



Update

November / December 2011



Information theory – and the complex relationships between information-theoretic measures, as depicted in this collage – played a critical role in the January SFI workshop on “Randomness, Structure, and Causality.” (Image: Gabriel Garcia)

Seeking a ‘calculus of complexity’ 22 years later

Jim Crutchfield harkens back (with a detectable amount of romance) to a historic 1989 SFI workshop at which a who’s who of chaos theorists began a speculative effort to devise a way to measure what they were seeing in many kinds of complex adaptive systems – a “calculus of complexity,” as some now call it. In Jim’s view, their imaginations hadn’t yet risen to the challenge.

“We had been thinking of complex systems in terms of their physical principles, trying to

be better bookkeepers for the types of energy and its flow in a system,” he says. But some, such as the meeting’s organizer, SFI External Professor Wojciech Zurek, had begun to think of information as an essential character of complex systems, one of the innovations that has expanded the field’s horizons in the last 20 years.

“The meeting colored much of the evolution of complex systems science since then,” says Jim, an SFI External Professor and

director of the Complexity Sciences Center at UC Davis.

Twenty-two years later a special issue of the journal *Chaos*, published in October, contains more than a dozen papers focusing on the progress made since 1989. The papers, many co-authored by researchers affiliated with SFI, arose from a January 2011 workshop, organized by Jim and SFI External Professor John Machta (physics, Amherst) and attended by a [more on page 4](#)



Think broadly, challenge orthodoxy A Q&A with Faculty Chair Doug Erwin

Doug Erwin has been a part of SFI since the late 1990s, at various times a visiting scholar, a member of the external faculty, chair of the Science Steering Committee, a part-time resident professor, and now (since July 1, 2011) chair of the faculty. The Update sat down with Doug recently to discuss his thoughts, and his plans for SFI science, during his two-year appointment.

Update: You’ve been Faculty Chair for a few months now, and you are splitting your time between Santa Fe and your role as a senior scientist and curator of paleobiology at the National Museum of Natural History of the Smithsonian Institution in Washington, D.C. How are you balancing what looks like two full-time positions?

Doug Erwin: Well, it’s a challenge. When we first started talking about this, there was some disagreement on whether or not this could work, but Jerry convinced me I could do this and still keep my position at the Smithsonian. There are times when I have to put one or the other role first to focus on something I’m doing. But I can never be in one or the other role for long. The big challenge right now is that I’ve been trying to finish up a book. Once that’s out of the way I think it will be easier. But I am not planning to give up my research, so I will be half-time at SFI for the full two years. [more on page 3](#)

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INSIDE SFI

Annual meeting asks when does ‘oneness’ matter?

Different scientific disciplines traditionally approach their subject matters quite differently. Physics tends to focus on generalities and aggregates, whereas biology tends to focus on particularities and individuals.

SFI Distinguished Professor Geoffrey West has remarked, in fact, that had Galileo been a biologist, he might have noted the minutely differing air resistances on the two distinct objects he dropped from the Leaning Tower of Pisa, and perhaps written extensively about how every object falls at a unique speed.

Such differing worldviews can sometimes spark scientific disagreement. This year’s SFI Business Network and Board of Trustees Symposium November 3-5 puts these differences center stage.

“Does the Individual Matter?” looks at the role of individuals in complex systems and [more on page 2](#)

RESEARCH NEWS

Hidden mutations may prompt evolutionary leaps

From drug resistance to eyeballs, organisms are packed with traits that seem to have, at some point, required a quantum leap of adaptation.

A decades-old theory proposing the mechanism responsible for such evolutionary leaps is called cryptic variation, where mutated genes with no immediate function or selection pressure gather in a genome to be expressed collectively in the right conditions.

A recent study gives the concept an empirical nod.

SFI External Professor Andreas Wagner, incoming SFI Omidyar Fellow Evandro Ferrada, and Eric Hayden, all of Switzerland’s University of Zurich, took a ribozyme – RNA that doubles as an [more on page 4](#)

SFI IN THE NEWS

On September 12 in *Time magazine*, SFI Science Board member and External Professor John Geanakoplos weighs in on the complex roles real estate debt and depressed home values play in suppressing an economic recovery.

