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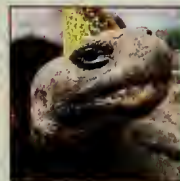
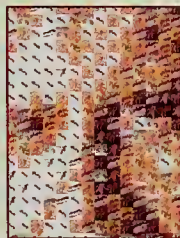
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THE NATURAL MOMENT

BEETLE JUICE

Photographs by Rick Lieder





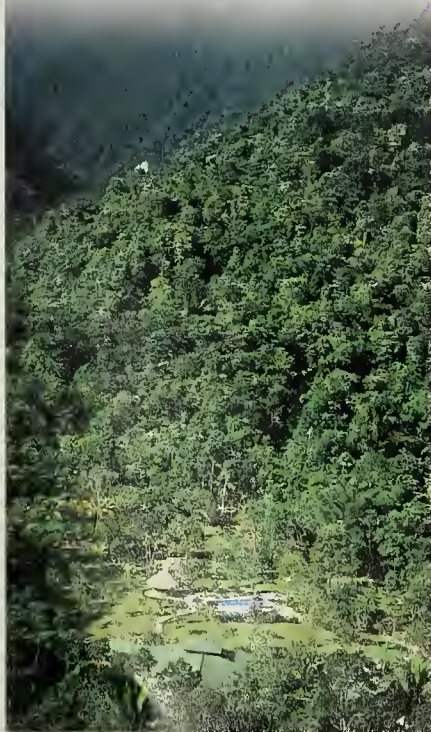


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THE NATURAL EXPLANATION BY ERIN ESPELIE



Before fireflies took up “flash-dancing,” their ancestors likely relied on pheromones to find a partner, as many insects do. Light first appeared in the larvae—probably to advertise their toxicity and so warn away predators—and only later evolved into a seducer supreme for the adults. Thus firefly courtship now attracts a lot of outside attention. In southern Michigan last July, Rick Lieder had no trouble spotting males blinking in the air, females in low-lying vegetation biding their time to blink back, and pairs about to mate.

How can fireflies, aka lightning bugs, afford such flashiness? (For the record, they're neither flies [order Diptera] nor bugs [Hemiptera], but beetles [Coleoptera].) In brief, many of them taste awful, and predators indiscriminately avoid them. Nearly all of the 2,000 or so firefly species worldwide sport black, yellow, and red coloration, lest their notoriety for an unsavory cocktail of chemicals be overlooked in the daytime.

Absent predators, fireflies are free to turn up the wattage. At dusk in Southeast Asia, male *Pteroptyx* fireflies remain stationary, blinking

in unison by the thousands. North and South American fireflies must be slightly more surreptitious, because of a voracious genus of predatory firefly. *Photuris* females have garnered the moniker “femmes fatales” because they lure in foreign males, *Photinus*—the fireflies pictured here. Each

firefly species tends to have its own flash pattern and *Photuris* females can mimic several. By emitting the signals of lusty *Photinus* females, a femme fatale turns hopeful males into meals. (She actually harvests their chemical repellents for her own defense.)

Sara Lewis, an evolutionary ecologist at Tufts University, emphasizes how sexual selection has shaped firefly evolution and studies what female fireflies want in a mate. In general, the brighter, the faster, the longer (in duration), and the more pulses a male can emit, the better. So competition is fierce among males. Copulation can last up to nine hours, to ensure paternity. Sometimes “love knots” arise when single males try to break up already mating couples.

Depending on habitat, though, preferences can change. In fact, some firefly species have lost their light-producing abilities and reverted to pheromones. As people crowd out open spaces and light pollution increases, more firefly species may follow that dark route.

“Wait until dark” is not usually the motto of photographers working without a flash or a tripod, but Rick Lieder prefers natural light and likes chasing fireflies at dusk. Lieder is both a photographer and a painter. His artwork has graced the covers of two Newbery honorees, *A Single Shard* (Medal winner) and *Princess Academy* (Honor Book), and will be featured in a children's book to be published in 2010. More of his work can be seen at <http://bugdreams.com>.



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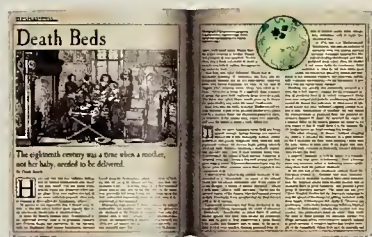
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WORD EXCHANGE

Hebrew Lesson

A little more than a year ago, linguist Sarah Grey Thomason reported on a Native American language that is on the brink of disappearing ["At a Loss for Words," 12/07-1/08]. Subsequently, Allen Tobias, a writer and producer for print, film, and video, suggested a contrasting language story, that of Hebrew, which was revived as a "mother tongue" during the twentieth century. Tobias, whose specialties are public health, natural sciences, and—most pertinently—modern history, looked into the subject on our behalf and recommended we contact Benjamin Harshav, author of *Language in Time of Revolution*. We think you will find Harshav's analysis in this month's issue rich and original. Is it natural history? Yes, it is: the adaptation of human groups to the environment (which includes their social circumstances), largely achieved through culture, is part of nature.

Vittorio Maestro
Editor in Chief



Honorable Mention

I was amazed that Druin Burch could write "Death Beds" [11/08] on puerperal, or childbed, fever without once mentioning the Hungarian physician Ignaz Semmelweis. In 1847 Semmelweis recognized independently that the cause of contagion was an agent carried by dirty hands, and made hand washing mandatory for his students entering the obstetric wards of Vienna General Hospital. Like Oliver Wendell Holmes Sr., he faced skepticism and ridicule for his ideas.
Gabor Markus
Buffalo, New York



nature.net by robert anderson

SUPERORGANISMS



I have a love/hate relationship with the ants, termites, bees, and wasps that organize into miniature societies. Their castes and capacity for intricate group behavior create alien worlds as enthralling as any in science fiction. But social insects may bite, sting, or slowly eat your house. And just the idea of hundreds or thousands of insects acting in sync, with some mysterious group intelligence, is frightening. The well-known scientist and author E. O. Wilson betrays no such ambivalence, however. To learn about his career, go to www.eowilson.org and click on "about" and then "life & work." Wilson's new book with Bert Hölldobler, reviewed in this issue, is *The Superorganism*. To explore my guide to related Web sites, please visit the magazine online (www.naturalhistorymag.com).

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

DRUIN BURCH REPLIES: Several readers correctly noted that Semmelweis is traditionally given credit (along with Holmes) for introducing hand washing in maternity hospitals and the consequent drop in puerperal fever. Semmelweis played an important role and possessed a truth ahead of his time. But he was neither alone in this nor very successful in persuading others. Had I been given more space, I would undoubtedly have mentioned him, as stories on childbed fever usually do. But on reflection, I am glad I did not. Semmelweis's name deserves to be remembered but does not merit ubiquity. A more glaring omission was Louis Pasteur.

NATURAL HISTORY welcomes correspondence from readers. Letters should be sent via e-mail to nhmag@naturalhistorymag.com or by fax to 646-356-6511. All letters should include a daytime telephone number, and all letters may be edited for length and clarity.

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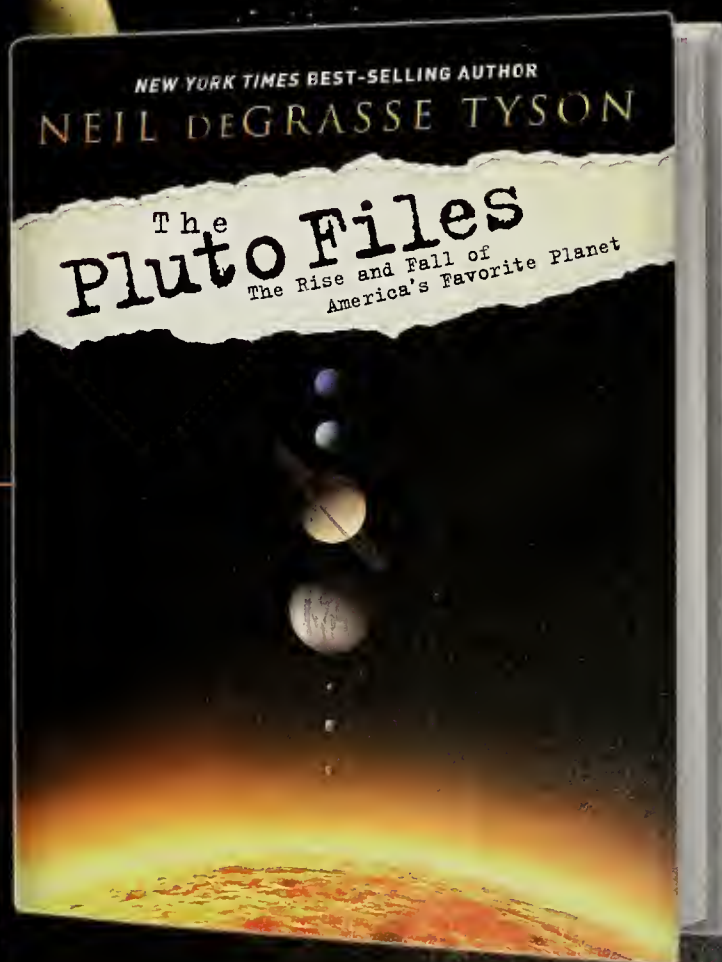


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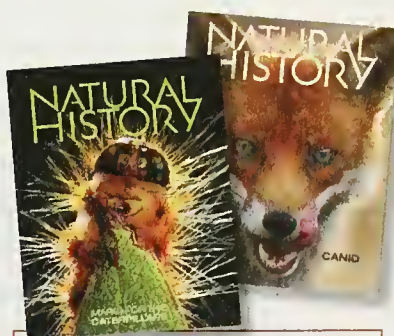
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SAMPLINGS

Mystery Leaf

When a high-ranking Mesopotamian woman named Pu-Abi was laid to rest in the Royal Cemetery of Ur some 4,500 years ago, she wore a spectacular head-dress. The adornment, disinterred in the 1920s, in what is now Iraq, sports numerous gold leaves modeled after an unknown species—and so do numerous less-elaborate accessories buried with other women at Ur. Archaeologists have proposed several trees native to the area as leaf models, but none quite match.

So Margareta Tengberg, of the René Ginouvès Institute for Archaeology and Anthropology in Nanterre, France, and two colleagues searched farther afield, and now propose a new botanical prototype: the sissoo tree—also known as shisham or Indian rosewood. The team points out

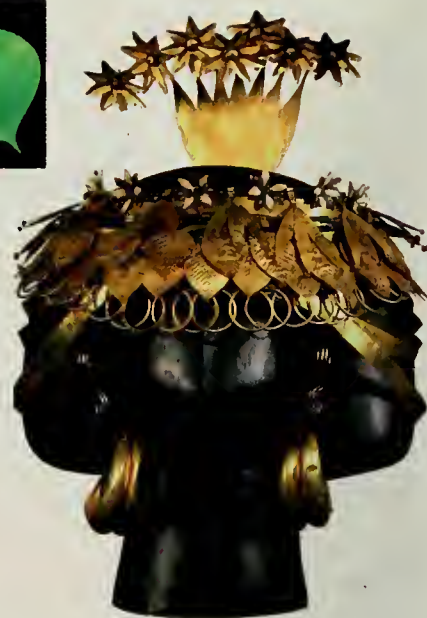
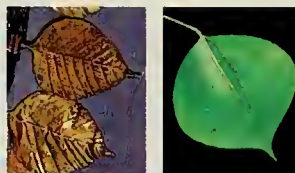
that sissoo leaves, with their pointy ends, smooth edges, and straight veins, are dead ringers for the golden burial ornaments.

Then as now, wild sissoo trees grew from eastern Iran to the Indus Valley, at least 800 miles away from Ur. Yet the tree could well have been an object of trade; beautiful handles and boxes crafted from its hard, dark wood have turned up elsewhere in the Middle East, and its oil has medicinal properties.

Still, why model funeral ornaments on sissoo leaves? Association with an imported luxury is one possibility, but the team thinks symbolism the likeliest explanation. The sissoo grows only near water and may have signified life eternal to people inhabiting a dry land.

(Antiquity)

—Stéphan Reeb



Pu-Abi's headdress, above; gold necklace (detail), top left; sissoo-tree leaf, top right

DNA Hopscotch

Genes are normally inherited from parents, but they can also be inserted into a genome by viruses, plasmids, and other foreign agents—a phenomenon called horizontal transfer. Bacteria are promiscuous gene swappers, but horizontal transfer has been documented in only a few multicellular organisms: a handful of plants, insects, and fishes. That short list just grew notably longer, thanks to a study by geneticists at the University of Texas at Arlington.

John K. Pace II, his graduate advisor Cédric Feschotte, and two colleagues were studying the genome of the bush baby, a nocturnal African primate, when they discovered a group of trans-

posons—long DNA strands that can move around and copy themselves within the genome. Surveying GenBank, a database of gene sequences, the team was surprised to uncover the same transposons in other vertebrate genomes: tenrec (a hedgehog), little brown bat, mouse, rat, opossum, green anole lizard, and African clawed frog all had them. But the other twenty-seven vertebrate genomes in the database did not.

Only horizontal transfer could explain how a small group of distantly related species came to share the same transposons. Originally, the transposons may have jumped from a parasitic or prey species independently to each of the eight vertebrates, perhaps carried by an infectious virus. Or they may have jumped to one vertebrate and from there to the others. In any case, the transfers didn't happen yesterday. The amount of genetic variation between the transposons indicates that they jumped between 15 million and 46 million years ago. (PNAS)

—S.R.

In or Out?

Newly discovered fossils from New Mexico and China are providing contradictory clues to the origin of the turtle's shell. Two hypotheses have long competed as the evolutionary explanation. One proposes that ancestral turtles grew bony plates on their skin that eventually fused with one another and with underlying ribs. The other holds that the ribs expanded and became embedded in the skin, which ossified to form the shell.

Walter G. Joyce, now at the University of Tübingen in Germany, and four colleagues report that the shell of the New Mexican fossil—about 210 million years old—is very thin and doesn't quite connect to the ribs. Bony spines on the neck show that ancient turtles' skin could readily ossify. Points go to the “from the skin in” hypothesis.

Chun Li, of the Chinese Academy of Sciences in Beijing, and four colleagues describe three Chinese fossils. At 220 million years old, the fossils represent the most primitive turtle species known. The species has a plastron—the ventral part of the shell—but, intriguingly, only a poorly developed carapace—the dorsal part. The dorsal ribs are markedly expanded, scoring points for the “from the ribs out” scenario.

To confound matters even more, the Chinese turtle was aquatic, the American turtle terrestrial. Perhaps the turtle shell evolved in one environment and adapted to suit the other. For now, it seems, the shell hides its origins just as well as it does its owner. (Proceedings of the Royal Society B, Nature)

—S.R.

Ancient turtles from China (artist's rendering)



Monodelphis domestica, a Brazilian opossum with some unusual DNA

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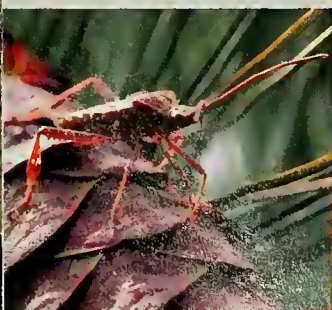
The western conifer-seed bug, *Leptoglossus occidentalis*, has a peculiar world view. Objects stand out against the background as a result not of their color, but of their temperature—and the infrared radiation that comes with it. Trees, warmed by their active metabolism, appear as if on fire, and their even warmer reproductive organs—in conifers, the cones—seem to glow like embers. The bugs navigate this thermoscape using infrared receptors to locate the precious seed-bearing cones they feed on.

Stephen Takács of Simon Fraser University in Burnaby, British Columbia, and several colleagues discovered the novel system after noticing that conifer-seed bugs are often attracted to warm objects in people's homes.

