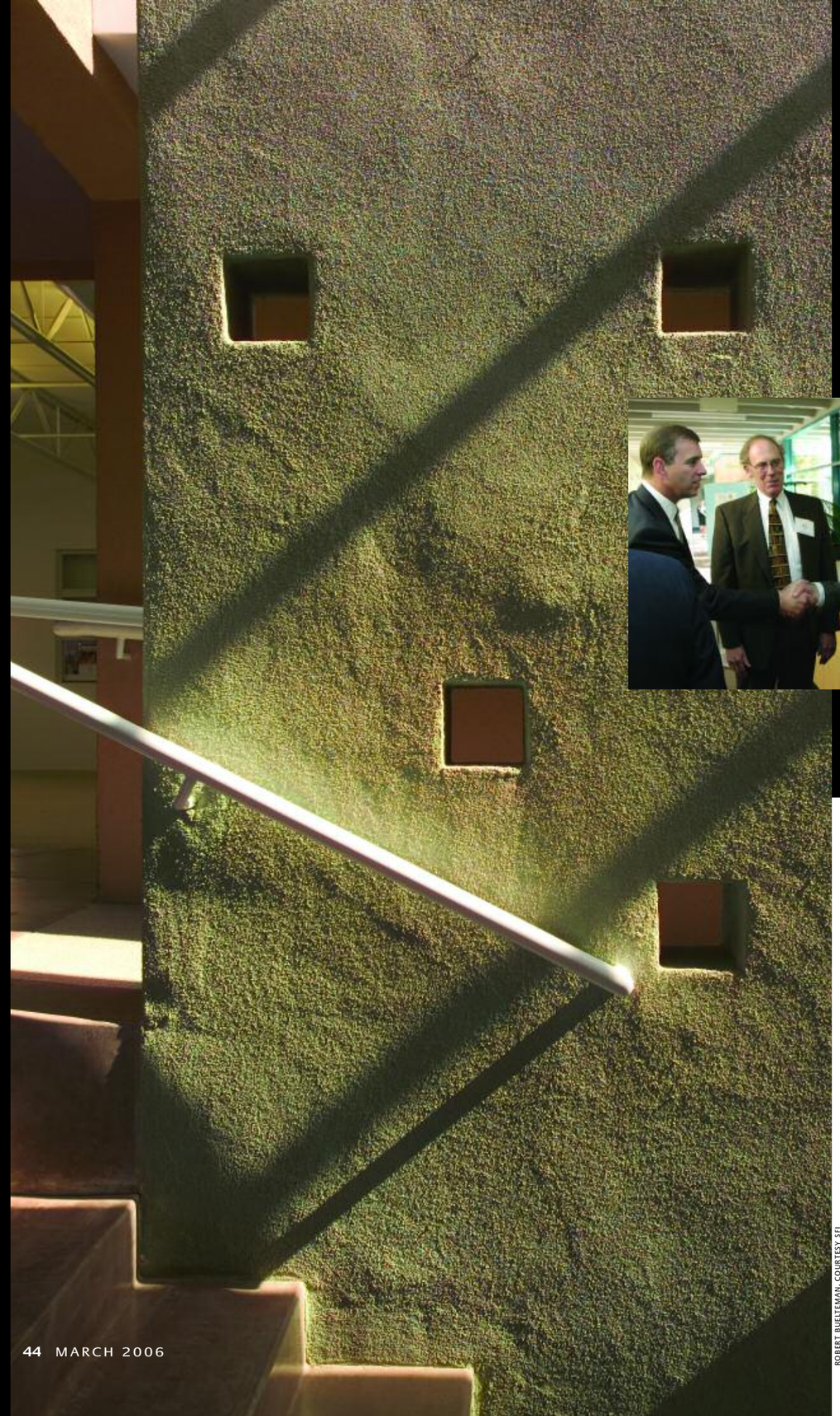
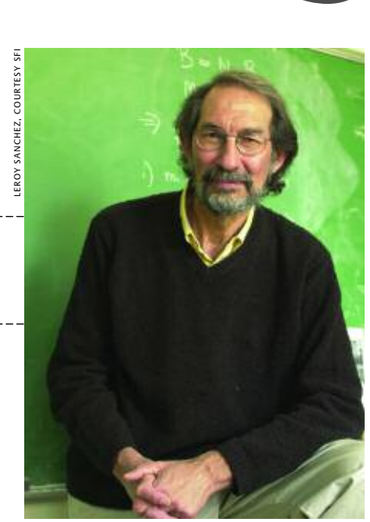


