, and Carrie Buck surely belonged with this majority. Laughlin reported:

> *Generally feeble-mindedness is caused by the inheritance of degenerate qualities; but sometimes it might be caused by environmental factors which are not hereditary. In the case given, the evidence points strongly toward the feeble-mindedness and moral delinquency of Carrie Buck being due, primarily, to inheritance and not to environment.*

Carrie Buck's daughter was then, and has always been, the pivotal figure of this painful case. As I stated before, we tend (often at our peril) to regard two as potential accident and three as an established pattern. The supposed imbecility of Emma and Carrie might have been coincidental, but the diagnosis of similar deficiency for Vivian Buck (made by a social worker, as we shall see, when Vivian was but six months old) tipped the balance in Laughlin's favor and led Holmes to declare the Buck lineage inherently corrupt by deficient heredity. Vivian sealed the pattern—*three* generations of imbeciles are enough. Besides, had Carrie not given illegitimate birth to Vivian, the issue (in both senses) would never have emerged.



Hospital Form No. 131

VIRGINIA:

BEFORE THE STATE HOSPITAL BOARD

AT

(Institution)

In re ______________, Register No. ______ Inmate — Order for Sexual Sterilization

Upon the petition of ______________,

Superintendent of ______________

and upon consideration of the evidence introduced at the hearing of this matter, the Board finds that the said inmate is {insane / idiotic / imbecile / feeble-minded / epileptic} and by the laws of heredity is the probable potential parent of socially indequate offsprings likewise afflicted; that the said inmate may be sexually sterilized without deterimeut to {his / her} general health, and that the welfare of the inmate and of society will be promoted by such sterilization.

Therefore, it appearing that all proper parties have been duly served with proper notice of these proceedings, and have been heard or given an opportunity to be heard, it is ordered that ______________ (Superintendent) ______________ {perform / have performed} by Dr. ______________, on the said inmate the operation of {vasectomy / salpingectomy} after not less than thirty (30) days from the date hereof.

______________ (Designated Member of Board)

Dated ______________

Note: Make two copies; one for guardian or committee and one for Record.

Official Virginia hospital form for sexual sterilization

Oliver Wendell Holmes viewed his work with pride. The man so renowned for his principle of judicial restraint, who had proclaimed that freedom must not be curtailed without "clear and present danger"—without the equivalent of falsely yelling "fire" in a crowded theater—wrote of his judgment in *Buck v. Bell:* "I felt that I was getting near the first principle of real reform."

And so the case of *Buck v. Bell* remained for fifty years, a footnote to a moment of American history perhaps best forgotten. And then, in 1980, it reemerged to prick our collective conscience, when Dr. K. Ray Nelson, then director of the Lynchburg Hospital where Carrie Buck was sterilized, researched the records of his institution and discovered that more than 4,000 sterilizations had been performed, the last as late as 1972. He also found Carrie Buck, alive and well near Charlottesville, and her sister Doris, covertly sterilized under the same law (she was told that her operation was for appendicitis), and now, with fierce dignity, dejected and bitter because she had wanted a child more than anything else in her life and had finally, in her old age, learned why she had never conceived.

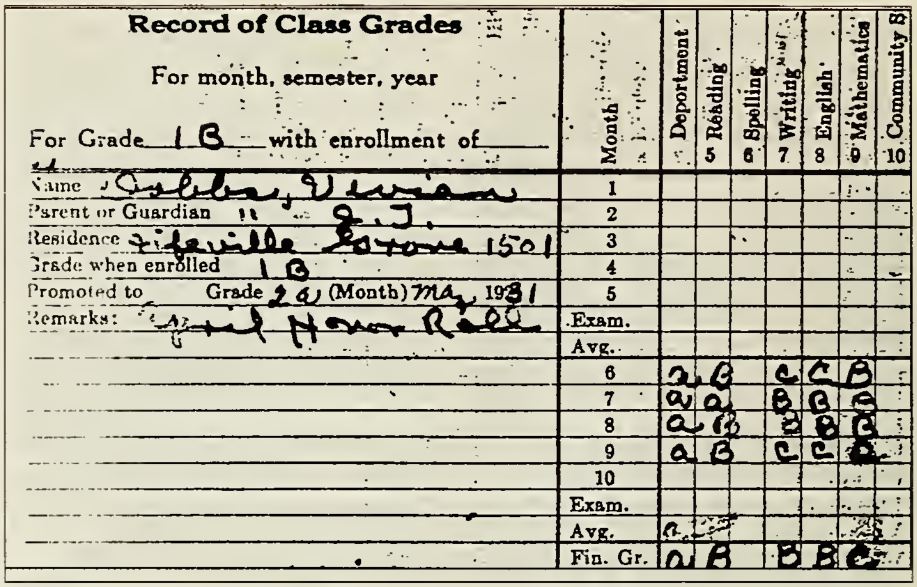
As scholars and reporters visited Carrie Buck and her sister, what a few experts had known all along became abundantly clear to everyone. Carrie Buck was a woman of obviously normal intelligence. For example, Paul A. Lombardo of the School of Law at the University of Virginia, and a leading scholar of the *Buck v. Bell* case, wrote in a letter to me:

> *As for Carrie, when I met her she was reading newspapers daily and joining a more literate friend to assist at regular bouts with the crossword puzzles. She was not a sophisticated woman, and lacked social graces, but mental health professionals who examined her in later life confirmed my impressions that she was neither mentally ill nor retarded.*

On what evidence, then, was Carrie Buck consigned to the State

Colony for Epileptics and Feeble-Minded on January 23, 1924? I have seen the text of her commitment hearing; it is, to say the least, cursory and contradictory. Beyond the simple and undocumented say-so of her foster parents, and her own brief appearance before a commission of two doctors and a justice of the peace, no evidence was presented. Even the crude and early Stanford-Binet test, so fatally flawed as a measure of innate worth (see my book *The Mismeasure of Man*, although the evidence of Carrie's own case suffices) but at least clothed with the aura of quantitative respectability, had not yet been applied.

When we understand why Carrie Buck was committed in January 1924, we can finally comprehend the hidden meaning of her case and its message for us today. The silent key, again and as always, is her daughter Vivian, born on March 28, 1924, and then but an evident bump on her belly. Carrie Buck was one of several illegitimate children borne by her mother, Emma. She grew up with foster parents, J.T. and Alice Dobbs, and continued to live with them, helping out with chores around the house. She was apparently raped by a relative of her foster parents, then blamed for her resultant pregnancy. Almost surely, she was (as they used to say) committed to hide her shame (and her rapist's identity), not because enlightened science had just discovered her true mental status. In short, she was sent away to have her baby. Her case never was about mental deficiency; it was always a matter of sexual morality and social deviance. The annals of her trial and hearing reek with the contempt of the well-off and well-bred for poor people of "loose morals." Who really cared whether Vivian was a baby of normal intelligence; she was the illegitimate child of an illegitimate woman. Two generations of bastards are enough. Harry Laughlin began his "family history" of the Bucks by writing: "These people belong to the shiftless, ignorant and worthless class of anti-social whites of the South."


Record of Class Grades
For month, semester, year
For Grade 1B with enrollment of
Name Dobbs, Vivian
Parent or Guardian J.T.
Residence Fifeville Grove 1501
Grade when enrolled 1B
Promoted to Grade 2A (Month) May 1931
Remarks: Honor Roll

Month	Deportment 5	Reading 5	Spelling 6	Writing 7	English 8	Mathematics 9	Community 10
1							
2							
3							
4							
5							
Exam.							
Avg.							
6	a	B		C	C	B	
7	a	a		B	B	B	
8	a	B		B	B	B	
9	a	B		C	C	B	
10							
Exam.							
Avg.	a						
Fin. Gr.	a	B		B	B	B	

Charlottesville school record of 1931 notes Vivian Dobbs made honor roll.

We know little of Emma Buck and her life, but we have no more reason to suspect her than her daughter Carrie of true mental deficiency. Their deviance was social and sexual; the charge of imbecility was a cover-up, Mr. Justice Holmes notwithstanding.

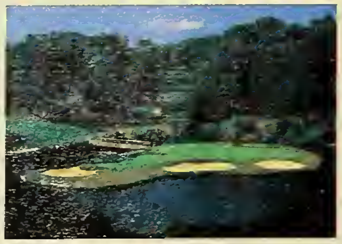
We come then to the crux of the case, Carrie's daughter, Vivian. What evidence was ever adduced for her mental deficiency? This and only this: At the original trial in late 1924, when Vivian Buck was seven months old, a Miss Wilhelm, social worker for the Red Cross, appeared before the court. She began by stating honestly the true reason for Carrie Buck's commitment:

> *Mr. Dobbs, who had charge of the girl, had taken her when a small child, had reported to Miss Duke [the temporary secretary of Public Welfare for Albemarle County] that the girl was pregnant and that he wanted to have her committed somewhere—to have her sent to some institution.*

Miss Wilhelm then rendered her judgment of Vivian Buck by comparing her with the normal granddaughter of Mrs. Dobbs, born just three days earlier:

> *It is difficult to judge probabilities of a child as young as that, but it seems to me not quite a normal baby. In its appearance—I should say that perhaps my knowledge of the mother may prejudice me in that regard, but I saw the child at the same time as Mrs. Dobbs' daughter's baby, which is only three days older than this one, and there is a very decided difference in the development of the babies. That was about two weeks ago. There is a look about it that is not quite normal, but just what it is, I can't tell.*

This short testimony, and nothing else, formed all the evidence for the crucial third generation of imbeciles. Cross-examination revealed that neither Vivian nor the Dobbs grandchild could walk or talk, and that "Mrs. Dobbs' daughter's baby is a very responsive baby. When you play with it or try to attract its attention—it is a baby that you can play with. The other baby is not. It seems very apathetic and not responsive." Miss Wilhelm then urged Carrie Buck's sterilization: "I think," she said, "it would at least pre-



vent the propagation of her kind." Several years later, Miss Wilhelm denied that she had ever examined Vivian or deemed the child feebleminded.

Unfortunately, Vivian died at age eight of "enteric colitis" (as recorded on her death certificate), an ambiguous diagnosis that could mean many things but may well indicate that she fell victim to one of the preventable childhood diseases of poverty (a grim reminder of the real subject in *Buck v. Bell*). She is therefore mute as a witness in our reassessment of her famous case.

When *Buck v. Bell* resurfaced in 1980, it immediately struck me that Vivian's case was crucial and that evidence for the mental status of a child who died at age eight might best be found in report cards. I have therefore been trying to track down Vivian Buck's school records for the past four years and have finally succeeded. (They were supplied to me by Dr. Paul A. Lombardo, who also sent other documents, including Miss Wilhelm's testimony, and spent several hours answering my questions by mail and Lord knows how much time playing successful detective in re Vivian's school records. I have never met Dr. Lombardo; he did all this work for kindness, collegiality, and love of the game of knowledge, not for expected reward or even requested acknowledgment. In a profession—academics—so often marked by pettiness and silly squabbling over meaningless priorities, this generosity must be recorded and celebrated as a sign of how things can and should be.)

Vivian Buck was adopted by the Dobbs family, who had raised (but later sent away) her mother, Carrie. As Vivian Alice Elaine Dobbs, she attended the Venable Public Elementary School of Charlottesville for four terms, from September 1930 until May 1932, a month before her death. She was a perfectly normal, quite average student, neither particularly outstanding nor much troubled. In those days before grade inflation, when C mean "good, 81–87" (as defined on her report card) rather than barely scraping by, Vivian Dobbs received A's and B's for deportment and C's for all academic subjects but mathematics (which was always difficult for her, and where she scored D) during her first term in Grade 1A, from September 1930 to January 1931. She improved during her second term in 1B, meriting an A in deportment, C in mathematics, and B in all other academic subjects; she was on the honor roll in April 1931. Promoted to 2A, she had trouble during the fall term of 1931, failing mathematics and spelling but receiving A in deportment, B in reading, and C in writing and English. She was "retained in 2A" for the next term—or "left back" as we used to say, and scarcely a sign of imbecility as I remember all my buddies who suffered a similar fate. In any case, she again did well in her final term, with B in deportment, reading, and spelling, and C in writing, English, and mathematics during her last month in school. This offspring of "lewd and immoral" women excelled in deportment and performed adequately, although not brilliantly, in her academic subjects.

In short, we can only agree with the conclusion that Dr. Lombardo has reached in his research on *Buck v. Bell*—there were no imbeciles, not a one, among the three generations of Bucks. I don't know that such correction of cruel but forgotten errors of history counts for much, but it is at least satisfying to learn that forced eugenic sterilization, a procedure of such dubious morality, earned its official justification (and won its most quoted line of rhetoric) on a patent falsehood.

Carrie Buck died last year. By a quirk of fate, and not by memory or design, she was buried just a few steps from her only daughter's grave. In the umpteenth and ultimate verse of a favorite old ballad, a rose and a brier—the sweet and the bitter—emerge from the tombs of Barbara Allen and her lover, twining about each other in the union of death. May Carrie and Vivian, victims in different ways and in the flower of youth, rest together in peace. □


J. BECKETT; AMNH

AT THE AMERICAN MUSEUM OF NATURAL HISTORY Stephen Jay Gould (left) and Niles Eldredge, curator of paleontology, with Norman Newell, curator emeritus (seated). The occasion was Dr. Newell's ninetieth birthday in 1999. The two younger scientists—who gained joint acclaim for their theory of punctuated equilibrium—both studied under Dr. Newell as graduate students.

CONTRIBUTORS

Lowell Dingus ("Ground Breakers of Patagonia," page 40) divides his fieldwork between the badlands of Patagonia and the deserts of Mongolia. Since 1991 he has been the chief geologist of the American Museum of Natural History's ongoing expeditions to the Gobi. Closer to home in New York City, he is president of the InfoQuest Foundation, which promotes scientific research projects. Dingus (center) is co-author, with Timothy Rowe, of *The Mistaken Extinction* (W. H. Freeman, 1997). A native of Argentina, **Luis M. Chiappe** (left) is curator and chairman of the department of vertebrate paleontology at the Natural History Museum of Los Angeles County. He is a specialist in the origins and evolution of birds and has done fieldwork in Mongolia, North America, and Spain, as well as Patagonia. Dingus and Chiappe have written about their early Auca Mahuevo discoveries in *Walking on Eggs* (Scribners, 2001) and in a children's book, *The Tiniest Giants: Discovering Dinosaur Eggs* (Doubleday, 1999). Originally from Buenos Aires, **Rodolfo A. Coria** (right) resides in the Argentine province of Neuquén, not far from the sauropod nesting grounds. He started his career in paleontology by working as a volunteer at the National Science Museum in Buenos Aires under the supervision of the renowned Argentine paleontologist José Bonaparte. Coria is currently the director of the Carmen Funes Museum in the town of Plaza Huincul, also in Neuquén. Illustrator **Nicholas Frankfurt,** who studied art at Yale, began working at AMNH in 1994, just after completing high school. He has excavated titanosaur nests in Patagonia and worked in Mongolia and China. His favorite subjects are prehistoric reptiles and horseshoe crabs.

A decade ago, anthropologist **Paul Stoller** ("Trading Places," page 48) heard that people from Niger were selling sweatshirts on 125th Street in New York City. Since he had already done considerable fieldwork in Niger, he eagerly hopped a bus and made his first trip to Harlem. "Within minutes after I arrived," he says, "when the street vendors learned that I spoke Songhay, they were feeding me lunch and asking after mutual acquaintances in Niger." In the years since, these "new immigrants" taught Stoller, right, about their lives, which he describes in his latest book, *Money Has No Smell: The Africanization of New York City* (University of Chicago Press, 2002). Among his other books are *In Sorcery's Shadow: A Memoir of Apprenticeship Among the Songhay of Niger* and *Jaguar: A Story of Africans in America* (University of Chicago Press, 1989 and 1999, respectively). Stoller is a professor of anthropology at West Chester University of Pennsylvania. Born in France and now a naturalized U.S. citizen who lives with his family in New York City, **Frank Fournier** knows something about the challenges faced by immigrants. An internationally published and exhibited photographer, he has recorded a series of extraordinary stories, including the tragedies of internecine war in Rwanda, rape victims in Bosnia, and infants afflicted with AIDS in Romania, as well as rescue efforts in the aftermath of the eruption of Colombia's Nevado del Ruiz volcano. Fournier has received various World Press Photo awards and is a member of Contact Press Images. For the past several years he has been documenting the Mourides, a group of Muslim traders from Senegal who are active in New York City.

Lee Boyd ("Reborn Free," page 56), a professor of biology at Washburn University in Topeka, Kansas, has been studying the behavior of horses for twenty-five years. After completing a master's thesis on feral horses in Wyoming's Red Desert, she began to research captive Przewalski's horses. Boyd still observes this endangered species but is now able to do so in the horses' native land, thanks to her involvement in a project sponsored jointly by a Dutch group (the Foundation for the Preservation and Protection of the Przewalski Horse) and the Mongolian Association for the Conservation of Nature and the Environment. Veteran photographer **Frans Lanting** frequently contributes to a variety of publications, including *Natural History*. Born in the Netherlands, Lanting lives near Monterey Bay, California. For more information on the prize-winning photographer and his work, go to www.lanting.com.

J. Scott Turner ("A Superorganism's Fuzzy Boundaries," page 62) is an associate professor of biology at the State University of New York's College of Environmental Science and Forestry in Syracuse. He says he "literally stumbled across" his work on southern African termites (work that is now supported by the Earthwatch Institute) while negotiating the termite-mound-infested university campus in Mmabatho, South Africa, where he taught in 1990. Turner set about measuring gas exchange in the mounds and immediately found it was "not what the established literature said [it] should be. Thus," he reports, "began my interest." For further reading about structures of this kind, he suggests his book *The Extended Organism: The Physiology of Animal-Built Structures* (Harvard University Press, 2000), which will be released in paperback this fall.

Born in northern Israel, **Avi Klapfer** ("The Natural Moment," page 78) has lived in the United States, Costa Rica, and Palau, Micronesia. He discovered diving and boating in the Red Sea while serving in the Israeli navy but began taking underwater photos in the 1980s as a dive-boat operator in Palau. Klapfer first came upon rosy-lipped batfish in 1993, on a dive to a depth of about a hundred feet—relatively shallow for the fish but relatively deep for a human. To photograph these shy, sedentary subjects, he planned a special dive and captured the aloof individual featured in this issue after following it for half an hour. Using two underwater strobes, he took the picture with the only camera he has ever owned—a manual Nikon F-3 in Aquatica housing—and a Nikon 55mm macrolens.

FINDINGS

GARY MESZAROS; PHOTO RESEARCHERS, INC.

A female cicada killer struggles to drag her oversize prey to her burrow.

Spurred On to Greater Depths

Large barbs on her hind legs turn a female cicada killer into a soil-moving machine.

By Joe Coelho

Its translucent orange wings buzzing, a giant wasp dragged a large green cicada along the ground toward a redbud tree. The hymenopteran's size, markings, and behavior easily identified it as a cicada killer. Only moments before, my wife had called my attention to this drama unfolding alongside our house in Indianapolis, and I had grabbed my video camera and rushed out to record it. As I filmed, the wasp clutched the cicada's belly against its own, using its middle pair of legs, and tried to climb up the side of the tree with its two free pairs. After several failed attempts at dragging its large quarry up the trunk, the cicada killer eventually dropped the prey and flew away.

As a newcomer to the Midwest in the early 1990s, I soon became fascinated with these giant wasps, and over the past ten years I've investigated many aspects of their biology and behavior. Cicada killers range throughout the United States east of the Rocky Mountains. At a length of one and a half inches and a weight of one gram, females are twice as large as males, ranking among the largest of the North American wasps. By comparison, the familiar honeybee weighs just under a tenth of a gram. Despite its name, only the female cicada killer actually hunts cicadas. After locating one, she paralyzes it with her sting and transports it to her elaborate underground burrow, where she lays an egg on it. Within a few days, the egg hatches into a grub that devours the paralyzed prey alive. Only wasp grubs feed on cicadas; as adults, both sexes turn instead to carbohydrate fuel, such as the sap of sunflower plants.

While cicada killers are large insects, so, too, are their only prey: the annual, or dog-day, cicadas, thus named because they emerge during the hottest days of summer. In fact, a cicada can weigh up to three times as much as a female wasp. Females are rarely able to take off with such oversize prey in tow, but most sidestep the problem by dragging the cicada along the ground and up a tree, then launching themselves into the air and flying downward toward their burrow. In the absence of suitable trees, cicada killers have been known to let a willing human observer stand in as a launch pad, climbing to the top of his head to gain altitude. Others, like the one I witnessed struggling in my yard, are so overloaded that they have difficulty even climbing.

Not all people familiar with cicada killers are fans of these insects, especially once they've seen the dramatic pockmarking of their lawns caused by the females' prodigious digging. Each burrow is extensive, and discarded soil accumulates in a considerable pile outside the entrance; my students and I found that an individual female often moves more than two pounds of soil when digging a burrow—a thousand times her own weight in dirt. And at an inch wide, her burrow's entrance hole appears to have been made by a rodent rather than an insect. The males do not dig but can be quite intimidating. The first sex to emerge as adults, they congregate to patrol territories where new females will surface. Indeed, the presence of the huge insects, combined with the disruption of property, can be so distressing that one Indiana woman chose to move rather than tolerate the annual invasion of her yard, and an Illinois town closed its public park in 1996 due to a large wasp infestation.

A cicada can weigh up to three times as much as a female wasp.

FRED SISKIND

In summer, the burrow holes of wasps freckle lawns across the eastern United States.

Discounting the difference in size, male and female cicada killers closely resemble each other. Both sexes have a pair of "spurs" on each hind leg where the tibia, or fourth leg segment, joins the tarsus, or foot. But the females' spurs are much larger relative to their body size than are those of the males.

I wondered what function the extra-large spurs might serve, assuming that it must be related to some behavior unique to females. In 1966, Howard Ensign Evans, an American authority on wasp behavior, noted the sexual dimorphism of the spurs, citing a 1919 book by P. G. Howes, and speculated that they were used to support prey during flight. Howes had removed the spurs from the legs of a female cicada killer and reported that the next cicada she carried was held in a more vertical position. He concluded from this simple experiment that the spurs functioned in carrying prey. I wondered, however, if this conclusion could have been the chance result of conducting just one experiment on a single wasp. In fact, I have often seen wasps with spurs intact carrying cicadas vertically.