To find out more, the team first measured the temperature and radiation of different pine-tree parts. Cones were as many as 27 Fahrenheit degrees warmer than needles and emitted proportionally stronger infrared radiation. Then, they tested the ability of conifer-seed bugs to perceive the radiation. Placed in cooled experimental boxes, the insects were offered the choice of a strong or weak infrared source. Insects overwhelmingly chose the strong radiation. Electron micrographs of the insects' abdomens revealed eight bristly organs that, when irradiated, responded with frantic electrical activity. Moreover, when the presumed receptors were covered, the bugs lost their infrared "vision."

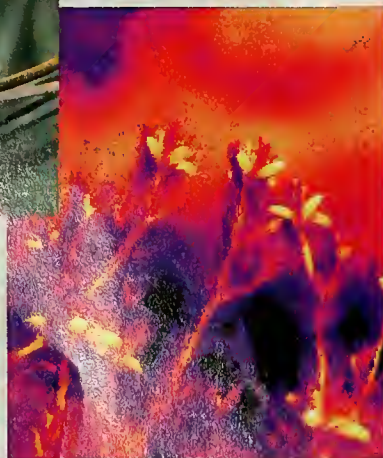
Takács and his team suspect that many other insect species can sense infrared, and that some plants use the radiation to advertise to pollinators. (*Proceedings of the Royal Society B*)

—Graciela Flores



Western conifer-seed bug

Thermograph shows that pine cones are warmer and emit more infrared radiation than needles.



BOTH IMAGES: STEPHEN TAKÁCS

Queen of Her Castle

In fiddler-crab architecture, chimneys—cylindrical mud walls the crabs build around their burrow entrance—have various functions. Depending on the crab species, they hide the hideout from wandering males looking for lodging, shield mating males from rivals, or regulate the burrow's temperature and humidity. News from Australia now suggests that the fiddler crab *Uca capricornis* uses chimneys to conceal its burrow from intruders, and that females do more building than males.

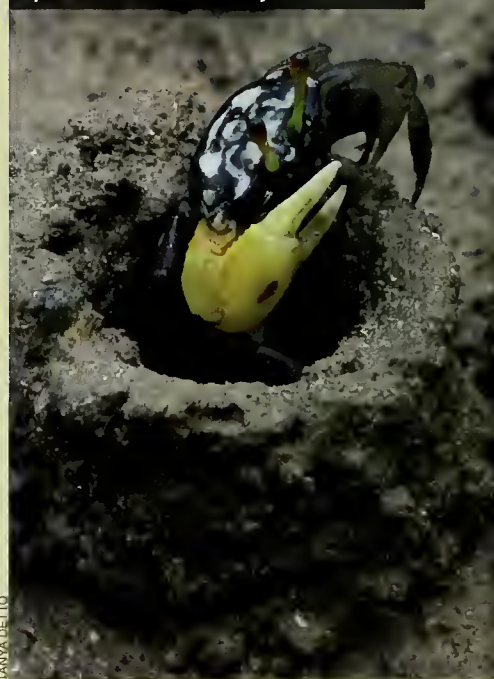
Ecologist Patricia R.Y. Backwell and her team at the Australian National University in Canberra observed the behavior of *U. capricornis* chimney builders and nonbuilders, males and females, and individuals of various ages. To test chimney function, they released a crab near burrows with or without chimneys. Most intruders could not find concealed burrows, and even when they did, it took much longer than finding exposed ones. The chimneys effectively kept would-be usurpers out.

As for the gender bias, females lack the enlarged claw—the "fiddle"—that males possess, and so they are ill-equipped to defend their territory directly. They are efficient feeders, however: their two small claws can alternate to deliver food to the mouth almost continuously. Thus well-fed females can afford

to spend time and energy on construction projects. As it turns out, females build more chimneys than males because they have to, and because they can. (*Biology Letters*)

—G.F.

Male fiddler crab, *Uca capricornis*, perches on his chimney.



TANYA BETTO

Onboard Computer

Two chemists at the California Institute of Technology have engineered a cellular "computer" within the genetic material of living yeast cells. The cells can signal the presence or absence of two drugs in their environment—theophylline, a former asthma treatment, and tetracycline, an antibiotic—by activating a gene that makes a fluorescent protein.

The cell engineers, Maung Nyan Win and Christina D. Smolke, have programmed several simple logical operations. A cell can signal when both drugs are present (AND, in the parlance of computer programmers), when either one or the other is present (OR), when neither is present (NOR), or when one particular drug is present but the other absent (NAND).

To build their biocomputer, Win and Smolke inserted three kinds of RNA into yeast cells: aptamers, which bind to specific molecules; enzymes called ribozymes; and "transmitter" sequences that let the aptamers turn the ribozymes on or off. They deployed a small set of aptamers, ribozymes, and transmitters, in various combinations, to program the logical operations. The foreign RNA worked independently of the cells' own machinery without hampering its normal function.

Win and Smolke's feat is a step toward the development of programmable cellular tools that could one day help detect cancer, selectively deliver drugs to sick organs, degrade specific pollutants, enhance food production, and more. (*Science*)

—S.R.

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SAMPLINGS

Rocky Road

Diamonds may be forever, but that's not true of most minerals. In fact, about two-thirds of the 4,300 known minerals on Earth today owe their existence to biological processes, and thus evolved fairly recently in geological terms. So says Robert M. Hazen of the Carnegie Institution in Washington, D.C., who with seven colleagues identified three phases of mineral evolution.

The first phase began more than 4.55 billion years ago, as the solar system started developing. Chemical elements came together, forming about 250 simple minerals that in turn coalesced into planets. On Earth, the second phase stretched from 4.55 billion to 2.5 billion years ago, starting with the violent collision that formed the Moon. Earth's temperature and pressure varied wildly; plate tectonics began churning the planet's surface; and volatiles appeared, such as water and

carbon dioxide, helping to redistribute the elements. Those changes enabled the evolution of some 1,250 new minerals.

Finally, during the past 2.5 billion years, biological processes—particularly photosynthesis—have profoundly affected mineral composition by oxygenating the atmosphere and thus promoting oxidation of ores. Malachite, turquoise, and nearly 3,000 other minerals could occur only on a living planet, Hazen says.

Minerals do not undergo such Darwinian processes as natural selection or competition for niches. Still, Hazen notes, mineral evolution is more than simple change over time. The diverse and complex mineral assemblages on Earth today result from a sequence of irreversible physical and biological processes, starting with those simple pre-solar accretions.

(*American Mineralogist*)

—Harvey Leifert

Turquoise could not exist on a lifeless planet.



Female warthog and young take shelter in a burrow.

Hog Haven

Think "burrow dweller," and the animal that springs to mind might be a gopher, maybe an owl—but certainly not a pig. Yet each night African warthogs hunker down inside burrows, usually choosing the abandoned digs of an aardvark. They back down into a tunnel that leads to a circular chamber, point their formidable tusks toward the entrance, and settle in to enjoy some hakuna matata time.

Sometimes several adolescents or adult females even share the same den, with females caring for any dependent young cooperatively. That's unusual behavior for an ungulate, and it doesn't appear to improve piglet survival. Could it be that a scarcity of real estate dictates the curious domestic arrangements?

No, say Angela M. White, of the University of Nevada, Reno, and Elissa Z. Cameron, of the University of Pretoria in South Africa. Their recent survey of a South African game reserve, home to more than 3,500 warthogs, indicates that at least half the burrows are unoccupied on any given night. Moreover, there was no correlation between the percentage of mothers bunking up together and the percentage of burrows occupied—not what you'd expect if dens were scarce.

White and Cameron think the communal denning and piglet rearing may help warthogs forge alliances and find safety in numbers against the many predators that enjoy ham dinners.

(*Animal Behaviour*)

—S.R.

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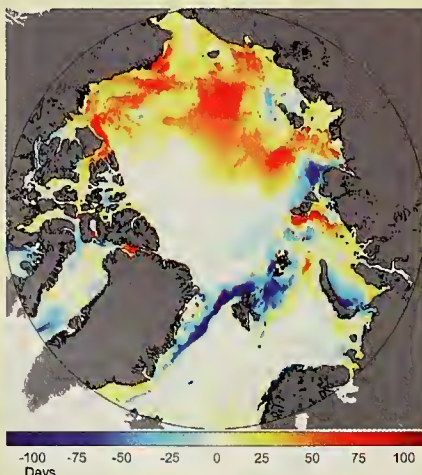


THE WARMING EARTH

Let There Be Light

In thirty years of satellite surveillance, never has there been so little ice covering the Arctic Ocean as in the summer of 2007. (And 2008 was a close second.) Images show a 39 percent loss compared with the 1979–2000 average, a dramatic extension of a trend that started in the early 1970s. The sea ice will almost certainly continue to decrease, exacerbating changes already affecting the region's food chain—from the bottom up and from the top down.

Comparing satellite images of Arctic sea ice with both satellite and field data on chlorophyll concentrations, Kevin R. Arrigo and two colleagues at Stanford University calculated that phytoplankton production in 2007



Warm colors on a map of the Arctic show areas where the 2007 phytoplankton growing season exceeded that of 2006—by as many as a hundred days.

was 23 percent higher than the 1998–2002 average. All that missing ice let more light stream into the water, boosting photosynthesis; the phytoplankton colonized a greater area and benefited from a longer growing season than ever before.

Less sea ice and more phytoplankton in coming years will probably mean farewell to polar bears and ringed seals, which depend on the ice, and hello to zooplankton and fishes, which feed directly or indirectly on the microscopic plants. Arrigo extends a guarded welcome to the surging phytoplankton, which will absorb extra carbon dioxide—though the effect on global warming may be largely offset by the loss of reflective ice. (*Geophysical Research Letters*)

—S.R.

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Learning Lizards

Text and Photographs by Arnold B. Grobman

Several years after my retirement from the University of Missouri—St. Louis, my wife, Hulda, and I settled on Virgin Gorda in the British Virgin Islands. As a biologist, I developed an interest in the native fauna. In particular, I enjoyed the nearly ubiquitous lizard populations and decided to spend some time writing an educational pamphlet about them.

Although acquainted with the scientific names, I did not know what the locals called their eight native lizard species. To find out, I began to visit the Blue Haven at lunchtime—a tavern where a group of working men gathered to have a few beers, shoot pool, and eat. One was an electrician, one a plumber, one a fisherman; the professions of the others I did not happen to learn.

Several weeks later, I casually brought along a selection of my lizard photographs to the Blue Haven. “That’s a cotton ginner,” said one of the men, when shown the first photo. The others agreed. The next picture was unanimously deemed a “man” lizard. They concurred among themselves on the names for eight kinds of lizards. I thought that was remarkable. These men, whose occupations did not provide opportunities for spending time in

the fields or woods of Virgin Gorda, were nearly correct in identifying the eight lizards of the island. (They lumped two species that look almost identical under one name, whereas they bestowed two names on another species that is sexually dimorphic.)

Mission accomplished, I wrote the pamphlet, printed 4,000 copies at fifty-two cents apiece, and sold them at gift shops for fifty cents. I also donated about 350 copies to local schools. Later I asked a teacher whether the youngsters were making any use of them.

“Oh yes,” she replied. “At recess they used to try to step on the lizards. It was rather a game. Now they run out to the yard, and I hear shouts, ‘That’s a doctor lizard.’ ‘No,’ that’s a man lizard.’ ‘On that tree, there’s a yellow-sided lizard.’ They no longer try to step on the lizards. Any attempt to do so is frowned on by other classmates.”

Friends of mine at the St. Louis Zoo, who knew of my newfound interest, wanted some live specimens of the *Sphaerodactylus parthenopion* lizard, which is reputed to be the smallest lizard in the world. The curators were anxious to see if they could successfully breed the creatures in their laboratory. So I set



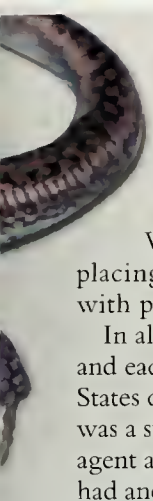
Ground lizard
(*Ameiva exsul*)



Doctor lizard
(*Anolis stratulus*)



Man lizard (*Anolis cristatellus*)



out to transport that species and several others from Virgin Gorda to Missouri, by placing them in mayonnaise jars with perforated lids.

In all I made four trips to the zoo, and each encounter with United States customs at the San Juan airport was a surprise. The first time, the agent asked what kinds of lizards I had and if I had permission to export them. I handed him a letter from the British Virgin Islands minister of agriculture and a list of the species. He asked me if I had any *Varanus* lizards. (He could have determined that I hadn't by looking at the list or inspecting my jars of lizards.) I responded by gently advising him that *Varanus* does not occur in Virgin Gorda and, in fact, does not occur in the Western Hemisphere. With that, I cleared customs with my lizards.

On my second trip the customs agent was a burly fellow. "You call

those lizards," he shouted derisively, when I showed him my jars. "In Puerto Rico we have them this big!" He extended his forearm to indicate the distance between his fingertips and his elbow. "Go on," he said.

The agent on my third trip was a young woman. "I have some live lizards to declare," I said and started to open my briefcase. "Oh," she protested, "don't show them to me. I hate those things." And I was whisked through customs.

On my fourth trip, my agent was a likeable man whose first language obviously was not English. He looked at the jars containing the small lizards and asked, "Is insecta?"

"No," I replied, "animalia."

"Okay," he said and I cleared customs.

I found those incidents amusing, but also troubling. One of the responsibilities of U.S. customs agents

is to prevent the entrance of noxious animals into the country. None of the four I encountered knew whether the animals I was transporting were harmful or whether I intended to release them in southern Florida, where they could thrive. Indeed, those agents seemed less interested in learning about lizards than my drinking buddies and the Virgin Gorda schoolchildren.

ARNOLD B. GROBMAN, a biologist and educator, was born in Newark, New Jersey, in 1918. He received his Ph.D. from the University of Rochester, and later served on the faculty there. He has also worked at the University of Florida, Rutgers University, the University of Illinois at Chicago, and the University of Missouri—St. Louis.



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Seeing Corals with



The sweetest words to a scientist, to paraphrase Isaac Asimov, may be not "Eureka! I've found it!" but "Hmm . . . that's funny. What's *that* doing there?" A historian of science often has the same experience: a bit of data pops up that just doesn't seem to fit in with the rest. Yet, if greeted with curiosity and openness, the anomaly can lead to an unanticipated treasure. I experienced such a serendipitous moment on October 3, 2006, in a small museum storage building in the English countryside. It wasn't as dramatic as detecting an unaccounted wobble in a planetary orbit, or a *Staphylococcus*-free zone around a growth of *Penicillium* mold. But a seemingly out-of-place painting in the archive of the Bromley Museum, near Charles Darwin's home in Kent, set off an unexpected cascade of insights into Darwin's life and thought.

The Bromley Museum (located in Orpington, in the London borough of Bromley) houses an important collection of local history in a medieval stone hall called the Priory. I had learned that among its treasures is a trove of about twenty paintings of prehistoric scenes produced by an artist collaborating with a scientist, possibly the very first examples of the genre now called "paleoart." They were created in 1871—the same year that Darwin published *The Descent of Man*—when the idea of the great antiquity

of humankind was still new and startling. The artist, Ernest Griset, whose drawings often appeared in *Punch* magazine, worked with pioneer prehistorian and polymath John Lubbock, Darwin's protégé and only student. The scion of a banking family, Lubbock had commissioned the series of paintings.

When I visited the Priory, Adrian Green, the curator at the time, invited me to the small storehouse behind the museum, where he showed me the dramatic Griset watercolors. Spear-toting hunters chased bison or surrounded a woolly mammoth in some of the images, while other paintings depicted tribal life in the Paleolithic and Neolithic. (Lubbock had coined both terms in his 1865 book, *Pre-historic Times*.) Such imaginary reconstructions may seem commonplace today, but they were a bold departure from primal scenes based on stories of the Bible. It was a pleasure to view them, knowing they had been locked away for many years and had never even been published.