In a September 13 *Daily Texan* article about the plausibility of the movie *Contagion*, SFI External Professors Lauren Ancel Meyers and Joshua Epstein note the importance of considering the highly interconnected and conditional nature of contagious viruses, actions of responders, and behaviors of people..

A September 13 article in *The Atlantic* mentions SFI research that finds surprising statistical regularities among cities, patterns the researchers relate to an underlying "urban metabolism."

Although the events of 9/11 might seem random and unexpected, they were somewhat predictable, says former SFI Omidyar Fellow Aaron Clauset in a September 13 *Boston Globe* article summarizing what we've learned about terrorism since 9/11.

Researchers, including SFI Professor Cris Moore, have shown one computer security algorithm to be immune to the type of attack that with quantum computers could bring down RSA, the cryptosystem in almost-universal use, according to the September 16 *Science News*.

All animals communicate, but of all the species on Earth, humans alone have language. SFI External Professor Mark Pagel asks why in a September 26 *Santa Fe New Mexican* article.

SFI External Professor W. Brian Arthur argues in an October 10 *McKinsey Quarterly* essay, later cited in the *New York Times*, that a deep, slow, and silent transformation of our economy is taking place today as a second digital economy supplants the physical one.

Research by SFI Distinguished Fellow Murray Gell-Mann and Stanford anthropologist Merritt Ruhlen on the word orders of ancient languages received widespread coverage, including in *USA Today*, *New Scientist*, *MSNBC.com*, the *Huffington Post*, and on Fox News.

SFI Science Board member Richard Lenski has been studying the evolution of 12 strains of *E. coli* since 1988, more than 50,000 generations, an example of the value of long-term datasets, according to an October 17 article in *Wired*.

SFI Professor J. Doyne Farmer and External Professor John Geanakoplos say in a yet-unpublished paper that "hyperbolic discounting," a mathematical method for valuing future events that has been largely rejected by economists for its "irrationality," can for far-future payoffs be more rational than economists' traditional methods, according to the October 21 *New Scientist*.

In the October 24 *Santa Fe New Mexican*, SFI's Chris Wood asks what the evolved brain has that modern computers don't, and suggests that having a more comprehensive understanding of the brain would allow us to apply new computational approaches to problem solving.

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> Oneness

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considers when the components of such systems can be treated as aggregates and their behaviors understood as a whole, and when it is important to pay attention to the unique characteristics and behaviors of the components.

The meeting also will explore the meaning of individuality when nearly all individuals can be broken down into subsystems and subunits.

"There's a hierarchy of scales – one scientist's aggregate is another's individual," notes Chris Wood, SFI's VP for Administration and Manager of the Business Network. He and SFI Faculty Chair Doug Erwin are organizing the meeting.

Traditionally, as you move from the physical to the biological to the social sciences, the more important individuals and their quirks have become. But it will be difficult to predict from a speaker's background – be it physics, economics, or law – how he or she will answer the question in the meeting's title, says Doug. ■



In many cultures and religions the mandala signifies spiritual oneness with the universe. (Image: Gabriel Garcia)

IN MEMORIAM

Former SFI Trustee Bob Galvin died October 11 at the age of 89. He was a member of SFI's Board of Trustees, and at times chairman, from 1995 to 2007. ■

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The *SFI Update* is published bimonthly by the Institute to keep its community informed. Please send comments or questions to John German at jdg@santafe.edu.



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RESEARCH NEWS

Immune system dynamics, monkeys, and the art of maintaining social order

At both the cellular and societal levels, conflict can spread through contagion, and new research by SFI scientists reveals that a healthy society keeps aggressive individuals in check much as a healthy immune system controls infection.