Furthermore, it didn't make sense to me that females would need such an adaptation to carry cicadas, since wasps have perfectly good pretarsi (pairs of tiny hooks on the ends of their feet) with which to hold objects. I suspected instead that the spurs might be useful for digging. When excavating their burrows, female cicada killers loosen the soil by biting at the compact earth with their mandibles. They then use their forelegs to throw the loosened particles back and under their bodies, and their hind legs to push the accumulating dirt out of the hole. Since wasps have long, thin legs, I conjectured that the spurs might help move soil by providing the hind legs with more surface area—akin to using a snow shovel instead of a garden spade.

At my former institution, Western Illinois University, undergraduate student Kimberly Wiedman Yee and I began to investigate this hypothesis. Examining the insect's legs under a microscope, we found that there were no muscles or tendons attached to the spurs, so we knew that the wasp couldn't be moving them voluntarily. Instead, the spurs are passively movable. They attach to a small region of soft, leathery cuticle that is quite unlike the rigid armor covering most of the insect's body; bending the joint between the tibia and tarsus pulls on this flexible skin, which in turn pulls on the base of the spur, extending it out and away from the leg.

When we manipulated the hind legs by hand, the spurs extended until increased resistance stopped them at a right angle to the leg. In the reverse direction, we could flex the spurs without difficulty until they folded flat against the leg. Using a device that measures force, we determined that the spurs exerted a good deal of force when extended, but virtually none at all when flexed down toward the leg.

JOHN M. COFFMAN; PHOTO RESEARCHERS, INC.

A cutaway view of a burrow reveals individual chambers that house one or two paralyzed cicadas for each wasp grub.

To understand how female wasps make use of their leg spurs, we videotaped the insects digging their burrows in the wild. Reviewing the tapes in slow motion, we saw that while pushing soil, the hind leg is thrust in an arc back and outward. At the beginning of this motion, the joint between tibia and tarsus is bent, extending the spurs to a position where they would exert a significant force when pushed against the soil. That is, the spurs are actually useful in moving dirt. When a wasp carries a cicada, by contrast, its hind legs remain straight, with the spurs collapsed against the leg. The obvious conclusion is that the spurs are well suited to the needs of digging but are useless in prey carriage.

Many bees and wasps have small spurs on their hind legs that they use for grooming. These grooming spurs probably evolved initially from the ordinary spines present on the cuticle of most insects. Among female cicada killers, these spurs may have taken on a secondary function in digging. Natural selection would have favored larger spurs, because the increased surface area allows more soil to be moved during each stroke of the wasp's hind leg.

This improved digging efficiency could allow a female cicada killer to excavate more extensive burrows or to complete a burrow faster. Both factors bear significantly on reproductive success. In addition to constructing the main burrow tunnel, a female must dig separate branching chambers to hold each of her sixteen or so eggs, along with the immobilized prey—and her average life span of two weeks means she has little time to waste. From the mass of a typical dirt pile and the digging rate of an average female, Yee and I calculated that a wasp can complete a burrow in one night, a notion consistent with field observations. Since female cicada killers locate their prey visually, nocturnal digging gives the wasps more daylight hours for hunting cicadas: one for each male larva and two for each female, providing the future huntresses with enough nourishment to grow to their greater size.

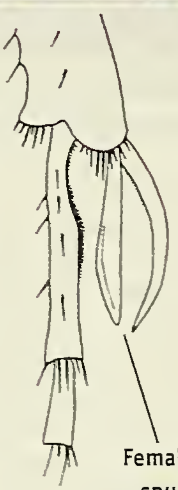
When digging a burrow, an individual female often moves a thousand times her own weight in dirt.

Interestingly, the great golden digger wasp, a close relative of the cicada killer, does not have enlarged spurs and digs only with its forelegs. According to Evans, digging with the hind legs is unusual among the many wasp species that burrow. Digging insects that follow a dedicated underground lifestyle (such as mole crickets and cicada nymphs) typically have six spiny, rather stout legs that make effective shovels. Hence, they need no spurs. Although the cicada killer's digging tools don't follow this common pattern, they do get the job done. The wasp's hind tibial spurs are a classic example of the way evolution often operates: tinkering with existing structures and co-opting them for new uses. The cicada killer's spurs may be imperfectly adapted to the needs of digging, but cicada killers are also quite good fliers. Their spurs are lightweight and collapsible, an ideal evolutionary compromise between the demands of digging and the requirements for flying.


JOHN HEIDECKER: NATURE PHOTOS


JOHN M. COFFMAN: PHOTO RESEARCHERS, INC.

An expert digger, a female cicada killer clears a runway, above. She'll also dig a central tunnel and numerous separate chambers in which to put her eggs and prey, inset.



Joe Coelho is an associate professor of biology at Culver-Stockton College in Canton, Missouri, and does fieldwork on a variety of insect species in the Midwest.

IN THE FIELD

Making Mountains Out of Molecules

With so many sperm in the sea, how does an urchin egg find Mr. Right?

By Peter J. Marchand

A burst of sperm from a green urchin (individuals vary in hue) looks like wafting smoke.

Christiane Biermann stretched as far over the edge of the boat dock as she dared, reached into the cold water of Friday Harbor on San Juan Island in Washington State, and gently plucked a sea urchin from atop a submerged pipeline. Rolling over on her side and holding it up, she gave me my first lesson in echinoid identification. It was a green urchin, strikingly beautiful in its rounded form and thick covering of stout, inch-long spines. She put it back into the water with the care and admiration befitting a marine biologist. In a few seconds she came up with another—this one a smaller, buff-colored pallid urchin. Christiane proclaimed, with the delight of discovery, "Pallids aren't supposed to be here. They're usually in deeper water."

Then came the second surprise of the afternoon. Minutes after Christiane replaced the two urchins, individuals of both species began to spawn. Releasing small clouds of eggs and sperm into the water, they looked like miniature volcanoes awakening from a long dormancy. (Gender in sea urchins is indistinguishable until they begin spawning. The male erupts with a streaming cloud of smoky white sperm while the female expels her creamy eggs in a bubbling, lavalike flow.) Christiane was ecstatic. In her several years of studying urchins, she had witnessed this fleeting event only in her marine tanks at the University of Washington's Friday Harbor Laboratories. Now, here were urchins of two different species, side by side in their natural environment, setting their eggs and sperm adrift to find one another and unite.

It was a brief, serendipitous moment, and it vividly brought to mind an intriguing question regarding the evolution of marine invertebrates. How do two closely related species living in the same environment and spawning at the same time remain genetically separate? Green and pallid urchins are found together in waters from Norway to the Canadian Arctic and south to Maine. On the west coast of North America, they range from northern California to the Bering Strait. Over large parts of their distribution, they share habitat with two or three additional species. Greens and pallids also overlap in depth: greens are generally found from the intertidal zone down to about 300 feet of water, and pallids usually range from about 50 to more than 500 feet. But in the open ocean, there are no physical barriers, such as mountain ranges, to keep the urchins apart, and no specific behaviors or courtship rituals, like those of some vertebrate species, to keep them from interbreeding. Yet green-pallid hybrids are rare in nature.

One way in which broadcast spawners—animals that simply release great numbers of eggs and sperm into the water—avoid interbreeding is to spawn in different seasons. In coastal Norway, for example, green urchins have been observed spawning in late winter and pallids in spring or early summer. Elsewhere, however, the spawning of these two species often takes place at the same time. The environmental cues that trigger spawning remain unknown, but, as we could see from the boat dock that afternoon, the release of eggs or sperm by one individual can result in spontaneous release by others in the vicinity. Still, eggs and sperm of the two species must somehow be able to sort themselves out. One possibility, Christiane suggested, is the existence of specific molecules on the surface of eggs that are able to "recognize" their own species but not others. Such chemical gate-keeping, she offered, could take place at two critical points in the fertilization process.

PETER J. MARCHAND

It's a girl: A pallid urchin releases a creamy effluent of eggs.

A sea-urchin egg is surrounded by a protective covering known as the vitelline envelope, which in turn is covered with a thick coat of jelly. At the first stage of fertilization, sperm loosely attaches to the outer jelly. If the sperm is of the right species, a carbohydrate molecule on the jelly triggers a reaction: a sperm compartment ruptures and releases enzymes that dissolve a pathway through the jelly coat and toward the egg. The rupture also exposes a special protein, called bindin, at the head of the sperm cell. At the second stage, when the sperm cell reaches the vitelline envelope, other recognition molecules allow bindin of the correct species to attach the sperm tightly to the egg. Fertilization can then take place.

Christiane is exploring the possibility that both the egg-jelly molecule that triggers the rupture and the recognition molecules for bindin are species-specific, and she is meeting with some success. Researchers from the Scripps Institution of Oceanography and the University of Hawaii have already demonstrated that in different urchin species, bindin from one species fails to attach firmly to eggs of another. Now Christiane has evidence that the egg-jelly molecule of green urchins does not induce the rupture in pallid urchin sperm, and vice versa. The system isn't foolproof: when overwhelmed by sperm of another species, eggs—or their recognition molecules—occasionally allow one through. But the rarity of natural hybrids may indicate that even when strange sperm are allowed to enter, environmental factors may work against the hybrids and serve to keep the species distinct.

On the dock, with the spawning activity winding down and the last of my camera film used up, I gazed across the bay and thought about the diversity of organisms riding out their genetic fortunes in the merging currents of the open seas. As a terrestrial ecologist, I had long appreciated the importance of physical barriers, such as prominent mountain ranges, in separating species and maintaining diversity. It occurred to me now that in the relatively uniform marine environment, the subtle chemical barriers that reproductively isolate these sea urchins effectively make mountains out of molecules.

PETER J. MARCHAND

Spine to spine: A green (left) and a pallid urchin perch on an underwater pipeline.

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

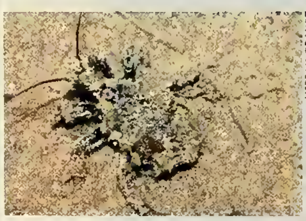
SAMPLINGS

By Stéphan Reebs

HIDDEN TO ALL Nymphs of the West African assassin bug *Paredocla* commonly wear two disguises at the same time. The first is a full coat of dust; the second is a "backpack" of plant material and insect remains, held in place by specially secreted threads. Because of the dust, prey (ants) cannot detect the bugs by smell or touch, while the backpack visually conceals the bugs from their own predators (spiders and geckos). The effectiveness of this costume was demonstrated by Miriam Brandt, of the University of Regensburg, and Dieter Mahsberg, of the University of Würzburg. They measured the reactions of prey and predator to bugs stripped of their backpack or forced to go dustless after being raised in a clean environment. Removal of the dust coat mattered only to the prey, and removal of the backpack only to the predators. ("Bugs With a Backpack: The Function of Nymphal Camouflage in the West African Assassin Bugs *Paredocla* and *Acanthaspis* spp.," *Animal Behaviour* 63, 2002)


MIRIAM BRANDT

Backpack


MIRIAM BRANDT

Dust coating


Moose calf browsing in Denali National Park and Preserve, Alaska

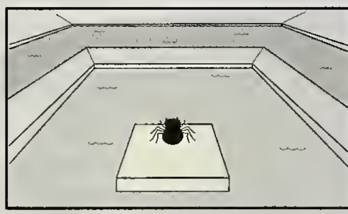
YVA MOMATIUK AND JOHN EASTCOTT; MINDEN PICTURES

DROOLING IS GOOD Browsing herbivores often leave behind gifts in their saliva: substances that promote the regrowth of grass. Margareta Bergman, of the Swedish University of Agricultural Sciences, wondered if woody plants, too, might be stimulated by saliva. Striving for as much authenticity as possible, she tore off the top third of sallow *(Salix caprea)* saplings with a moose jawbone and then applied small quantities of moose saliva to some, but not all, of them. After fifteen weeks of regrowth, the saplings that had received the saliva treatment had produced a greater number of side branches. Bergman postulates that this response might be particular to woody plants. (An increase in stem length is usually observed in saliva-treated grasses and other nonwoody plants.) What remains to be done is to identify the growth-promoting factors in moose saliva. They may be similar to the thiamine found in cow saliva or to the epidermal growth factor in mouse saliva—substances that are known to help grasses bounce back after being clipped. ("Can Saliva From Moose, *Alces alces*, Affect Growth Responses in the Sallow, *Salix caprea*?" *Oikos* 96, 2002)

ANTSY HOME BUYERS In many parts of the world, ants set up house in hollow (or excavatable) swellings that form on tree twigs or leaves. The trees and ants live in partnership: the ants attack and feed on insects that eat the trees' leaves, and in return, the trees provide a home for the ants. In the tradition of "If you build it, they will come," ant trees typically grow these little chambers, or domatia (from the Latin *domus*, for house), without any prompting from the ants. But there is now evidence that the ants themselves can trigger domatia-like growths in some trees. Working from a crane some eighty feet up in the canopy of a rainforest in southern Venezuela, Nico Blüthgen, of the University of Bonn, and Jens Wesenberg, of the University of Leipzig, saw workers of the ant genus *Pseudomyrmex* biting holes in twigs of several *Vochysia vismiaefolia* trees already covered in domatia. Two weeks later, the twigs started to swell, and over the next two to three months, they doubled in diameter. Curious, the biologists also pierced holes in twigs (with a battery-powered drill) and found that this, too, led to swelling—which meant that the wounds themselves, and not chemicals released by the biting ants, were the triggers. (Many plants are known to swell in response to wounds.) The enlarged twig sections, both ant- and human-caused, were not hollow, but after observing ants carrying plant pith out of some of the holes, the researchers speculated that ants may excavate the swellings. If future work confirms their idea, it will be the first example of ants exploiting the swelling response in plants so as to increase their real-estate holdings. ("Ants Induce Domatia in a Rain Forest Tree *[Vochysia vismiaefolia]*," *Biotropica* 33:4, 2001)

EXPERIMENT OF THE MONTH

As one might expect, given its common name, the Australian jumping spider *Portia fimbriata* can leap. But somewhat surprisingly, this terrestrial arachnid doesn't mind swimming, either. Robert R. Jackson, of the University of Canterbury in New Zealand, and colleagues made use of the spider's aquatic talents in an experiment to determine how this animal would respond when presented with a problem it had never before encountered. The researchers marooned spiders, one at a time, on a tiny "island" in the middle of an "atoll" in a water-filled tray. The spiders could get closer to freedom (the edge of the tray, which the jumping spiders could clearly see with their acute vision) by first reaching the atoll.



A spider's dilemma

STÉPHAN REEBS

Some individuals attempted to do so by initially leaping, which generally got them midway to the atoll, and then swimming the rest of the way. Others swam from the start. The researchers used a scoop to make waves, helping some spiders reach the atoll while washing others back to the central island. All those that made it to the atoll employed the same tactic they had used when leaving the island (whether that had been to leap first or to start out swimming) to finish their journey to the edge of the tray. In contrast, almost all the spiders that failed to reach the atoll the first time switched tactics the next time they attempted the trip from island to tray's edge—leaping if they had swum and swimming if they had leaped. Spiders in the genus *Portia* are known to employ trial-and-error tactics when hunting prey (other spiders), tapping out different signals on the web of an intended victim until they come up with one that induces the prey to expose itself. The current study shows that these spiders are able to apply problem-solving skills that probably evolved in one context—hunting—to another, unfamiliar context. ("Trial-and-Error Solving of a Confinement Problem by a Jumping Spider, *Portia fimbriata*," *Behaviour* 138, 2001)

GUPPY LOVE During courtship, female guppies are attracted to green, black, and especially orange spots on the flanks of males. F. Helen Rodd, of the University of Toronto, and colleagues suggest that this color preference may have arisen from a taste for orange food. On the island of Trinidad, they watched guppies voraciously feeding on the rare and highly nutritious orange fruits of the cabrehash tree *(Sloanea laurifolia)*, some of which had fallen into streams. After placing artificially colored disks in the water, the biologists observed that females (and males, too, though to a lesser extent) approached and pecked at orange disks more than at disks of any other color—with red a close second. Moreover, a comparison of six different guppy populations revealed a strong correlation between the strength of females' preference for males with bright spots and females' rate of pecking at orange objects.

Guppies *(Poecilia reticulata)*

E.R. DEGGINGER; BRUCE COLEMAN, INC.

The population in which the females were most often attracted to males with the brightest orange spots, for example, was also the one in which females pecked most vigorously at orange disks. Because orange objects in nature are likely to be food, perhaps in the course of guppy evolution the way to a female's heart has been through her eyes . . . and her stomach. ("A Possible Non-Sexual Origin of Mate Preference: Are Male Guppies Mimicking Fruit?" *Proceedings of the Royal Society of London* B 269, 2002)

CRACKING A MYSTERY Stones whose surfaces have shallow pits about the size of a quarter are often unearthed at archaeological sites, but nobody is sure what their function was. One Pleistocene site, located in the Middle East near the Jordan River, recently provided the best evidence yet that early humans might have used such stones to crack nuts. The idea is that over time, the repeated crushing of hard shells between the rocks would have formed the pits. When Naama Goren-Inbar, of the Hebrew University of Jerusalem, and colleagues investigated the 780,000-year-old site, they found, along with the pitted stones, well-preserved remains of nut-bearing plants, many of which still exist today (including almond, pistachio, prickly water lily, and water chestnut). The shapes of the pits on many of the stones resemble those found on the rock hammers and anvils used for nut cracking by present-day hunter-gatherers. That nutcrackers existed in prehistoric times makes sense: nuts were presumably just as nutritious then—and as maddeningly hard to break open without tools—as they are now. ("Nuts, Nut Cracking, and Pitted Stones at Gesher Benot Ya'aqov, Israel," *Proceedings of the National Academy of Sciences* 99:4, 2002)

!Kung woman cracking nuts

ANTHONY BANNISTER; EARTH SCENES

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

MUSEUM EVENTS IN JULY AND AUGUST

"BASEBALL AS AMERICA"

Film 7/20 (Spanish-Language Baseball Weekend series): *¡Viva Cepeda!* Mario Díaz's profile of slugger Orlando Cepeda (with English subtitles). Kaufmann Theater, 1:00–2:00 P.M.

Panel 7/20 (in Spanish only): "Béisbol: La experiencia latinoamericana." Orlando Cepeda, Mario Díaz, and others. Kaufmann Theater, 2:10–4:30 P.M.

Workshop 7/20 (in Spanish only): "La representación del béisbol." Artist Josefina Báez. Calder Lab, 3:30–5:30 P.M.

Film 7/21: *Béisbol en la República Dominicana.* Documentary (with English subtitles) followed by Q&A. Kaufmann Theater, 1:00–2:00 P.M.

Discussion 7/21 (in Spanish only): "Charlando con un Grande de las Grandes Ligas." Juan Antonio Marichal, the "Dominican Dandy," formerly of the San Francisco Giants. Kaufmann Theater, 2:30–3:30 P.M.

Film 7/28: *Kings on the Hill: Baseball's Forgotten Men,* narrated by Ossie Davis. Discussion with co-producer Rob Ruck and Negro League chronicler Byron Motley. Linder Theater, 1:00–2:30 P.M.

Performance 7/28: "Hitmakers, Heroes & Homeruns: A Musical Celebration of Jazz and Negro League Baseball." Performing artist Byron Motley. Kaufmann Theater, 3:30–4:30 P.M.

"INDIGENOUS PEOPLES: OLD WAYS AND NEW CHALLENGES"

Lecture 8/10: "Indigenous Peoples of the Himalaya." Sher Malik, of the Indigenous Peoples Survival Foundation. Linder Theater, 1:00–2:00 P.M.

Film 8/10: *Cave Rock: The Issue.* Rock climbing at a sacred site. Discussion with Washoe/Paiute activist Barbara James Snyder. Linder Theater, 2:00–3:00 P.M.

Poetry Reading 8/10: Dean Hutchins and other native American poets. Linder Theater, 3:00–4:00 P.M.

INSIDE AND OUTSIDE THE MUSEUM

Summer camp at AMNH. 7/8–7/12: Paleontology. 7/15–7/19: Archaeology. 7/22–7/26: Herpetology. 7/29–8/2: Astrophysics. For children entering grades 4 and 5 this fall. 9:00 A.M.–4:00 P.M. Details at (212) 769-5079.

Lecture 7/10 (Reports From the Field series): "The Great Shark Hype." Peter Benchley, author and marine conservationist. Linder Theater, 7:00 P.M.

Workshops 7/11, 7/25: Introductory talk and instruction provides a basic understanding of genomics and DNA sequencing procedures. Calder Lab, 6:00–9:00 P.M.

Workshops 7/13, 7/20: "Imagining the Museum." Designer and writer Jennifer George. Portrait Room, 2:00–3:30 P.M.

AMNH Book Club. 7/14: *Wild Nights: Nature Returns to the City,* by Anne Matthews. 8/18: *Of Moths and Men: An Evolutionary Tale,* by Judith Hooper. Details at (212) 769-5200. Portrait Room, 3:00–4:30 P.M.

Lecture 7/17 (Reports From the Field series): "Science Bulletins at the South Pole." Vivian Trakinski and Jason Lelchuk, both of AMNH's *Science Bulletins.* Linder Theater, 7:00 P.M.

Performance 7/20: "Folklore Nuevayorquino/New York Folklore." Composer, guitarist, and ethnomusicologist Cristian Amigo. Kaufmann Theater, 6:00 P.M.

Concert 7/25 (Art/Science Collision series): "An Evening of Theremin" (with graphics). This instrument is played without being touched. AMNH senior preparator David McCornack and musician Pamelia Kurstin. Hayden Planetarium, 7:00 P.M.

Sing-along 7/27, 7/28 (in Spanish only): "Canciones de Latinoamérica." Chilean folklorist Mochi Parra. Calder Lab, 2:00–3:00 P.M.

Percussion workshop 7/27: "Ritmos del Sur/Rhythms From the South." Calder Lab, 4:00–5:30 P.M.