My heart truly raced, though, when Green pulled out a triptych of a tropical coral island encircling a blue lagoon, fringed with palm trees and white sand. "This one is signed and dated 1871 by the same artist, Ernest Griset," he said. "But we don't have any idea what it is, or why it is archived here with Lubbock's prehistory collection."

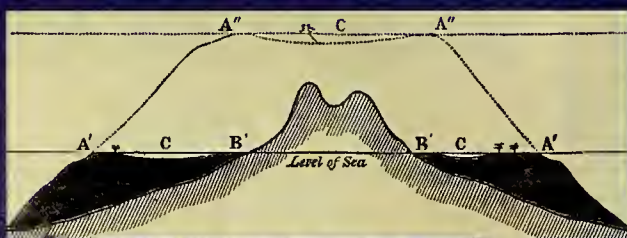


Diagram from *Voyage of the Beagle* (1839), in which Darwin proposed that coral deposits build up on the sides of sinking volcanic cones, forming a characteristic circular structure where they meet above the summit.

the Eye of Reason

A rediscovered painting celebrates Charles Darwin's view of life

BY RICHARD MILNER

Micronesian atoll, encircling a lagoon, in the South Pacific

I instantly had a hunch, however, strengthened when a tiny detail caught my eye—a sailing ship near the horizon of the painting's central panel. Darwin loved coral lagoon islands and theorized about their origins. His first scientific book, which he published in 1842, was *The Structure and Distribution of Coral Reefs*. In it he described three types of coral reefs: *barrier reefs*, which rise like walls out of the sea, separated from land by a channel; *fringing reefs*, which stretch along a shoreline; and *atolls*, which are circular islands that enclose a lagoon, like the one in Griset's painting. Could this be a long-lost representation of one of Darwin's atolls, commissioned by Lubbock as a surprise for the 62-year-old naturalist—complete with the ship of his youth, HMS *Beagle*?

Long before Darwin became interested in coral reefs and atolls, sailors and explorers had wondered how they originated. Some had suggested that fish—working together by the thousands—had built the structures by carrying grains of sand in their mouths. Others realized that the reefs had been built by billions of tiny soft-bodied polyps (Darwin called them “coral insects”) that secreted chambers of calcium carbonate around themselves. But why were such huge forms created, and how did atolls take on their circular shapes? Some naturalists considered coral reefs to be communal homes, like wasp nests or beehives, only on a much grander

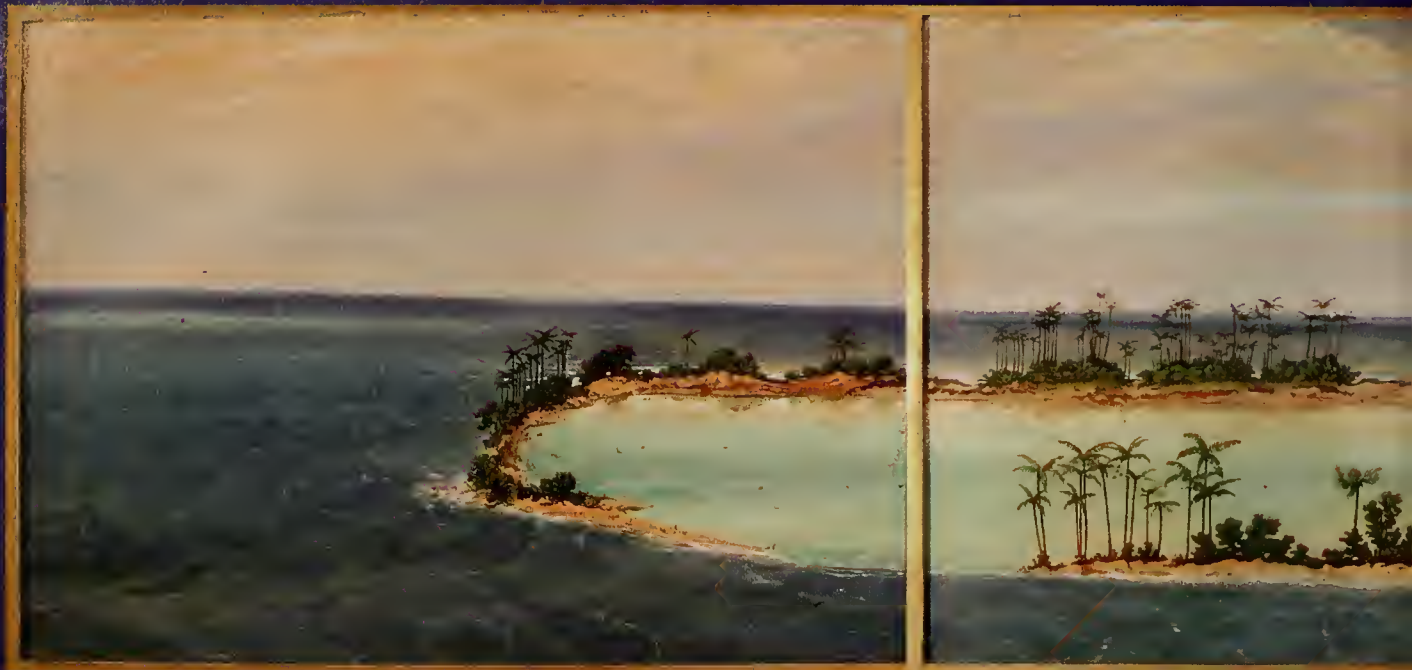
scale. No one yet had any idea of how deeply reefs were anchored in the sea, or how long it might have taken to produce one.

The young Darwin who embarked on the world-changing voyage of the *Beagle* may have been predisposed to a fascination with coral reefs thanks to his grandfather Erasmus. A physician, philosopher, botanist, inventor, and poet, Erasmus Darwin was the first naturalist in Europe to publish a coherent theory of evolution, anticipating many of Charles's ideas by seventy years—and he did much of it in verse! (His book-length poem *The Temple of Nature*, for example, includes *Islands and Continents raised by Earthquakes*.) The Darwin family's ancestral coat of arms consisted of three scallop shells in a row. To that escutcheon, Erasmus flamboyantly added the motto *E conchis omnia* (“everything from shells”). In 1770 he had it painted on his carriage, but later removed it when the local cleric's accusations of blasphemy threatened his medical practice. It had been the eighteenth-century equivalent of displaying a Darwin Fish bumper sticker on a Kansas ambulance.

While the *Beagle* visited the Chilean coast in January 1835, Darwin witnessed a volcanic eruption, and he got caught in a major earthquake onshore in February. He immediately



Detail of the ship in Ernest Griset's watercolor shows a striking resemblance to HMS *Beagle*.



Ernest Griset's 1871 triptych of an atoll. The long-forgotten watercolor was discovered by the author in a British museum storeroom among a cache of paintings commissioned by John Lubbock. It may have been timed to celebrate Darwin's revised and updated 1874 reissue of his 1842 treatise on coral reefs.

began to realize that the surrounding land exemplified the doctrine set out by geologist Charles Lyell in his *Principles of Geology*: that given enough time, the natural, observable forces at work today were sufficient to explain the formation of major geological features without the need to invoke supernatural catastrophes. Exploring inland, Darwin and Captain Robert Fitz-Roy found mussel beds rotting ten feet above the waterline, indicating recent uplift. That made Darwin think of marine shells he'd seen near Valparaíso, fully 1,300 feet above sea level. He concluded that "successive small uprisings, such as that which accompanied or caused the earthquake" were lifting up the land, as were oceanic volcanoes—which he observed in the Galápagos, also in 1835. In an 1844 letter, Darwin recalled that even "when seeing a thing never seen by Lyell, one yet saw it partially through his eyes."

And so, too, Darwin was able to theorize on things he hadn't yet seen, say coral reefs. Uplift in land areas, he reasoned, ought to be counterbalanced by oceanic subsidence. Such subsidence could explain reefs and atolls, and in turn, those structures would provide persuasive evidence that large areas of ocean floor were in fact subsiding. Darwin knew that live reef-building corals grow only in fairly shallow water, though he did not yet know why. His brilliant insight was to realize that coral animals would keep building on top of older skeletons to stay within their zone of life as their foundation slowly sank. He wrote, "We must look at a Lagoon Island as a monument raised by myriads of tiny architects, to

mark the spot where a former land lies buried in the depths of the ocean."

From April 1 through 12, 1836, Darwin and Fitz-Roy explored the Coros, or Keeling, Islands in the northeast Indian Ocean. That marked the first (and perhaps only) time Darwin actually set foot on a coral island [see *Darwin's diary entry on the opposite page*]. Investigating both the ocean and lagoon sides of the South Keeling atoll, Darwin expressed awe that the tiny creatures could create such "monuments":

The naturalist will feel this astonishment more deeply after having examined the soft and almost gelatinous bodies of these apparently insignificant creatures, and when he knows that the solid reef increases only on the outer edge, which day and night is lashed by the breakers of an ocean never at rest.

He was further amazed to find that delicate, branching species thrived only in the calm, clear waters of the lagoon, while much harder, boulder-like brain corals (genus *Porites*) inhabited the edges, where they withstood the violent poundings of the crashing waves.

Historian of science Randal Keynes—Darwin's great-great-grandson—wrote me that he rates Darwin's account of his time on the Keeling Islands as one of the key passages in the whole *Journal of Researches* (1839), later retitled *Voyage of the Beagle*. "What makes the importance of the view for him particularly clear is the language of his account of it in his diary entry for 6 April 1836," writes Keynes, highlighting Darwin's use of the words "simplicity" and "grandeur" in his description:

[T]here is to my mind a considerable degree of grandeur in the view of the outer shores of these Lagoon



A DIARY OF THE "BEAGLE" SPECIMEN MUSEUM, FEBRUARY 1836, THE LUTHERAN FAMILY

Islands. There is a simplicity in the barrier-like beach, the margin of green bushes & tall *Coccoloba* nuts, the solid flat of Coral rock, strewn with occasional great fragments, & the line of furious breakers all rounding away towards either hand.

Sandra Herbert, in *Charles Darwin, Geologist* (Cornell University Press, 2005), also calls attention to the fact that he used those "two of his favorite words" to describe atolls, words found in the famous last sentence of *On the Origin of Species*:

There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.

Darwin's delight in and admiration of the Keeling atolls spurred him to complete his theory of coral reef formation, which he had conceived in the earthquakes of Chile and developed further after seeing the spectacular, reef-ringed volcanic island of Moorea (then called Eimeo), near Tahiti, in November 1835. (Now part of French Polynesia, mysterious-looking Moorea was the model for the island of Bali Ha'i in the Rodgers and Hammerstein musical *South Pacific*—though not in James Michener's novel *Tales of the South Pacific*, on which the musical was based.) Although the *Beagle* did not land on Moorea, Darwin got a very good view of it by climbing more than two thousand feet up a Tahitian mountain. The island's skyline of jagged volcanic peaks rose abruptly from the mirror-still lagoon sheltered by its barrier reef. Darwin was struck by the evidence that vast areas of the ocean floor—not just

BEAGLE DIARY ----- APRIL 1, 1836

On entering the Lagoon the scene is very curious & rather pretty . . . The shoal, clear & still water of the lagoon, resting in its greater part on white sand, is when illuminated by a vertical sun of a most vivid green. This brilliant expanse, which is several miles wide, is on all sides divided . . . from the dark

heaving water of the ocean by a line of breakers . . . [As] a white cloud affords a pleasing contrast so in the lagoon dark bands of living Coral are seen through the emerald green water . . . [T]he beach of glittering white Calcareous sand, forms the border to these fairy spots.— C. Darwin

larger landmasses—were seething with activity, both seismic and animal. In *Voyage of the Beagle* he wrote:

We feel surprise when travelers tell us of the vast dimensions of the Pyramids and other great ruins, but how utterly insignificant are the greatest of these, when compared to these mountains of stone accumulated by the agency of various minute and tender animals! This is a wonder which does not at first strike the eye of the body, but, after reflection, the eye of reason.

Upon his return to England in the fall of 1836, Darwin couldn't wait to explain his theory of coral reefs to Lyell. Less than a month after the *Beagle* docked, the two men met for the first time. As Darwin related it to a friend, Lyell "was so overcome with delight that he danced about." Lyell soon wrote to Darwin, "I could think of nothing for days after your lesson on coral reefs, but of the tops of submerged continents. It is all true, but do not flatter yourself that you will be believed, till you are growing bald, like me, with hard work & vexation at the incredulity in the world."

Lyell reveled in Darwin's theory even though it differed from his. As coral expert and historian of science David R. Stoddart at the University of Cali-

fornia, Berkeley, explains, to account for the circular form of atolls. "Lyell had suggested that the corals colonized the rims of slightly submerged volcanic craters. Darwin on the other hand proposed a sequential transformation of fringing reefs into barrier reefs and then into atolls as the corals continued to grow upwards through repeated slight movements of subsidence of the usually volcanic reef foundations."

Throughout the nineteenth century—and after Darwin's death in 1882—Darwin's theory of reef formation remained contentious. Alexander Agassiz, son of the anti-evolutionist Harvard zoologist Louis Agassiz, spent forty years and his considerable fortune visiting hundreds of the world's reefs, but died before he could write a contradictory theory. For some decades, around the turn of the century, Darwin's coral reef theory, like his evolution theory, fell out of favor with scientists, but eventually both returned with renewed vigor. The saga of the controversies that surged around the coral theory has been beautifully told in

Reef Madness: Charles Darwin, Alexander Agassiz, and the Meaning of Coral (Pantheon, 2005) by David Dobbs.

Agassiz and others thought they had found reefs forming in areas where the seafloor was lifting rather than sinking. Some geologists even blasted Darwin's method of doing science: rather than seeking patterns of coral reef distribution on charts and maps, they argued, he needed to visit more reefs firsthand, as they had done. However, Darwin thought that more visits to reefs were pointless unless "some doubly rich millionaire" could be induced to make deep core drillings that would reveal their structure.

Not until 1950—while attempting to destroy Eniwetok, an atoll in the Marshall Islands, near the equator in the Pacific Ocean—did science find definitive answers. Preparatory to testing a hydrogen bomb there, the U.S. Government sent geophysicists to drill test cores of the coral deeper than anyone had previously done. Dobbs relates that finally, at 4,200 feet, the drills hit "a greenish basalt, the volcanic mountain on which the reef had originated."

A BRIEF HISTORY OF REEF SCIENCE

BY JENNIFER A. LANE

Coral reefs are among the most intricate and diverse ecosystems on Earth, yet people long considered them mainly as sources of food and dangers to navigation. Scientific understanding of corals dates back less than 300 years, to 1727. That's when the French naturalist Jean André Peyssonnel identified corals as animals. Scholars, who at the time presumed they were plants, or perhaps rocks, laughed Peyssonnel out of the French Academy of Sciences. Subsequent research proved Peyssonnel correct, launching an effort to catalog the world's coral species.

Among the first to be described scientifically were specimens collected in the South Pacific during the first voyage of Captain James Cook, between 1768 and 1771. The next major advance in understanding came in 1842, when Charles Darwin explained coral-reef formation. Post-Darwinian discoveries have involved nearly every area of science, from geology and zoology to human medicine. Taxonomic studies have identified some 850 extant reef-building coral species, as well as tens of thousands of reef-dwelling organisms, and ecological research has illuminated the complex interrelationships among them.

An important landmark in reef biology was the 1931 finding by the British scientist Charles M. Yonge that single-celled photo-

synthetic algae called zooxanthellae, which inhabit the digestive cells of reef-building corals, are symbionts. The oxygen and nutrients they produce speed their hosts' growth, letting the uppermost portion of the reef remain near the life-giving light and warmth of the ocean surface, even as the seafloor subsides. The energy captured photosynthetically also helps make reefs unusually productive and diverse, comparable to tropical rainforests.