SFI's David Krakauer and Jessica Flack and their colleague Karen Page (University College London) investigated two strategies for mitigating social aggression that Flack had observed in a society of pigtailed macaque monkeys.

In one strategy, monkeys approached aggressors to try to mollify them either before a fight or during a lapse. By contrast, some monkeys directly and aggressively intervened during fights to subdue brawlers. The latter approach, which biologists call policing, was displayed primarily by a small subset of socially powerful monkeys.

To investigate the relative merits of policing versus pacifying, the scientists used math-

ematical models inspired by the dynamics of immune system T and B cells. The models showed that policing, which is similar, roughly speaking, to T cells directly attacking contagions, was the far more efficient strategy for containing aggression. This held so long as the police were socially powerful, as was observed in the macaque society.

"The data indicate that a small subset of the group performs policing, everyone engages in pacifying, and policing is better than pacifying at controlling the escalation of aggression when the policers are powerful," they wrote in *PLoS One*.

They also likened an overly powerful police force to an auto-immune disorder in which an over active immune system attacks healthy cells.

In future work, the researchers intend to explore other parallels between immune system dynamics and social conflict. ■

BUSINESS NETWORK NEWS

Business people and educators ask 'What can we do about education?'

In September in Santa Fe, SFI Business Network members joined national and regional educators to explore the complexities of science, technology, engineering, and mathematics (STEM) education in the United States.

Organized by Rick Stephens and Michael Richey of The Boeing Company, Nora Sabelli of SRI International, and SFI's Ginger Richardson and Chris Wood, the meeting treated STEM education and the U.S. workforce as a complex system. Participants sought underlying causes for the education system not adequately educating the workforce to meet the needs of business and industry.

Shirley Malcom, head of the Directorate for Education and Human Resources Programs at the American Association for the Advance-

ment of Science, felt "it was refreshing to have that kind of conversation with people who know we're totally about complex systems. We were able to talk about nonstandard solutions."

Michael Richey said the result of convening so many diverse thought leaders was "discussions I hadn't heard before."

Nora Sabelli said the meeting offered new ways of thinking. "The interaction between the supporting environment and the educational system is where the problems lie," she added. "It takes time for these ideas to be absorbed."

Ginger Richardson says several new project collaborations have developed from connections made at this meeting. ■

From the editor: Thanks for the 'nonlinearities'

Results of SFI's first T-shirt slogan contest are in. The 35 entries ranged from the laugh-out-loud to the slightly-too-obscure. Mostly they were the nodding-grin variety. Thanks to everyone who entered.

Background: We announced in July we were seeking a couple of catchy new slogans to go on T-shirts that would become mementos for SFI visitors. We were looking for slogans that are infectious, nerdy, and a bit irreverent. Above all, winning slogans needed to demonstrate an insider's understanding of SFI and complexity science.

After an initial round of judging in which entries were rank-ordered based on the preferences of a few dozen people hanging around SFI one afternoon, SFI's President's Group considered the list and picked three winners. Here they are, in no particular order.

- **Where Intelligence Isn't Artificial**, submitted by Don Heitler. (Don, a CPA, says this proves more or less that accountants sometimes have a creative side.)

- **Undisciplined Science**, submitted by External Professor Stephan Mertens. ("Undisciplined Science" also happens to be the title of a blog by Stephan's friend Brian Hayes, who gave his permission to re-use it.)

- **Transcending meta-inter-multi-trans-disciplinarity**, adapted by SFI's President's Group from a slightly less-hyphenated version submitted by me (awkward!). I feel obligated to point out that I had no say in the judging, and like all the entries my submission remained anonymous throughout the process.

T-shirts with these slogans are available now for \$20 each at SFI's front desk – in red, blue, and black, respectively – for as long as supplies last.