Celestial Highlights 7/30, 8/27: Joe Rao, meteorologist and *Natural History* columnist. Space Theater, 6:30 P.M.

University Without Walls (telephone courses). 8/1–8/22, 11:00 A.M. (four Thursdays): "Big Cats." 8/5, 3:00 P.M.: "Feathered Wonders." Advance registration required. Details from DOROT at (212) 769-2850 or toll-free at (877) 819-9147.

Film and roundtable 8/7 (Reports From the Field series): *Rising Waters: Global Warming and the Fate of the Pacific Islands.* Discussion with Andrea Torrice, the film's director, and others. Linder Theater, 7:00 P.M.

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. Space Show tickets, retail products, and Museum memberships are also available online. To make reservations for programs and events, call (212) 769-5200.

ROD MICKENS; AMNH

JAZZ AT THE MUSEUM

Starry Nights: Friday Under the Sphere. Live jazz, free with Museum admission. Rose Center for Earth and Space. Two sets every Friday, 5:45 and 7:15 P.M. For more information, check www.amnh.org/rose/.

THIS LAND

On the Flyways

Birds, butterflies, and plants have a sanctuary in Canada's smallest national park.

By Robert H. Mohlenbrock

Point Pelee, the tip of a ten-mile-long peninsula that juts south into Lake Erie, is the southernmost extent of mainland Canada (the truly southernmost bits of Canadian territory are nearby Pelee and Middle Islands). Together with the latitude, the moderating influence of the lake gives the peninsula a relatively warm climate for Canada. The result is that the plant and animal life in this part of Ontario has more in common with that found in the United States from the Carolinas to the central Midwest than with that in other parts of Canada. An additional natural feature of the region is that the Atlantic and Mississippi Flyways converge here, so that large numbers of migrating birds appear during the spring and autumn. In large part to provide a bird sanctuary, the southern eight square miles of the peninsula were set aside in 1918 to create Point Pelee National Park.

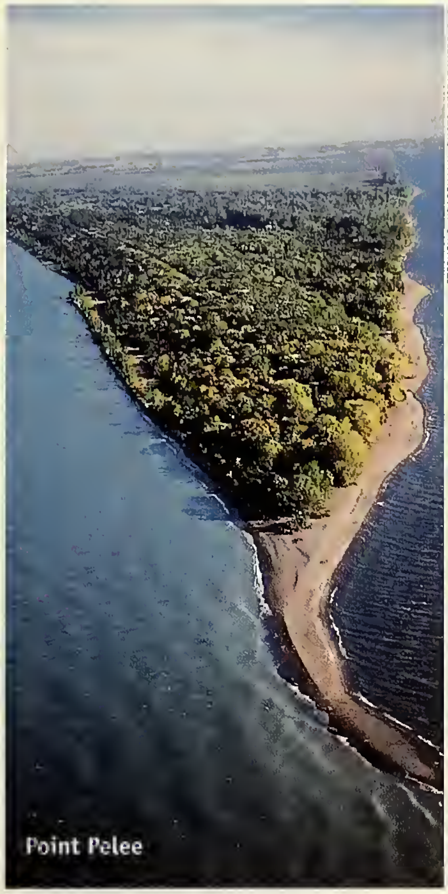
TOM LAZAR: ANIMALS ANIMALS

A killdeer nesting in Point Pelee National Park

The park lies about 180 miles southwest of Toronto and 35 miles southeast of Detroit, Michigan. The entrance is framed by a forest canopy of hackberry, with flowering dogwood, wild black cherry, and box elder (Manitoba maple) forming a lush secondary layer. In summer, the huge, foot-wide leaves of cow parsnip line the roadside in several places. A fine visitors center explains much of the park's cultural and natural history; most visitors take the shuttle from there to a spot near the peninsula's tip. After a short hike through the woods, one emerges onto the sandy point.

The nearly two-mile Woodland Nature Trail provides the best introduction to the forest habitat, called eastern deciduous in the United States but here commonly referred to as Carolinian. The mile-long Marsh Boardwalk, which passes through what has been named a Wetland of International Importance (a Ramsar site), protects the biological community while keeping hikers' feet dry; each end of the boardwalk has an observation tower. The park's marsh includes large stands of cattails as well as open tracts of water surrounded by mudflats.

Migrating birds can be seen as early as January, when horned larks arrive, followed by waterfowl in February and March. Forty-two species of warblers have been recorded, including the Kentucky warbler and the worm-



Point Pelee

STEPHEN J. KRASEMANN; PHOTO RESEARCHERS, INC.

For visitor information, contact:
Point Pelee National Park
407 Robson Street, RR1
Leamington, Ontario N8H 3V4
Canada
(519) 322-2365
http://parkscanada.pch.gc.ca/parks/ontario/point_pelee/

eating warbler. Former park staff member J. Robertson Graham reports that the northern cardinal, the Carolina wren, and various other species have extended their breeding ranges north onto the peninsula since 1900, perhaps because of a gradual warming trend in the region.

The black bears that once roamed Point Pelee National Park are now gone, but coyotes, red foxes, raccoons, opossums, weasels, and muskrat are still around. The marsh supports American toads, midland painted turtles, Blanding's turtles, snapping turtles, and Lake Erie water snakes. Monarch butterflies are another animal

JOE LEMONNIER

attraction at the park. They begin heading south when the weather cools, usually in late August. Ontario's monarch population funnels onto the point, where the butterflies gather in great numbers on the trees and shrubs. There they await favorable winds and temperatures before crossing Lake Erie and continuing on to overwinter sites in Mexico.

HABITATS

Eastern deciduous forest. The woods near Point Pelee contain hackberry, red mulberry, red cedar, chokecherry, and green ash above shrubby thickets of wild red raspberry and wild gooseberry. Wildflowers: starry false Solomon's-seal, smooth sweet cicely, bladder campion, blue wood aster (also known as large-leaved aster), large-flowered bellwort, white avens. Venturing off the trail is not recommended because of the abundance of stinging nettle.

Additional trees and shrubs along the Woodland Nature Trail: white ash, basswood, black walnut, chestnut oak, rough-leaved dogwood. Wildflowers: cut-leaved toothwort, wood anemone, white trillium, roundlobe hepatica, bloodroot, dutchman's-breeches, columbine, false Solomon's-seal,

Yellow warbler

BROCK MAY; PHOTO RESEARCHERS, INC.

waterleaf, blue phlox, wild bergamot, Canada anemone, tall bellflower, various goldenrods and asters.

Marsh. Cattail is the most conspicuous species. Sandbar willow and stiff dogwood (also known as gray dogwood) line the edges of the marsh, and water willow sometimes grows as an arching shrub in shallow standing water. In the open water are watershield, spatterdock, white water lily, and several species of duckweed. Totally submerged are bladderwort, coontail, and water milfoil. Marsh fern, water horehound, spotted touch-me-not, great water dock, and lake sedge live on the soupy mudflats.

Savanna. In the drier parts of the park, where few trees grow except for red cedar, are some openings known as savannas. Plants here include prairie rose, nodding onion, gray-headed coneflower, butterfly weed, green milkweed, hoary puccoon, and even eastern prickly pear cactus.

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.

UNIVERSE

Cosmos on the Table

By Neil deGrasse Tyson

An astrophysicist looks at chemistry's most famous chart.

For many people, the periodic table is a forgotten oddity—a chart full of squares and cryptic letters last encountered on the wall in a high-school chemistry class. As a way of organizing the chemical behavior of all known and yet-to-be-known elements in the universe, the table ought instead to be a cultural icon: testimony to the enterprise of science as an international human adventure conducted in laboratories, particle accelerators, and on the frontier of the cosmos itself.

Yet every now and then, even a scientist can't help thinking of the periodic table as a menagerie of one-of-a-kind animals conceived by Dr. Seuss. How else could we accept that sodium is a poisonous, reactive metal that you can cut with a butter knife and that pure chlorine is a smelly, deadly gas, yet when added together they make sodium chloride, a harmless, biologically essential compound better known as table salt? Or how about hydrogen and oxygen? One is explosive. The other promotes combustion. Yet the two gases combined make liquid water, which (among other things) puts out fires.

Amid these chemical concoctions we find elements significant to the cosmos, allowing me to offer a view of the periodic table through the lens of an astrophysicist.

With only one proton in its nucleus, hydrogen is the lightest and simplest element, made entirely during the big bang. Hydrogen further lays claim to two-thirds of all the atoms in the human body and to about 90 percent of all the atoms in the cosmos, right on down to our solar system. The hydrogen in the core of the massive planet Jupiter is under so much pressure that it behaves more like a conductive metal than like a gas, creating the strongest magnetic field among the planets. The eighteenth-century English scientist Henry Cavendish isolated hydrogen in 1766 during his experiments with H_2O (*hydro-genes* is Greek for "water-forming"). But he is best known among astrophysicists as the first to calculate Earth's mass, after being the first to come up with an accurate value for Newton's gravitational constant.

Every second of every day, 63 billion tons of fast-moving hydrogen atoms are turned into helium as they slam together within the 15,000,000°K core of the Sun.

Helium is widely known as an over-the-counter gas that, when inhaled, temporarily increases the vibrational frequency of air within your larynx, leaving you sounding like Mickey Mouse. Helium's nucleus contains two

ROBERT GROSSMAN

Long-Term Care Coverage

Who needs it; How to find the best policy

Americans are living longer than ever and are now facing the important decision of whether to purchase long-term care insurance. Most people buy this coverage to protect assets, preserve independence and provide quality care. A growing number of younger people are buying it to help their aging parents.

In general, long-term care protection makes sense for those with assets of at least $75,000 (excluding your home and car) and an annual income of at least $25,000.

With over 100 policies on the market—each with different benefits, premiums, exclusions and application requirements—it pays to comparison shop. According to respected *Money Magazine* financial editor, Jean Chatzky, "Your best bet is to get quotes from at least three companies."[1] In addition, you should consider a policy with at least a three-year term—the average time people need care.

Look for a daily benefit that would cover the average daily nursing-facility cost in your area. The national average is over $50,000 per year, but in some areas it can run twice as much.[2]

The high cost of long-term care could threaten your retirement dreams.

What is your risk of needing long-term care?

The odds may be greater than you think. Consider this:

- More than half the U.S. population will require long-term care in their lifetime.
- 3 million Americans currently receive long-term care in a facility...and 40% of them are between the ages of 18 and 64.
- Today, more than 1.5 million people reside in assisted living facilities in the United States.
- More than 6 million American seniors who live at home must depend on regular assistance from family or friends.[3]

Look for an elimination period (the time before your benefits begin) of 90 days. Remember, this is catastrophic coverage. Most people who need the insurance can afford the cost of care for three months. Plus, this approach lowers your cost—in some cases, by as much as 30% per year. Equally important, insist on insurers rated "A" or better by A.M. Best and "strong" by Standard & Poor's and Moody's.

If you'd like to receive three quotes with just one call, Long-Term Care Quote will provide them—free of charge. The company—which has been recommended in *Consumers Digest, Kiplinger's, Mature Outlook* and on NBC's *The Early Today Show*—will ask for basic information on your age, health and location, then shop up to 17 top-rated carriers on your behalf. You'll get details and quotes on the three most suitable policies for you, plus a copy of *The Consumer's Guide to Long-Term Care Insurance.*

To request your free Information Kit and personalized quotes, either write to Long-Term Care Quote, 600 W. Ray Road, Bldg. D4, Chandler, AZ 85225*, visit www.longtermcarequote.com or call 1-800-587-3279.

* Please be sure to include your date of birth. [1] *USA Weekend*, June 15, 1998; [2] The Health Insurance Association of America, 2000; [3] Americans for Long-Term Care Security, August 2001; Writing agent Robert W. Davis, CA License #0B78024. All inquiries will be kept strictly confidential.

protons, and although it's a distant second to hydrogen in cosmic abundance, there's four times more of it than of the rest of the elements in the universe combined. One of the pillars of big bang cosmology is the prediction that in every region of the universe, no less than about 8 percent of all atoms are helium, manufactured in that quantity during the birth of the cosmos. Since the thermonuclear fusion of hydrogen within stars gives you helium, some regions of the cosmos could easily accumulate more than their 8 percent share of helium, but, as expected, no one has ever found a galaxy with less.

Two-thirds of the atoms in the human body, and about 90 percent of the atoms in the cosmos, are hydrogen.

Some thirty years before it was discovered and isolated on Earth, helium was detected in the Sun's spectrum during the total solar eclipse of 1868. The name "helium" was duly derived from Helios, the Greek sun god. And with more than 90 percent of hydrogen's buoyancy in air but without its explosive demeanor, helium is the gas of choice for the outsize balloon creatures of the Macy's Thanksgiving Day Parade. The department store is rumored to be second only to the U.S. military as the nation's top consumer of helium.

Lithium is the third simplest element in the universe, with three protons in its nucleus. Like hydrogen and helium, lithium was made in the big bang. Unlike helium, which can be manufactured in stars, lithium is fragile and easily destroyed by nuclear reactions. Another prediction of big bang cosmology is that we can expect no more than one in a hundred million atoms in any region of the universe to be lithium. No one has yet found a place with more. The combination of the lower limit for helium and the upper limit for lithium imposes a potent dual constraint on tests for big bang cosmology.

The element carbon is found in more than half of all the kinds of molecules in existence. Given the cosmic abundance of carbon—forged in the cores of dying stars, churned up to their surfaces, and released copiously into galaxies—no other element affords a better foundation for the chemistry and diversity of life. Just edging out carbon in abundance is oxygen, also forged and released in stellar remains. Both oxygen and carbon are major ingredients for life as we know it.

But what about life as we don't know it? How about life based on the element silicon? Silicon sits directly below carbon on the periodic table, allowing it to combine with all the same elements and to form analogous compounds. In the end, however, we expect carbon to prevail as the main foundation of living things because it's ten times more abundant than silicon in the cosmos and its chemical bonds are substantially stronger. Complex molecules based on carbon are therefore hardy and more likely to survive environmental stress. But that doesn't stop science fiction writers from including silicon-based life in their alien inventory.

In addition to being an active ingredient in table salt, sodium is the most commonly used glowing gas in municipal streetlamps across the nation. Sodium vapor lamps "burn" longer and brighter than conventional incandescent bulbs of the same wattage. Of the two varieties in use, the common, high-pressure lamp has a light apricot hue, while the rarer, low-pressure lamp looks orange. All light pollution is bad for astronomy, but low-pressure sodium lamps are the least bad, because their contamination can be easily subtracted from spectroscopic data. In a model of civic cooperation, the entire city of Tucson, Arizona—the nearest large municipality to the Kitt Peak National Observatory—has converted its streetlights to low-pressure sodium lamps.

Aluminum is more than 8 percent of Earth's crust yet was unknown to the ancients and unfamiliar to our grandparents. The element was not isolated until 1825 and did not enter common household use until the 1960s, when tin-lined steel cans and tinfoil yielded to aluminum cans and aluminum foil. Polished aluminum makes an excellent reflector of visible light and is the coating of choice for nearly all telescope mirrors today.

Although titanium is only 70 percent denser than aluminum, it's more than twice as strong. So titanium, the ninth most abundant element in Earth's crust, is the darling of modern engineering. Many products, such as military aircraft components, are improved by the use of this light, strong metal.

Silicon-based molecules lack hardiness, but sci-fi writers haven't given up on silicon-based aliens.

With oxygen atoms outnumbering carbon atoms in most regions of the universe, every carbon can, and often does, latch onto one or two oxygens, forming carbon monoxide or carbon dioxide. The leftover oxygen will bond with other things, such as titanium. The spectra of most red giant stars are riddled with features traceable to titanium oxide, which itself is no stranger to stars on Earth: star sapphires and star rubies owe their radiant asterisms to titanium oxide impurities in their crystal lattices. Also, the white paint used for telescope domes features titanium oxide, which happens to be highly radiative in the infrared part of the spectrum. At nightfall, the sun-heated dome cools efficiently, enabling the temperature of the air around the telescope to rapidly track the descending temperature of the outside air. With this arrangement, the light from stars and other cosmic objects comes through sharp and clear.

By at least one measure, iron ranks as the most important element in the universe. Beginning with helium, massive stars create larger and larger elements in their cores, until they reach iron. With twenty-six protons in its nucleus, iron's distinction comes from having the least binding energy per nuclear particle of any element. This means something quite simple: If you split iron nuclei (fission), they absorb energy. If you combine iron nuclei (fusion), they also absorb energy. Stars, however, are in the business of *liberating* energy. By the time a high-mass star has manufactured iron in its core, it has no choice but to collapse under its own weight and rebound in a titanic explosion known as a supernova, outshining a billion suns for more than a week, spreading a trove of manufactured elements into the galaxy, and enabling planets, parsnips, and people to form.

The soft metal gallium has such a low melting point that it will liquefy on contact with your hand. Apart from this parlor demo, gallium is not interesting to astrophysicists except as one of the ingredients in a gallium chloride vat used to detect elusive neutrinos from the Sun. In this experiment, physicists monitor a hundred tons of liquid gallium chloride for any collisions between neutrinos and gallium nuclei. Each such encounter turns gallium into germanium and emits a measurable spark of X-ray light. This experiment, and others with similar goals, have all detected a lower number of neutrinos than predicted, forcing particle physicists to scratch their heads and then go home to modify the theory of neutrinos.

All forms of the element technetium are radioactive and have relatively short half-lives. Not surprisingly, this element was unknown on Earth until it was manufactured in particle accelerators, where we now make it on demand. Technetium bears this homemade feature in its name, which derives from the Greek *technetos*, meaning "artificial." For reasons not yet fully understood, technetium lives in the atmospheres of some red giant stars. This alone would not be cause for alarm, except that technetium isotopes have half-lives that are much, much shorter than the life expectancy of the stars in which the element is found. In other words, these stars cannot have been born with the stuff, for if they had been, none of it would be left by now. There is also no known mechanism that explains how technetium can be created in a star's core *and* get dredged up to the surface, for all to see. Its mysterious behavior forced spectroscopists to retune their models of stellar structure, allowing for fusion in places much closer to the stars' surface.

Along with osmium and platinum, iridium is one of the densest elements in the periodic table: two cubic feet of it weigh as much as a Buick. This makes a lump of iridium one of the world's best paperweights—able to defy all known office fans. Iridium is also the world's most famous smoking gun. A thin layer of clay at the famous K-T boundary in geological strata is anomalously rich in iridium and dates from 65 million years ago. Of course, that's when every land species larger than a bread box, including the legendary dinosaurs, went extinct. Iridium is rare on Earth's surface but relatively common in metallic asteroids. Whatever might have been your favorite theory for destroying the dinosaurs, a killer asteroid from outer space now seems quite compelling.

An unknown element was discovered in debris from the first hydrogen bomb test in the Pacific in November 1952. I don't know how Albert would have felt about this, but the element was named einsteinium, in his honor. I might have called it armageddium instead.

Twelve entries in the periodic table share names with objects that orbit the Sun.

Besides titanium (Titan is Saturn's largest moon) and europium (Europa is one of Jupiter's four largest moons), we have phosphorus, whose name (from the Greek for "light bearing") was used in ancient times to refer to the planet Venus when it appeared before sunrise in the dawn sky.

Selenium comes from *selēnē* (the ancient Greek word for "Moon") and is so named because the element was discovered together with the element tellurium, which had already been named for Earth, from the Latin *tellus*.

On January 1, 1801, Italian astronomer Giuseppe Piazzi discovered a new planet orbiting the Sun in the suspiciously large gap between Mars and Jupiter. In keeping with the tradition of naming bodies in the solar system after classical deities, the object was named Ceres, after the goddess of the harvest. ("Ceres" is, of course, the root of the word "cereal.") At the time, there was much excitement in the scientific community, and the next element to be discovered was named cerium, in the object's honor. The year after the discovery of Ceres, another planet was found orbiting the Sun in the same gap. Discovered by German astronomer Heinrich Olbers, this object was named for Pallas Athena, the Greek goddess of wisdom and war. Predictably, the next element to be discovered was named palladium, in the planet's honor. The planet-fest ended a few decades later, after dozens more items with similar orbits were discovered. Closer analysis revealed that these objects were much smaller than the smallest known planets. A new swath of real estate, populated by small, craggy chunks of rock and metal, had been identified in the solar system. Ceres and Pallas are asteroids, not planets, and they live in the asteroid belt, now known to contain tens of thousands of objects—somewhat more than the number of elements in the periodic table.

A new element was discovered in debris from the first H-bomb test in the Pacific. It was named einsteinium. I might have called it armageddium.

The metal mercury, liquid and runny at room temperature, and the planet Mercury, the fastest of all planets in the solar system, both owe their identity to the speedy Roman god of the same name.

Used as a fuel in nuclear reactors, the radioactive metal thorium—while named for Thor, the hammer-wielding chief Germanic god—also evokes Jupiter, the lightning-bolt-wielding god of Roman mythology. And, by Jove, recent Hubble Space Telescope images of Jupiter's polar regions reveal extensive electrical discharges deep within that planet's turbulent layers of clouds.

Alas, Saturn, my favorite planet, has no element named for it, but Uranus, Neptune, and Pluto are famously represented. Uranium was discovered in 1789 and named in honor of the planet discovered by William Herschel just eight years earlier. All isotopes of uranium are unstable, spontaneously decaying to lighter elements, accompanied by the release of energy. The first atomic bomb ever used in warfare had uranium as its active ingredient and was dropped by the United States on the Japanese city of Hiroshima. With ninety-two protons packed in its nucleus, uranium is widely described as the largest naturally occurring element, although trace amounts of some larger elements do occur in nature.

If Uranus deserved an element named in its honor, so did Neptune. Unlike uranium, however, which was discovered shortly after the planet, neptunium was discovered in 1940, a full ninety-six years after German astronomer Johann Galle found Neptune in the sky. Just as Neptune comes right after Uranus in the solar system, so, too, does neptunium come right after uranium in the periodic table.