Examination of fossil reefs has revealed their long evolutionary history. In 1924, the paleontologist Percy E. Raymond described the Chazy Reef formation of Isle La Motte, Vermont, as "the oldest coral reef in the world." At approximately 450 million years old, Chazy is the earliest known reef in which primitive corals began to play a small structural role. The first modern stony corals appeared more than 200 million years later.

We now know that reefs existed long before the first corals evolved. Microscopic algae built the earliest reefs—leathery algal mats interleaved with sediment, called stromatolites—at least 2 billion years ago, before multicellular lifeforms had evolved, and possibly much earlier. Later, the spongelike archaeocyathids, now extinct, became the first animals to build reefs. Bryozoans, tiny colonial animals that secrete a hard calcareous skeleton much like that of modern corals,

briefly dominated reef building until they were replaced by primitive corals, according to Roger J. Cuffey, a geologist at Pennsylvania State University in University Park.

Many reef studies have had even broader scientific implications. In 1963, the late Cornell University geologist John W. Wells used the finding that corals grow faster during the day than at night to show that Earth's rotation has been slowing, because of friction induced by the tides, by about two seconds per 100,000 years. From the rhythm of daily growth evident in fossil coral, Wells calculated that during the Devonian period (between 417 million and 354 million years ago), a year had approximately 400 twenty-one-hour days.

In recent decades, reef ecosystems have become the source of important new treatments for various human maladies: the chemotherapy drug Ara-C and the anti-viral drugs AZT and Acyclovir derive from compounds isolated from a Caribbean sponge, for example. Scientists continue exploring the biology of coral reefs, focusing not only on benefits to people, but on preserving reefs from the substantial threats they face.

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Dating of the tiny fossils in the bottommost layer of coral showed that the reef had gotten its start in the Eocene. For more than thirty million years this reef had been growing—an inch every millennium—on a sinking volcano, thickening as the lava beneath it subsided.

Over the next few years, many more drillings and echo soundings confirmed that with rare exceptions, reefs had formed only in areas of seafloor subsidence all over the Pacific and Caribbean. Although Darwin couldn't have

foreseen it, his model fit perfectly with theories of plate tectonics. In David Dobbs's words, "the movement of the earth's huge plates explains the subsidence of the Pacific and many other reef areas. Darwin's theory was astoundingly correct."

And it was as correct biologically as it was geologically. We know now that reef-building corals thrive only where their symbiotic, photosynthetic algae can receive sufficient sunlight to generate nutrients for the polyps (a depth of about eighty feet seems to be optimal). While the ocean floor beneath them keeps sinking, colonies keep reaching upwards to receive sunlight. As they do so, they secrete calcium carbonate, adding their minute contribution on top of the accumulated skeletons of millions of years. [See sidebar on opposite page for more information on corals.]

Truth to tell, not all of this raced through my mind as I beheld Ernest Griset's painting of an atoll. But I was well acquainted with Darwin's theory of coral reefs, and perhaps more important, I knew about his close association with John Lubbock, who commissioned the artwork. Lubbock's father (also named John) was the major landowner in the Kent countryside. The family's huge estate, High Elms, with its twenty-two-room mansion, was about a mile and a half from Down House, Darwin's home. Indeed, Darwin's property was a small island in the holdings of Lubbock.

From the age of eight, the younger John was mentored by Darwin, twenty-five years his senior. As he matured, Lubbock took up many of his teacher's interests, including classification of barnacles, the relationship between insects and flowers, paleontology, and human prehistory. Later an inveterate collector of prehistoric stone tools, ethnographic artifacts, and insect colonies, young Lubbock must have filled his indulgent father's mansion with birds' nests, fossils, and flasks of pond water. So fascinated was the son by



John Lubbock, Darwin's only student, examines a captive colony of ants in 1900.

tales of the South Seas that he built an artificial grotto decorated with corals and shells near the big house.

Darwin frequently walked the footpath between his home and High Elms, where he may have offered advice during the planning of Griset's paintings or viewed and discussed each one as it was completed. However, neither Darwin nor Lubbock ever used them to illustrate their books. And by the mid-twentieth century, the paintings had been removed by the family from High Elms. That

was fortunate, because in August 1967 the great mansion burned down (oddly, on what the grateful British populace had dubbed "St. Lubbock's Day," the secular bank holiday Lubbock instituted). The estate grounds are now a public park and nature reserve.

When Lubbock commissioned the triptych of the coral atoll, Darwin was preparing to reissue a revised and updated edition of *The Structure and Distribution of Coral Reefs*, three decades after its initial publication. It seems plausible that Lubbock planned the painting as a surprise for Darwin, to commemorate that significant milestone. In Griset's brushstrokes, Darwin's tropical atoll appears isolated beneath a vast sky—jewel-like, pristine, and mysterious. The sailing ship is barely sketched in, but it is unmistakably a classic brig-sloop of the Cherokee class [see painting detail on page 19]. It even has a stripe along the hull and gun ports along the side, as the *Beagle* did.

The painting remains sequestered against English winters in the stone-brick storeroom at the Priory. Within its timeless world, the atoll awaits the arrival of the iconic sailing ship on the horizon, bearing a young man who seeks to elucidate its mysteries. While studying corals, he will experience serendipity on a grand scale. By casting his "eye of reason" on natural phenomena that, operating over immense periods of time, create "forms most beautiful and most wonderful," he will change forever our view of life.

Contributing Editor **Richard Milner**, an associate in the Division of Anthropology at the American Museum of Natural History, has performed his one-man musical, *Charles Darwin: Live & In Concert*, worldwide. His new book, *Darwin's Universe: Evolution from A to Z*, will be published this spring by the University of California Press.



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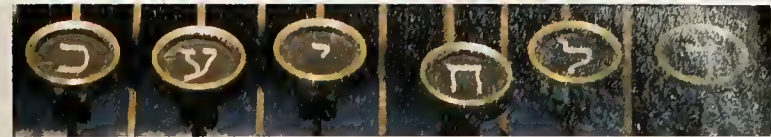
Flowers Have No Names

BY BENJAMIN HARSHAV

The revival of Hebrew as a living language after two thousand years was no miracle.

Above: Discount bookstalls set up in 1926 on Tel Aviv's Rothschild Boulevard initiated a "Hebrew Book Day." The tradition continues, now with Hebrew Book Week held throughout Israel. Right: Hebrew Book Week at the Israel Museum in Jerusalem, 2005.





To forge a national identity in the modern age, a group of people required a common history, with a common mythology and treasure trove of memories, culture, and literature; a traditional territory; and a national language. Some nations acquired power over a territory and established a “nation-state”; smaller nations that lacked political sovereignty, especially within the Russian and Austro-Hungarian Empires, defined themselves by their culture and language. To that end, immense efforts were invested in reviving old, “dead” languages, such as Irish, Welsh, and Breton, but none of them became the base language of a nation. With one exception: Hebrew.

Hebrew was the language of the Bible. It had faded as a spoken language even before the Christian era: in the Hellenistic period, Jews in Palestine spoke Aramaic and the upper classes spoke Greek. Yet the final death knell for spoken Hebrew was the dispersion of Jews after the destruction of the Second Temple in Jerusalem in A.D. 70.

As a small wandering minority in the Diaspora, or lands outside Palestine, the Jews adopted the languages of the local inhabitants, yet they also wrote and read Hebrew and Aramaic. During the Middle Ages, most of them lived in

Christian Europe, but they were gradually expelled from England, France, German cities, Spain, and Portugal. As a result, in the sixteenth century most of world Jewry was concentrated in Poland, which then also included what is now Lithuania, Belarus, and western Ukraine, making it the largest kingdom of Europe.

When Poland was dismantled by its neighbors at the end of the eighteenth century, the Jews went with the territory. Most were absorbed into the Russian Empire, but were kept in the occupied former Polish territories, in a huge geographical ghetto termed the Pale of Settlement. During the eighteenth and nineteenth centuries the Jewish population there grew rapidly, four- or five-fold in the course of eighty years. Christian peasants still made up the bulk of the population in the Pale; they lived in agricultural villages as slaves (“serfs”) who—until their liberation in 1861—could be bought and sold with their villages. Expelled by decree, Jews made up only about 1 percent of the population of the villages, where they managed flour mills and taverns, peddled merchandise and crafts. But Jews constituted a real majority in hundreds of towns, spread like polka dots over a vast territory.

In the nineteenth century, in a typical small town (shtetl), Jews constituted two-thirds of the population, and increasingly in the cities they made up from a third to half the inhabitants. From those more urban settings Jews dominated much of the economy of western Russia. Though devoid of civil rights, such as the right to own land or to hold government jobs, they developed local light industries (paper, wood, even hog bristle for brushes exported to England), artisan crafts, banking, and trade. They had their own educational system, hospitals, philanthropic and professional organizations, literature, publishers, and newspapers. Intellectual life in the Pale was divided between pious Talmudic scholarship and the ferment of the Haskalah, or Jewish Enlightenment—a movement inspired by the broader European Enlightenment—which encouraged Jews to study the secular arts and sciences and drew them toward assimilation into European society.

The Jews had three private languages that separated them from their neighbors, all written in their own Hebrew alphabet: Hebrew, the “Holy Tongue,” the language of the Jewish Bible and of many prayers; the difficult Aramaic, the frame language of the Talmud, the compendium of religious law studied in higher schools (yeshivas); and the European-based Yiddish, used for personal and public communication, even for rabbinical legal proceedings. Among Jews in the Diaspora, neither Hebrew nor Aramaic was instilled as a spoken language. Understanding texts in those tongues required learning, and the language of education was Yiddish, even when the texts being taught were written in Hebrew or Aramaic.

Though venerated, Hebrew was not a living, everyday language, and it might have remained in its restricted



context but for the tensions that beset Jewish society. The shtetl population was exploding, poverty was rampant, and there were waves of pogroms against Jews, especially in 1881–1882 and thereafter. Those factors created enormous pressures, and future-oriented political ideologies swept the young generation, pushing in many different directions. Within this veritable modern Jewish revolution was an outward trend, with millions of Jews emigrating to the United States, western Europe, and elsewhere, assimilating to the dominant cultures, learning the dominant languages, and contributing to general culture and science. And there was an inward mobilization to build a new Jewish nation, largely modeled upon the institutions of European secular culture.

The latter objective could have been brought about in the languages of the countries where Jews lived, but the

Hebrew language was inextricably intertwined with Zionism, the movement to settle modern, forward-looking Jews in “the promised land,” referred to as the Land of Israel (Eretz Israel). The initial goal was the establishment of a Hebrew community with its own culture and educational and political structure. This *yishuv* (settlement) would pave the way for an independent state, the state of Israel. The ideology of the language revival was connected to the ideology of Zionism, though not all Hebrew writers in the Diaspora were Zionists, and many Zionists wrote and read Yiddish.

The prophet of the revival was the Lithuanian Eliezer Ben-Yehuda (1858–1922). An intellectual freethinker and devoted student of Hebrew, he emigrated to Jerusalem in 1881 and devoted his life to promoting Hebrew as a spoken language, coining new words and writing a dictionary listing all the words used in Hebrew literature from ancient to modern times. He was a fanatical pioneer of Hebrew as a “mother tongue” and refused to speak any other language with people who could understand Hebrew. But his determination to speak the new language ran up against severe limitations. The Hebrew writer and prominent literary editor Yosef Klausner, who visited Ben-Yehuda in 1912, reported that Ben-Yehuda communicated with his wife in gestures and signs, for half the time she did not understand the simplest words, and he would not give in and speak Russian or Yiddish. Another story relates that when he wanted his wife to pour him a cup of coffee, he lacked the words for “cup,” “saucer,” “pour,” and “spoon,” so he said, “Take that and do that and bring me that and I’ll drink.” Indeed, it took twenty-five years from Ben-Yehuda’s arrival in Jerusalem until Hebrew became a spoken language, the base language of a small society. But he was the symbol of the revival of Hebrew.

A strong, emotionally charged ideology inspired devotion and sacrifice for the revival of Hebrew. But that was not enough. The language revolution required a unique intersection of three complex historical factors in one generation and in the lives and personal experiences of many individuals. One was the life of the “dead” language in the Diaspora; the second was the impact of European secular culture on the revival of Hebrew literature in the nineteenth and twentieth centuries; and the third was the establishment of new social cells (the communal *kibbutzim*, Hebrew schools, and the first Hebrew city, Tel Aviv) by young people who cut themselves off from the chain of generations.

As a dead language, Hebrew was a metaphor for the “dead” nation, which had lost its independence and honor two thousand years ago. Over the centuries since, the religious world had provided a library of Hebrew texts; vivid meanings of many Hebrew words and phrases, embedded

The Lithuanian Eliezer Ben-Yehuda, who emigrated to Jerusalem in 1881, championed Hebrew as a spoken language, coining new words and compiling a comprehensive Hebrew dictionary (or, as the major Hebrew writers at the time called it, “Ben-Yehuda’s word factory”).

strongest candidates were Yiddish and Hebrew—there was a “war of languages” between those two mediums. And in the whirlwind of political and worldly options, one option was to revive the language of the Bible in the land of the Bible. For that to succeed, Hebrew would have to become the base for the emergence of a new, secular Jewish society and culture, enabling its users to express the totality of twentieth-century experience as well as their own historical context. It would have to be a means to forge a new social identity, irrespective of various countries of origin, languages, and political views.

By the 1880s, thousands of pious Jews already lived in Palestine, having gone there to pray and to die in the Holy Land. But the movement to revive the



JEWISH VIRTUAL LIBRARY

in daily life and spoken language; and the habit of analyzing the meanings of words. Yet Hebrew was perceived as dead because even those who knew the words did not habitually make new sentences or converse in Hebrew. It was no child's "mother tongue," and it covered only a limited range of topics. You could not say such mundane things in Hebrew as "train," "pencil," "teapot," "towel," or "culture."

Through secular Hebrew literature and modern newspapers, writers tried to enlarge the scope of civilization that can be described in Hebrew. Translations were an important tool to enlarge the vocabulary. In 1859 a Hebrew translation of *The Mysteries of Paris* by Eugène Sue appeared in Vilna. In his introduction, the Hebrew poet and grammarian Adam HaCohen Levenson praised the wonderful achievement of the Hebrew translation, for "the splendor of the language is the splendor of her people and in her honor they too will be honored." He wished that the language "might return to her past state and . . . return . . . to speak again of all the works of the Lord and all His creations in heaven and on earth" until "she speaks about every wisdom [that is, discipline] and every science and every art." The legendary Ben-Yehuda was a direct disciple of that dream.

That endeavor opened Hebrew texts to new thematic domains of knowledge and imagination. Writers freely formulated new sentences and new texts in Hebrew and mastered new genres in literature, journalism, and thought. A wealth of international words and terms flooded the Hebrew media and were assimilated into the language. The renaissance of Hebrew literature and journalism meant the extension of a religious language into the secular, representational, political, and aesthetic domains. Speakers only had to compose new, oral sentences to absorb and activate that treasure. A bridge was erected to link European culture to this biblical language, now totally transformed.

But much more was required for Hebrew to become a living language. The American Yiddish poet, linguist, and lexicographer Yehoash (Solomon Blumgarten), already at work on his translation of the whole Bible into Yiddish, came to Palestine in 1913. Walking in the settlement of Ekron, he saw a girl of fifteen or sixteen sitting in the window of her home, above a beautiful flowerbed. He asked



"Keep the gate open, we have no other [gate]": Jewish refugees arrive in Haifa in June of 1946, despite British attempts to restrict immigration under the Mandate for Palestine.

her in Hebrew: "What is the name of these flowers?" To which she replied: "Flowers have no names."