JANE BERNARD

ROBERT BUELTEMAN, COURTESY SFI

**CONCEIVED AS A "NEW ATHENS," THE SANTA FE INSTITUTE BRINGS TOGETHER A PANTHEON OF BRILLIANT MINDS TO ASK THE BIG QUESTIONS**

# the science of synergy



LEROY SANCHEZ, COURTESY SFI

Brainiacs: Above, physicist Geoffrey West, president of the interdisciplinary institute; left, workshop participants, including Prince Andrew, Duke of York (far left)

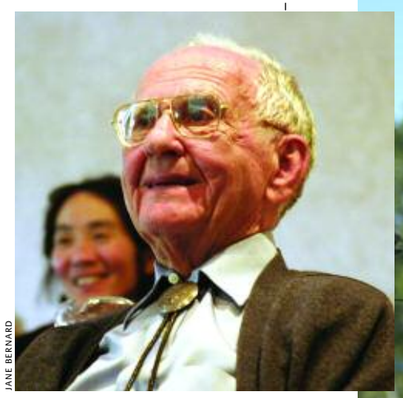
BY ELIZABETH WOLF

**on this dark, crescent-moon night,** Venus glitters like the central diamond in a crown of stars. The city lights of Santa Fe, tumbling like a river west toward the Jemez Mountains, look as though they've been poured from some giant vessel of liquid illumination. More than one guest on the grand portico overlooking it all pauses to take in the view, sipping it with their eyes as if it were inspiration for their next stroke of genius.

Leaning against the railing, an economist jokes about relaxing trade barriers by spiking drinks with oxytocin, the "cuddle hormone" released during bonding experiences such as nursing and sex. Murray Gell-Mann sidles closer; this is getting interesting. "Tell me," the Nobel laureate asks with a wry smile, "is the condition of being too trusting known as 'oxytosis'? Like 'halitosis'?" After the chuckles subside, talk turns to the Dead Sea Scrolls, then British telecommunications, then—what else?—lizard populations on the Galápagos.

In this crowd, there is nothing unusual about such intellectual shape-shifting. There is nothing surprising about an economist versed in endocrinology. Or a chemist studying brain development. Or a theoretical physicist searching for the original mother tongue. This, after all, is the Santa Fe Institute, a private, nonprofit think tank world-renowned for its unique interdisciplinary approach. For more than 20 years, the center has brought together world-class researchers in physics, biology, economics, anthropology, linguistics, neuroscience, and other disciplines to storm the frontiers of knowledge. Even the arts and humanities are represented: novelist Cormac McCarthy and photographer Robert Buelteman are artists in residence, hobnobbing freely with the scientists.