Neptunium was discovered by the nuclear physics group working at the University of California, Berkeley. The Berkeley cyclotron created many elements never (or almost never) found in nature—including plutonium, which directly follows neptunium in the table. Plutonium was, of course, named for Pluto, which Clyde Tombaugh had discovered 10 years earlier, in 1930. Just as with the discovery of Ceres 129 years before that, excitement prevailed. Pluto was the first planet discovered by an American and, in the absence of better data, was widely regarded as a planet commensurate in size and mass with

For reasons I have yet to determine, many people don't like chemicals. Perhaps the names just sound dangerous.

Uranus and Neptune. As measurements of Pluto's size got better and better, the planet kept getting smaller and smaller. Our knowledge of Pluto's dimensions did not stabilize until the late 1970s, during the *Voyager* missions to the outer solar system. We now know that cold, icy Pluto has the embarrassing distinction of being littler than the solar system's six largest moons. Like the asteroids, hundreds more objects were later discovered in the outer solar system, with orbits similar to that of Pluto, signaling the existence of a theretofore uncharted reservoir called the Kuiper belt. In this regard, one could argue that Ceres, Pallas, and Pluto slipped into the periodic table under false pretenses.

Weapons-grade plutonium was the active ingredient in the atomic bomb that devastated the Japanese city of Nagasaki just three days after the uranium bomb was dropped over Hiroshima, bringing a swift end to World War II. Small quantities of non-weapons-grade radioactive plutonium can be used to power radioisotope thermoelectric generators (sensibly abbreviated RTGs) on spacecraft that travel to the outer solar system. Way out there, the intensity of sunlight has diminished below levels useful to solar panels. One pound of plutonium will generate 10 million kilowatt-hours of heat energy, which is enough to power a household lightbulb for 11,000 years or a human being for just as long.

And so ends our cosmic journey from the beginning of the cosmos to the edge of the solar system. For reasons I have yet to determine, many people don't like chemicals, which might explain the perennial efforts to rid foods of them. Perhaps sesquipedalian chemical names just sound dangerous. But in that case, we should blame the chemists and not the chemicals themselves. Personally, I am quite comfortable with chemicals. My favorite stars, as well as my best friends, are made of them.

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

P. S. Who would have thought, before Stephen Jay Gould landed on the pages of *Natural History*, that essays on science could be raised to a form of art? The success of his efforts gave me hidden confidence to step onto this landscape with him. From 1995 (my first) through 2001 (his last) I shared his space, with each of our contributions bookending the central articles of this magazine. We wrote, of course, on completely different subjects. But I continually felt a deep kinship of mission—a mission, set by Gould himself, that forces me every month to ask of the universe, What stories have I yet to tell? What turns of phrase will I use to tell it? How best can I share with readers this glorious journey of the soul we call science? □

NOW HEAR THIS

Psst! Sounds Like a Meteor

In the debate about whether or not meteors make noise, skeptics have had the upper hand until now.

By Alan Burdick

Depiction of a Leonid shower over Paris, 1870

IMAGE SELECT/ART RESOURCE, NY

In the wee hours of November 18, 2001, while meteor gazers sat outdoors enjoying a dazzling Leonid shower, a puzzled few sat indoors typing e-mails to NASA.

"Do meteors make noise?" two perplexed viewers in North Carolina wanted to know. They had heard "a crackling to hissing sound" several times that evening, just as the meteors flared overhead. Likewise, an observer in Mississippi heard "a hissing sound" right when a meteor streaked across the sky. A third person heard sizzling; a fourth, "a kind of swish." That shouldn't happen, one viewer pointed out. Sound travels far more slowly than light; you might hear a sonic boom several moments after a meteor appears, but simultaneously hearing and seeing the "swish" of a meteor is as impossible as seeing distant lightning and hearing the accompanying thunder at the same time. Yet this viewer, too, had heard "a faint fizzing" noise from several Leonid meteors that night. "I hope I'm not going crazy!" she added.

Not to worry, says Dejan Vinkovic, coordinator of the Global Electrophonic Fireball Survey. Vinkovic, a graduate student in physics at the University of Kentucky in Lexington, began the survey two years ago in an effort to gather a database of earwitness reports of these whispering meteors ("electrophonic fireballs" in the literature). He knows full well that reputable scientists have dismissed the phenomenon for centuries; in 1719, astronomer Edmund Halley discounted such anecdotes as "the Effects of Fancy." But not only has Vinkovic heard the sounds himself, he was recently part of an international team of scientists that, for the first time in history, successfully captured them on tape. "Nobody had actually recorded these sounds under controlled conditions," he says. "We proved that it can be done."

Reports of noisy meteors date back to at least the year 817, when a Chinese observer documented a meteor with a sound "like a flock of cranes in flight." In 1676, Italian astronomer Geminiano Montanari observed one that sounded like "the rattling of a great Cart running over Stones." Montanari was also the first to doubt his ears: his calculations put the meteor thirty-eight miles up in the sky—too far away, he knew, for its sound to reach him instantly. A spectacular Leonid storm in 1833 generated further anecdotes of meteors that swished, whooshed, or, in one case, "resembled the noise of a child's popgun." Failing any suitable explanation, however, the reports were again dismissed as figments of imagination.

There the matter rested for a century and a half. How could sound waves travel at the speed of light? A few inconclusive experiments were conducted. Tenuous theories arose and sank. Finally in 1980, Colin Keay, of the University of Newcastle in Australia, offered a strange yet geophysically rational explanation. As meteors fall through Earth's magnetic field, he proposed, they generate radio signals audible to the human ear.

Ordinarily that would be impossible, Keay knew. Radio waves are electromagnetic, not acoustic. Acoustic waves are vibrations of molecules: when a wing flaps, it compresses the surrounding air in a series of waves that reach the inner ear and are perceived as sound. Electromagnetic waves, which include radio signals and visible light, don't need a medium to propagate and don't make an impression on the human ear. Even radio waves of 20 Hz to 20,000 Hz—quite low frequencies, corresponding to the range of acoustic frequencies that humans can register as sound—are, by themselves, inaudible.

To bridge this gap, humans invented the transducer, a device that efficiently translates electromagnetic waves into physical, air-moving waves and hence sound. Amazingly, in laboratory experiments Keay found that even ordinary objects can act as transducers. Slips of paper, aluminum foil, even eyeglasses: when Keay exposed them to rapidly shifting electromagnetic fields (that is, radio waves of very low frequency), the objects oscillated ever so slightly, creating weak—and faintly audible—acoustic waves.

Keay postulated that the same thing happens outdoors under a meteor shower: falling meteors generate very low-frequency radio signals that travel at the speed of light to the ground, where they cause pine needles, blades of grass, and other small objects to tremble slightly and whisper to any stargazer within earshot. Mundane objects become celestial heralds, instantly announcing the arrival of shooting stars. A meteor plummets, and the lawn chair or the pine tree speaks.

Keay's theory helped explain the rarity of noisy meteors. Only very rarely does a meteor generate sufficient electromagnetic energy to make pine needles move. Even then, the sounds are faint; one meteor watcher may hear noises, while a friend standing ten feet away may hear nothing. Keay suggested that his theory could also account for controversial age-old reports that the aurora borealis, which is essentially an electrical disruption of Earth's magnetic field, sometimes speaks to its viewers.

In 1998 Dejan Vinkovic joined a team of scientists led by Slaven Garaj, a physicist at the Swiss Federal Institute of Technology in Lausanne, Switzerland, in an effort to test Keay's theory in the field. They journeyed to Mongolia—remote, quiet, albeit a little cold in November—to observe and record what was expected to be a major Leonid shower. The team set up a video camera, a radio antenna, and two sets of microphones: one open to the voices of the scientists as they watched the sky; the other isolated in boxes containing paper and aluminum foil, which would function as transducers. To count as electrophonic, the researchers agreed, a sound would have to be heard by two viewers and be recorded on all the devices, and the devices would have to synchronize within .04 second. With those restrictions, and many controls, they recorded the sounds (and sights) of not one but two separate meteors—two ghostly but unambiguous "pops" at about 250 Hz. "We concluded that electrophonic sounds are really a real phenomenon," Garaj says, "not a psychological phenomenon."

"Nobody had actually recorded these sounds under controlled conditions. We proved that it can be done."

The recordings have quieted many long-standing skeptics. Jeremy Tatum, a physicist/astronomer—and the self-described "Unbeliever-in-Chief" of electrophonics—wrote an open letter to the Canadian Space Agency's Meteorites and Impacts Advisory Committee, of which he is a member. "Their paper does supply convincing evidence of the reality of simultaneous sound and its instrumental detection under carefully controlled and designed scientific experiment," he declared. "This has come far closer to convincing me than anything to date."

Still, a question remained: How does a meteor generate radio waves in the first place? Keay proposed that in the turbulent wake of a meteor, Earth's magnetic field lines become twisted and trapped, forming "magnetic spaghetti" that produces radio waves in the course of untangling itself. Another group of scientists has proposed that a meteor builds up an electrical charge as it plummets. Whenever the charge reaches a critical maximum, the meteor releases electrical energy, shedding electrons, and the process begins once more, creating pulse after pulse of radio waves as the meteor moves along.

The 1998 recordings suggest to Garaj that neither explanation suffices. The mathematics of both theories require that a meteor be at least ten inches wide (enormous, as meteors go) to be able to produce radio waves energetic enough to vibrate eyeglasses and pine needles. But a Leonid meteor is tiny, a supersonic mote of dust. And the radio frequencies detected from the meteors in Mongolia were far lower than those predicted by current theories. "There's something else beyond these theories that is responsible for electrophonic sounds," Garaj says.

As for Vinkovic, he hopes the Global Electrophonic Fireball Survey will shed some light, and sound, on the matter. Anyone who has heard a meteor can go to his Web site and fill out a standardized response form. When a hundred or so have come in, Vinkovic hopes to conduct the types of statistical analyses that will prove far more convincing than randomly gathered anecdotes. He is, in effect, catching stars with the Internet; last November's Leonid shower netted him twenty responses.

Meanwhile, Garaj, Vinkovic, and their colleagues are on the hunt for more hard evidence. They'll set up their recording equipment again this November (though probably not in Mongolia), when another flashy Leonid show is expected. They've also begun designing an unmanned device that will automatically record both visual and audio traces of meteors. It will enable them to catch more sounds with less effort—and perhaps to catch some sleep.

Alan Burdick is writing a book about nature for Farrar, Straus and Giroux.

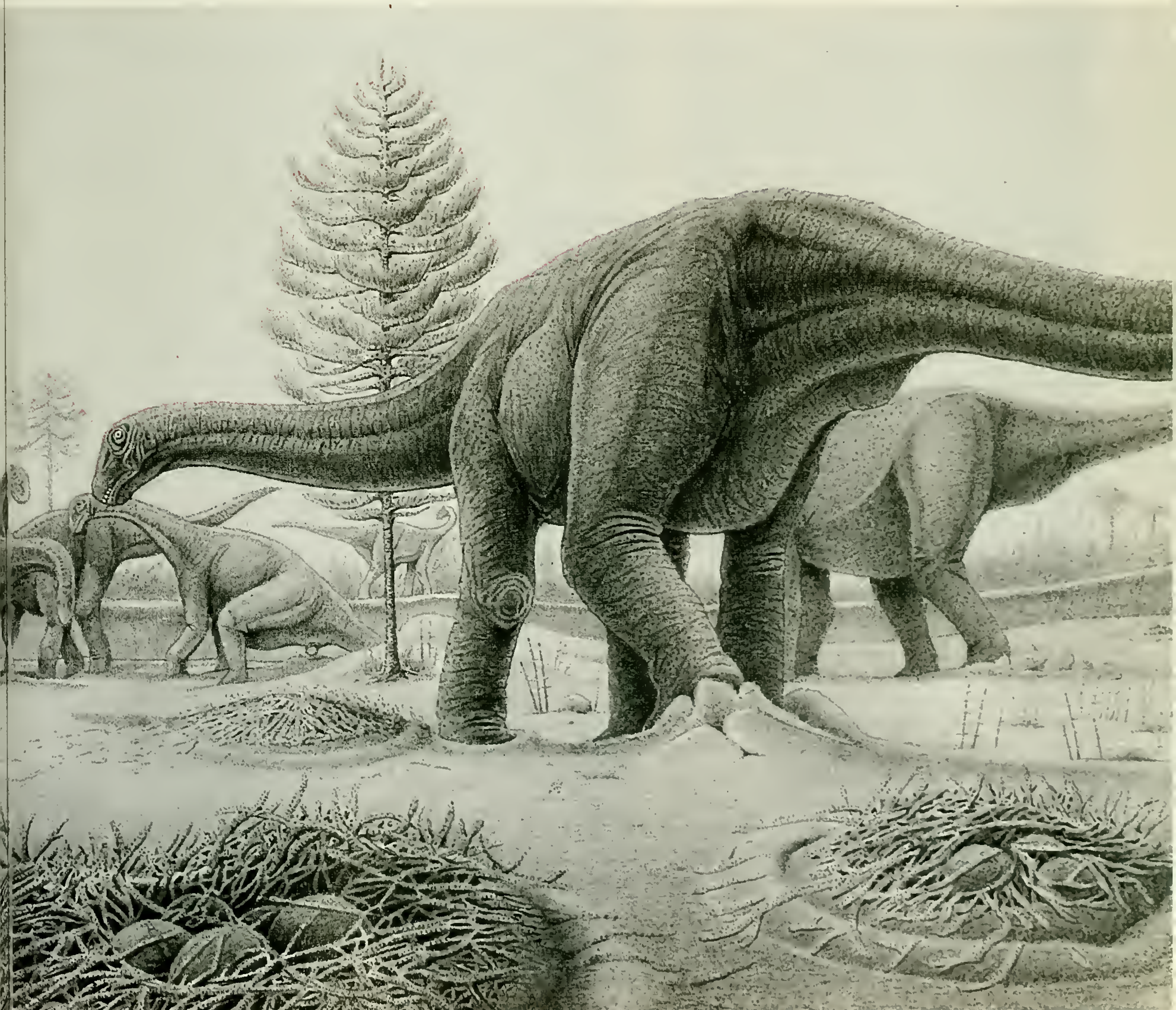
GROUND BREAKERS

Paleontologists rarely have the chance to document dinosaur behavior. In Argentina, the authors found rock-solid evidence of a sauropod's private life.

OF PATAGONIA

Story by Lowell Dingus,
Luis M. Chiappe, and
Rodolfo A. Coria
Illustrations by Nicholas Frankfurt

On the day when the first of the herds arrived, the sun was hot. Dozens of huge beasts crossed a silt-laden river and trekked across the vast mudflats. From other directions, more of their kind made their stately way across dry streambeds onto the flats, occasionally



Previous pages: Massive titanosaurs attend to a delicate task, shaping mud or sand into soft receptacles and depositing their eggs. After covering the clutch with vegetation, the females will retreat from the nesting grounds.

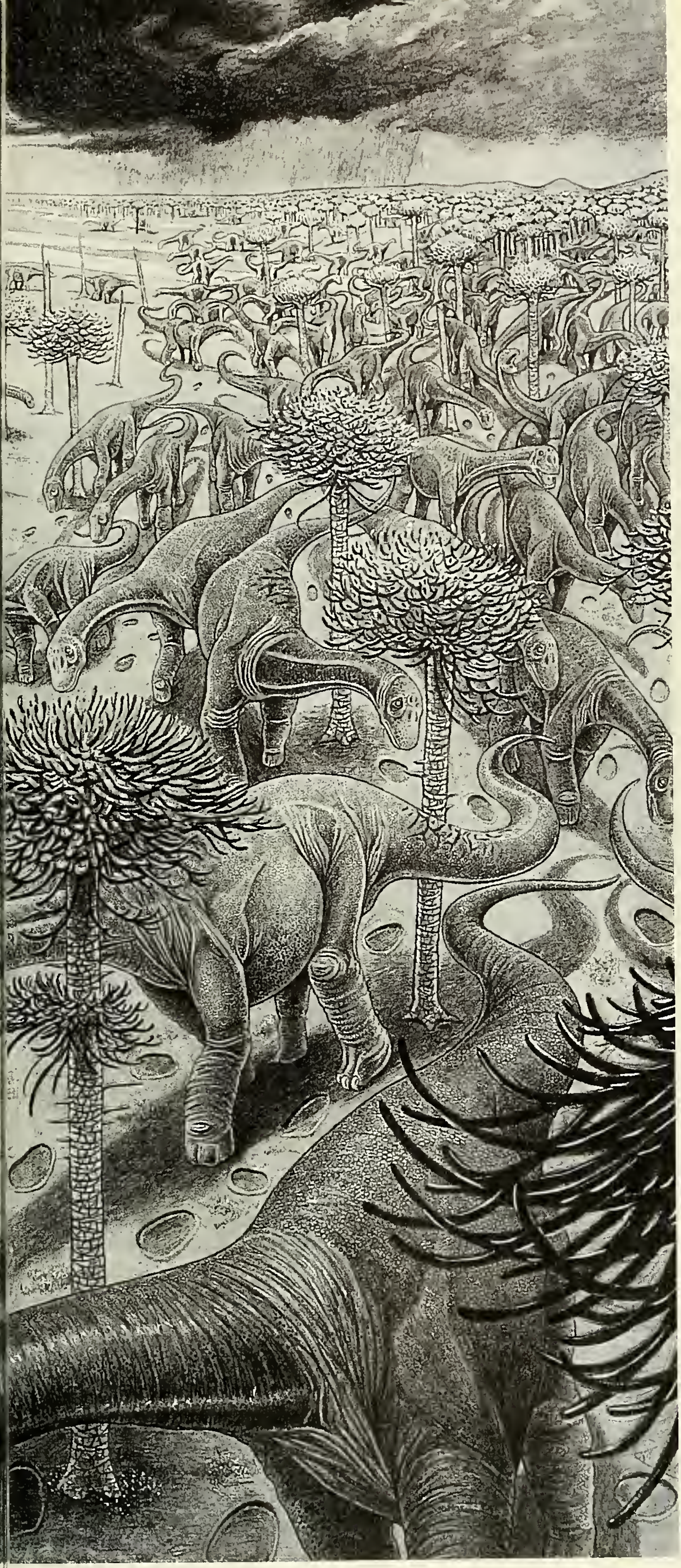
stopping to tear off and consume whole conifer branches. Within a week the landscape was pockmarked with their footprints, as hundreds of the quadrupeds milled about, so close that their long tails occasionally lashed against their neighbors. Soon, some of them began to act with deliberation. Pawing the ground with their hind feet, the creatures dug roomy holes in the mud, then maneuvered their bulky hindquarters into position over the depressions. One after another, round eggs dropped to the soft ground. The animals then draped a few stalks of horsetails and *Araucaria* over their nests and ambled to the periphery of the flats, their task completed. In a few weeks, barring freak floods and raids by predators, the sun- and vegetation-warmed eggs would begin to rock and their inhabitants to stretch and break loose, already hungry, but toothed and ready to fend for themselves.

We are able to envision this scenario of an 80-million-year-old event thanks to the preservation

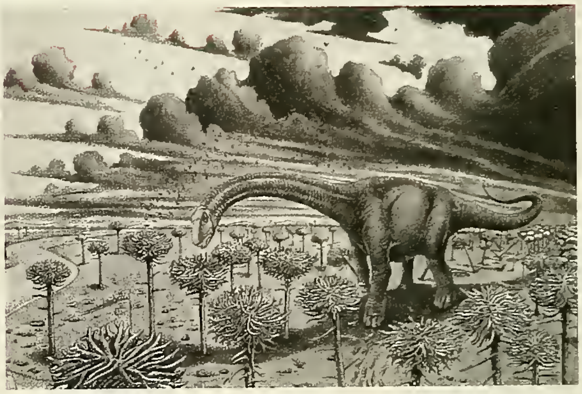
LOWELL DINGUS

The egg site in the Patagonian badlands, above, is marked by bands of sandstone and mudstone.

and fossilization of eggs that occurred when floods did indeed wipe out the nesting attempts of thousands of dinosaurs. Those ancient catastrophes have enriched our understanding of life on Earth and illuminated the behavior of sauropods—among the largest animals ever to tread our planet. Ever since remains of these four-footed herbivores were first discovered and studied, between 1840 and 1880, their fossil bones have amazed paleontologists and the public by providing evidence for the gargantuan dimensions of the adults. The shape of their teeth has suggested what and how they ate. But aside from trackways, or series of fossilized footprints—which establish that sauropods at least occasionally lived in herds—fossils incorporating direct evidence



Hundreds of the huge quadrupeds milled about the mudflats, so close that their long tails lashed against their neighbors.



The titanosaurs of Auca Mahuevo, left, reached lengths of 40 to 50 feet. An earlier Patagonian titanosaur, *Argentinosaurus*, above, was more than twice as long.

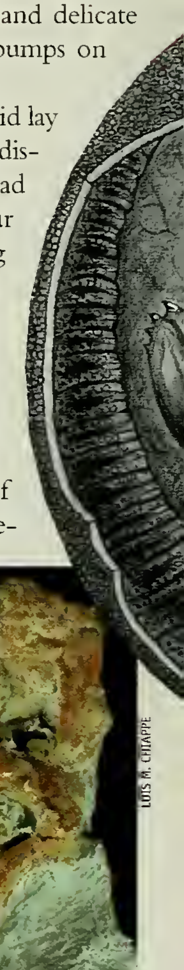
of behavior, such as how they reproduced, have been almost nonexistent. Because no modern land animals even approach sauropod size, scientists have had no living analogue to use as a guide to possible behavior. Throughout the twentieth century, however, paleontologists did turn up tantalizing clues that fueled speculation. The discovery of huge, round fossil eggs in Europe, Asia, South America, and North America led some researchers to conclude that the eggs had been produced by sauropods. Others argued that such immense creatures were more likely to have given birth to live young. Lacking unequivocal sauropod nests, eggs, or embryos, paleontologists could not confidently reject either view, despite the widely publicized discovery of such fossil evidence for other kinds of dinosaurs—including duckbill nesting grounds in Montana and clutches of eggs of theropods in the Gobi desert in Mongolia.