Indeed, to have names for flowers in a living language (rather than in a learned dictionary), you need ideological youth movements and modern schools that admire nature and go on outings in nature; you also need botany textbooks, publishers who publish them, and teachers who teach the subject. You need, then, a society that reads books and a collective effort to coin names for the flora of the land. And you need settlements in nature, money to build them, and armed units to defend them. Words come with matching worlds, and one could not be known without the other. The whole cluster of life of a society requires a language to describe it, and the language needs a world to support it. The whole package sprang up suddenly, carried by idealists who were busy building a nation.

In Hebrew, *aliya* ("ascent") refers to immigration into the Land of Israel, regarded as a return from long exile. The First Aliya was a wave of approximately 30,000 immigrants who arrived between 1881 and 1903. Supported by the French philanthropist and patron of the arts Baron Edmond James de Rothschild (1845–1934), they built the first Zionist settlements in Palestine, at the time a primitive province of the stagnant, harsh, and tyrannical Ottoman Empire. The Second Aliya (1903–1914) came under the impact of renewed pogroms in Russia and the failed Russian Revolution of 1905. About 2.5 million Jews went to the West, especially to the United States, and only 35,000 immigrated into Palestine. And, according to one of them, later the foremost founder of the modern state of Israel, David Ben-Gurion, 90 percent of that number left within one year. Of those that remained, about two hundred workers formed the small, ideologically coherent community in which it was really

possible to implement the Hebrew revival. In that way, it resembled other avant-garde movements of the twentieth century in art and in politics.

It was a determined core community around which the Labor Zionist movement crystallized, leading to the emergence of small, wandering collectives of workers that later became the foundation of the kibbutz movement. Those early groups were made up of idealists; mostly unmarried men, separated from their parents' world in Europe, abandoning the language, stories, and beliefs of their grandparents, half starving, eating the bitter olives, singing and arguing ideology into the night. When they adopted the slogan, "Our world stands on three things: on Hebrew land, on Hebrew work, and on the Hebrew language," the first nucleus of a Hebrew-speaking society was established.

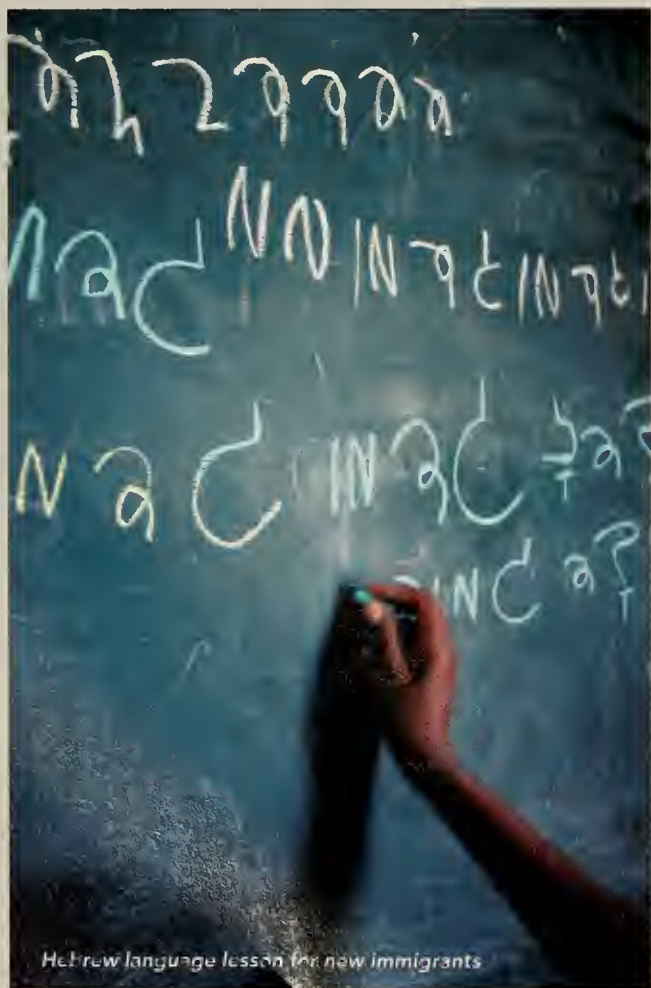
A parallel force was the founding of Tel Aviv in 1909, "the first Jewish city in two thousand years." All government institutions, schools, and banks were, in principle, conducted in Hebrew. In 1905 the first Hebrew high school had been founded in Jaffa; four years later it was moved to Theodore Herzl Street in a Tel Aviv still under

construction, where, as Gimnasia Herzliya, it became the center of the new city and the cradle of the cultural elite. In 1906, the art school Bezalel, and in 1908 the Hebrew Gimnasia, were opened in Jerusalem. Finally, in 1913, a great language strike of teachers and students forced all schools of the German "Ezra" organization, including the *Technion*, the Haifa Technological Institute, to switch to Hebrew. Thus, the educational network was conquered for the new language.

Among the obstacles, however, was that as a written language Hebrew had become one-sided, focused on a limited range of religious topics. Words for everyday things were only incidentally preserved in texts. Through research these were identified and compiled, restoring or adapting vocabulary to modern use. Just finding names for the flowers proved to be no simple task. At first the rose was named *shoshana* as in the Song of Songs. But further research into biblical botany and the language of old texts changed the decision: *vered* became a rose and *shoshana*, a lily! The confusion persists to this day, and people continue to buy a dozen *shoshanim*, as well as *vradin*.

Biblical words and roots had to be adapted to the new world. Thus *hashmal* in modern Hebrew means "electricity." The word—a strange one, with four consonants instead of the regular three—appeared only in one incident in the Bible, in the prophet Ezekiel's "Vision of the Divine Glory." At best, however, the Bible is a limited resource, and various ways of expanding the vocabulary developed. For example, Ben-Yehuda's *sakhrakhok* ("long-distance conversation") was defeated by the irresistible *telefon*, but the verb forms follow Hebrew grammar rules by rearranging the same four consonants (with *f* turned into *p*): *letalpen* ("to call"), *tilpanti* ("I called"), *talpen* ("Call!"). Purists might object, but Hebrew's ability to engulf and transform foreign words was a sign of life.

There was also the question of pronunciation. The people actively reviving Hebrew were Yiddish-speaking Central and Eastern European Jews, otherwise known as Ashkenazim. But they had turned their backs on their parents' shtetl world. For the new spoken Hebrew they looked to the Sephardic dialect, believed to preserve a more authentic, precise rendering of ancient Hebrew. Associated with the glories of Spanish Jewry, it also was more prestigious. (It had the advantages, too, of being more inclusive of non-Ashkenazi Jews and of sidestepping rivalries between various Ashkenazi subdialects.) In fact, neither ultimately prevailed. Israeli Hebrew combines a simplified range of Ashkenazi consonants and Sephardic vowels. And the Sephardic stress on the last syllable, preferred for Hebrew words, is complemented by the Ashkenazi stress on the penultimate syllable for imported words, slang, even names (DAvid and SAra, in contrast to the Sephardic daVID and saRA).



Hebrew language lesson for new immigrants

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Children listen to a story at Kibbutz Yakum ("[It] will arise"), established in 1947 near Netanya.

None of it was easy. As Shlomo Lavi, who came with the Second Aliya and later became one of the founders of the first Kibbutz Ein Harod in 1921, recalled, "It cannot be appreciated how much it costs a man to go from speaking one language to another and especially to a language that is not yet a spoken language. How much breaking of the will it takes. And how many torments of the soul that wants to speak and has something to say—and is mute and stammering." And the spiritual leader of the labor movement, Berl Katznelson, who read a great deal of Hebrew literature, reminisced: "In the first days, I had a hard time with Hebrew. . . . When I came to Eretz-Israel, I couldn't make a natural sentence in Hebrew and I didn't want to talk a foreign language. I decided I wouldn't utter a foreign word. And for ten days, I didn't speak at all; when I was forced to answer—I would reply with some Biblical verse close to the issue." Nevertheless, in a short time he became one of the finest essayists in modern Hebrew.

Rachel Katznelson, a discerning literary critic who was later the editor of the socialist women's monthly *Dvar Ha-Poelet* ("the word of the working woman"), wrote: "I realized the revolutionary nature of Hebrew literature as opposed to Yiddish. . . . We had to betray Yiddish even though we paid for this as for any betrayal. . . . The revolution, the revolt of our generation against itself—we found it in Hebrew literature" ("Language Insomnia," 1918). The impact of Hebrew literature on the pioneers was decisive. During World War I, the Jews of Tel Aviv were expelled by the Turks, most leaving for Egypt, and when they returned they formed the leadership of the new Jewish national entity. One requirement to be a representative in the Elected Assembly was the ability to speak Hebrew.

In 1918, the British army had conquered the land, and in 1922, the League of Nations established the British Mandate for Palestine. Winston Churchill, the British Colonial Secretary at the time, issued the following statement:

During the last two or three generations the Jews have recreated in Palestine a community now numbering 80,000, [that] has its own political organs; an elected assembly for the direction of its domestic concerns; elected councils in the towns; and an organization for the control of its schools. . . . Its business is conducted in Hebrew as a vernacular language, and a Hebrew press serves its needs. . . . This community, then, with its town and country population, its political, religious, and social organizations, its own language, its own customs, its own life, has in fact "national" characteristics.

That was an act of formal acceptance of the scattered Jewish communities in Palestine as a secular nation and Hebrew as its official language.

The enduring paradox of the revival of the Hebrew language lies in the tension between the language of the Bible and the requirements of a modern language for an advanced society, interconnected with the European and American world. The revival started in Hebrew literature of the *Haskalah* (Enlightenment) in the nineteenth century. The writers of the *Haskalah* admired the beautiful Bible above all other historical layers of Hebrew (notably the ugly and "boring" Talmud). But they were no Zionists in the political sense, whereas those who went to live in the land of the Bible in the twentieth century needed to enlarge the language to adapt it to the needs of modern media, literature, and science. A count of words used in an editorial of the prestigious newspaper *HaAretz*, for example, shows that only 5 percent were biblical Hebrew, preserving both the biblical form and meaning. For a national identity in the modern age, you also need the other 95 percent. Against all odds, the revived Hebrew flowered into a rich language and literature that can serve for anything from stream-of-consciousness fiction to nuclear physics, and that is grounded in the spoken language of childhood.

Author of *Language in Time of Revolution*

(University of California Press, 1993),

Benjamin Harshav (formerly Hrushovski) is a professor of Comparative Literature and of Hebrew Language and Literature at Yale University. Born in Vilna (Vilnius) in 1928, he fought in the Israeli War of Independence in 1948. Harshav is a recipient of the EMET (Art, Science, Culture) Prize, the highest Israeli award for lifetime achievement in those fields. He has published widely on literary theory, Hebrew and Yiddish literature, and the work of Marc Chagall.



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REVIEW

Could an Ant Colony Read This Book?

By Robert R. Dunn



In biology one can spend a lifetime studying an obscure sliver of life—be it fish ovaries, flea legs, or the mites that live in the nostrils of birds. It's often that obsessive focus that makes broader truths come clear. Edward O. Wilson and Bert Hölldobler [*above, right and left*] exemplify that peculiar truism. They met in 1969 when Wilson was a forty-year-old professor at Harvard University and Hölldobler, thirty-three, had come from Frankfurt, Germany, to stay a year as a visiting scholar. Wilson was already well known for his studies of chemical communication and biogeography. Hölldobler was just beginning his work as a behavioral ecologist. They did not know it, but they were about to forge an enduring collaboration, “built” (in Wilson’s words) “upon a close friendship and a common lifelong commitment to the study of ants.” Together they would write tens of papers and three books, among them a Pulitzer Prize winner: their epic 700-page treatise, *The Ants* (1990).

That said, the two have led very different lives as scientists. Hölldobler has remained doggedly focused on ants, nearly always experimentally. He has revealed the intricacies of ant communication and how that communication—whether by scent, touch, or sound—underlies cooperative behavior.

Wilson, instead, has used a worldview developed from his study of ants to do foundational and often controversial work in broader areas. He popularized the term *sociobiology* and literally wrote the book on the evolution of human social behavior (two books, in fact: *Sociobiology: The New Synthesis*, 1975, and *On Human Nature*, 1978—the latter also a Pulitzer Prize winner). At the time, the idea that genes controlled our actions sparked outrage. In his 1984 book *Biophilia*, Wilson refined and built on the hypothesis that we humans have an inherent fondness for nature, rooted in our genes. But with advancing age, Wilson too has come back to the ants: he even has a novel forthcoming that features them.

Now Hölldobler and Wilson have

coauthored another major book, *The Superorganism*, which breathes new life into a notion that intrigued scientists before World War I: that a colony of social insects is analogous to an individual. The concept of the superorganism—which compares a colony’s members to a body’s cells and sometimes its nest to the body’s skeleton—fell out of favor as research increasingly focused on the genes of individuals. Hölldobler and Wilson, building on new insights into the evolution and workings of insect societies, seek to bring it back. To them, “superorganism” is more than a metaphor; it is a unit in the hierarchy of biological organization, falling somewhere between an ecosystem and an individual. And, they argue, it is the most useful level of biological organization at which to examine how pieces are assembled to make a whole—be it an association of bacteria, a single creature, or a whole society—as well as to understand what holds all organisms together, even when the pieces struggle toward independent goals.

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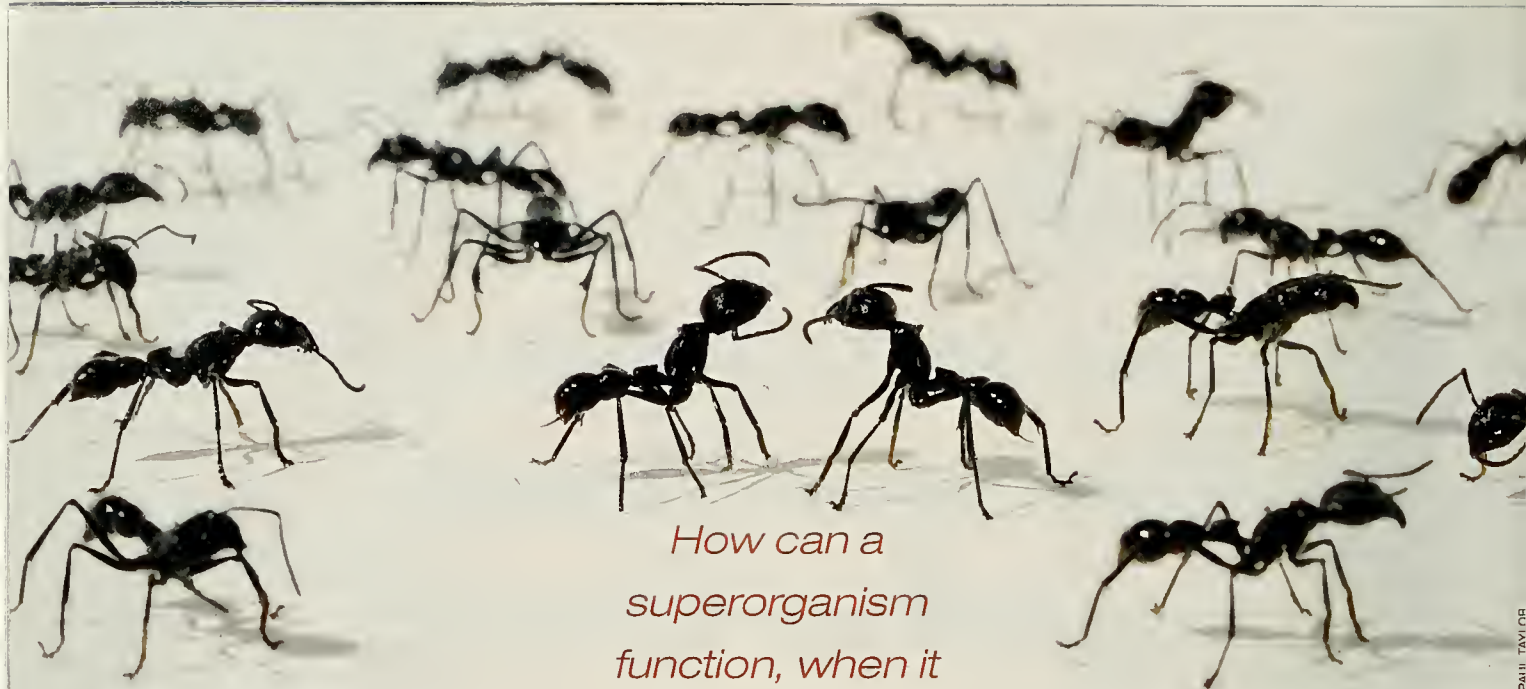
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*How can a
superorganism
function, when it
depends upon
the combined
operation of tiny,
short-lived minds?*

been only a few occasions when separate individuals have come together to cooperate and, in doing so, have become so well integrated that we now recognize them as a single organism. Those include the origin of cells with mitochondria, from an early symbiosis between two different species of bacteria; plant cells, which arose when a eukaryotic cell (a cell with a nucleus) incorporated a photosynthetic bacterium, the grandmama of all chloroplasts; and multicellular creatures in general, which have arisen multiple times. To those, Hölldobler and Wilson would add the more sophisticated colonies of social insects (leaf-cutter ants, some termites, honeybees, and the like).