JANE BERNARD



JANE BERNARD

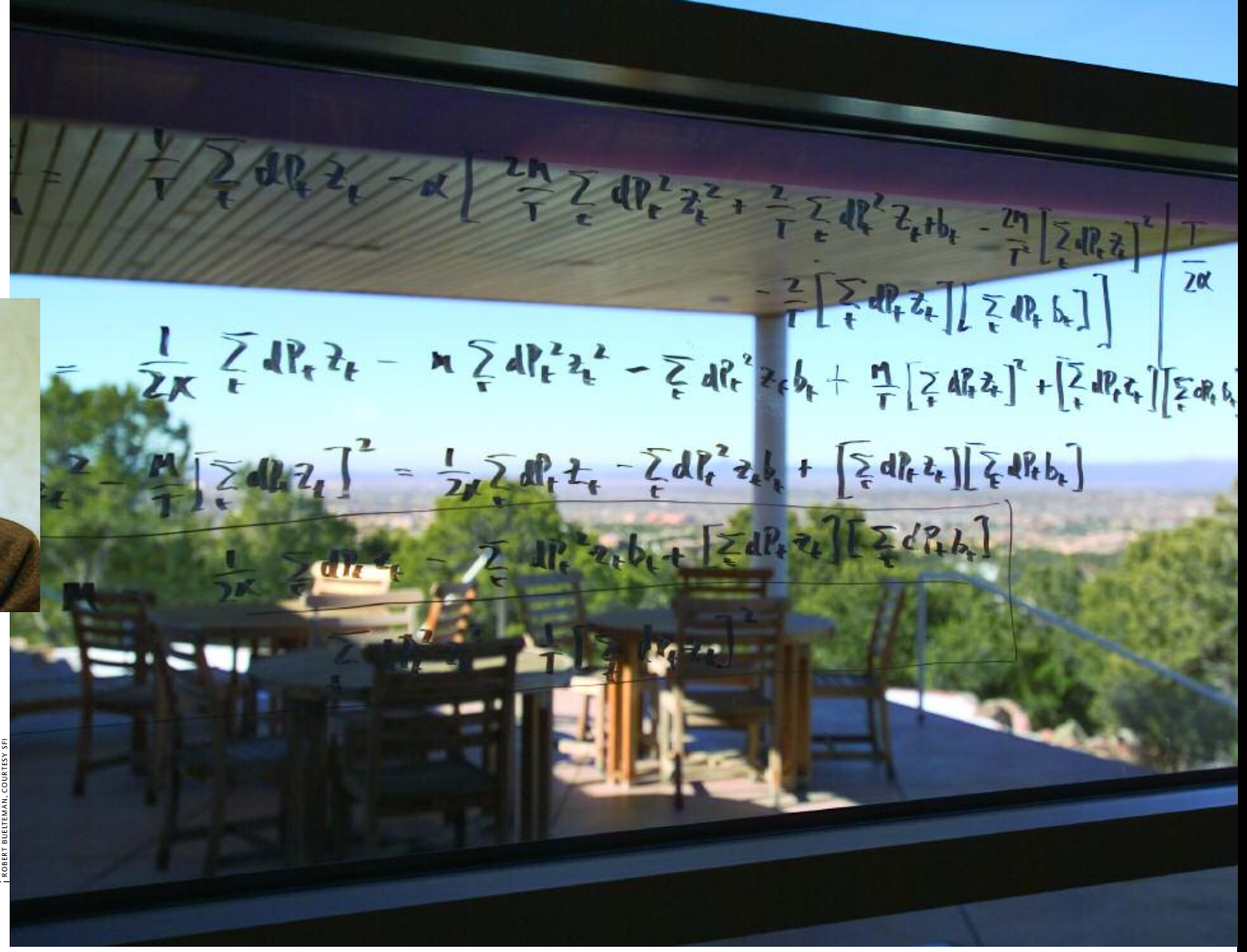
**SFI has been described as a "state of mind," one equally at ease with mastery and muddle, capable of both pinpoint analysis and wide, wild pattern recognition.**

At its core is a mission to discover the fundamental principles underlying biological, social, and artificial systems. Whether participants come as faculty, visiting students, postdoctoral fellows, board members, or business affiliates, whether they stay for an afternoon workshop or a years-long collaboration, the common refrain is: "The Santa Fe Institute completely changed my view of science. It totally opened my eyes."

Indeed, SFI has been described as a "state of mind," one equally at ease with both mastery and muddle, capable of both pinpoint analysis and wide, wild pattern recognition. No wonder the institute attracts mavericks and misfits, people like J. Doyne Farmer and Norman Packard, who, as graduate students, invented miniature wearable computers to beat Vegas casinos at roulette. In 1991 these pioneers of chaos theory cofounded the Prediction Company, applying their newfangled principles of "phynance"—the intersection of physics and finance—to profit from currency markets.