That changed in 1997, when our crew discovered vast sauropod nesting grounds in the rugged badlands of Patagonia, in Argentina. At the site, located about 600 miles southwest of Buenos Aires, thousands of clusters of spherical, six-inch-diameter eggs are strewn across several square miles of desert. We named the site Auca Mahuevo, in part after an extinct volcano, Auca Mahuida, that towers over the region, and in part for a contracted version of the Spanish for "more eggs." For five subsequent field seasons, our crew has scoured the badlands and discovered the identity of the egg-laying sauropods, how their young grew, and other clues to the private lives of these Patagonian dinosaurs.

We had an image of what the hatchlings looked like: a foot long, they had large eyes, big heads, and long necks.


L. MEEKER


LUIS M. CHIAPPE



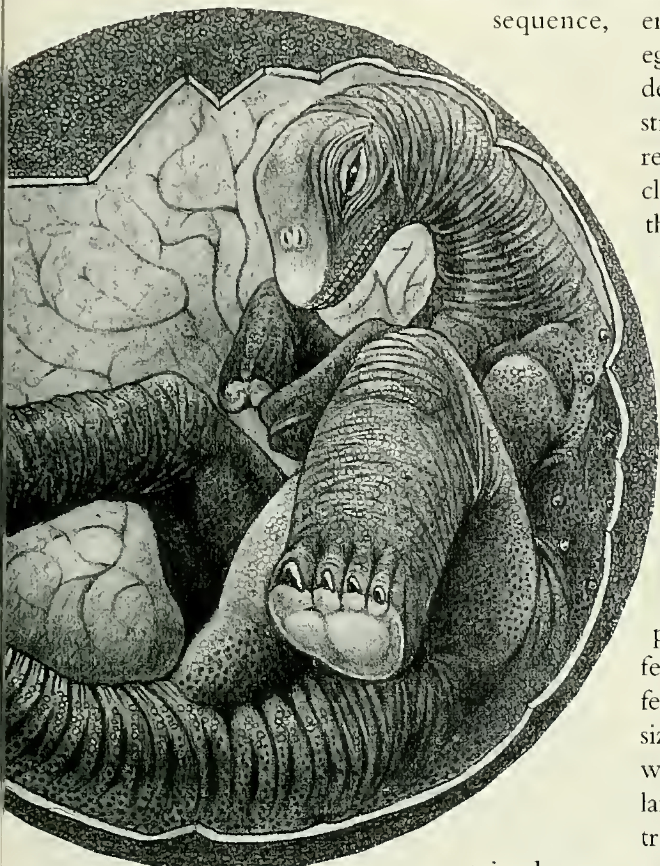
Baby titanosaur skin reveals a varied pattern of scales, above. A large eye orbit is visible in the inch-long skull of an embryo, right.

Within some of the eggs, we found fossilized embryos, the first embryos of a sauropod ever uncovered. The skulls, large in relation to the bodies, as are those of most young animals, are only about an inch long. The bony structure of the skulls is very similar to that found in a group of South American sauropods called titanosaurs. This identification is strengthened by the embryos' minute teeth, less than one-sixteenth of an inch long, which are also like those of titanosaurs. In another first, we found small patches of the embryos' fossilized skin inside the eggs; the skin is covered with beads that form rows of large knobs and delicate roselike patterns, somewhat like the bumps on the hide of modern Gila monsters.

So we knew that some titanosaurs did lay eggs similar to the large round ones discovered elsewhere. Furthermore, we had a vivid snapshot of what titanosaur hatchlings looked like: they had long necks and disproportionately large eyes, even for their big heads, and were about a foot long. We knew the adult size of other titanosaurs found in Patagonia, and from this we estimated that these youngsters would have grown into adults that, while not the largest of sauropods, would still have reached respectable lengths of between forty and fifty feet and would have weighed several tons.

More recently, the rocks of Auca Mahuevo led us to another discovery. Over the past 80 million years, the sand and mud of the sauropod nesting grounds have solidified into sandstone and mudstone that are visible today as distinct bands or layers in the site's ridges, buttes, and ravines. The layers were laid down over time by ancient streams that crossed a gently sloping floodplain. Lower layers are older than higher ones, and each represents a different chapter in the history of the site and of the animals that lived there. Our geological investigations indicated that the shallow streams occasionally overflowed onto the flats, and when they did, mud blanketed the eggs, killing and entombing the embryos inside.

We found that at least four layers, at different levels in the rock sequence, contained eggs that had been buried in mud. This was direct evidence that the sauropods had returned to Auca Mahuevo at least four different times to lay their eggs. Whether they did so annually or at intervals of many years is unknown, but such "site fidelity" exists in many modern reptiles, such as turtles, as well as in many birds.



Some of the rock layers held so many eggs that they could be called egg beds, just as sediments with abundant fossil bones are termed bone beds. But to our eyes, the eggs weathering out—exposed on the surface—appeared to form clusters. This, and the absence of any geological evidence that strong water currents or other processes had moved and grouped the eggs, suggested that each individual cluster was deposited by a laying female in a distinct nest.

To test this idea, we constructed a three-dimensional map of some of the egg beds. In the richest egg layer, we mapped the distribution of more than 300 eggs in an area of about twenty-five square yards. Then we measured the depth of individual eggs, which turned out to be situated at two levels, separated by about four inches of sediment. Both layers contained predominantly whole eggs, with little or no fragmented eggshell between the apparent clusters. Our spatial analysis showed that the eggs in each level were, to a statistically significant degree, grouped rather than randomly distributed, strongly suggesting that the clusters did indeed represent clutches. Seven of the nine discernible clutches in this egg bed held between fifteen and thirty-four eggs, considerably more than the ten or fewer eggs commonly reported for groups of possible sauropod eggs from Europe.

In a mapping project at another Auca Mahuevo site, we focused on the distance between egg clutches. We chose two sample areas where eggs from the same two-foot-thick layer were exposed on a gradual slope. In one area, we mapped seventy-four egg clutches within about 1,800 square yards, and in the other, thirty-one clutches scattered over about 500 square yards. Although in a couple of densely packed spots the clutches were only two to four feet apart, most were separated by nine or ten feet—still a tight pattern. Given this density and the size of adult sauropods, it is unlikely that parents were involved in caring for the eggs after they were laid. A mother *Oviraptor,* being smaller than an ostrich, could warm her eggs by sitting on them, but a female sauropod couldn't; lumbering back and forth around the nursery would be a hazard, and incubating eggs with her body could easily devastate the clutch.

Folded within the 6-inch-diameter egg and nourished by the yolk sac, a titanosaur is almost ready to emerge, left. Even in the egg, the young may have exercised their well-developed jaws, lined with tiny teeth, in preparation for their first posthatch meal.

Dinosaur embryos are rare, but well-preserved nests—actual structures built to contain eggs—are even rarer. Paleontologists have often treated nests and egg clutches as if they were synonymous, but in a clearly identifiable fossil nest, the composition of the rock formed by the sediment in which a clutch was originally laid must be distinguishable from the rock that formed from whatever sediment buried and preserved the clutch. Fortunately for us, a few of the Auca Mahuevo titanosaurs chose to deposit their eggs on the sand of a dry streambed instead of on the muddy floodplain. When water from a nearby active stream flooded into the dry watercourse, the nests and eggs, like those on the flats,

Predators such as *Aucasaurus*, below, could have hunted for eggs and young and, perhaps in packs, menaced adult sauropods.

were inundated with mud. The difference in grain size and color between the subsequently petrified sand that constituted the nest and the mud that filled it allowed us to discern the architecture around the eggs.

Today these egg-containing streambed nests are preserved as irregular depressions, three to four feet across, in pink or gray sandstone. The edges of the depressions consist of tilted layers of sandstone,

Opposite page: Leaving only footprints, adult titanosaurs move off, while precocial hatchlings venture out of the nests.

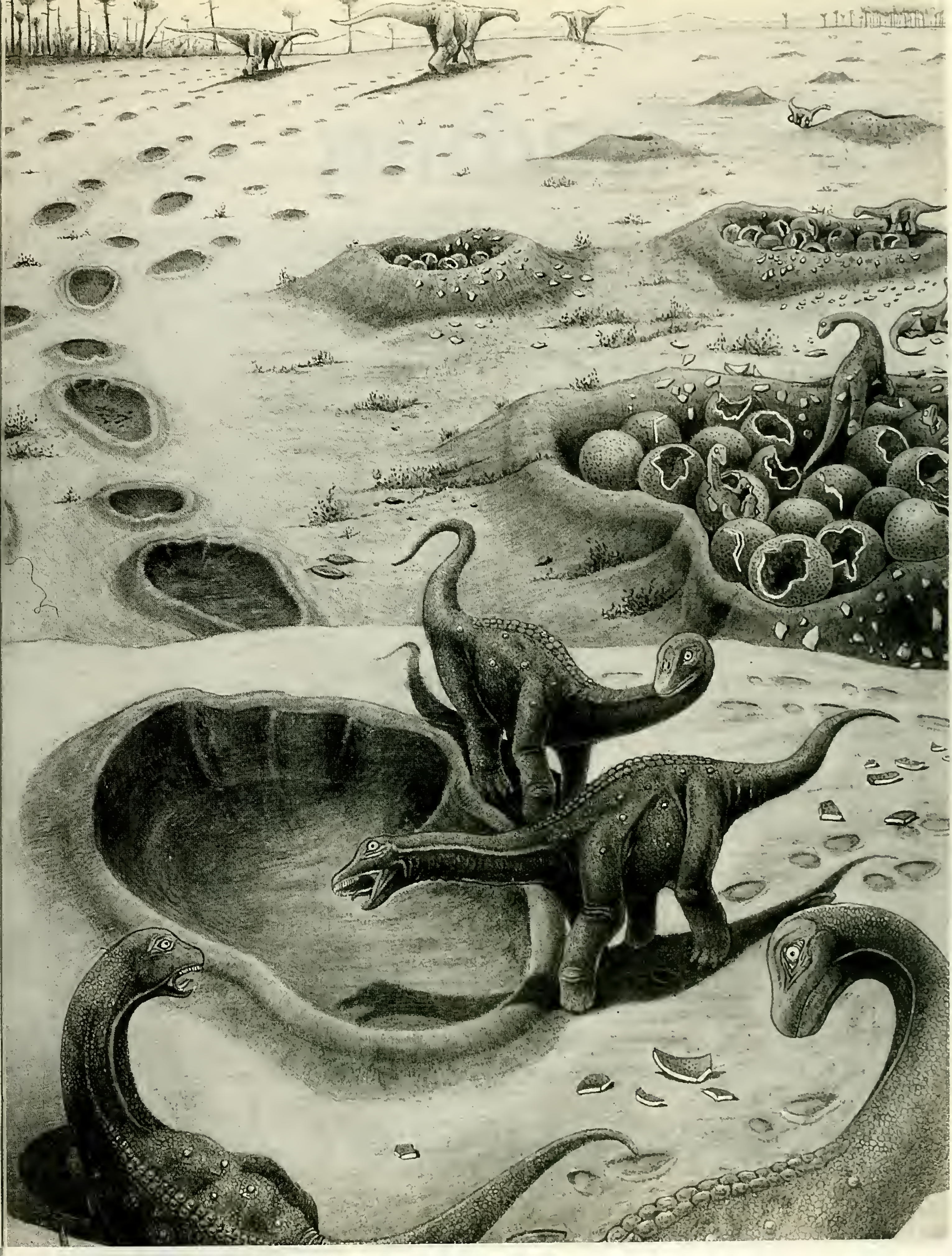
called cross beds, and their bowls are filled with mudstone. The cross beds originally formed when currents moved sandbars down the channel, but on the periphery of the depressions, these tilted layers are cut off and capped by ridges of sandstone several inches high. The ridges are formless, with no layering or tilting. After examining the depressions, we were certain that we had found the first sauropod nests that could be well documented.

After excavating the nest, the female titanosaur laid between fifteen and thirty-four round eggs.

The places at which the tilted cross beds were sheared off indicate where an adult dinosaur dug a bowl-shaped space in the sand. The ridge, or rim, was nothing other than the excavated debris piled around the hole. Although the eggs in these nests held no embryos, they were similar in size, shape, and shell structure to the Auca Mahuevo eggs that did enclose embryos, so we believe that the nests were constructed by the same kind of titanosaur. We presume that the task of digging the nest fell to the female, although we cannot be sure. After excavating the nest, the female laid as many as thirty-four eggs. Characteristics of the mudstone led us to infer that the mother titanosaurs did not kick sand or sediment onto the clutch, the way a sea turtle scrapes sand to cover her eggs before she heads back to the ocean. But the composition and structure of the eggshell do suggest that the female may have placed vegetation on top of the eggs, as alligators and mound-building birds such as brush turkeys and mallee fowl do today. Even in the absence of parental care, the eggs would have been warmed by plant materials rotting in the heat of the sun.

If the adult titanosaurs stayed in the area after the eggs were laid, they may well have patrolled the borders of the nesting ground to keep potential predators away from both the herd and the hatchlings. And the presence of imposing predators at Auca Mahuevo is undeniable. In 1999, our crew discovered a new, twenty-foot-long, bipedal meat-eater that we have named *Aucasaurus*, as well as fragmentary remains of an even larger, tyrannosaur-sized carnivore.

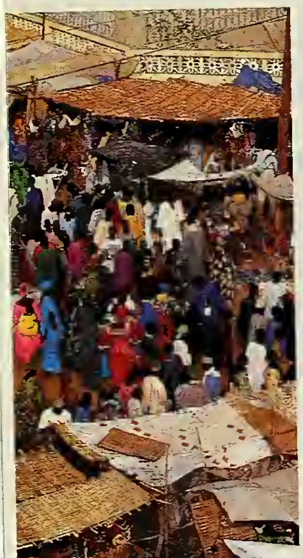
In successful nesting seasons, when floods did not inundate the nesting ground and predation was not severe, many young titanosaurs would survive. They would grow up to face the challenges of the Cretaceous world beyond the mudflats. Our fossil and geological findings allow us to visualize a full-grown female returning, perhaps decades later, to her birthplace to carry on her evolutionary lineage by digging a nest and laying her own eggs in the soft mud. □



Trading Places

Muslim merchants from

Story by Paul Stoller
Photographs by Frank Fournier CONTACT PRESS IMAGES



Senegalese markets such as the one above are part of the multinational West African trade network. Right: Mady Camara, a clothes designer from Guinea, works in Harlem.

Adapted from Money Has No Smell: The Africanization of New York City, *by Paul Stoller. Published by The University of Chicago Press.*

Born in Niger, Issifi Mayaki learned his father's trade: selling indigenous African cloth, including antique textiles. With his impeccable French, he developed a clientele among French expatriates in the city of Abidjan, Côte d'Ivoire, and after picking up English he successfully cultivated members of Abidjan's English-speaking diplomatic community as well as African American visitors. Then in 1992, at the age of thirty, Mayaki began eyeing the lucrative market in the United States. Deciding to take a gamble, he packed up and airfreighted much of his stock to New York City, bought a round-trip ticket (as required for a six-month business visitor's visa), and set out to make his fortune.

At first, things went well. Upon arriving, Mayaki found lodging with fellow traders at a run-down, ostensibly single-room-occupancy hotel on West 77th Street in Manhattan and started making contacts. But several weeks later, after he sent out a large shipment of Ghanaian *kente* cloth, the recipient refused to pay. Mayaki's telephone calls and faxes went unanswered. Much of the inventory of valuable fabrics that had taken him years to collect in Africa was thus lost in a matter of weeks. In fact, he was stranded: to meet expenses, he had already sold the return portion of his air ticket.

Mayaki turned to his compatriots for assistance, and they pooled money to provide him with a loan. Adapting quickly to new circumstances, he decided to stock up on rap, rhythm and blues, and jazz cassettes to market to African Americans in Harlem. He set up a table on West 125th Street near the famed Apollo Theater and eventually took up residence with another trader living nearby. After city authorities cleared out the 125th Street market area, Mayaki relocated to the Malcolm Shabazz Harlem Market on West 116th Street, where he rented a

Vest Africa expand their markets to New York City.

stall for seven dollars a day and began to sell textiles along with cassettes and a few CDs. In time, he again became a cloth merchant.

"Was it difficult to negotiate the crossroads of New York City?" I once asked him.

"Life in New York is filled with uncertainties," he answered. "If I fall sick, will I be able to get help? Will Immigration detain and deport me? Will I make enough money to send to my family in Niger and Côte d'Ivoire? Will I make enough to

"I sell my products to any person . . . for if I am honest, money has no smell."

pay my bills? So far, God has blessed me. The only certainty is that I have always been a trader and will always be a trader."

Two integrated aspects of his cultural heritage have enabled Mayaki to walk the myriad economic and social paths of New York City: the practices of West African trade and the teachings of Islam. Throughout the history of West Africa, specialized traders have, through kinship or patron-client relations, established large corporate networks. The most notable of these professional traders belong to two ethnic groups, the Hausa (Mayaki's group) and the Malinke, sometimes referred to as the Dyula. Other major players are Songhay from Niger and Mali, Wolof from Senegal, and Soninke from Gambia. Like their ancestors, West African traders in New York City have well-established procedures and organizations for obtaining informal credit and raising capital, and they adhere to Islamic precepts concerning commercial transactions.

Recent immigrants from tropical regions have to adjust to New York City's climate.

From the earliest years of the *ummah* (the Muslim community of believers), which was established by the prophet Muhammad in the early seventh century A.D., traders were urged to interact in cooperative ways that would increase commerce. Various passages in the Qur'an speak of manifesting goodwill, providing correct weight, and not giving false oaths in transactions. More emphatically, Muhammad opposed monopolistic practices that could undermine cooperative relations. So when Mayaki (who regularly studies the Qur'an and the Hadith, or record of the Prophet's sayings) speaks of hard work, honest commercial relations, and trust, these beliefs derive directly from Islam.

Boubé Mounkaila is a Songhay, not a Hausa, but like Mayaki, he came to New York City from Niger by way of Abidjan. At the Malcolm Shabazz Harlem Market, he sells wristwatches as well as leather sacks and handbags made in Niger. Mounkaila's watches adopt the styles and trademarks of DKNY, Gucci, Rolex, and Swiss Army brands, but he makes no secret of the fact that his are counterfeits.

"I must be honest in my dealings," he told me. "I let everyone know that what I sell are copies, not originals."

"They probably know anyway, from the price," I said. "I mean, it's hard to get a real Rolex for twenty-five dollars."

"It doesn't matter," replied Mounkaila. "I must tell them anyway. That is our way. I am a merchant, and I try to establish trust with my clients. That way, they will, *Inshallah*—God willing—come back." He connected his trading practices to Islam. "I try to be a good Muslim. I say my prayers five times a day, avoid alcohol and pork, and give to the unfortunate. I try to be honest in trade. That is our way, and it makes me a better trader."

While the founding of Islam triggered the expansion of trade from Arabia to North and West Africa, the extension of kinship ties—both fictive and real—provided a customary means of enlarging trade networks. The practices that made long-distance trade possible in West Africa hold today in New York City. Mayaki's network consists, first of all, of his paternal kin. He is obliged to send money to the family head (his father) and to look after his mother and brothers. But Mayaki also feels a social and economic loyalty to his "brother" traders. His most important transactions and dealings are with fellow Hausa from Niger whom he knows from Abidjan. To lesser degrees, his sense of trust and comfort extends to other Hausa traders and then to other West African traders. He can expect to give and receive a small amount of credit from any of these people, no matter their actual proximity to his informal personal trade network, which also includes Korean, Chinese, and Afghani suppliers. "Islam makes us traders strong, resilient, and disciplined," Mayaki says. "It encourages our creativity in new lands. It creates a climate of trust."

There are even several economic networks of Hausa and Songhay traders that sponsor "trade children" in New York City. In West Africa, established elder traders, or "fathers," pay airfare, procure visas, and provide investment capital for enterprising young men. In return, they receive a percentage of the profits that their "children" earn. One of these elder traders is El Hadj Soumana Tondi, who travels from West Africa to New York City every six weeks to, as he puts it, check up on his children at the Shabazz Market.

A shop, above, advertises the per-minute charges for calls made from its public phones. Cell phones, beepers, and faxes are other means of instant communication that keep West Africans in touch with their relatives and trading partners. Left: In a Senegalese-owned store, a taxi driver (right) visits with a friend.

Tens of thousands of West Africans, most of them men, have poured into the United States during the past fifteen years, usually settling in New York City or elsewhere on the East Coast. They are part of the wave of "new immigrants," consisting of people from developing countries affected by the economic and social dislocations brought on by globalization. Those who are literate and have work permits may drive yellow cabs or use their profits from vending to open a restaurant, boutique, or import-export business. But the majority enter a legal limbo, overstaying their visas. They become a vital part of the ever-growing informal sector, or underground economy, which evades the reach of government regulation and therefore goes untaxed.

Lower-income neighborhoods in New York City are major arenas of such economic activity. Like Ralph Ellison's "invisible man," many new immigrants walk in the shadows, their life stories and cultural backgrounds virtually unknown to the mainstream citizenry. Typical underground workers include the Trinidadian day-care employee for whom no Social Security forms are completed; the Guinean "gypsy cab" driver, possibly unlicensed or underinsured, who cruises parts of the city neglected by the yellow taxis; the Peruvian carpenter who crafts furniture in a space not zoned for manufacturing; the Thai woman who sews teddy bears in a poorly lit suburban garage; and, of course, the unlicensed Senegalese street vendor who shares informal market space in downtown Brooklyn or Lower

Like Ralph Ellison's "invisible man," many new immigrants walk in the shadows.

Manhattan with African Americans, Jamaicans, Vietnamese, Ecuadorians, and a host of others.

Although he has become a pragmatic player in the global economy, Issifi Mayaki maintains a judicious distance from a society whose values he finds both fascinating and disturbing. As it is, during his time in New York City, he has been torn by conflicting allegiances—to his wife and children; to

Street vendors, below, display their wares near Bloomingdale's department store in Manhattan. Many such traders are unlicensed; to avoid a summons, they're prepared to gather up their goods quickly.

Right: Wodia, a Guinean hairdresser in Harlem. Store owners must comply with U.S. immigration and New York City licensing regulations.