The authors begin their new book by considering the origins of societies. In doing so they set out to explain why the workers of many species of ants, bees, wasps, and termites give up reproduction, either partially or completely, to work for their overbearing mother. The simplest model of natural selection is that genes are carried by individual organisms, and that heritable genes belonging to the individuals that are more successful at surviving and reproducing will proliferate. But when the costs of going it alone are great and individuals living or working to-

gether are related, a model referred to as “kin selection” comes into play. If success in evolution revolves around passing on your genes, you should be willing to die for, maybe not one, but two brothers, because, on average, each shares half your genes.

That is the traditional view of how sociality has evolved. But both Hölldobler and Wilson argue that group selection (in addition to individual selection) is a crucial component of evolution in insect societies. In group-selection models, evolution favors the groups whose members cooperate more effectively, regardless of whether such cooperation helps a given individual (or that individual’s kin) reproduce. The two colleagues, however, hold somewhat different views.

Hölldobler sees the evolution of insect societies as proceeding along stepping stones. In a paper written jointly with the evolutionary biologist Hudson Kern Reeve, of Cornell University, he has stated that individual insects in nascent societies only cooperate with their

closest relatives, while still competing with other group members for the right to pass on the most genes. As societies grow larger and more complex, however, competition among colonies grows fiercer, and as a consequence, group selection begins to act. It is at this stage that Hölldobler sees insect societies as making the transition to superorganisms: conflict among individuals is restricted, workers never reproduce, and a colony begins to seem more and more like a body. Wilson, taking a more extreme position, has proposed a model that emphasizes group selection even for nascent colonies.

Such group selection models are controversial. Scientists who focus on genes—most vocal among them Richard Dawkins, author of *The Selfish Gene*—argue that selection on the gene is the real driving force behind selection on the individual, let alone the group. This clash of views is inherently compelling, perhaps in part because the question of why individuals cooperate seems so central to our own daily struggles.

Hölldobler and Wilson took five years to write *The Superorganism*—in part, one suspects, because they have attempted, as far as possible, to reconcile their differing opinions and to present a united front. Crucially,

Continued on page 34

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REVIEW

Continued from page 32

they agree that once societies reach a sufficient level of sophistication, they operate like organisms, becoming the primary targets on which selection acts, with the individual ants almost as limited in their autonomy as a body's cells.

Time will tell whether the broader community of scientists agrees with the views expressed in *The Superorganism*. Perhaps Hölldobler and Wilson's greater contribution, though, is their survey of the many ways that component individuals make highly evolved societies work efficiently, through simple behaviors governed by a hierarchy of rules—and the genes regulating those rules. How, in practice, does a superorganism function, when it depends upon "the combined operation of tiny and short-lived minds"?

Much of what prevents individual social insects from going their merry ways, and enables the most sophisticated societies to be so well integrated, involves communication and the division of labor. Within families such as that of the ants, Formicidae, social insects vary relatively little in their morphologies (that is why any three-year-old can learn to identify "an ant"). And much of the diversity in life histories, the basic ways of living, among species can be attributed simply to differences in chemical communication, caste systems, and perhaps also mutualisms—insect societies' interdependencies with other partner species.

Although their book's thesis potentially pertains to all social organisms, not just insects, Hölldobler and Wilson focus on ants, with bees relegated to a supporting role and only an occasional cameo by a wasp or termite. Some of the stories are already familiar, yet it is clear that dramatically more is now known about ants, particularly about variation among species, than when *The*

The Superorganism: The Beauty, Elegance, and Strangeness of Insect Societies

By Bert Hölldobler and Edward O. Wilson
W.W. Norton, 2008; \$55.00

Ants was published. Twenty years ago it would have been reasonable to talk about a typical ant colony in which a single queen mates once and produces eggs, the colony competes against all neighbors, and the fertile offspring fly to mate and start new colonies. No more. We now know of parthenogenetic ant species (in which males are unnecessary for reproduction); ant species that have no territorial boundaries among colonies; ant species in which all of the workers lay eggs; ant species in which many tens of queens but no workers lay eggs; species that have no workers at all; and species whose queens mate many times. Using the same basic parts, ants do it many ways.

In showing how much we have learned about the diversity of ant societies, Hölldobler and Wilson also, inadvertently, show something else: how much we owe to their research. It is easy to think, for example, that the fact that ants lay pheromone trails to attract each other to food has always been common knowledge. But it was worked out in large part by Hölldobler and Wilson, as was a great deal else. Like their subjects, the two communicated, "grubbing around and talking back and forth." They used division of labor (Hölldobler chasing down the mechanisms, Wilson thinking more broadly, integrating). Their successes are also due to their mutual respect as friends, and even to a bond of kinship. Wilson has called Hölldobler the younger brother he never had. They share no genes, but have done much for each other—and for the rest of us.

ROBERT R. DUNN is an ecologist in the Department of Biology at North Carolina State University in Raleigh. His first book, *Every Living Thing: Man's Obsessive Quest to Catalog Life*, from Nanobacteria to New Monkeys, was recently published by Harper Collins/Smithsonian.



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Six-Legged Soldiers:
Using Insects as Weapons of War
by Jeffrey A. Lockwood
Oxford University Press, 2009;
\$27.95

Humans, according to Aristotle, are the only political animals, but that hasn't stopped insects from fighting alongside us in military conflicts worldwide since the dawn of civilization. The ancient Mayans, more than 4,500 years ago, filled gourds with stinging insects to harass would-be attackers. In A.D. 908 defenders of Chester, England, collected all available beehives and tossed them into tunnels dug by invaders, successfully repulsing a hostile army of Danes and Norwegians.

According to entomologist and science writer Jeffrey A. Lockwood of the University of Wyoming, who has combed the literature of ancient and modern warfare, military leaders have ignored insects at their own peril. Some infestations were relatively passive: mosquitoes carrying yellow fever successfully defended North America against Napoleonic incursions; during the Russian Revolution, typhus-bearing lice killed millions of civilians and combatants, prompting Vladimir Lenin to declare that "either socialism will defeat the louse, or the louse will defeat socialism."

By the mid-twentieth century, the louse had lost. For that matter, the impact of all diseases on troops in the field lessened as the sciences of epidemiology and entomology were incorporated into the practice of military hygiene. But Lockwood's arch-villain is General Ishii Shiro, who headed a vast Japanese biological-warfare effort called Unit 731 during World War II. General Ishii's agency found numerous ways to infest opposing populations with disease-carrying insects. For instance,

bombs and crop-duster planes filled with plague-infected fleas were tested "successfully" in China.

Undoubtedly many world superpowers, especially the United States and its former rival the Soviet Union, have mounted vigorous research in the use of insects as vectors for both human and agricultural disease. Documentation of modern military entomology, however, is hard to come by. Thus much of the second half of this book is rife with claims and counterclaims. Did the United States deploy plague-bearing insects in Korea or drop citrus-killing aphids on Castro's Cuba? Regardless of whether any of these charges are provable, it's clear from this chilling account that insect warfare is, even more than in the past, a formidable danger. "The proboscis," as Lockwood grimly quips, is still "mightier than the sword."



All hail the chloroplasts! Oliver Morton loves those tiny organelles, and so should we, for our lives and our livelihoods depend on their diligent work in taking sunlight and turning it into chemical energy. The first third of this often poetic study of photosynthesis by journalist Morton is a "science procedural," in the spirit of John McPhee's *Basin and Range*, focusing on the investigators who have unlocked the secrets of photosynthesis.

As early as the late 1700s, English minister and teacher Joseph Priestley had advanced the idea that plants took something from the air (which we now know as carbon dioxide) and put something else back into the at-

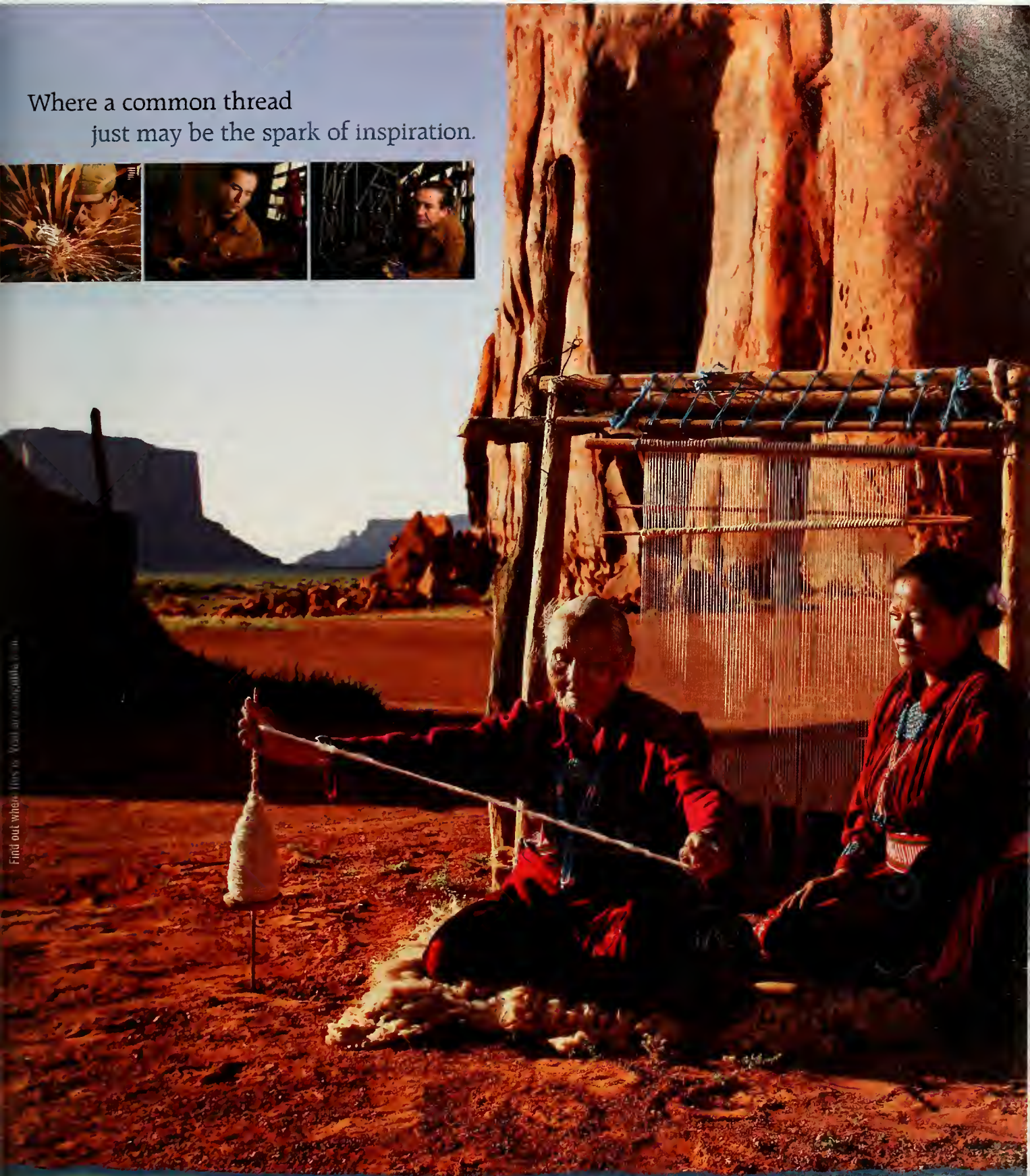
mosphere that animals needed to live (oxygen); his Dutch contemporary Jan Ingenhousz figured out that they could do so only in sunlight. In 1804, Swiss scientist Nicolas-Théodore de Saussure grasped that plants were making food in the process. But the precise mechanism of that transformation wasn't uncovered until the twentieth century, when, using newly discovered radioisotopes, scientists were first able to tag and trace atoms of carbon as they shuttled through the metabolic pathways of plants.

Readers outside the biochemical community are unlikely to recognize the names of the scientists who carried out this research—Andrew Benson, Robin Hill, and Martin Kamen, to name a few. But, as Morton makes clear through accounts of intellectual wrangling, their insights were as significant to our understanding of the well-springs of life as the discovery of the structure of DNA. If Watson and Crick are better known to the public, perhaps it is because photosynthesis can't be summarized as iconically as the double helix.

Plants are, of course, the reason why ours is the only planet in the solar system with an oxygen-rich atmosphere. Morton takes us back a couple of billion years to when photosynthetic bacteria opened the way for the profusion of life today. He convinces us that chloroplasts may be small, but as major consumers of sunlight and carbon dioxide, they play a crucial role in Earth's energy balance. As we face the challenges of global warming and dwindling fossil-fuel reserves, an understanding of those green organelles may be the key to a sunny future for us all.

LAURENCE A. MARSCHALL is W.K.T. Sahn Professor of Physics at Gettysburg College in Pennsylvania, and coauthor, with Stephen P. Maran, of Galileo's New Universe: The Revolution in Our Understanding of the Cosmos, published by BenBella Books.

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ARIZONA
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THIS LAND BY ROBERT H. MOHLENBROCK

Rocket Land

Wildlife finds a haven where space shuttles fly.

A long Florida's eastern coastline a string of peninsulas and islands intercedes between the Atlantic Ocean and a succession of lagoons, estuaries, and waterways. Among those barrier lands is a fifty-mile-long peninsula that extends from the mainland near Titusville to the south-southeast, sheltering the northern end of a stretch of water known as Indian River. The peninsula encompasses what was once a separate island, Merritt

Island, whose name is now applied to the entire peninsula. Shell middens—the accumulated trash from ancient meals—show that Native Americans made regular use of the locale's resources as long as nine thousand years ago. Would-be Spanish colonizers first landed there around 1565, but were driven away by the local inhabitants. During the nineteenth century, citrus growers and a trickle of homesteaders gained a foothold in the area, but



Manatee

it consisted largely of salt marsh, a habitat whose rich wildlife included a daunting population of mosquitoes. In 1957, when my family and I began making wintertime treks to Florida from Illinois, we found little reason to venture off U.S. Highway 1 as we passed through Titusville.

Things quickly changed, how-



Birds convening in Merritt Island salt marsh include great egret, snowy egret, wood stork, and white ibis.