Then there's theoretical biologist Stuart Kauffman, a latter-day physician who nearly flunked out of medical school; he went on to receive a MacArthur Foundation "genius grant" for his theory of the mysterious self-organization exhibited in networks ranging from ecosystems to economies—a phenomenon he calls "order for free." Economist Brian Arthur's peers scoffed at his unconventional ideas so relentlessly, he nearly left the field. Today people like Bill Miller, considered the most successful fund manager in American history, swear by Arthur's analysis of the economy as a complex, evolving system. And there's Miller himself. Chairman of SFI's board of trustees, the CEO of Legg Mason has beaten the S&P 500 for the past 15 years in a row, a feat unmatched by any fund manager in the world. His strategy comes in part, he says, from work done at SFI.

"The institute is where we all thought we were going when we dreamed of the academic life," says SFI president Geoffrey West, formerly a distinguished senior research fellow at Los Alamos National Laboratories. Most university departments discourage interdisciplinary research. Grants, after all, are typically awarded for narrowly defined problems; careers are advanced by breakthroughs made within a discipline, not by blurring the boundaries between them. Here, says West, scholars can flourish, think freely, go "out of bounds" without penalty. Turns out scientists globally are hungry for this bold, beyond-borders approach. SFI has ignited similar centers in Chile, the United Kingdom, France, the Netherlands, India, and China. And that's just the beginning.



ROBERT BUELTEMAN, COURTESY SFI

The writing on the wall: Clockwise from far left, fund manager Bill Miller is chairman of SFI's board; co-founder George Cowan at SFI's 20th anniversary party in 2004; equations cover the windows at the institute.

## george cowan

was no stranger to explosive moments in science. Trained as a chemist, the former research director for Los Alamos had been an eyewitness to the very first hydrogen-bomb detonation. An eruption equal to a thousand Hiroshimas, the test weapon vaporized the Pacific island on which it was dropped. By the early 1980s, Cowan and his colleagues were searching for a new, broader scientific charter. During the senior fellows' regular lunches together, one topic kept coming up: the idea of creating a freestanding, independent institute devoted primarily to pure science, not policy-driven research. There would be no departments, no tenured faculty, no degree granting, no administrative fetters to compromise the mission. They envisioned a "new Athens" where the world's most brilliant minds would gather to spark each other and blaze trails through uncharted territory.

Santa Fe was the natural choice for this idyll of erudition: it was close to Los Alamos—but not too close, cosmopolitan yet off the beaten track, and breathtakingly beautiful. What's more, the City Different was a haven for diversity and experimentation. People came to Santa Fe to reinvent themselves; now, so would science.

City on a hill: Clockwise from far left, Anasazi-style interior wall; SFI's main entrance; Nobel laureate Murray Gell-Mann in deep thought; Zen, the feline-in-residence

THIS PAGE: ROBERT BUELTEMAN, COURTESY SFI

Idealistic? Of course. But possible, especially once Murray Gell-Mann called to say *Count me in*. Cowan knew the physicist's star power would help the cause. Gell-Mann was a living legend, an über-intellect who dazzled all who met him (if they survived his often scathing wit and withering gaze, that is). Eerily precocious, he was multiplying by age 3, entered Yale at 15, earned his doctorate from MIT at 21, and was a full professor at Caltech at 26. In 1969 he won the Nobel Prize in physics—solo—for his revolutionary ordering of elementary particles. A consummate polymath, Gell-Mann's voracious curiosity gobbled subjects—including natural history, archaeology, depth psychology, creative thinking, biological evolution, the study of ancient and medieval coins, sustainable development, conservation, and global public policy—as if they were a handful of cocktail peanuts. What's more, he knew everyone who was anyone, and was a director of the John D. and Catherine T. MacArthur Foundation, to boot.