Some other clever entries (wish we could print them all):

- **SFI: Modeling Everything But Clothing**

- **So Complex Only We Know What We're Talking About**

- **The Magic Happens at Afternoon Tea**

- **SFI: Indescribable by Standard Theories**

- **Revenge of the Undisciplined**

- **The Simplest Theories of Everything Anywhere**

- **Nonlinearitee** (thanks for the headline, Patrick Andrews)

- **Makin' Tea, Takin' Names**

Heitler and Mertens have received SFI's long-time favorite fundraising memento, the Murray Gell-Mann bobble head doll, signed by Murray, and they and Hayes will get T-shirts with their slogans on them.

– John German (jdg@santafe.edu)

Video: SFI's David Krakauer explores the extraordinarily convergent theories from math, physics, computation, and biology describing the emergence of intelligence on Earth, and speculates about the future for biological intelligence in a world of distributed thinking machines. Source: Stanislaw Ulam Memorial Lecture Series.

Video: SFI's Geoffrey West and Luis Bettencourt explain how the constraints of networks define the "metabolism" of all cities. Source: SFI-produced video.

Video: SFI Professor Doyne Farmer discusses a project to create an agent-based model of the U.S. economy. Source: Institute for New Economic Thinking video interview.

Video: Molly Van Houweling explores what free access to digital media and blurring of the copyright laws mean for the legal system, for platform owners (such as Facebook and YouTube), for digital media consumers, and for those who create new content in our digital world. Source: SFI Community Lecture.

Video: SFI External Professor and Yale economist John Geanakoplos argues for banks to write down the balances on upside-down mortgages to spur an economic recovery. Source: MSNBC's Squawk Box.

Video: SFI External Professor Mark Pagel asks why, of all the species on Earth, humans alone have language. Source: 2011 TED Global presentation.

Video: SFI Professor Sam Bowles discusses economic inequality in America, the evolution of altruism in the human species, and his new book. Source: "Report from Santa Fe" interview with Lorene Mills.

Video: SFI Distinguished Professor Geoffrey West and External Professor Raissa D'Souza offer perspectives from their fields on the nature of time. Source: Foundational Questions Institute conference presentation.

Video: SFI's Omidyar Fellows describe their research pursuits and the scientific freedom offered by the Omidyar Fellowship. Source: Three SFI-produced videos.

RESEARCH NEWS

Old sentences with verbs likely ended

The proto-language from which most modern languages descended likely featured a Yoda-like verb-last sentence structure, suggest SFI Distinguished Fellow Murray Gell-Mann and Stanford anthropologist Merritt Ruhlen in a paper published in *PNAS*.

The researchers utilized a tentative family tree for 2,135 past and present languages, placing



Murray Gell-Mann

languages on the tree based on comparisons of similar sounds with similar meanings.

They note that most attested languages – including languages spoken now and recent languages for which we have written examples – follow a subject-object-verb (SOV) sentence structure, such as "He the bear killed."

According to the tree, languages that feature a subject-verb-object (SVO) word order, such as English, descended from SOV languages, as did languages featuring the more rare VSO and VOS word orders and the very rare OVS and OSV word orders.

Reverting to SOV was unusual and in those cases reversion can be attributed to a process known as borrowing, or diffusion, from one language to another, they say.

"Many linguists have concluded that word order changes have washed back and forth long enough to produce a kind of equilibrium," says Murray. "We disagree. The evolutionary path of word order changes can, in most cases, be reconstructed, and we find that it moves away from SOV, most often to SVO."

The question of how long ago this proto-language was spoken is unresolved – some say 50,000 years ago, others, such as Murray, suggest it could have emerged from a much more recent linguistic bottleneck. ■

PEOPLE

Rebecca Goldstein is 4th Miller Scholar



Novelist and philosopher Rebecca Newberger Goldstein is SFI's fourth Miller Scholar. She arrived in late September and plans to stay at least two months.

While at SFI she is working on her new

book, *Dialogues Out of Time: Plato Debates His Critics*, which, she says, argues for the "empirical stubbornness" of some of the problems Plato introduced. The book is interspersed with dialogues of the sort Plato wrote. She has him debating both famous intellectuals and others in contemporary contexts – for example, discussing whether crowd-sourcing answers ethical questions during a visit to the Googleplex, or exploring the question of personal identity while he is having an MRI.