HABITATS

Salt marsh Open water harbors fish and shrimp preyed upon by long-legged wading birds, belted kingfishers, and other avian species. Shorebirds find ample meals buried in mudflats: worms, crabs, clams, and snails. Vegetation must tolerate salt water to survive. Continuous stands of needlegrass rush and several

species of cordgrasses are punctuated by such ferns as the six-foot or taller giant leather fern and the smaller swamp fern. Red, white, and black mangroves are common. Red mangroves are the ones with large prop roots, structures that circulate air to underground and underwater roots; black mangroves send

up dozens of short, slender stems called pneumatophores around their base for the same purpose; and white mangroves, which may also produce a few pneumatophores, can be recognized from the pair of minute bumps, called salt glands, on each leaf stalk. Wildflowers bordering the marsh include

seaside goldenrod, perennial salt-marsh aster, sea oxeye, bushy bluestem, and limewater brookweed.

Palm and oak hammock Hammocks are forested areas that occur on slightly raised land adjacent to salt marshes. Palm hammock, lower than the oak in eleva-

ever. The facility now known as Cape Canaveral Air Force Station, on an outer barrier island just to the east of Merritt Island, was becoming too small to accommodate the nation's burgeoning space program. In 1963 the federal government completed the purchase of nearly 220 square miles of land, dune, water, and marsh. The once separate part of Merritt Island was joined to the rest of the peninsula as the National Aeronautics and Space Administration began building what is now the John F. Kennedy Space Center.

Only a modest amount of land was actually needed for launch pads and other facilities; the rest was set aside as a buffer zone. The entire tract is designated the Merritt Island National Wildlife Refuge, with public access to about half the area—and more around the time of shuttle launches and landings—restricted for reasons of safety and security. A large portion is also shared with Canaveral National Seashore.

In developing the space center, the government built dikes so that mudflats in and around the salt marsh could be flooded during mosquito-breeding season. This cut down on the mosquitoes, but unfortunately contributed to pushing the dusky seaside sparrow (which lived in only one other area besides the salt marsh) into extinction. Conservation measures failed to save the bird.

While continuing to control mosquitoes, in 1969 the U.S. Fish and Wildlife Service, which manages the refuge, began regulating

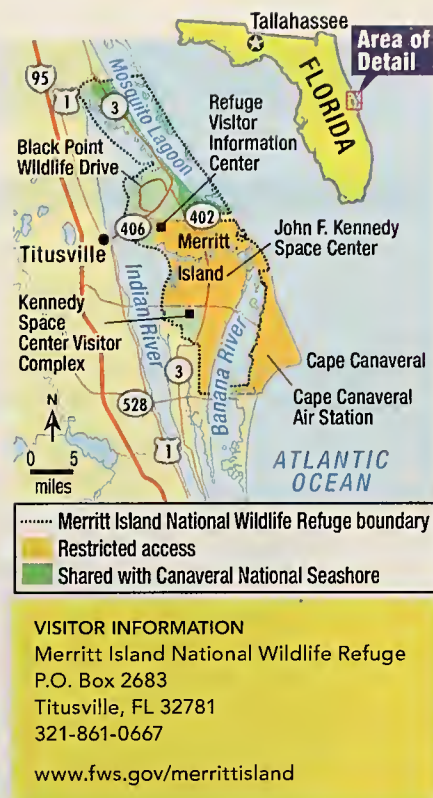
water levels and salinity in the impoundments, and even eliminating some of the dikes, to restore salt marsh and benefit wildlife. In the meantime, though, the suppression of fire—a natural part of the ecosystem—was allowing several species of scrub oaks, normally shrub-size, to grow into trees on the higher, drier areas. Scrubland habitat, home to three threatened species—the scrub jay, gopher tortoise, and eastern indigo snake—was giving way to thicketed humps, called hammocks, of palm and oak. Park biologists now compensate by cutting back some of the overgrowth and setting controlled fires.

First-time visitors should begin their journey at the Visitor Information Center off State Route 402. A short orientation trail is available behind the visitor center. The seven-mile Black Point Wildlife Drive through restored salt marsh is also a must. Taking the drive for the dozenth time, I saw great blue herons, tricolored herons, great egrets, reddish egrets, snowy egrets, roseate



Red maple fruits

ROBERT SWINSKY



spoonbills, wood storks, anhingas, white and glossy ibises, and the sassy-looking belted kingfishers, not to mention avocets, skimmers, stilts, and many kinds of ducks and gulls. Elsewhere, motorists can reach a place to spot manatees.

Hikers may follow a two-mile loop through a palm hammock, a half-mile trail through an oak hammock, and a mile-long loop in the Florida scrub. For the more ambitious, the five-mile Cruickshank Trail, a loop with its trailhead midway along the Black Point Wildlife Drive, takes you through salt marsh.

ROBERT H. MOHLENBROCK is a distinguished professor emeritus of plant biology at Southern Illinois University Carbondale.

tion, with a wetter understory, is dominated by cabbage palmetto. Among the other trees are American elm, laurel oak, red maple, and twinberry—a tropical tree with reddish-brown mottled bark that is in the same family as eucalyptus. On slightly higher and drier ground, palm hammock shades into

oak hammock, which has large specimens of live oak as well as laurel oak, though cabbage palmettos are common here as well. Among the other trees are common persimmon, swamp bay, and a couple of subtropical trees with magnolia-like leaves known as myrsine and marlberry. Huge vines of frost

grape hang heavily from some of the larger trees.

Pine flatwoods Slash pines dominate this flat terrain, with Chapman oak present where flatwoods transition to scrub. The understory includes fetterbush, gallberry holly, saw palmetto, wax myrtle, and other shrubs

and herbs. If hiking here, watch out for eastern diamondback rattlesnakes.

Florida scrub Saw palmetto, wax myrtle, and bush-size myrtle oak and sand live oak dominate this drier, open habitat. Prickly vines of several species known as greenbriers abound.

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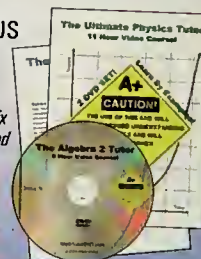
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29. ST. MARY'S COUNTY

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30. WORCESTER COUNTY

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For those of us who live in the northern latitudes, Castor and Pollux, the brightest stars of Gemini—the Twins—are nearly overhead around 10 P.M. local time on February 1, and

noted, and in 1803 William Herschel, the German-born British astronomer and composer, demonstrated that they revolve around each other. It takes Castor A and B about 445 years to

have nested orbits and whirl around a shared center of gravity, called the barycenter, in a matter of days. And then, off to the south of Castor A and B lies Castor C, a much dimmer orb that (based on observations so far) appears to be orbiting the main double pair in a 14,000-year cycle. By now you may have guessed that Castor C is also a double star, Ca and Cb. Those two—both red dwarfs—take less than twenty hours to revolve around their barycenter.

Phil Batchelor, a computer programmer and computer graphics artist based in New Zealand, has modeled the Castor system in 3-D using the space simulator Celestia. Images of the star orbits [illustration at left] are based on snapshots from his simulation. (Web links enabling readers to explore the simulation for themselves are posted at www.naturalhistorymag.com.) To help visualize this remarkable sextuplet stellar family, though, I like to picture three waltzing couples in a giant ballroom. Two of the couples, A and B, whirl within a few feet of each other in one corner of the dance floor, while the third pair, C, circles slowly around the edge of the room.

JOE RAO is a broadcast meteorologist and an associate and lecturer at the Hayden Planetarium in New York City (www.haydenplanetarium.org)



Castor system viewed from Earth (center and inset top right), with orbits of double stars A, B, and C viewed from above

around 8 P.M. by month's end. The two stars were named in antiquity for the mythical sons of Leda, but in 1678 the Italian astronomer Giovanni Domenico Cassini saw through an early telescope that one of them, Castor, was actually two stars, a fact rediscovered in 1718. Between 1719 and 1759, a change in angle between those two stars, dubbed Castor A and B, was

make the full circuit as they follow overlapping elliptical orbits.

But there's more! Both A and B themselves turn out to be doubles, which we can tell by the spectrographic Doppler effect, even though their respective components—Aa and Ab, Ba and Bb—are too close together to be separated optically. In each of those two pairs, the stars

larger (though thinner) as the planet approaches Earth, is easy to see in a clear sky even before sunset.

22 Just before sunrise, seek out the slender sliver of an old crescent Moon, low near the east-southeast horizon. Mercury and Jupiter are to the Moon's lower left.

24 Jupiter and Mercury engage in a close conjunction about a half hour before sunrise, low in the east-southeast. In the evening at 8:35 P.M. EST, the Moon is new.

27 Venus and the crescent Moon make a spectacular conjunction from before sunset into the depths of darkness. Venus sits about 1.5 degrees above and to the right of the Moon. Don't miss it!

FEBRUARY NIGHTS OUT

2 The Moon waxes to first quarter at 6:13 P.M. eastern standard time (EST).

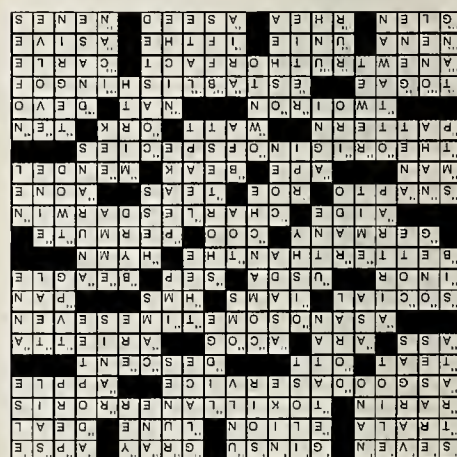
9 The Moon becomes full at 9:49 A.M. EST. Viewers in the far west can see it undergo a penumbral eclipse: at 6:38 A.M. Pacific Standard Time the Moon's upper rim should appear shaded.

11 The gibbous Moon rises early this evening; the bright, yellowish-white "star" hovering about 8 degrees above it and slightly to its left is Saturn.

16 The Moon wanes to last quarter at 4:37 P.M. EST.

19 Venus, its crescent having grown

Answers to Endpaper Crossword



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At the Museum

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Of Poets and Presidents

AMNH celebrates African-American Heritage Month

When Barack Obama accepted the Democratic nomination last August, he recalled an event 45 years earlier on the Mall before the Lincoln Memorial, when people came “to hear a young preacher from Georgia.” It was August 1963, and the Rev. Dr. Martin Luther King, Jr., delivered his historic “I Have a Dream” speech at the end of his March on Washington for Jobs and Freedom.

“The men and women who gathered there could have heard many things,” Obama said. “They could have heard words of anger and discord. They could have been told to succumb to the fear and frustrations of so many dreams deferred. But what the people heard instead—people of every creed and color, from every walk of life—is that, in America, our destiny is inextricably linked, that together our dreams can be one.”

It didn't take long for those in the know to pick up on the phrase “so many dreams deferred” and its homage to the late poet Langston Hughes. It was Hughes who wrote the now-legendary lines, “*What happens to a dream deferred? Does it dry up like a raisin in the sun?...Maybe it just sags like a heavy load. Or does it explode?*”

As the American Museum of Natural History marks African-American Heritage Month on February 21, only weeks after Barack Obama's inauguration as the first African-American President of the United States, perhaps the most poignant tribute is the scheduled reading of the works of Langston Hughes.

Born James Mercer Langston Hughes in 1902, the poet counted among his ancestors John Mercer Langston, thought to be the first African American ever to hold public office in the United States. John Mercer Langston began his career as the first black lawyer in Ohio and was elected Town Clerk of Brownhelm, Ohio, in 1855; he then served on the city council of Oberlin, Ohio, from 1865 to 1867, and after a contested election, became the first African-American Congressman from Virginia. (Speaking of firsts, Lorraine Hansberry's play “A Raisin in the Sun,” which took



Duke Ellington and his orchestra in the 1930s

its title from Hughes' poem, was produced on Broadway and won the 1959 New York Drama Critics' Circle Award for Best American Play, both firsts for an African-American woman. The play was inspired by the Hansberry family's legal battle against racially segregated housing laws in Chicago.)

Langston Hughes, like President Obama, had roots in the Midwest and came to New York to study at Columbia University. While there, he gravitated to Harlem, where he heard the blues, jazz, and gospel music critics say influenced the rhythms of his poetry. This period of the 1920s came to be known as the Harlem Renaissance, a flourishing of African-American art, music, literature, and dance that reverberates to this day.

The Museum will revisit this rich literary and musical legacy in *Harlem Serenade: A Moment In Time*, an afternoon of performances and presentations Saturday, February 21, in the Museum's Kaufmann and Linder Theaters. Free with admission, the program includes dance, poetry, and selected film clips. Participants can experience the dynamic sounds of the National Jazz Museum in Harlem's All-Star Orchestra; see a special performance by some of the original Cotton Club Dancers and young dancers carrying on the tradition; and, of course, hear the poetry of Langston Hughes, who has been called the poet laureate of Harlem.

If Hughes wrote about dreams deferred, he also countered such foreboding with “I Dream a World,” an exuberant poem with a message of hope much like the one conveyed by Barack Obama's presidential campaign. “*I dream a world,*” Hughes wrote, “*where all will know sweet freedom's way...where black or white, whatever race you be, will share the bounties of the earth and every man is free, where wretchedness will hang its head and joy, like a pearl, attends the needs of all mankind. Of such I dream, my world!*”

This event is co-produced by Community Works and the New Heritage Theatre Group under the artistic direction of James Stovall.

The Changing Poles

In the late 1950s, the early 1930s, and the early 1880s, scientists and explorers pooled their efforts to understand the Earth at its edges, the Arctic and Antarctic, the North and South Poles. Next month, the fourth and largest such collaborative science program comes to a close, and the American Museum of Natural History will acknowledge its accomplishments, hosting the third New York City International Polar Weekend on February 7 and 8. This family-friendly event, from noon to 5 pm each day, is designed to put the public in touch with the groundbreaking work of the International Polar Year (IPY).

The IPY, which began in March 2007, is an intense, internationally coordinated campaign of research and interdisciplinary collaboration among thousands of scientists from more than 60 nations, dedicated to understanding polar environments and the dramatic changes confronting them—one of the urgent issues addressed in the Museum's current exhibition *Climate Change: The Threat to Life and A New Energy Future*.

The weekend program will feature events and activities for all ages, including performances, short talks, Northern art, film clips, and a chance to meet a host of scientists in an interactive "Polar Fair." Two artists, Cornelia Kavanaugh and Marcia Clark, will display their polar-inspired art along with selected works from a group of Siberian youth, courtesy of the Woods Hole Oceanographic Institution in Woods Hole, Massachusetts. Among the scientific experts participating are Mary Albert, a mechanical research engineer with Cold Regions Research

and Engineering Laboratory, U.S. Army Corps of Engineers, in Hanover, New Hampshire, and the former chair of the U.S. Committee to the IPY; Michael Castellini, Associate Dean of the University of Alaska, Fairbanks, Professor in the School of Fisheries and Ocean Science and Director of the University's Institute of Marine Science; Richard Alley, Evan Pugh Professor of Geosciences at Penn State University; Stephanie Pfirman, Hirschhorn Professor and Department Chair, Department of Environmental Science, Barnard College; geologist Richard Glenn, President of the Barrow Arctic Science Consortium; and Andrew Revkin, environmental reporter for the New York Times.

The weekend is sponsored by AMNH, Lamont-Doherty Earth Observatory, Columbia University, Barnard College, the Explorers Club, and Wings WorldQuest, with special participation from the Norwegian consulate and in partnership with Polar Palooza, a public education and outreach project supported by the National Science Foundation and NASA, bringing information and insights about the Poles to large public audiences across America through national science-center and museum tours.



NEW YORK CITY INTERNATIONAL **POLAR** WEEKEND

Small Fish, Big Ocean

Every year, an amazing migration brings billions of sardines to the KwaZulu-Natal Coast of Africa, setting off a feeding frenzy among gannets, seals, dolphins, whales, sharks, and other fish. *Wild Ocean*, the exciting film now showing in the Museum's LeFrak IMAX Theater, captures this spectacle as only the giant screen can.