Gell-Mann wanted the center to study something as grand and enduring as evolutionary biology or the origin of the universe, something sweeping, the "emerging synthesis" of contemporary science. At the founding workshops, held in 1984 to flush out what such a synthesis might be, "it turned out that just about every speech was related to simplicity and complexity, randomness and regularity, and adaptation and evolution," the physicist says.

And so it was that the Santa Fe Institute became the birthplace of complexity science, the interdisciplinary study of the deep commonalities among such complex systems as forests, societies, the Internet, the human immune system. How do we account for the order, the self-organization, that emerges in flocking birds, hurricanes, the world economy? When SFI was incorporated in 1984, complexity was a revolutionary new field of inquiry; today it is has entered the mainstream as the subject of numerous college science courses and the premise of such popular books as Malcolm Gladwell's *The Tipping Point* and James Surowiecki's *The Wisdom of Crowds*.

The Santa Fe Institute at last had a mission, a leadership—Cowan as president, Gell-Mann as board chairman—

ERIC SWANSON

and seed money supplied by Cowan's friend Art Spiegel, of the Spiegel Catalog fortune, IBM, the National Science Foundation, and the MacArthur Foundation. Citicorp's John Reed ratcheted things up a notch when, in 1986, he asked SFI if it could help design a new model of economic forecasting. This was not just idle curiosity on the chairman's part: his company economists had cost the corporation $15 billion in uncollectable Third World debt. SFI jumped at the chance, convening a plenary that included 10 physicists, invited by Nobelist Phil Anderson, and 10 economists, the guests of Nobelist Kenneth Arrow.

No one knew how it would go. Neither economists nor physicists—nor Nobel Prize winners—were exactly famous for their modesty. On top of that, the two groups didn't speak the same technical language or share a methodology. The first day, the physicists nailed the economists on their pie-in-the-sky assumptions; the economists blanched at the physicists' back-of-the-envelope calculations. But once the chest-beating was over (one participant dubbed it the "Me Tarzan, you Jane" period), the scholars found common ground, swinging into stimulating, fruitful conversations that sometimes lasted until three in the morning. The end result: the launch of SFI's revolutionary economics program, initially funded by Citicorp and run by Stanford's Brian Arthur and the University of Michigan's John Holland.

Finally, in 1987 the institute found a cramped but comfy home, in the old Cristo Rey Convent on gallery-studded Canyon Road. Cowan set up his headquarters in what had been the mother superior's office.

"let's meet on Pod C terrace," a postdoc fellow calls out to his mentor down the hall. The days at the convent are long gone. Today the institute occupies a grand Territorial-style hacienda on Hyde Park Road, nestled in the Sangre de Cristo foothills. When George Cowan first saw it, he quipped, "If the ancient Greeks had owned this property, they would have built a temple." With its slim Doric columns and elegant proportions, the building does have a classical air, despite the addition of ultra-modern open areas, or "pods," designed to encourage folks to gather and talk. On the first level, floor-to-ceiling windows wrap around a sunny outdoor courtyard. It's not uncommon to see the glass covered with equations, diagrams, and notes. So too in the conference room: every wall doubles as a writing surface.

One of SFI's main "products" is metaphor creation. Just as earlier generations raised on Newtonian notions of a "clockwork universe" looked to mechanics for analogies, researchers today study complex adaptive systems in nature for ways to understand or design things. It was immunology, for example, that gave Stephanie Forrest and David Ackley of UNM a metaphor for computer security. In their view, today's computer is a technological "bubble boy," marginally protected by anti-virus programs and firewalls but lacking a full-blown immune