"The issues Plato raised are, with modifications, still percolating in our society today," she says. "The book is not as much about Plato *per se* as it is about the ethical, metaphysical, and epistemological problems that are still with us. The book is meant for a popular audience, but I probably say enough that's philosophically interesting so as to get philosophers riled up against me."

Goldstein, who holds a PhD in philosophy from Princeton, has published nine books of both

fiction and nonfiction that entangle emotion, intellect, and science. Among her novels are *The Mind-Body Problem*; *Properties of Light: A Novel of Love, Betrayal, and Quantum Physics*; and *Thirty-Six Arguments for the Existence of God: A Work of Fiction*. Her two nonfiction books are *Incompleteness: The Proof and Paradox of Kurt Gödel* and *Betraying Spinoza: The Renegade Jew who Gave Us Modernity*.

Currently she is a research associate in the psychology department at Harvard. She has been a professor of philosophy at Rutgers, Barnard, and Trinity College. In 2011 she was named Humanist of the Year by the American Humanist Association. She is a MacArthur Fellow, a Guggenheim Fellow, and a Radcliffe Fellow, as well as a member of the American Academy of Arts and Sciences.

Former Board Chair Bill Miller underwrites the Miller Scholars program to bring to SFI high-profile intellectuals, formalizing the notion that a diverse environment made up of thoughtful people from a variety of fields, including the sciences and the arts, is one reason the Institute is a source of ideas and tends to attract thoughtful, interesting people.

Previous SFI Miller Scholars were philosopher Daniel Dennett, quantum physicist Seth Lloyd, and actor-playwright-director Sam Shepard. ■

> Q&A with Doug Erwin continued from page 1

Update: What originally brought you to SFI?

Doug: When I read Brian Arthur's book on increasing returns [*Increasing Returns and Path Dependence in the Economy*, University of Michigan Press, Ann Arbor, 1994] it really resonated with the work I was doing in paleontology and how evolutionary innovation happens in biological systems. I think economics and evolution are about the same thing: the distribution of scarce resources by intelligent agents. Economics and evolution are, in fact, descended from the same field. Thomas Malthus gave his ideas to Charles Darwin. So there is a long intellectual link between the two. The hard problem is whether you can move beyond metaphor and find some underlying traction. I think you can. In the last couple of years I have been using ideas from economics a lot more, such as positive feedbacks, and applying them to issues of evolutionary innovation. And I keep finding connections. Jennifer Dunne and I have done some research on food webs in the paleontological record. Doyme Farmer and I, over lunch and tea, have worked out an idea to study the evolutionary patterns of hedge funds. So the more time I spend at SFI, the more ideas I find to work on. I think that's the experience of everyone here.

Update: How has the Institute changed?

Doug: The first thing that comes to mind is the emphasis on data. When I got here, SFI was becoming more involved with empirical datasets. It had been almost purely theoretical. With the data revolution in science, we are all swimming in data, to the point where we almost need to go back the other direction and develop the theory with which to understand the data. In many fields, such as high-energy physics and astronomy, they actually throw away more data than they use. Confronted with that problem, there are, I think, two paths. You can say, well, all we can do is describe the patterns we see. The other is to say, well, we need theory to know what we are looking for in the data.

Another shift I have seen at SFI is that the [Omidyar Fellowship] has continued to grow and to become a central activity. That is today a major strength of SFI. Also, and I'm not sure if this is a positive or a negative, there are far fewer workshops than there were 10 or 15 years ago. There is a tendency now toward smaller and shorter-duration working groups. Finally, a trend that I think is not unique to SFI but is part of a broader trend within the sciences is that there are fewer crazy ideas. That reflects, I think, a maturing of SFI. SFI has always been good at, and maybe needs to be better at, allowing people the freedom to challenge assumptions and ask out-of-the-box questions. The sort of thing that Eric Smith has been doing in his work with Harold Morowitz on the origins of life. We need to make sure we have a place for people to do that. I'm really glad to see that Simon DeDeo has started up the Friday-afternoon "Reckless Ideas" discussions.