Monique, the girlfriend he has acquired, and her child; to his mother, father, and brothers; and to his own desires. One warm January day, I went to the Shabazz Market to see Mayaki, and we got into a discussion about his family, whom he had not seen in five years. "I miss Africa so much that I've become a nasty person, giving everybody a hard time," he lamented. "I really want to go back and see my family."

Mayaki's wife, children, and mother live near Maradi, Niger, in West Africa's hot, dusty,

Diakite Aboubacar, above, assists other immigrants with tax and immigration forms and provides translation and other services.

windswept Sahel. His father and three of his brothers are merchants who live in Abidjan. At the time of our conversation, a fourth brother, who had trained as a schoolteacher in Niger, was living in Melbourne, Australia, where he worked in a boutique specializing in African art.

Talk of his family compelled Mayaki to think of his mother. "For me," he said, "there is no more important person than my mother. You know how it is between sons and mothers. I really miss my mother. But when I tell this to Monique, she thinks that I really miss my wife. I care very much for Monique, and I respect my wife, but my mother is more important. We are of the same blood."

Mayaki reiterated that Americans couldn't understand why family is so important to Africans. "*You* understand," he said to me, "because you lived there for seven years. But Monique?" He shook his head. "Maybe next year I'll go back," he went on. "One of my brothers will come here. After I train him, I'll go back to Abidjan and he'll stay here."

For some reason, the unusual warmth that day hadn't drawn many customers to the market. Passing merchants offered their greetings to us. A young African American woman asked if Mayaki had Dutch Wax cloth. He searched through the bolts and found some. The woman didn't like the color scheme and sauntered away. Mayaki turned back to me, and we continued our conversation.

"There are two important things in my life: family and things that stir my heart. I sell my products to any person, Christian or Muslim, pastors or drug dealers, for if I am honest, money has no smell. If God grants me money in exchange for

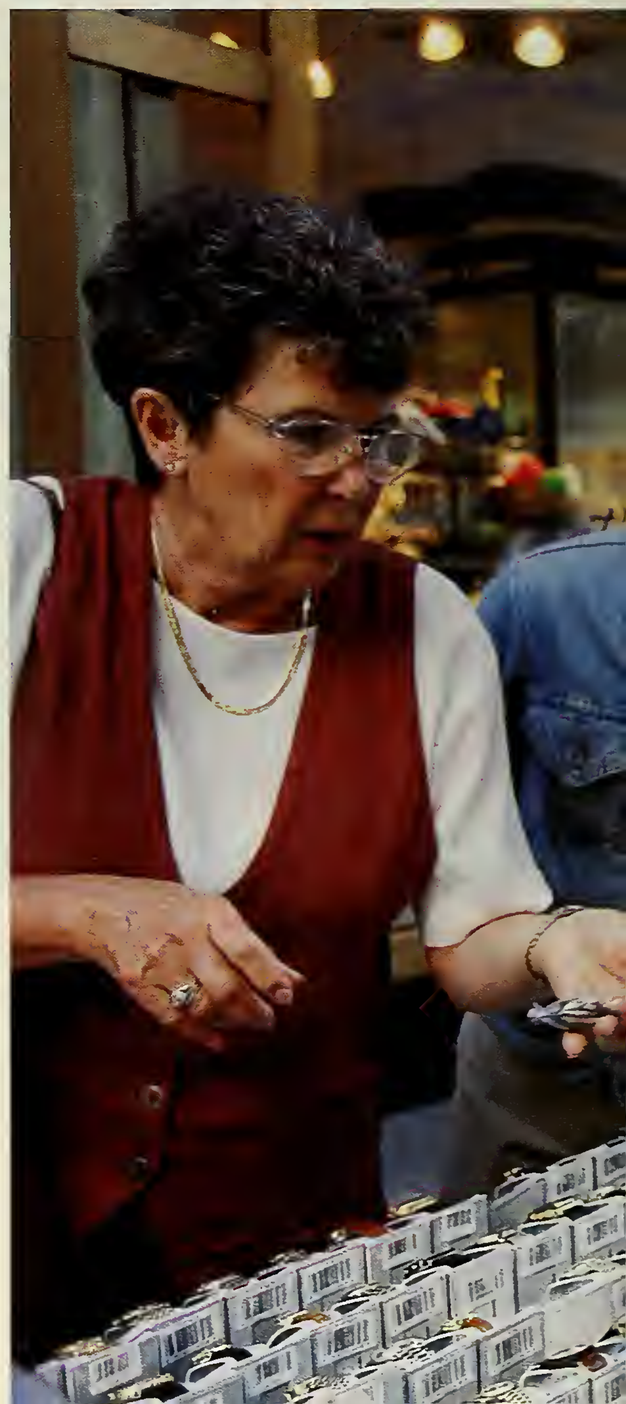
Clothing and fabrics from Africa are among the items for sale at Fatou's store in Harlem.

hard work, I must first make sure that my family is okay, that they're well fed, well clothed, well housed, and in good health. Then, if there is something left, I buy things that stir my heart." Mayaki pointed to his black leather jacket and said he had bought it at the Gap. He touched his corduroy trousers. "The Gap. I bought three pair." He unzipped his jacket to reveal a rust-colored linen shirt. "The Gap also," he said, smiling.

Mayaki was able to make these purchases because of a successful winter holiday season—a season that in much of the United States now includes Kwanzaa, a recently established African American community and cultural celebration spanning December 26 through January 1. Mayaki had rented space at the Jacob K. Javits Convention Center, the site of New York City's annual Kwanzaa Fest, and had sold a great deal of cloth to African Americans who wished to honor African values and to buy African products.

In the current climate, marked by suspicion and vilification of all things Muslim, Mayaki and his brother traders present a positive and dynamic portrait of how Islam bolsters the growth of trade and social relations. During their time in New York City, West Africans have established new partnerships, mastering the culture of capitalism while reinforcing traditions of long-distance African trading. They have staked out individual space in a

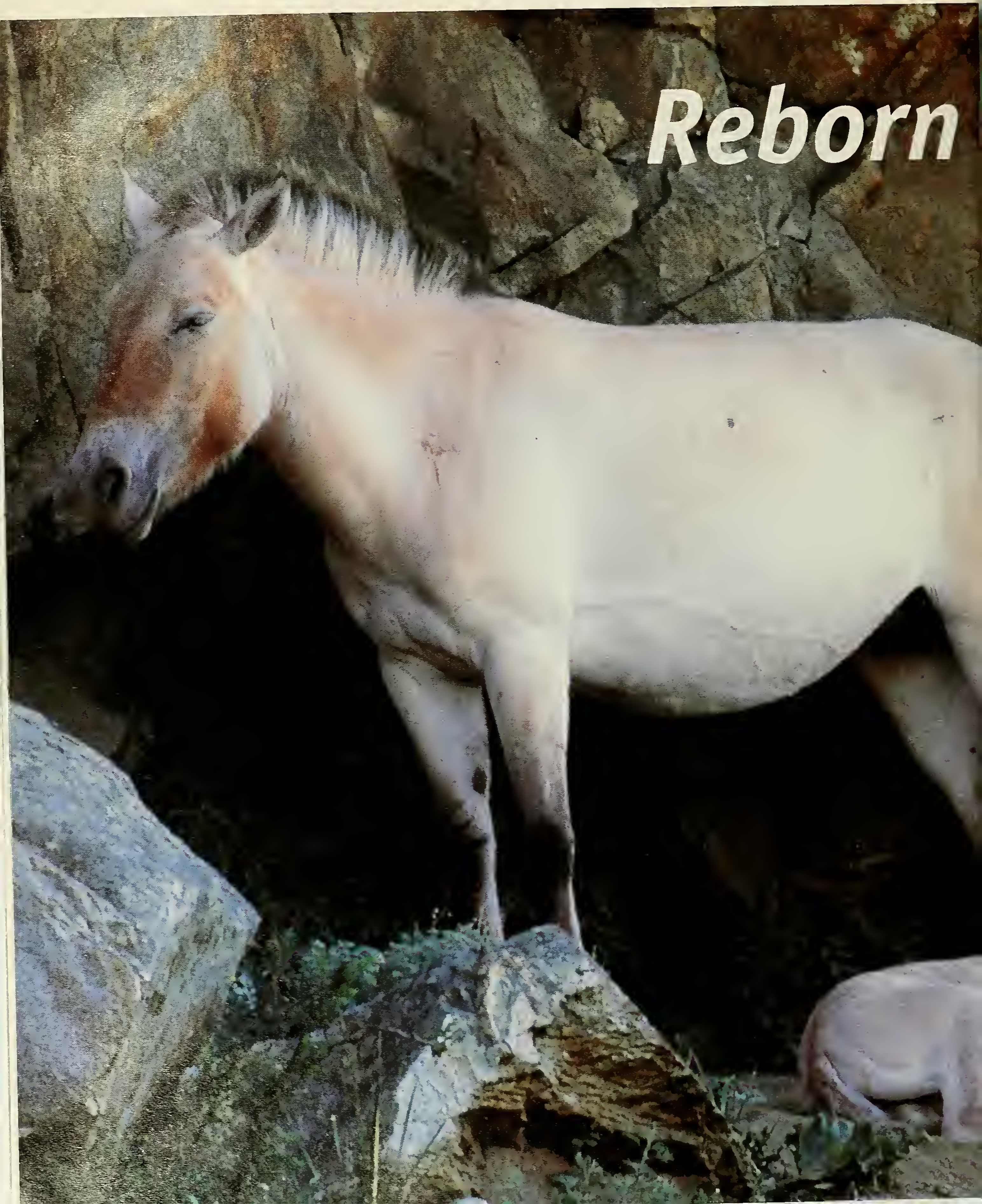
Some West African traders tour "the bush": Kansas City, Indianapolis, Detroit. . . .



market culture while engaging in the cooperative economics dictated by Islam and by long-standing West African commercial practices. They have adapted to the unfamiliar stresses of big-city life in the United States while reaffirming their African identities. Traders like Mayaki have much to teach us about how urban society works in contemporary America.

From April through October, some West Africans pack vans with African leather goods, textiles, and jewelry, along with Chinese- or Korean-made baseball caps and T-shirts that display logos of U.S. sports teams. Thus equipped, they tour through what they call "the bush"—Indianapolis, Kansas City, Detroit—following the circuit of African American trade shows and Third World cultural fairs. With his newly purchased van, Issifi Mayaki has recently become one of these mobile merchants. Although he travels the side roads of America, he is by no means isolated, for his beeper and cell phone enable him to stay connected to business associates, friends, and family in the United States and Africa. And if, by chance, his successful travels in the American bush transport him to the Gap, he might well follow his heart to browse and perhaps buy. ☐

Pape Babou, a licensed vendor, sells watches to tourists and Midtown office workers on Madison Avenue.

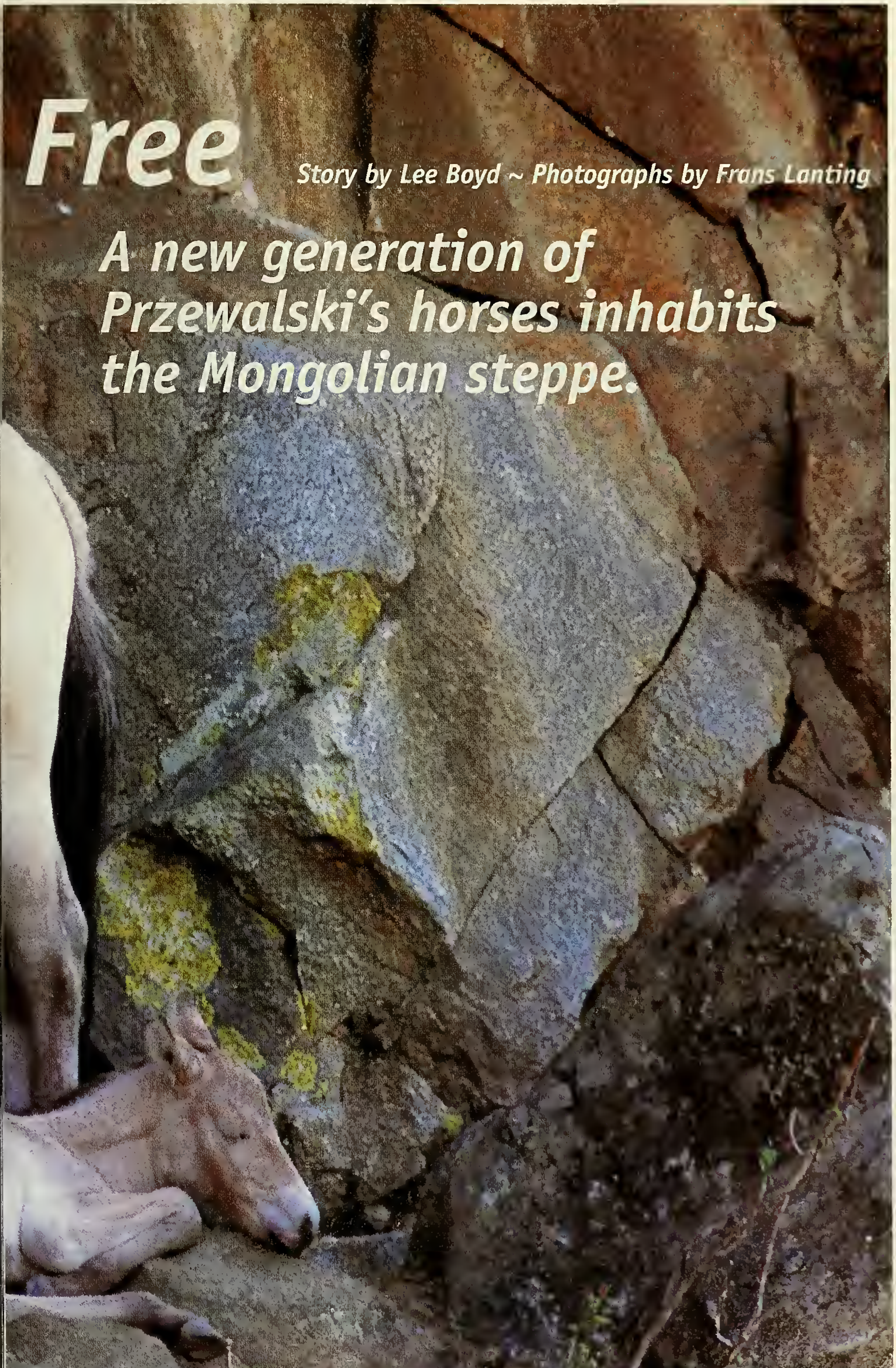


Reborn

Free

Story by Lee Boyd ~ Photographs by Frans Lanting

A new generation of Przewalski's horses inhabits the Mongolian steppe.



Atop a breezy ridge, a mare and her foal (both born in the wild) find relief from the hot sun. Rocky outcrops, whether in nearby birch forests or out in the open, are consistently cooler than even the shaded ground around them.

When I first saw the hills surrounding Ulaanbaatar in 1994, I experienced the oddest sense that I was coming home. I had arrived to assist Mongolian and Dutch conservation groups with the reintroduction of endangered Przewalski's horses *(Equus ferus przewalskii)* to their native land. Having spent years studying captive takhi (their Mongolian name, now adopted by the rest of the world), as well as the behavior of mustangs in Wyoming, I had come to document the behavior and unfettered move-

Below: A Przewalski's horse roams its home range.

A national park is now home to about a hundred free-ranging takhi.

ment of the first sixteen captive-born horses released into Hustain Nuruu Steppe Reserve.

Not since the 1960s, less than a hundred years after Przewalski's horse was brought to the attention of the Western world, had the species roamed free. It is the closest living relative of the domestic horse *(Equus caballus)*, and despite a difference in chromosome number, the two species are the only members of the equid family still capable of producing fertile offspring if interbred. All takhi living today descend from approximately fifteen animals caught near the turn of the twentieth century. By 1992, owing to careful breeding, the international zoo population exceeded a thousand animals; returning a portion of them to the Mongolian steppe finally became feasible.

Left: Harassed by her father, a kicking filly will soon leave her natal harem in search of a new group and will start reproducing. Below: A wild-born stallion herds mares stolen from an older, once-captive male.

Prior to the extinction of the species in the wild, almost no biological information had been recorded about Przewalski's horses except that they form social groups consisting of a stallion, his harem of several mares, and their offspring. My colleagues and I found that the reintroduced animals, upon release, quickly established home ranges; fidelity to the release site proved so strong that reintroductions had to be spread throughout the reserve. A dominant male and his mares travel three to six miles a day—grazing, dozing, mud-bathing, stopping at streams and natural mineral licks—and sleep, clustered together, for about four hours a night. This

year, nearly a decade after the first reintroductions, about a hundred Przewalski's horses, half of them wild-born, are freely roaming the reserve, which in 1998 became Hustai National Park.

Each group of takhi is recognizable; some bands are elusive and can be spotted for only a few moments in birch forests, while others come to the grounds of the park's research center at night, seeking refuge from wolves. One fascinating aspect of our research has been observing the departure of juvenile horses from their natal groups. Fillies are the first to leave, at approximately two years of age; they may then shop around for a harem in which to begin their reproductive career.

Defending his harem, a Przewalski's stallion (right) chases off a domestic horse. Local livestock are drawn to Hustai National Park, a lush oasis on the Mongolian steppe.

Males mature more slowly; at three, they begin to pester mares in estrus and are driven out of their natal group. These stallions spend a couple of years in the company of other bachelors, practicing the fighting skills necessary to assemble a harem of their own. They obtain females either by picking up dispersing fillies or by raiding established harems and stealing away some or all of the mares. Each time I visit Hustai National Park, I must familiarize myself anew with the ever-changing bands. It has been exciting, though bittersweet, to see captive-born stallions—after so successfully readapting to the land of their ancestors—be dethroned by a generation of rivals that they sired. □

A Superorganism's Fuzzy Boundaries

The breathing termite mounds of southern Africa raise the question, Where does "animate" end and "inanimate" begin?

By J. Scott Turner

They look like the curlicue-topped mountain that overlooks the Grinch's Whoville: cones of soil and sand, up to thirty feet tall, topped with earthen spires pointing toward the noon sun. Common on the savannas of southern Africa, they are termite mounds, constructed by the fungus-cultivating termite *Macrotermes michaelseni*. Locals call these structures "ant heaps." In Afrikaans, termites are *rysmeere* (literally, rice ants); sometimes the insects are called white ants. Termites are not ants, however: their ancestors are social cockroaches, not the wasps from which ants descend. And neither is the termite mound a heap, a haphazard pile of dirt. Opening it reveals a complicated internal architecture: a capacious central chimney from which radiates a complex network of passages, connecting ultimately to an array of thin-walled tunnels that lie under the mound's surface like veins on an arm. Most interesting, though, is what you do not see: termites. The mound is not a habitation for the millions of termites that built it. Their residence is a nest below the mound, a spherical underground city about six feet in diameter.

The mound's internal architecture betokens its purpose. The mound ventilates the nest, a service that the termites desperately need. A few tiny termites may not breathe much, but a couple million of them together consume oxygen at a rate roughly that of a large rabbit. And the termites are not the only heavy breathers in the nest.

Macrotermes species each grow a particular species of fungus that predigests the termites' food. The insects swallow grass, bark, dead wood, and undigested matter in other animals' fecal pellets and quickly pass them, undigested, within the nest, where the fungus can break down the material. This fungus, together with bacteria and other soil microorganisms, raises the oxygen requirement to the amount needed by a cow. Indeed, ranchers in northern Namibia think of each termite mound as the equivalent of one livestock unit: each nest's foraging insects eat about the same quantity of grass as would one head of cattle. A cow buried alive would soon die without access to air, and so it is with a termite colony: without ventilation, it would suffocate.

Entomologists have long ascribed respiratory functions to these termite mounds, and for many years they thought the mound's workings were pretty well understood. It was a fine story, first told in the late 1950s by Swiss scientist Martin Lüscher, who was investigating the mounds of *Macrotermes natalensis*. Lüscher had the ingenious, but at best only partly correct, idea that a colony's metabolism could power its ventilation and maintain the nest's remarkably constant temperature. The energy of the termites' collective "hot breath" heated the air in the nest, Lüscher surmised, and the warmed air would waft up through the mound's tunnels. The air rising from the nest would eventually cool and pass down again through the conduits near the mound's surface. In these passages, the air would be refreshed by diffusion through the structure's porous walls before being sent on another circuit through the nest.

Lüscher's scheme (a version of what is known as thermosiphon ventilation) seemed to provide a model for the environmental regulation of termite colonies. This sort of self-regulating process is known as homeostasis. The human body's maintenance of a certain internal temperature is an ex-

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Opposite page: A huge mound built by a colony of *Macrotermes* termites ventilates a subterranean nest. Mounds can reach a height of thirty feet. Workers, above, take about a year to put together a mound.

PAUL FRANKLIN; OXFORD SCIENTIFIC FILMS

ANTHONY BANNISTER; NHPA

conditioners. But the temperature in underground chambers is inherently steady, so a mound built to cool a subterranean nest seems superfluous. Experiments in which termite mounds were capped put the lid on the air-conditioning hypothesis, because the temperature in the nests did not change.

But if the mound isn't an air conditioner, what is it? The problem captivated me. I thought that the mound had to do something besides passively connect the nest to the air outside, if only because building such a structure is an enormous investment of energy and time: a *Macrotermes* mound contains, on average, about five cubic yards of soil and takes a mature colony about one year to build. Perhaps the mound controlled—if not nest temperature—some other aspect of the nest environment, such as humidity or concentrations of oxygen or carbon dioxide. Aided by a grant from the Earthwatch Institute, I went off to Namibia to look into the matter.

A tiny, pale *Macrotermes* worker and a much larger soldier rely on the fungus *Termitomyces* (the white balls) for help in digesting cellulose.

ample. In *social* homeostasis, members of a colony coordinate their behavior to regulate their environment. Bees, for instance, collectively regulate hive temperature. When the weather is cold, they cluster into compact balls and shiver, warming the hive. When the weather turns hot, workers fan their wings at the entrance to the hive, cooling it. Hive temperature thus remains steady despite changes on the outside. Thermosiphon ventilation supposedly provided a termite colony with the capacity for achieving homeostasis. Together the insects built a mound: this constituted the social aspect. And when, for example, the colony generated more heat than it dissipated, accumulated heat would warm the nest air, making it more buoyant and moving it more rapidly through the structure. The accelerated ventilation would then cool the colony back down.