JANE BERNARD

## SFI FOR THE COMPLETE IDIOT

**Mantra:** "There is a fundamental unity to all life. It can and will be understood by science, and we'll take risks to get there."
**Picture this:** The Parthenon merged with the Starship *Enterprise*, parked on a hilltop and wirelessly networked with crew worldwide
**Vibe:** Brainy, elite, cutting-edge, omnivorous, creative, catalytic
**Founded:** 1984, by Los Alamos senior fellow George Cowan, physics Nobel laureate Murray Gell-Mann, and others
**Purpose:** To explore emerging syntheses in science via a multidisciplinary approach
**Research areas:** Complexity, networks, artificial life, evolutionary biology, brain development, computation, historical linguistics, quantum mechanics
**People:** 14 resident faculty, 66 external faculty, 12 postdoc fellows, 58 Business Network members, 20 staff
**To learn more:** Attend the Feb–Sept public lecture series. Read *The Quark and the Jaguar*, Murray Gell-Mann; *Strange Beauty*, George Johnson's biography of Gell-Mann; *Complexity*, Mitchell Waldrop; *Info Mesa*, Ed Regis; SFI's technical working papers and book series (see website). Check out the Complexity Science Summer School and research programs for grads, undergrads, and high school students and teachers.
**Contact:** 505-984-8800, www.santafe.edu

system capable of detecting intruders or defending or repairing itself.

Another research team crossed social insects and tumbleweeds, metaphorically speaking, to computer-model a fleet of wind-propelled rovers to bob along the surface of Mars. Artificial intelligence will enable these "swarmbots" to assemble teams to investigate points of interest in the landscape. Kurt Severance of NASA's Langley Research Center remembers the project's slow start as the interdisciplinary group learned one another's paradigms. "But once we got over the hump, the creative process was actually accelerated because we bounced off each other's ideas," says the senior computer engineer.

One of the most productive collaborations involves SFI president Geoffrey West, a high-energy physicist by training. UNM biologist Jim Brown and his then graduate student Brian Enquist were investigating how characteristics of living things vary according to body weight. Turns out there are constants across the scale. For example, both the blue whale and the shrew have a lifetime allotment of about a billion heartbeats; the tiny mammal just uses them up faster. Similarly, the human aorta is much larger than that of a mouse, but the capillaries of each species are nearly identical because the cells they're feeding are the same size. Surely there was a way to quantify these commonalities (which extend to the plant kingdom, too). For help with the mathematical modeling, the biologists called on West, who, coincidentally, had already been thinking about this puzzling question. After their first meeting, the physicist thought, *Oh, this is hopeless*. That was 10 years ago. Once the team put in the time and effort to build a shared vocabulary, methodology, and research plan, they produced acclaimed results. Both Brown and West say it's the most exciting, rewarding scientific work they've ever done.

SFI's list of research collaborations is a long and impressive one, connecting disciplines, institutions, and continents, all on an annual budget a behemoth like Harvard would use to wipe its nose. Indeed, the daily fluctuation alone of that university's $22.6 billion endowment would fund the center for years. On a recent flight, West chatted with the passenger next to him about the institute. The man was shocked. "You do all that on $80 million a year?" "No," the president corrected him, "*eight* million." Government and foundation grants supply about half that total; private contributions and corporate supporters—the Business Network—chip in about a quarter each.

Launched in 1992, "Biz Net" now boasts some 60 affiliates in finance, government, auto manufacturing, and high tech. Companies such as Boeing, Intel, Procter & Gamble, and Toyota shell out $35,000 a year for the "aha's" that keep them competitive. Honda, for example, sends its R&D scouts to scoop

**"You can wait for serendipity to strike while you're in the shower, or you can opt for a methodology for innovation."**

**—JAY SMETHURST**

projected consumer and technology trends. Says Sente Corp. director Jay Smethurst, "Business *is* innovation. You can wait for serendipity to strike while you're in the shower, or you can opt for a methodology for innovation—a disciplined process for creative combination. I know of no better source for that than the Santa Fe Institute."

In an ideal world, Geoffrey West says, there should be no need for SFI. The multidisciplinary, freethinking approach would be integrated into the mainstream. But until that mythical day arrives, the president says, in order to satisfy not only the mavericks and the dreamers but also the conceptual demands of an ever-more-complex, delicate, and interdependent world, "by God, there *better* be a Santa Fe Institute." SF