Viewers are invited to plunge into an epic struggle for survival under water, with voracious schools of fish, and on land, with local fishermen whose livelihood depends on the annual sardine migration. It is a thrilling and hopeful story in which business, government, and the local people join forces to protect this invaluable food

source through "sustainable" fishing practices, the goal of which is nothing less than the preservation of a circle of life that developed and evolved over millions of years—and has been under increasing threat since the early 20th century, when entire fish stocks began collapsing one by one. As the film's trailer explains, "The sea is changing. Overfishing and global warming threaten what balance remains. There are few places we can see the ocean as it was, as it should be, as it could be." *Wild Ocean* takes you there.

Wild Ocean was produced by the creators of the musical *STOMP* and Academy Award-nominated directors of the IMAX film *Pulse*; a *STOMP* Odyssey.

SAVE THE DATE Tuesday, March 10

2009 Isaac Asimov Memorial Debate
From Planets to Plutoids:
The New Solar System

Pluto may be gone from the list of planets in our solar system, but it is not forgotten. Last summer in Oslo, the International Astronomical Union decided to apply the name "plutoid" to all similar dwarf planets. This is just one of the fascinating developments in astrophysics that inspire this year's debate. Moderated by Neil deGrasse Tyson, The Frederick P. Rose Director of the Hayden Planetarium, this highly popular evening event honors the memory of the late Isaac Asimov, one of the most prolific and revered science writers of the 20th century.

At the Museum

AMERICAN MUSEUM OF NATURAL HISTORY 

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EXHIBITIONS

Climate Change: The Threat to Life and A New Energy Future
Through August 16, 2009
This timely exhibition explores the science, history, and impact of climate change on a global scale, providing a context for today's most urgent headlines and empowering and inspiring visitors of all ages.

Climate Change is organized by the American Museum of Natural History, New York (www.amnh.org), in collaboration with the Abu Dhabi Authority for Culture & Heritage, United Arab Emirates; The Cleveland Museum of Natural History; The Field Museum, Chicago; Instituto Sangari, São Paulo, Brazil; Junta de Castilla y León, Spain; Korea Green Foundation, Seoul; Natural History Museum of Denmark, Copenhagen; Papalote Museo del Niño, Mexico City, Mexico; and Saint Louis Science Center.

Climate Change is proudly presented by Bank of America.

Additional support has been provided by The Rockefeller Foundation. Additional support for *Climate Change* and its related educational programming has been provided by Mary and David Solomon, the Betsy and Jesse Fink Foundation, the Linden Trust for Conservation, and the Red Crane Foundation.

The Butterfly Conservatory
Through May 25, 2009
Mingle with up to 500 live, free-flying tropical butterflies in an enclosed habitat that approximates their natural environment.



AMNH

Saturn: Images from the Cassini-Huygens Mission
Through March 29, 2009
Explore details of Saturn's rings, moons, and atmosphere with images sent over half a billion miles by the Cassini spacecraft.

The support of the National Aeronautics and Space Administration is appreciated.

Special thanks to the Cassini imaging team, especially those scientists at Cornell University's Department of Astronomy, along with the staff of Cornell University photography. The Eastman Kodak Company of Rochester, New York, printed the images.

On Feathered Wings
Through May 25, 2009
Admire the work of renowned wildlife photographers whose artistry showcases the majesty of birds in flight.

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

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

GLOBAL WEEKENDS
International Polar Weekend
Saturday–Sunday,
February 7–8, 12–5 pm
AMNH hosts the third International Polar Weekend. Visit www.amnh.org/polar.

In collaboration with Barnard College, Lamont-Doherty Earth Observatory, Columbia University, and Polar-Palooza, with funding from NSF.

African-American Heritage Day
Harlem Serenade: A Moment in Time
Saturday, February 21, 1–5 pm
Celebrate African-American Heritage Month and Harlem's rich musical legacy. Visit www.amnh.org/blackhistory.

This event is co-produced with

Community Works and the New Heritage Theatre Group under the artistic direction of James Stovall.

Global Weekends are supported by the May and Samuel Rudin Family Foundation, Inc., the Tolan family, and the family of Frederick H. Leonhardt.

LECTURES
GLOBAL KITCHEN
Climate Change and Coffee
Tuesday, February 3, 6:30 pm
Todd Carmichael, La Colombe Torrefaction, and Danner Friedman, Rainforest Alliance, discuss growing coffee amid the realities of climate change.



DANNER FRIEDMAN, RAINFOREST ALLIANCE

Coffee cherries picked in Colombia on a Rainforest Alliance Certified farm

SCIENCE AND SOCIETY
Reporting on Climate Change: The Media and Public Understanding
Tuesday, February 10, 6:30 pm
With journalists Bud Ward, The Yale Forum on Climate Change & the Media; Bill Blakemore, ABC News; Diane Hawkins-Cox, CNN; and Andrew Revkin, The New York Times; along with Matthew Nisbet, American University School of Communication, and Michael Novacek, Senior VP and Provost of Science, AMNH.

FIELD TRIPS AND WORKSHOPS
Visualizing Climate Change
Three Thursdays,
February 19, 29, and March 5,
6:30–8:30 pm
Join Ned Gardiner, Visualization Program Manager for the National Oceanic and Atmospheric Administration (NOAA); and Linda Sohl, Center for Climate Systems, Columbia University, to learn techniques for understanding Earth's climate.

FAMILY AND CHILDREN'S PROGRAMS

Meet the Scientist
Sunday, February 1
Visitors 5 and older can chat with scientists and learn how they became interested in their fields. Call 212-313-7105 for details.

The Discovery Room was made possible by a grant from the Edward John Noble Foundation. The Discovery Room's programs are supported, in part, by Con Edison and by the New York City Council.

Wild, Wild World: Wolves
Saturday, February 14,
12–1 pm and 2–3 pm
Learn about these highly endangered predators with Atka, an Arctic gray wolf from the Wolf Conservation Center in South Salem, New York.

AFTER SCHOOL PROGRAMS
Courses in the Sciences, Session IV
February 23–April 3,
4:30–6:30 pm
Students interested in science can choose from a diverse range of topics. Visit www.amnh.org/education/highschool. (High school

students, grades 9–12)

Support for the After-School Programs is provided by the Goldman Sachs Foundation.

AMNH ADVENTURES: WINTER CAMPS

Monday–Friday, February 16–20, 9 am–4 pm

Each session includes hands-on investigations and behind-the-scenes tours. For further information, please call 212-769-5100.

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(For 2nd and 3rd graders)

Fossils and DNA

(For 4th and 5th graders)

Mission Earth:

Our Changing Planet

(For 6th and 7th graders)

MEMBERS' PROGRAMS BEHIND-THE-SCENES TOURS

INFORMATION

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

TICKETS AND REGISTRATION

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

AMNH eNotes delivers the latest information on Museum programs and events monthly via email. Visit www.amnh.org to sign up today!

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Behind the Scenes in Mammalogy

Thursday, February 5, 6:30 pm, 7 pm, and 7:30 pm

Visit the Museum's storage tanks and Osteological Prep Lab with Collections Manager Darrin Lunde and Collections Specialist Neil Duncan.

Behind the Scenes in The Sackler Institute for Comparative Genomics

Thursday, February 26,

6:30 pm, 7 pm, and 7:30 pm

With George Amato, Director of the SICG; Susan Perkins, Assistant Curator; and Julie Feinstein, Collections Manager.

WALKING TOURS

Rocks of Ages

Saturday, February 7, 10 am–12 pm and 1–3 pm

Join geologist Sidney Horenstein on this walking tour to learn about the

construction of the Cathedral Church of St. John the Divine.

FAMILY PROGRAMS

Mineral Collecting Workshop

Sunday, February 22,

10 am–12 pm and 1–3 pm

Learn to identify minerals with Senior Scientific Assistant Jamie Newman.

Cost includes a mini-collection of minerals. (For adults and children 8 and up)

HAYDEN PLANETARIUM PROGRAMS

TUESDAYS IN THE DOME

Celestial Highlights

Star Nests of Orion

Tuesday, February 24, 6:30 pm

These programs are supported, in part, by Val and Min-Myn Schaffner.

LECTURES

Touching the Heart of Magnetism in our Nearest Star

Monday, February 19, 7:30 pm

Explore the origin of the sun's evolving magnetism with Juri Toomre, JILA, University of Colorado at Boulder.

Cosmic Collisions

Journey into deep space to explore the hypersonic impacts that drive the formation of our universe. Narrated by Robert Redford.

Cosmic Collisions was developed in collaboration with the Denver Museum of Nature & Science; GOTO, Inc., Tokyo, Japan; and the Shanghai Science and Technology Museum.

Made possible through the generous support of CIT.

Cosmic Collisions was created by the American Museum of Natural History with the major support and partnership of the National Aeronautics and Space Administration's Science Mission Directorate, Heliophysics Division.

IMAX MOVIES

Wild Ocean

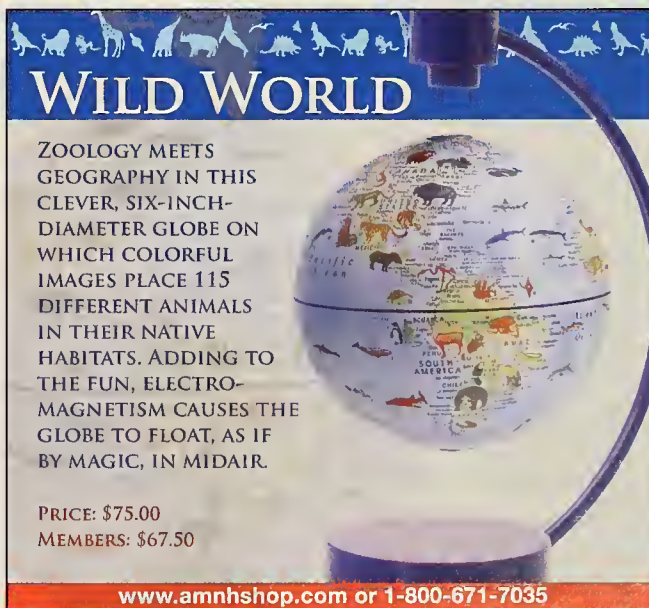
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LATE NIGHT DANCE PARTY

One Step Beyond

Friday, February 13

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ACROSS

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- 6 Infomercial knife
- 11 Asa ____, American botanist, friend and defender of 71-Across
- 15 Basilica area
- 19 What to sing while skipping
- 20 1988 medicine Nobelist Gertrude
- 21 Mathematical crescent
- 22 Good buy
- 23 "I'm a- ____ to go!"
- 24 Start of a quotation by 71-Across
- 27 Quotation, part 2
- 29 American pie pome
- 30 Standard equipment in most mammals
- 31 Giant Mel at Cooperstown
- 32 The ____ of Man (1871 work by 71-Across)
- 35 Mule's dad
- 36 Altar of the stars
- 37 Slip ____ : lose one's judgment
- 40 Short solo
- 44 Quotation, part 3
- 48 ____ insects (bees, ants, etc.)
- 51 "Good for life" sloganer
- 52 With 57-Across, ship that carried 71-Across
- 53 Chimp's genus
- 54 "Are you ____ out?"
- 55 U.S. Forest Service's superior
- 56 Typical Harvest Moon mo.
- 57 See 52-Across
- 60 Quotation, part 4
- 64 Song of praise
- 65 Alexander von Humboldt's native soil



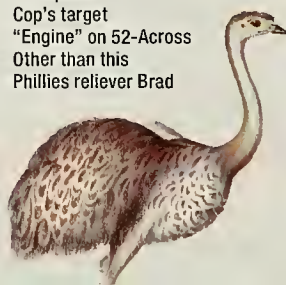
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- 66 Pigeon English?
- 67 Shuffle, in genetics or math
- 70 Assistant
- 71 Naturalist born 200 years ago
- 74 ____ attention: Look sharp!
- 77 Future fish
- 78 Afternoon socials
- 79 Top-drawer
- 80 Island home of tailless cats
- 81 Our close relative, according to 71-Across
- 82 Finches' variable appendage
- 83 Genetics pioneer Gregor
- 85 1859 masterwork by 71-Across
- 91 ____ recognition (perception of arrangement)
- 92 Light bulb power unit
- 93 1970s sitcom planet
- 94 Pound note bearing 71-Across's image
- 97 Golf club with a long vertical face
- 100 ____ Hist.
- 101 Evo-____ (modern biological field)
- 102 Garb in Roman tora

- 105 Quotation, part 5
- 110 End of the quotation
- 113 The Very Hungry Caterpillar author Eric
- 114 99 Luftballons pop singer
- 115 Combined, in Compiègne
- 116 "____ shoe fits ..."
- 117 "____ said many times ..."
- 118 Secluded valley
- 119 Ostrich cousin that inspired 71-Across
- 120 Thoreau's Faith in ____
- 121 Hawaiian geese

DOWN

- 1 Geologic layers
- 2 Removes
- 3 ABC TV's 20/20 newswoman Elizabeth
- 4 Middlemarch novelist
- 5 ____-technology (small-scale materials science)
- 6 Turn bronze
- 7 Admission of defeat
- 8 Victory goddess
- 9 Yves's eve
- 10 Sin City higher-learning institution
- 11 Yvette's iced
- 12 Lord of the Rings letters
- 13 Hydrocarbon ending
- 14 "So's ____ old man!"
- 15 Ex-orphan
- 16 Cop's target
- 17 "Engine" on 52-Across
- 18 Other than this
- 25 Phillies reliever Brad
- 26 Indian royalty
- 28 Home of golf's Blue Monster
- 33 They may be watching (abbr.)
- 34 "Able was I, ____ I saw Elba."
- 36 Comparison words
- 37 Carne ____
- 38 Southern Plains tribe
- 39 They may be chanted
- 41 Many a sitcom rating
- 42 Marsh duck
- 43 Queen ____'s lace
- 44 Odor block in plumbing
- 45 Like good gossip columns
- 46 Prayer pronoun
- 47 Little devil
- 48 Sis or bro
- 49 NASA force unit
- 50 Dove's house
- 55 Alternative Reader
- 56 Losing draw in straws
- 57 American polar explorer
- 58 71-Across's wife and first cousin ____ Wedgwood
- 59 Frogs and toads
- 61 What cars do with carbon dioxide
- 62 Hair co-writer James
- 63 Toast starter
- 64 Oil giant
- 67 Alice in Wonderland illustrator Mervyn
- 68 Lacking depth
- 69 One, to Wilhelm
- 71 Filmmaker Joel or Ethan
- 72 Took off
- 73 "____ Blu Dipinto di Blu" (Volare)
- 74 E-mail dispatcher (abbr.)
- 75 Okinawa capital
- 76 On a trapeze without ____
- 77 Alma mater of some engr.
- 81 Lambs: Latin
- 82 Arts deg.
- 83 Gaiety
- 84 Mouse reaction
- 86 Canadian capitalist
- 87 Moistened again
- 88 Displaced persons grp. (1946-1952)
- 89 ____-rent (proposed foreclosure remedy)
- 90 Didn't work too hard
- 94 Medicated shampoo brand
- 95 Adapt as a species
- 96 Bank's ad come-on
- 98 Secure anew
- 99 Kitty ____ (mistress in Irish history)
- 100 Habitat cut out for a species
- 101 Genetic enzyme
- 102 Astronaut's beverage
- 103 Law-school newbie
- 104 Heredity unit
- 106 Solo
- 107 Close companions (slangy abbr.)
- 108 After midnight, say
- 109 Words of confidence
- 111 1921 play about robots
- 112 Durham sch.



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Solution on page 42

BRENDAN EMMETT QUIGLEY, a regular contributor of crosswords to the New York Times, has four puzzle books forthcoming. He lives in Brookline, Massachusetts, and performs in the Boston Typewriter Orchestra.



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