As beautiful as Lüscher's idea was, though, it never quite added up. For one thing, thermosiphon ventilation requires that the mound have a rather specific architecture. How could the termites collectively "know" how to build the mound properly, and if they didn't get it right, how would they "know" it was wrong or how to fix it? Other things, too, simply didn't fit. Lüscher thought of the mounds as air

I had one big advantage that Martin Lüscher did not: miniature sensors that allowed me not only to measure in great detail the composition of the nest atmosphere but also to trace precisely how air moved through the tunnels of the nest and mound. The results were, shall we say, mixed. I was gratified to find that levels of oxygen and humidity in the nest were steady—and also different from the external world—as I thought they would be. Oxygen concentration averaged about 19 percent, compared with 21 percent in the atmosphere, and the humidity was 70 percent inside, compared with about 20 percent outside. But the movements of air I observed were puzzling. Not only was Lüscher's metabolism-driven circulation absent; the air seemed to move with no pattern at all.

But after three years of tracing flows in mounds and nests, taking apart several mounds to work out their architecture, and doing a lot of head scratching, I finally came to a pretty good understanding of how a mound operates. Metabolism does not power ventilation, as Lüscher thought. The wind

does. By building the mound upward into the stiffer breezes higher off the ground, the termites harness the wind to drive air movements in the mound's tunnels. The flow of the wind pushes air through the porous soil on the windward side and sucks it out on the leeward side, allowing the nest atmosphere to mix with fresh air from the outside world. This in itself is not surprising; lots of animals build structures that do similar things. What is remarkable is the pattern of ventilation: an in-and-out movement very similar to the way air flows into and out of our own lungs. In fact, what most distinguishes the action of the two "organs" is that the termites' is powered by the ebb and flow of wind instead of by the contractions of muscle.

I also got a pretty good idea of how the mound fits into the socially homeostatic system that regu-

Macrotermes *termites cultivate a particular species of fungus that predigests their food.*

lates the nest's atmosphere. Understanding the system requires thinking about the mound as not really an object but a process. Each year, the workers incorporate about a cubic yard of soil into the mound; meanwhile, the mound is eroding at about the same rate. Its structure is therefore a continually shifting balance between the locations on the mound where soil is added or removed and the rate at which the soil movement occurs. I learned that termites build or excavate the mound in reaction to the atmosphere inside the nest, making the mound a "smart" structure. If the nest is too stuffy, for example, the insects increase the upward rate of soil movement, extending the mound higher, into stiffer winds and more energetic ventilation. Linking soil transport with nest atmosphere results in homeostasis as the mound's structure is continually adjusted and readjusted to meet the "Goldilocks criterion": capturing wind that's not too strong and not too weak but ju-u-u-u-st right.

A puzzling question remains, however. The fungi are the major heavy breathers in the nest, consuming oxygen about five times faster than the termites do. Why, then, do the termites work so hard to build an earthen lung if the fungi, *Termitomyces,* actually do the most to make the nest air stuffy? To be sure, the act is not altruistic, because the fungi, by breaking down the termites' food, are performing a critical function. In a sense, the termites are "paid" for their work. But the fungi may be gaining much more than simply having termites supply them with a steady diet of cellulose: *Termitomyces,* you see, have competitors.

The nest is an ample resource for any fungus that can digest cellulose, and some, such as the common wood-rotting fungus *Xylaria,* consume so much so quickly that they are not very good at sharing this resource—either with other fungi or with termites. Via their feces, the termites inadvertently introduce into the mound the spores of many of these potential competitors. If the competitors were allowed to grow, they would quickly overwhelm the slower-growing *Termitomyces,* leaving both fungus and termite in the lurch. Yet only *Termitomyces* spores germinate and grow in the nest: the growth of all other fungi is suppressed, most likely by carbon dioxide, which exists at higher concentrations within the nest than in the normal atmosphere. *Macrotermes* do not build mounds to favor *Termitomyces*

Below: *Termitomyces* fungi push through the mound to produce mushrooms at the surface. Below left: Within the mound, they also flourish in "fungus combs" built for them by the termites.

MARK COLLINS; OXFORD SCIENTIFIC FILMS

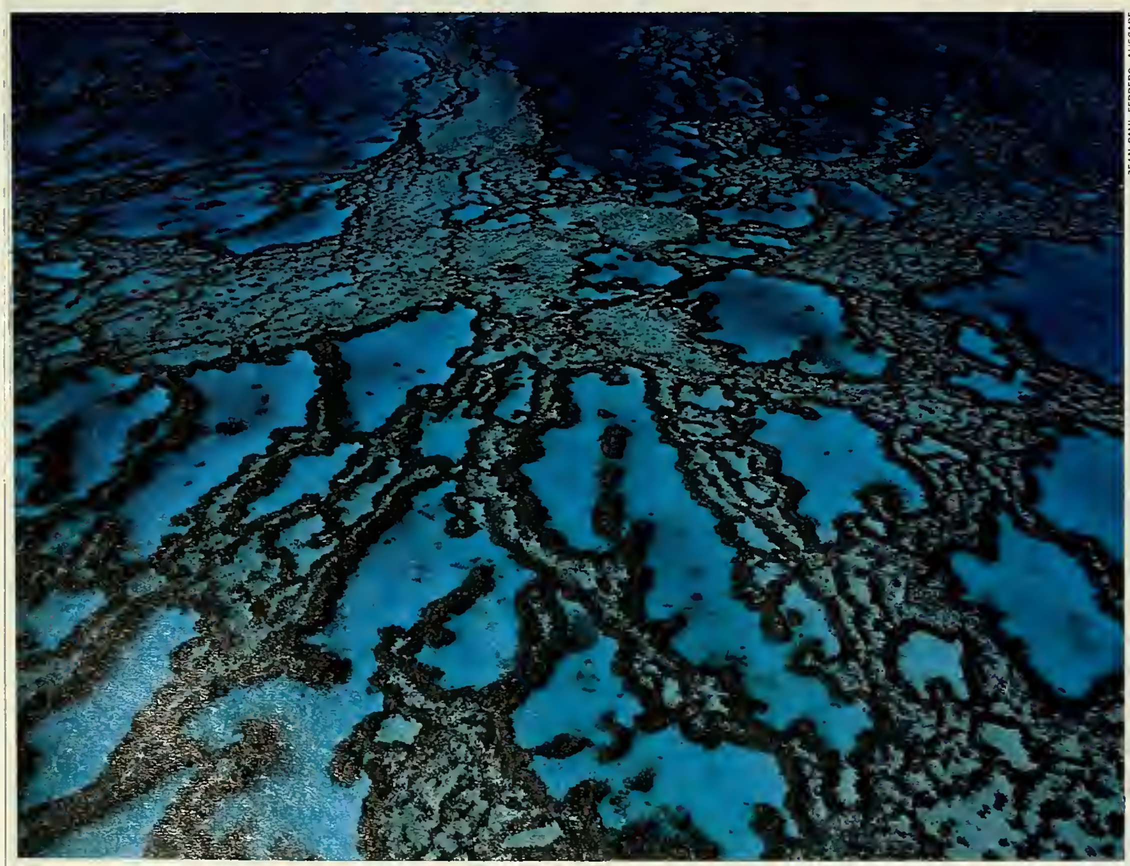
MARK COLLINS; OXFORD SCIENTIFIC FILMS

over other fungi just because the insects have some peculiar affinity for them. Rather, *Termitomyces* may be manipulating the building behavior of its termite hosts to provide an environment that suppresses the growth of the greedy species of fungi. In this sense, it may be the fungus that has cultivated the termites rather than the other way round.

The origin of such cooperation has been a puzzle for Darwinism ever since, well, Darwin. Putting energy into achieving homeostasis must provide genetic payoffs for those investing in it, or the behavior will disappear. Within an individual multicellular organism, balancing the activities of all the cells ultimately promotes the survival of only a few—the sperm or the eggs. However, since each of these gametes contains half the genetic material found in the cells that support it, there's still a payoff for all these nonreproducing support cells. A similar logic explains social homeostasis in social insects, whose "gametes"—the breeding caste—are genetically very similar to the sterile workers. But in genetically disparate groups, such as the coalition between *Macrotermes* and *Termitomyces,* some participants may not necessarily compensate others for investments in their reproductive success. Yet the termite colony is nothing if not a melding of disparate genetic interests. This melding, however, derives from common and interacting *physiological* interests and is directed at maintaining a particular association *(Macrotermes–Termitomyces)* while cutting out the possibility of other associations (such as *Macrotermes–Xylaria*). Thus the regulated environment, maintained by a constructed physiological organ—the mound—furthers the interests of both groups of inhabitants. The termite colony—insects, fungus, mound, and nest—becomes like any other body that is composed of functionally different parts working in concert and is ultimately capable of reproducing itself. Taken as a whole, the colony is an extended organism.

Organisms whose physiology extends well outside their bodies are in fact quite common in nature. These lifeforms pose interesting paradoxes. For example, which

NURIDSANY AND PERENNOU; PHOTO RESEARCHERS, INC.



JEAN-PAUL FERRERO; AUSCAPE

Extended physiology: The spider *Argyroneta aquatica*, right, builds an external gill by weaving an underwater web and filling it with air, allowing for the exchange of respiratory gases. Below: Coral reefs, like termite mounds, are the products of the joint evolution of the animate and the inanimate.

parts of an extended organism are alive and which are not? In the case of termite mounds, the termites and fungi certainly qualify as living, but so does the mound, in a sense. After all, it does just what our lungs do for us. The primary difference is in perspective. For a human, what is inside the body is pretty clear, but for the termite colony, "inside" includes the nest environment. And if the physiology of the colony extends beyond the organisms the group comprises, could extended organisms and the structures they build be directed toward the physiological regulation of ecosystems—or of Earth itself?

Those scenarios may seem unlikely, but the influence of extended physiology can be enormous, producing ecosystem-wide effects, even though the power of any given external physiological adaptation (such as aquatic beetles or water spiders using bubbles as external gills) may be very limited. *Macrotermes* colonies, for instance, are major components in the flow of carbon in the tropics. And coral reefs, which lie between intertidal zones and the deep of the sea, form a very rough boundary that allows for more efficient transfer of nutrients from the ocean to the coast than would be possible if no reefs were present.

The fungi may be manipulating their insect hosts into providing them with an environment that suppresses the growth of greedy competitors.

This idea of ecosystem regulation is a controversial proposition that lies at the heart of a long-simmering argument. Some scientists—such as James Lovelock, Lynn Margulis, and other proponents of the Gaia hypothesis—maintain that the Earth is literally alive, in the same way as a nominally inanimate termite mound can be said to be alive. Nonsense, say others, how could such a world evolve? It's not Earth that evolves; it's the organisms on it that do. To say otherwise is to return to a view of living nature—purposeful and cooperative—that modern Darwinism long ago eclipsed. Hang on, say the members of a third group. Isn't this simply a return to ecology's roots as a physiological science concerned with how living things regulate flows of matter, energy, and information through ecosystems? And why, they ask, should we dismiss such questions just because they're hard to fit into our current thinking on evolution?

As the controversy bubbles, how about reconsidering termite colonies (or any number of other extended organisms) and asking yourself, Where does the environment end and the organism begin? I suspect the answer will not come easily to you either. □

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Co-op building: A mound in a Botswana forest

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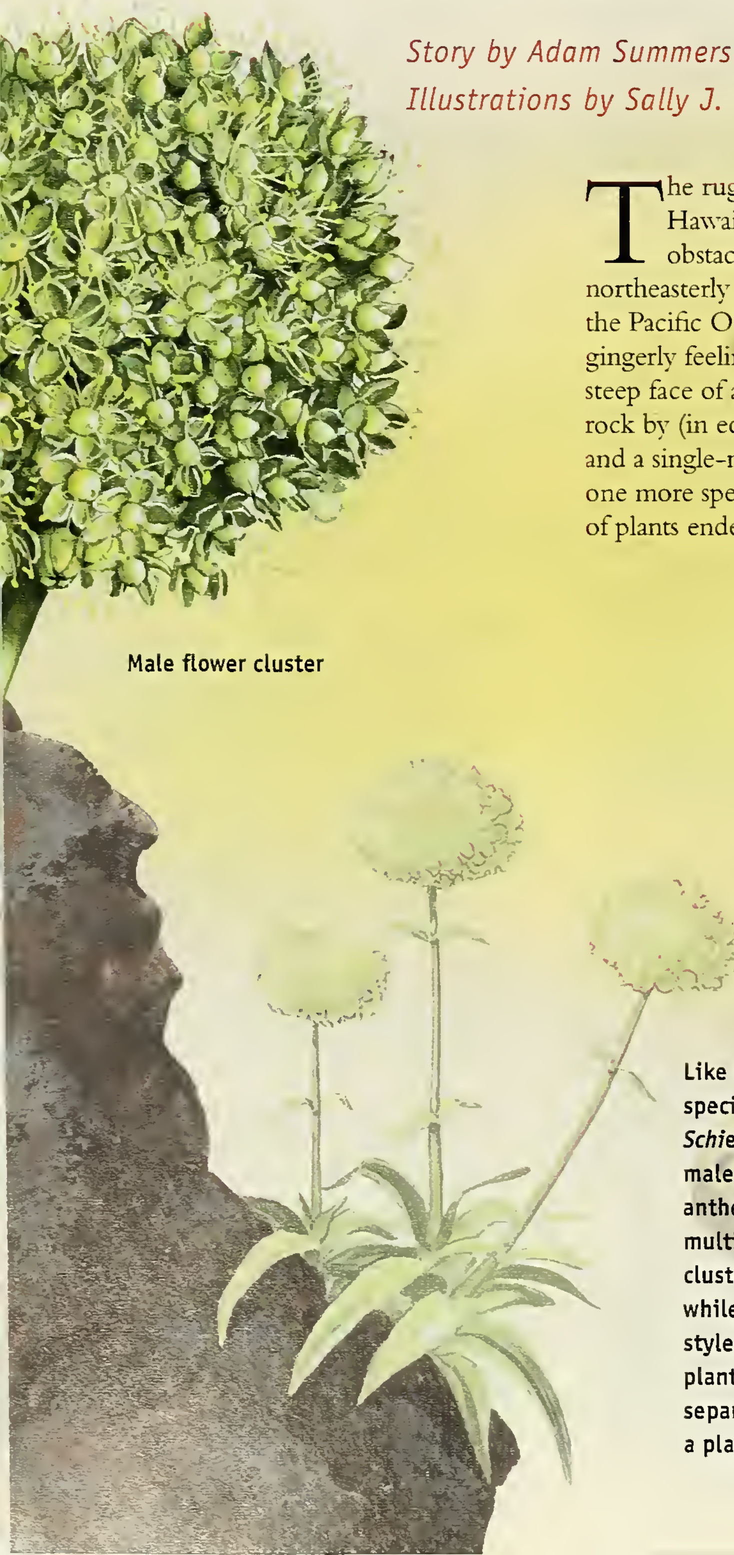
BIOMECHANICS

Sex Is in the Air

Birds do it. Bees do it. Sometimes even gentle breezes do it.

Story by Adam Summers
Illustrations by Sally J. Bensusen



Like many wind-pollinated species, Hawaii's cliff-dwelling *Schiedea globosa* plants can be male or female. Pollen-bearing anthers stick out from the multitude of tiny flowers clustered on the male plants, while protruding, elongate styles on the flowers of female plants capture the pollen. This separation of the sexes keeps a plant from fertilizing itself.

The rugged volcanic cliffs of the Hawaiian Islands are the first obstacles encountered by the northeasterly tradewinds roaring across the Pacific Ocean. Stephen Weller, gingerly feeling his way down the steep face of a cliff, is glued to the rock by (in equal parts) the stiff breeze and a single-minded desire to collect one more species of *Schiedea,* a genus of plants endemic to the Hawaiian Islands. He hopes to determine the role of wind—a distinctly nonbiological process—in the evolution of that most fundamental of biological functions: reproduction.

The complexity of plant reproduction is the bane of undergraduate biology. Lots of plants reproduce asexually, essentially cloning themselves, a method that sacrifices the advantages gained from the reshuffling of genes in sexual reproduction. In flowering plants that reproduce sexually, the analogues of sperm and eggs are, respectively, pollen and ovules, both produced within the flower. From there, things can get weird. Many plants have hermaphroditic flowers, which produce both pollen and ovules. Others have two kinds of flowers: some that produce only pollen and some that produce only ovules. In still other species, individual plants produce flowers of only one sex or the other. A flower that generates both pollen and ovules has the potential to fertilize itself, but such inbreeding can lead to a concentration of bad genes—perhaps a just reward for selfish behavior. For this reason, the architecture of most hermaphroditic flowers inhibits self-fertilization—for example, the anthers (which contain the pollen) will not be situated too close to the stigma (the upper part of the style, a stalklike structure that leads to the ovary). This increases the likelihood that pollen will be carried out of the flower, often by insects, birds, or bats, and be deposited somewhere far from home.

Anyone with spring allergies, however, is all too aware that many plants rely not on animals for pollination but on the wind. The drawback to this approach is that while a butterfly may flit from blossom to blossom in search of nectar, thereby boosting the chances that it will deliver pollen from one plant to another, a breeze has no destination in mind. A given pollen grain blowing in the wind is thus unlikely to land on a receptive stigma. To compensate, plants that are pollinated by the wind tend to produce lots and lots of pollen (often, tens of thousands of grains per flower). That coating of yellow powder on cars in the springtime is a testament to the number of grains needed to make up for the very remote chance of a meeting between male and female gametes.

But how to get the beautifully sculptured spheroids of pollen off the anther and into the air? This is not so simple a proposition as it might sound. Pollen grains are tiny: it would take two large ones, or about forty-five small ones, just to span the period at the end of this sentence. Pollen is, in fact, so small that it hides within the boundary layer, a film of air that remains still even on swiftly moving surfaces. (You may have noticed that dust builds up on the blades of ceiling fans. Even if the fan is never turned off, dust collects in the boundary layer, where the wind is not strong enough to move it.) To make sure that pollen gets scattered, the anthers of wind-pollinated flowers are built to shake and shimmy in the breeze.

Once airborne, pollen grains run the risk of sailing right past a suitable landing zone. Not coincidentally, the flowers of wind-pollinated plants are usually arranged in tight bunches that block the wind, creating eddies that increase the odds of successful pollen delivery. In some cases, the clustering of flowers actually serves as an aerodynamic sieve, helping ensure that only pollen grains of the appropriate size settle onto the stigma.

For a plant morphologist, a quick look at the level of pollen production and the shape and distribution of the flowers and floral parts is usually enough to tell whether a plant is pollinated by wind or by animals. Sometimes, however, morphological information is not enough. The issue can then be settled with an empirical, biomechanical test. In a large wind tunnel (the kind used for testing airfoils), plants are arranged in small groups so that the flow of air around them mimics the airflow in nature. The wind speed in the tunnel is varied, from the light breezes that might blow across a quiet valley floor to the near gales that frequently batter an exposed ridge. Airborne particles are collected on sticky microscope slides placed downwind of the plants. The farther pollen rides the artificial gusts, the more likely it belongs to a wind-pollinated plant.

The *Schiedea* that Stephen Weller was risking life and limb to collect grow on windy cliffs, but members of the genus can be found in just about every conceivable habitat, from forests (where the genus originated) to valleys and open country. Lusher than their wind-blasted cousins, the forest-dwelling species display flowers that are clearly pollinated by insects. But it would take a powerful insect, or a very brave bird, to pollinate the plants that cling to exposed slopes, consistently buffeted by thirty-mile-an-hour winds. As you might expect, the flowers on these plants have the shape and pollen count associated with the breezy mode of pollination.

Weller, together with his colleague Ann Sakai (both of whom are at the University of California, Irvine), noticed that wind-pollinated *Schiedea* species have flowers of a single sex, while insect-pollinated ones have hermaphroditic flowers. Plants that rely on the wind and that produce both prodigious amounts of pollen and flowers adapted to catch it, they reasoned, would be especially prone to "inbreeding depression" (when inbred offspring don't reproduce as well as individuals whose parents are less closely related) if their flowers were hermaphroditic. Could wind, with its quixotic eddies, drive the separation of male and female aspects of reproduction?

Female flower cluster

Having determined the pollination method of more than a dozen species based on anatomy alone, the researchers tested the rest inside the wind tunnel—running the tests in the evening because that is when the anthers release their pollen. When Weller and Sakai checked the slides for pollen, the answer was clear: Species of *Schiedea* that had moved from the forest into dry, windy habitats had evolved wind-pollinated flowers with separate male and female reproductive systems. In these plants, the answer to the question of whether their flowers can pollinate themselves is blowin' in the wind.

Adam Summers is an assistant professor of ecology and evolutionary biology at the University of California, Irvine (asummers@uci.edu).

OUT THERE

Good Morning, Starshine

Astronomers are closing in on cosmic dawn.

By Charles Liu

All of us have looked up at the clouds on an overcast morning, wondering when the skies will clear. Astronomers have long looked up, wondering a similar thing about the cosmos: when, after the birth of the universe, did things clear up, allowing visible light to shine? Recent observations have now provided the best measurements yet of the debut of starlight in space.

During the early part of its existence, our universe was so small and dense that light and matter intertwined: space was hot, dark, and ionized—filled with charged particles. About a half-million years after the big bang, however, the cosmos had grown large enough for matter and energy to move through space without immediately colliding. Electrons, protons, and neutrons came together to form neutral atoms—the basic building blocks of all visible matter in the universe.

Infrared light, microwaves, and radio waves began to stream across the universe as soon as matter and energy decoupled: astronomers often refer to this era of decoupling as a time when the universe became transparent. But visible and ultraviolet (UV) light couldn't go anywhere. Hydrogen atoms—nine-tenths of all the atoms in the universe—now permeated space, and they absorbed visible and UV light the way sponges absorb water. The hapless beams flew into a peasoup fog. Although the universe was no longer hot or ionized, it was still dark.