Update: How is SFI science doing?

Doug: I think we're doing well, overall. The challenge we have is making sure that we're asking broad enough questions. That's one of my responsibilities: challenging people to ask questions they couldn't ask if they were at a university or federal institution, where creative thinkers are selected out. For example, should we be studying human migration patterns in one area of the world during a particular time period? My answer is no. There are dozens of scientists around the world probably asking that same question. But if we ask what do human migration patterns in many parts of the world at many different time periods have in common, and what demographic and social conditions drove those migrations, and what do those similarities and differences tell us about the human species, that is a better question for SFI.

One thing I would like to see more of is a focus on themes that cross-cut the research here, themes like robustness, networks, and (one I hope will develop) resilience. We've learned after 9/11 and after the financial crisis that many of our complex systems are not now resilient, and we can do a lot better. I think we can learn a lot about biodiversity and other important issues through a better understanding of resilience. So a theme like that is both broadly important to SFI and also has a lot of inherent societal value, and so it is a perfect fit for SFI. We're talking about hosting theme weeks starting next year in which we invite outside experts and encourage many members of the external faculty to come, and we essentially devote an entire week to a single theme. Out of that we hope will come new initiatives and workshops and working groups that lead to interesting new collaborations.

Update: In your view, what is SFI's special role in the world?

Doug: It's creating the space and encouraging people to ask questions across disciplines, and to continue to broaden those questions. In the last couple of years we've seen studies of the evolution of cultures and the laws of history. We've continued to make inroads into the social sciences while solidifying our foundations in physics and mathematics and biology.

One thing I've been asking myself is if people like Doyme Farmer or Brian Arthur were 25 again, would they be able to do at SFI what they did in the 1980s. There are lots of transdisciplinary research centers around the world these days, but not everybody is good at picking out and nurturing these types of thinkers. We've done pretty well for the last 27 years, but it's getting harder and harder to do that. We should make sure this is a safe place to think in an unorthodox way, and encourage that revolutionary spirit. ■

> **Hidden mutations** continued from page 1

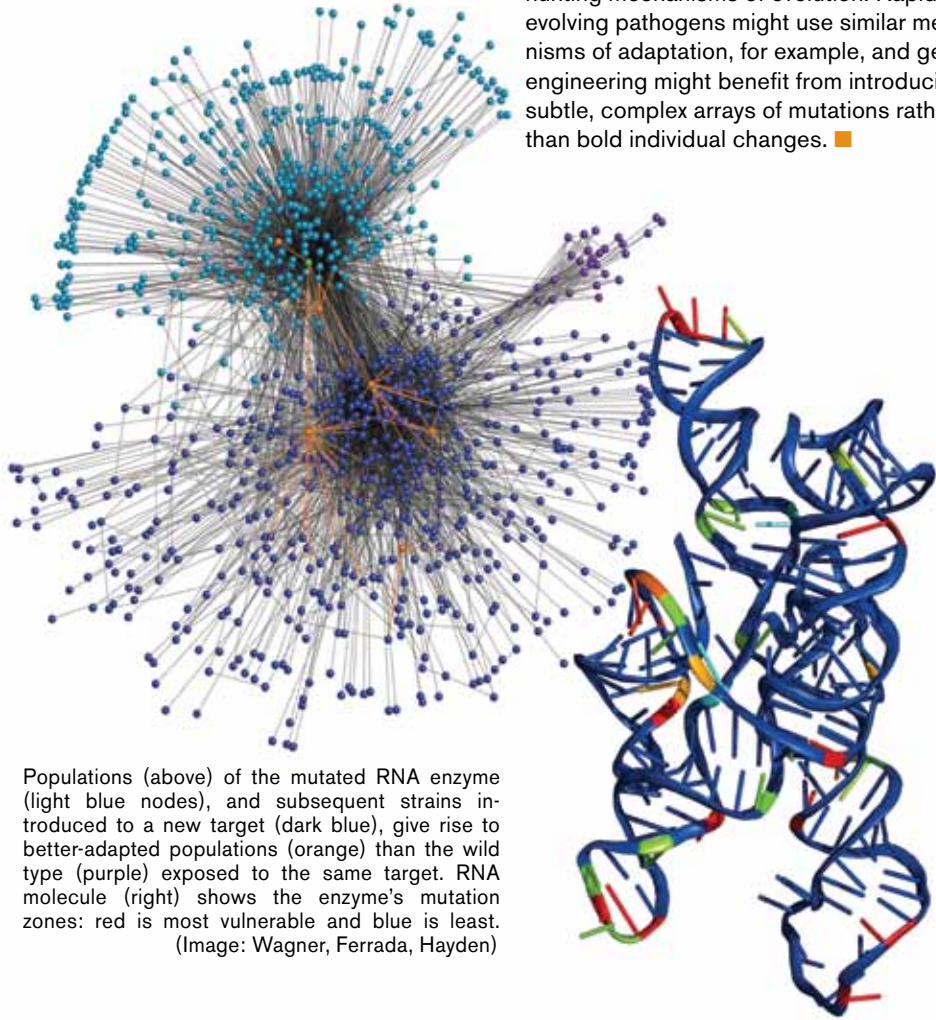
enzyme – from a hardy bacterium species and introduced mutations in two populations, with one population being cultivated in adverse chemical conditions. All later generations performed their main enzymatic function well, despite being loaded with mutations.

The team then gave the ribozyme a slightly more challenging molecule to catalyze and observed how well the enzyme worked on it. Those mutant ribozymes that were descended from the chemically stressed line adapted

to the task much faster than the other line, and both fared better than a wild population. The best adapters had specific combinations of changes to their genotypes.

“Thanks to RNA’s double duty, we could analyze both their fitness and their genome throughout the stages of mutation and adaptation,” says Evandro. “The study is the first to empirically demonstrate that genetic variation ‘unseen’ under certain conditions can foster adaptation under others.”

This finding could offer a new pathway in hunting mechanisms of evolution. Rapidly evolving pathogens might use similar mechanisms of adaptation, for example, and genetic engineering might benefit from introducing subtle, complex arrays of mutations rather than bold individual changes. ■



Populations (above) of the mutated RNA enzyme (light blue nodes), and subsequent strains introduced to a new target (dark blue), give rise to better-adapted populations (orange) than the wild type (purple) exposed to the same target. RNA molecule (right) shows the enzyme's mutation zones: red is most vulnerable and blue is least. (Image: Wagner, Ferrada, Hayden)

INSIDE SFI

Krakauer to lead Wisconsin Institute for Discovery at UW-Madison



SFI Professor David Krakauer has been named the first permanent director of the Wisconsin Institute for Discovery at the University of Wisconsin-Madison, a center for the transdisciplinary study of human health.



SFI Professor Jessica Flack will co-direct (with David) a Center for Complex Systems and Collective Computation at the university that builds on their work in Santa Fe.

The two announced their plans to the SFI community on September 20.

“We both very much view this as an opportunity to expand the great experiment of SFI in breaking down barriers to new knowledge, and bringing to a university and research laboratory setting the spirit of complexity science,” David wrote in a farewell email to SFI’s scientists and staff.

He added: “The SFI community has instilled in us values and ideas that are fundamental and important enough to transform the academic landscape, and we feel privileged to be a part of both the SFI network and to be helping to shape the nascent innovative vision of the WID at UW-Madison. We shall remain affiliated with SFI and hope that this next step in our lives will help to promote a vision of science centered around curiosity, discovery, and synthesis. We shall miss our many friends, the extraordinary atmosphere of SFI, and the mojo of Santa Fe, but we shall remain actively engaged and seek to build bridges between SFI and the WID that will enrich both communities. Thanks to everyone, researchers, trustees, staff and community who have helped to make our lives so enjoyable.”