So why can we see stars today? We owe that to the stars themselves. Think back to that overcast morning. The water droplets in the clouds absorbed the Sun's visible light, so the bright disk of the Sun was obscured until the rays heated the droplets enough to evaporate them, rendering the water transparent. Making hydrogen atoms transparent to light involves a similar but much more energetic event: beams of energy must ionize the atoms, splitting them into protons and electrons. (Not surprisingly, astronomers call this process reionization.) For hundreds of millions of years, nothing in the universe could clear the fog. But later, when the first stars formed, their powerful thermonuclear fires generated UV, X-ray, and gamma-ray photons, which had the energy to split the hydrogen atoms fogging up the universe. Eventually, visible light moved unimpeded through the thinning mist; ultraviolet light followed soon after, then X rays and gamma rays. Finally, the universe's Dark Age was over.

During the early part of its existence, our universe was so small and dense that light and matter intertwined.

Much like the clearing of a cloudy morning, reionization happened gradually. First a few bright spots appeared. Clear skies took over as the clouds shrank in size and number until only a few small ones remained. But finding the point at which the universe turned from dark to light has long eluded us astronomers, who want to know precisely when the stars became the universe's main source of light. Trouble is, stars have been blazing away for at least 10 billion years, and looking for anything that happened so long ago is very hard work.

Decades of searching have finally brought us a few tentative successes. Several groups of astronomers have been examining distant quasars to piece together what they've interpreted as the tail end of the Dark Age. A quasar, which contains a black hole at its center that acts like a titanic gravitational engine, produces more energy in one second than our Sun does in a million years. Quasars work like cosmic spotlights, revealing the presence of atomic hydrogen. In recent months, researchers at Caltech, UC Berkeley, and Princeton have all found hints of a boundary between opaque and transparent space. Their results suggest that the reionization of the cosmos occurred when the universe was 6–7 percent of its current age. For a 13-billion-year-old universe, this means that the Dark Age ended 12.1 to 12.2 billion years ago.

Astronomers at the University of Hawaii have used another technique to probe the timing of reionization. They're searching for superdistant, ancient protogalaxies lurking behind huge clusters of galaxies closer to Earth. These foreground clusters act as lenses that magnify the light of the protogalaxies and allow us to detect and study them. Their work pushes the end of the Dark Age back still further, to 12.3 billion years ago.

These latest discoveries sound like real progress—until we realize that they imply an almost fully formed universe by about 700 million years after the big bang. According to current models, that's not enough time to allow for the formation of either the quasars that illuminate the atomic gas or the protogalaxies that harbor the first stars. Are our theories of star and galaxy birth flawed? Or have we miscalculated the age of the universe? Revealing the edge of the cosmic fog merely emphasizes how much we have yet to learn about the universe's murky infancy.

Charles Liu is an astrophysicist with the Hayden Planetarium. He is also affiliated with Barnard College as a research scientist in the Department of Physics and Astronomy.

THE SKY IN JULY AND AUGUST

By Joe Rao

Mercury shines at dawn just above the east-northeastern horizon, close by Saturn, as July begins. It plunges in the direction of the Sun several days later, reaching superior conjunction on the 20th. By July 31 it returns to the evening sky, but sets about thirty-five minutes after sundown. Mercury makes a poor evening apparition in August, setting in the middle of twilight. The planet fades from magnitude -0.6 to +0.2 between August 6 and 31 and can be seen only with a pair of binoculars or a spotting scope.

Venus is the evening "star" this summer, bright and impressive during twilight for those with an unobstructed western view. The planet sets about two hours after sundown, roughly half an hour earlier than it did during June. It shines near the first-magnitude star Regulus, in the heart of the constellation Leo, on July 10. Venus's passage north of Regulus makes a striking sight for several evenings before and after the 10th. The star hangs 10° above and to the left of Venus on July 1; that distance shrinks to just over 1° by the 10th. During this pass, the planet appears 150 times brighter than the mighty star! Venus reaches the end of its tether to the Sun on the evening of August 22—achieving its greatest elongation, 46° east of the Sun. Unfortunately, the planet is heading southward even as it brightens, so despite its increasing separation from the Sun, it gradually loses altitude for viewers at midnorthern latitudes. On the 22nd, Venus is only about 16° above the horizon at sunset. By the end of August, it lies along our line of sight to Spica, the brightest star in Virgo. The planet is just 0.9° below the star on the evening of August 31—a pretty sight visible with or without optical aids. Venus shines 140 times brighter than Spica, but its greatest brilliance is still a month away.

Mars is on summer vacation. It reaches conjunction with the Sun on August 10, and solar glare renders Mars invisible all through July and August.

Jupiter is effectively hidden by the Sun throughout July and into the first week of August, reaching conjunction with it on July 19. In mid-August, the planet is low in the east-northeast at dawn. By month's end, it rises about two and a half hours before the Sun.

Saturn starts July very low on the east-northeastern horizon, submerged in the bright dawn twilight and very close to Mercury. On the morning of July 2, the brighter Mercury lies only 0.3° to Saturn's right. In the days that follow, they quickly separate as Saturn rises progressively earlier. By the end of July, the planet is rising before 3:00 A.M. local daylight time. During August, the interval between the rising of Saturn and that of the Sun increases from about three to more than five hours. By month's end, Saturn shines from on high at dawn, its splendid rings tilted almost to their maximum (26.5°) toward Earth.

The Moon wanes to last quarter on July 2 at 1:19 P.M. New Moon falls on July 10 at 6:26 A.M., and first quarter on the 17th at 12:47 A.M. The Moon is full on July 24 at 5:07 A.M. In August, last quarter comes on the 1st at 6:22 A.M. The Moon is new on August 8 at 3:15 P.M. and waxes full on August 22 at 6:29 P.M. On the 30th, at 10:31 P.M., the Moon wanes to last quarter for the second time in August.

The Perseid meteors reach their peak late on the nights of August 11 and 12. These fast, bright meteors frequently leave persistent trails. Viewing is best from midnight until the first light of dawn; a single observer might see fifty to a hundred shooting stars per hour from a vantage point that is free of bright lights and obstructions. Because the meteors appear to shoot away from the constellation Perseus, they are known as Perseids. More than a century ago, the Perseid peak occurred on the night of August 10th—the Feast of Saint Lawrence. Those looking skyward then referred to the Perseids as the fiery "tears of Lawrence."

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

REVIEW

"The Whole Mass a Paradice"

Is religion an adaptation that enables groups to function as single units?

By Frans B. M. de Waal

Religious altruism: for the greater good?

WORKS OF MERCY, CHAPEL OF SAN MARTINO DEI BUONOMINI, FLORENCE; SCALA/ART RESOURCE, NY

While many people have begun to worry about religious fanaticism and the violence it injects into the world, a biologist has decided to probe the evolution of religion. In doing so, David Sloan Wilson (no relation to entomologist Edward O. Wilson) compares organized religion to insect societies: harmonious and cooperative on the inside, intolerant of the outside.

Parallels between human and insect societies are far from new. As early as 1714, Dutch philosopher Bernard de Mandeville achieved widespread fame with his lengthy poem *The Fable of the Bees* (subtitled *Private Vices, Publick Benefits*), in which he compared civilization to a beehive wherein all individuals happily gratify one another's pride and vanity:

> *Thus every Part was full of Vice*
> *Yet the whole Mass a Paradice;*

Religions are the purported enemies of vice. The Taliban's religious police force, given the Orwellian title General Department for the Preservation of Virtue and Prevention of Vice, meted out floggings to women who allowed their faces or ankles to show. Fundamentalist Christians in the West are similarly intolerant, as illustrated most recently by the Reverend Jerry Falwell's comment that gays and lesbians are partly to blame for the 9/11 attacks. Yet somewhat surprisingly, Wilson does not dwell much on the coercive side of religion—not even when he discusses John Calvin's tightly controlled religious enclave in sixteenth-century Geneva. Wilson prefers to emphasize the cooperative and altruistic aspects of religious groups and their benefits for believers. Religion, he says, is a good thing for those who abide by its rules.

The argument is twofold: that organized religions function much like beehives or ant colonies, in which all members contribute to the greater good (sometimes at a cost to themselves but mostly to their benefit); and that the tendency to build such solidarity must have evolved by means of group selection. The first point is interesting and new, whereas the idea that selection can operate on entire groups—not only on individuals or on clans of close kin—has been offered many times before by the author (and is still regarded by many biologists as slightly heretical). If one group out-reproduces another and if groups don't mix—so the reasoning goes—the genes enabling the first group to do better will spread.

Darwin's Cathedral: Evolution, Religion, and the Nature of Society, *by David Sloan Wilson (University of Chicago Press)*

The book's strength is its convincing argument that religious groups often act like a single organism. We learn about Calvinism (in impressive detail), Judaism, early Christianity, established churches, modern sects, and a system of temples and aqueducts on Bali that are dedicated to the water goddess in the island's crater lake. The emphasis is not on what kind of god(s) people believe in, or on how they worship, but rather on what they get from religion.

French sociologist and philosopher Émile Durkheim used the phrase "secular utility" for benefits derived from belonging to a religious community. Quite in contrast to the antireligious obsessions of biologists such as T. H. Huxley and Richard Dawkins, the attitude Durkheim held was that something as pervasive and universal as religion must serve a social purpose; he would have shaken his head at the idea of religion as a maladaptive, parasitic "meme." And even though Wilson sees religions as misrepresenting reality, he agrees with Durkheim that they permit human groups to function as harmonious units: "Religions exist primarily for people to achieve together what they cannot achieve alone."

As a biologist, Wilson emphasizes the effect of religion on survival and reproduction. His views are nicely captured by a contrast he draws between early Christians and the surrounding Roman society, with its "extreme male domination and a form of status-striving that made marriage and families unattractive prospects for males." Preference for sons resulted in skyrocketing rates of female infanticide and, consequently, a disastrous imbalance of males and females within the population (Wilson cites a figure of 140 males for every 100 females). Early Christians, whose religion condemned abortion and infanticide, were expected to marry and to be highly fecund, and they soon outnumbered the Romans, whose population in fact declined. Moreover, when two plagues swept through the empire, killing up to a third of the inhabitants each time, the Christians fared better than the Romans—not because the germs (probably smallpox and measles) discriminated between people of different creeds but because the Christians cared for their sick. Heathens, wrote the Christian bishop Dionysius of Alexandria in the third century A.D., "pushed the sufferers away and fled from their dearest, throwing them into the roads before they were dead and treating unburied corpses as dirt, hoping thereby to avert the spread and contagion of the fatal disease." Even though Christians risked self-contamination, guess which group as a whole most effectively curbed mortality?

Where Wilson uses the effect of religion on population growth to fortify his case for selection at the group level, *Darwin's Cathedral* shows some gaps. For selection to favor one group over another—and for this to have genetic consequences—groups need to be reproductively isolated from one another. This applies well to ants and bees in massive colonies of great genetic homogeneity. All members serve the same reproductive female and do not breed with outsiders, even when they vanquish another colony. Wilson discusses genetic isolation in relation to the low hybridization rates between Jews and other religious groups, but this may be the exception rather than the rule. Most religions tend to proselytize and to accept or encourage marriages with converts, resulting in quite large, genetically diverse populations. Under such circumstances, gene flow is often high, and it is hard to see how group selection could be at work.

Ironically, given the topic of his book, Wilson's defense of group selection leans toward religious fervor and occasionally lends his writing a preachy tone. I had to laugh out loud, therefore, at one of his claims: "I approach others as a student rather than as a teacher." It is obvious that when the author climbs on his hobbyhorse, *we* are the ones meant to listen and to witness him (as he modestly calls the process in a chapter subhead) "Lifting the Fog From Multiple Streams of Evidence." But my amusement aside, I found *Darwin's Cathedral* a refreshing look at religion, bound to generate both heated and serious debate at a time when science and religion are all too often presented as antithetical.


MARK MOFFETT; MINDEN PICTURES

Weaver ants working in harmony

Frans B. M. de Waal is C. H. Candler Professor of Primate Behavior and director of Living Links at Emory University in Atlanta. His latest book is The Ape and the Sushi Master: Cultural Reflections of a Primatologist *(Basic Books, 2001).*

BOOKSHELF

Catapults, trebuchets, and gunpowder, according to environmental historian Alfred W. Crosby in **Throwing Fire:** *Projectile Technology Through History* (Cambridge University Press), can be traced back to our ancestors' aptitude for hurling stones and manipulating fire. Evolutionary psychologist Michael C. Corballis, however, makes the case in **From Hand to Mouth:** *The Origins of Language* (Princeton University Press) that a more profound step in *Homo sapiens*'s development was the transition from primate gesture to signed communication. In **The Complete World of the Dead Sea Scrolls** (Thames & Hudson), scholars Philip R. Davies, George J. Brooke, and Phillip R. Callaway detail how the scrolls, one of history's great language troves, depict the tumultuous Judaean world of 2,000 years ago. Language and technology may have helped build powerful civilizations, yet wars, soaring populations, and environmental changes have brought them down—a situation David Webster portrays in **The Fall of the Ancient**

Maya: *Solving the Mystery of the Maya Collapse* (Thames & Hudson).

However much our species has come to dominate the planet, our history is nevertheless intertwined with those of other animals, as Eric Scigliano shows us in **Love, War, and Circuses:** *The Age-Old Relationship Between Elephants and Humans* (Houghton Mifflin). The nature and behavior of these proboscideans have also haunted South African naturalist Lyall Watson, who evokes their world in **Elephantoms:** *Tracking the Elephant* (W. W. Norton). To find out about the rich emotional life of nonhuman species, read **Minding Animals:** *Awareness, Emotions, and Heart* (Oxford University Press), by cognitive ethologist Marc Bekoff. But such insights into the creature world come about only through painstaking research, as Heather E. Heying makes clear in her vivid chronicle of Malagasy fieldwork, **Antipode:** *Seasons With the Extraordinary Wildlife and Culture of Madagascar* (St. Martin's Press).

Little of terra firma remains untouched. Historian Steven Stoll's **Larding the Lean Earth:** *Soil and Society in Nineteenth-Century America* (Hill and Wang) shows how farming is "the central biological and ecological relationship in any settled society and the most profound way that humans have changed the world over the last ten thousand years." In **Travels in the Genetically Modified Zone** (Harvard University Press), biologist Mark L. Winston polls scientists, activists, farmers, consumers, and government regulators as to the extent and implications of the newest kinds of crop manipulation. Another looming reality is global warming, and William H. Calvin's **A Brain for All Seasons:** *Human Evolution & Abrupt Climate Change* (University of Chicago Press) is of particular interest; he claims that cataclysmic environmental events have brought about correspondingly swift adaptive changes in the human brain.

The books mentioned here are usually available in the Museum Shop, (212) 769-5150.

PHOTOGRAPHY

ZALMAÏ

Eclipse, *photographs by Zalmaï; preface by Atiq Rahimi (Umbrage Editions)*

nature.net

In Search of Another Earth

By Robert Anderson

One of the enduring themes of science fiction is the discovery of a distant Earth-like planet. You know, a hospitable place where humanity could get a fresh start and perhaps even create a utopia. Such fantasies may soon have a grounding in reality, as I learned at NASA's "Planet Quest" Web site (planetquest.jpl.nasa.gov/). At the time of my visit, the number of planets discovered outside our solar system stood at seventy-six, with the newest addition circling the star HD 136118.

I clicked on "New Worlds Atlas" to check out possible alternatives to our own planet. You can search the list by selecting a variable, such as planets with host stars visible to the naked eye (which is nice, because you can go right outside and look at them), or a planet type: gas giant, hot Jupiter, or terrestrial (more or less Earth-like). I clicked on the latter and . . . zero. Apparently, we still lack the means to detect planets as small as our own.

But all that is about to change. The site lists a number of future NASA missions designed to increase our chances of finding alien worlds. The new technologies are impressive. One of them is a fleet of space telescopes flying in precise formation; the net effect will be equivalent to an enormous eye, capable of detecting smaller planets. I'll bet that within a decade we'll have a few worlds in the terrestrial category to dream about. Then the only problem will be how to get there. Currently, the closest planet in the "New Worlds Atlas" is 10.4 years away—that is, if we're traveling at the speed of light.

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

EXPLORER GUIDE

THE NATURAL MOMENT

Maybe It's Maybelline

Varied and wonderful, the successful life-forms of our planet are exquisitely shaped by evolutionary forces, honed by competition, physically fine-tuned to their environment, and so on. What, then, can one make of a creature that looks like it was designed by a committee of comedians or as though it evolved in a theatrical prop room? The rosy-lipped batfish, for example. This individual, photographed near Cocos Island off the Pacific side of Costa Rica, is a member of a species endemic to Cocos. (Its closest relative, the red-lipped batfish, lives near the Galápagos Islands.)

Batfishes are indeed fish, and when seen from above may look like bats, but probably more like splayed frogs with tails. The unicorn effect on the head is a snout. "It's firm," says ichthyologist and batfish expert John McCosker, "sort of like chicken gristle," and it protects a thin, retractable appendage that the batfish deploys to lure small edible fishes. The legs (they're pectoral fins, really) allow batfishes to crawl about the seafloor. They are reluctant swimmers and, according to McCosker, prefer to "sit upright, like old tail-dragging airplanes."

While its fringing white bristles may give this species a sensory edge in its preferred habitat—usually more than 125 feet down—the red Mick Jagger lips are harder to fathom. Without an artificial light source, such as a photographer's strobe, red coloring can't be seen at such depths.

These fish are shy, says photographer Avi Klapfer, and tend to turn their back to divers and walk away. Although he couldn't get this rosy-lip to smile, Klapfer managed, after half an hour, to capture this portrait.—*Judy Rice*

Photograph by **Avi Klapfer** JEFF ROTMAN PHOTOGRAPHY

ENDPAPER

No Fly Zone

By Elizabeth Cator

One summer day, I spent several idle moments beside a still, shallow creek near my home, trying to goad the water striders there into flying. I had never seen them fly, but I believed they could do it. When fully grown, these insects all have long, elegant wings (which many other species of striders lack) yet keep them stowed on their backs, as if too precious or impractical for everyday use. What would it take to make the striders rise above their element, the thin surface film between water and air, and trust themselves completely to the air?

In the night a cold front had come through and, with it, a windfall of phantom midges. Their tiny, pale corpses littered the surface of the water. Water striders darted among them, feeding—lingering at some for the few seconds it took to insert their stylets and draw out the liquefied viscera, while stopping at others, drained already, for only an instant. To one side of this floating banquet, a lone strider rested near the bank. I crept up on it.

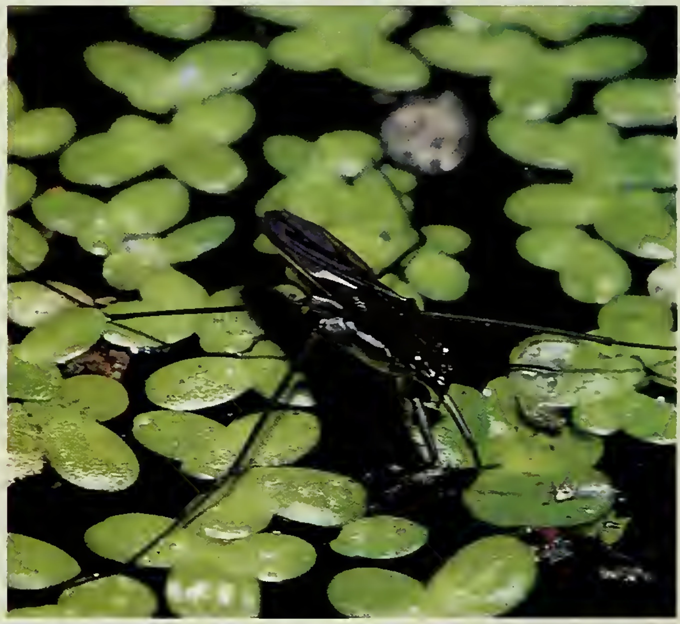
From a distance, the resting strider looked like a sliver of debris, a half inch of twig or gray bark. As I moved closer, long, hair-thin legs came into focus, the back two pairs angled to form an X. Closer still . . . and with a lightning flick of those legs, the strider shot away. Its feet, the only parts of the insect in contact with the water, sparked diamond-points of light on the surface.

This effort carried the strider perhaps an inch. I approached it again, this time dimpling the water with a stick, and the strider burst into a long run of skips like a skimming stone. But it did not fly. Ripples circled out among the feeding striders, which scattered left and right in the commotion. I went after them, harried them with the stick, dropped pebbles beside them, but even in the general panic they fled on foot. Their wings remained as if glued to their backs. Eventually, ashamed of myself for tormenting them, I gave up.

It was not the first time the behavior of these striders had baffled me. While reading about water striders in general, I came across the description of a courtship ritual that is an insect idyll if ever there was one. The male of a certain species, so I read, first locates the ideal spot for his intended mate to lay her eggs. He may favor a floating leaf of water plantain (which is plentiful in our creek). Taking hold of it, he begins to swish his middle legs back and forth, very rapidly, to create the one particular pattern of ripples in the water that females of his species find attractive.

A female approaches; he is playing her song. She taps him with a foot in greeting, then settles alongside and allows him to hop on board. A charming picture. One sunny day I sat down beside our creek, hoping to see it for myself.

Before long I observed a male strider—distinguishable by his shorter, paler body—approach a female on the open water. With no preliminaries at all, he seized her from behind. As he struggled to mount, he overturned them both.



KENNETH H. THOMAS; PHOTO RESEARCHERS, INC.

Water strider *(Gerris remigis)*

He hung on, and for a moment they were both belly-up in the creek. Still joined, they rose vertically, half in and half out of the water, and toppled, right side up and one atop the other, flat onto the surface.

For a time the pair quietly rode the water as one. Then the female, rearing up, capsized them both again. They struggled, regained their footing, and skittered apart. The female was now on her own to seek that perfect spot for egg laying. The male at once pounced upon another female.

Well. So much for romantic rippling at a leafy rendezvous. While that may be the etiquette in some strider circles, evidently it is not how things are done down at the local creek. Here, all a strider needs to know is how to walk on water.

English-born Elizabeth Cator is an embroiderer. She watches bugs in Hartwood, Virginia.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