The WID’s current research focuses include tissue engineering scaffold research, living environments laboratory, systems biology, epigenetics, and optimization. Krakauer plans to expand the institute’s portfolio and broaden the set of contributing disciplines. ■

> **Calculus of complexity** continued from page 1

subset of today’s vanguard of complex systems theory.

“Many of us felt it was time to revisit the questions, and to ask what innovations are needed for the coming decades, as complex systems ideas continue to extend their influence in the sciences and humanities,” he says.

The five-day January meeting, titled “Randomness, Structure, and Causality,” focused on whether complexity measures and mechanisms are, on a theoretic level, “one size fits all” for vastly different kinds of systems, or whether they are by necessity tied to the specific kind of complex system being studied; in other words, can complexity in a quantum system be measured in the same way as complexity in an ecological system or financial market?

The group included representation from physics, biology, computer science, social science, and mathematics, with particular emphasis on those who have constructively bridged both theory and experiment.

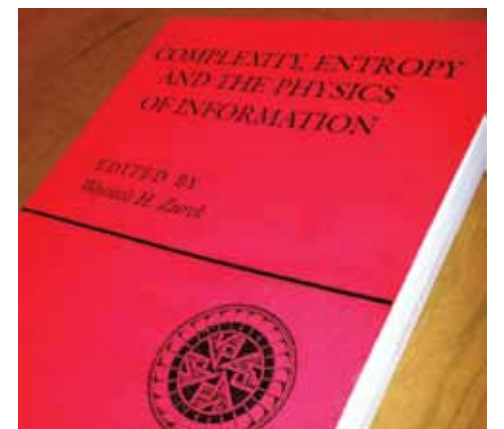
The verdict: “We’ve made good on, say, half of our original hopes, which is quite satisfying,” Jim says. “Our conceptual foundations are more clearly developed today. We’ve seen huge increases in the technical depth in defining and measuring complexity. We have models and algorithms for working with real data. We can talk in a rigorous way about how ‘patterned’ a system is. Our questions are much more precise.”

But complexity theorists still face challenges. “I am optimistic we can make good on the promise of a ‘physics of information.’ We can open up physics-style modeling to other kinds of systems and disciplines, not on a domain-by-domain basis, but based on fundamental principles of complexity,” he says.

He also worries about education. “At some point our new understandings need to be translated out of the journals and into graduate programs and textbooks,” he says.

The meeting re-enthused Jim. “I realize I am probably as ignorant now of where we’ll be in 20 years as I was then about where we would be today, but at least I can see the progress.”

Chaos Volume 21, Issue 3 is available online at <http://chaos.aip.org/>. ■



Proceedings of the 1989 meeting.

Achievements



SFI Trustee Pierre Omidyar and his wife **Pam Omidyar** were awarded the Carnegie Medal of Philanthropy at a New York Public Library ceremony on October 20. The Omidyars

were one of nine families/couples being recognized by the Carnegie family of organizations for their philanthropic work and contributions to society.



SFI External Professor Hans Joachim Schellnhuber on October 4 was awarded Germany’s Order of Merit, first class, by German President Christian Wulff for his “great commitment that has significantly contributed to a general change in awareness in national and international climate policies.” In September

he was awarded the 2011 Volvo Environment Prize. John is founder and director of the Potsdam Institute for Climate Impact Research.



SFI External Professor Lauren Ancel Meyers

has been named the new director of the Division of Statistics and Scientific Computation at The University of Texas at Austin. She

is known for her network-based mathematical methods to study the complexity of disease transmission, human behavior, and the evolution of pathogens. She is a former SFI postdoctoral fellow.



SFI External Professor Santiago Elena is among

46 life scientists recently elected to lifelong membership in the EMBO, an organization of 1500 leading scientists that seeks to shape careers and influence science and research policy in Europe. Elena is a professor in the Evolutionary Systems Virology Group at the Instituto de Biología Molecular y Celular de Plantas (Spain).

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