



Update

July / August 2011



(Image: Gabriel Garcia for SFI)

Evolving software inspired by biology

You probably wouldn't call a biologist to fix your computer, but new research suggests that ideas from biology could be the key to quickly fixing problems in the computer software we rely on.

Maintaining software costs some \$70 billion annually just in the U.S., says SFI Science Board co-chair and University of New Mexico computer scientist Stephanie Forrest. Debugging programs is a major part of that cost.

It's an overwhelming task for human programmers, who in some cases face hundreds of newly discovered glitches every day, she says. Worse, some of those bugs make software more vulnerable to hackers. "We can't afford to wait," she says.

Stephanie and her colleagues are applying a biologically inspired approach to software debugging called "evolutionary computation" – a kind of natural selection for software. In effect,

it starts with a glitchy program, creates a group of slight variations on the original, and keeps the best variations as part of the next generation of the program. Then, repeat until the software does what it's supposed to do.

The Defense Advanced Research Projects Agency recently awarded Stephanie and her collaborators \$3.2 million over four years to develop the idea.

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BUSINESS NETWORK NEWS

Software complexity for business

A May 11 SFI Business Network topical meeting in Boston, held at and co-organized by Fidelity Investments, brought together the latest academic research on software complexity with some of the concrete challenges industry faces with large, highly co-evolved, and connected software systems.

Speakers included SFI Science Board co-chair Stephanie Forrest on evolutionary computation; SFI External Professor Cosma Shalizi on how to measure complexity in science and technology; Carnegie-Mellon computer science professor Ed Clarke on model checking as a highly effective verification technology; and Lockheed Martin Chief Scientist Ned

Allen on verifying and validating large-scale software systems.

Chris Wood, SFI Director of the Business Network, says the collaboration between SFI and Fidelity resulted in a "compelling exploration of a topic of great import for the corporate and business community." ■

RESEARCH NEWS

Study: Complex technologies improve more slowly

It's no secret that the complexity of a technology's design influences how easy it will be to modify. A satellite simply has more parts than a toaster, and how each of the satellite's parts functions depends more integrally on the functionality of all the other parts.

A new study by several SFI-affiliated researchers demonstrates a way to measure the interconnectedness of a technology's components and predict which technologies are likeliest to advance rapidly and which, due to their complexity, are likely to improve more slowly.



(Image: www.istockphoto.com)

Knowing this can help policy makers make better investment decisions between, for example, two renewable energy technologies, or help engineers create designs with better prospects for improvement. The paper appeared in the May 16 PNAS.

The researchers devised a way of mathematically modeling complexity, breaking a system down into its individual components and then mapping the interconnections among these components.

"It gives you a way to think about how the structure of the technology affects the rate of

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INSIDE SFI

Doug Erwin is SFI's new faculty chair

SFI Professor Doug Erwin, senior scientist and curator of paleobiology at the National Museum of Natural History of the Smithsonian Institution, has begun his term as SFI's Chair of the Faculty. His appointment began July 1, 2011, and ends June 30, 2013.

A longtime member of SFI's research community, Doug holds a PhD from UC Santa Barbara. His research focuses on major evolutionary transitions, evolutionary innovation, and diversification, especially as they relate to mass extinction and recovery events. He has attempted to understand both the role of developmental invention in generating novel

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INSIDE SFI

2011 Ulam Lectures ponder intelligence

From the formation of the earth from interstellar dust it has taken just under five billion years for matter to be able to speculate about its own origins. But how did intelligence come to be, and what is intelligence anyway?

In a series of three community lectures in Santa Fe themed "Cognitive ubiquity: The evolution of intelligence on earth," SFI Professor David Krakauer will explore the many theories and observations that bear on the emergence of intelligence.

This year's SFI Ulam Memorial Lecture series will be held at the James A. Little Theater in Santa Fe. All lectures begin at 7:30 p.m. Admission is free, but seating is limited. The 2011 Ulam series is generously underwritten by the Peters Family Foundation.

• **Part one: The adversarial quartet, Tuesday, August 30.** Starting with our efforts to define and measure order and intelligence, David will survey key ideas from the history of mathematics, physics, computation, and biology that have somewhat extraordinarily converged on very similar explanations for adaptive and intelligent behavior.

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LIT BITS

Ecospace utilization during the Ediacaran radiation and the Cambrian eco-explosion; Bush, A.M.; Bambach, R.K.; **Doug Erwin**; *Quantifying the Evolution of Early Life: Numerical Approaches to the Evaluation of Fossils and Ancient Ecosystems*, 2011

Finite size scaling in the local abundances of geographic populations; Abades, S.R.; **Pablo Marquet**; *Biological Research* 44 (1), 2011

Is liberal society a parasite on tradition? **Sam Bowles**; *Philosophy & Public Affairs* 39 (1), Winter 2011

Phenotypic plasticity can facilitate adaptive evolution in gene regulatory circuits; Espinosa-Soto, C.; Martin, O.C.; **Andreas Wagner**; *BMC*

Evolutionary Biology 11, January 6, 2011

Topological similarities in electrical and hydrological drainage networks; Soni, V.H.; Ketisch, P.M.; Rodriguez, J.D.; Shpunt, A.; **Alfred Hübler**; *Journal of Applied Physics* 109 (3), February 1, 2011

maxAlike: Maximum likelihood-based sequence reconstruction with application to improved primer design for unknown sequences; Menzel, P.; **Peter Stadler**; Gorodkin, J.; *Bioinformatics* 27 (3), February 1, 2011

Dynamics of molecular evolution and phylogeography of barley yellow dwarf virus-PAV; Wu, B.L.; Blanchard-Letort, A.; Liu, Y.; Zhou, G.H.; Wang, X.F.; **Santiago Elena**; *PLOS One* 6 (2), February 4, 2011

Nonparametric sparsification of complex multiscale networks; Foti, N.J.; Hughes, J.M.; **Dan Rockmore**; *PLOS One* 6 (2), February 8, 2011

Structural discrimination of robustness in transcriptional feedforward loops for pattern formation; Rodrigo, G.; **Santiago Elena**; *PLOS One* 6 (2), February 14, 2011

Virus infection suppresses *Nicotiana benthamiana* adaptive phenotypic plasticity; Bedhomme, S.; **Santiago Elena**; *PLOS One* 6 (2), February 17, 2011

Universal scaling of production rates across mammalian lineages; **Marcus Hamilton**; Davidson, A.D.; Sibly, R.M.; **Jim Brown**; *Proceedings of the Royal Society B – Biological Sciences*

278 (1705), February 22, 2011

Optimal H1N1 vaccination strategies based on self-interest versus group interest; Shim, E.; **Lauren Ancel Meyers**; Galvani, A.P.; *BMC Public Health* 11 (suppl.), February 25, 2011

A simple derivation and classification of common probability distributions based on information symmetry and measurement scale; Frank, S.A.; **D. Eric Smith**; *Journal of Evolutionary Biology* 24 (3), March 2011

Historical changes in marine resources, food-web structure, and ecosystem functioning in the Adriatic Sea, Mediterranean; Lotze, H.K.; Coll, M.; **Jennifer Dunne**; *Ecosystems* 14 (2), March 2011

Achievements



SFI External Professor Mark Pagel, a professor of biological sciences at Reading University (U.K.), has been named a Fellow of the Royal Society. He joins some 1,500 current Royal Society Fellows who constitute the U.K.'s most eminent scientists, engineers, and technologists. Fellows are elected through a peer review process and a vote by existing fellows.



SFI Science Board co-chair and External Professor Marcus Feldman, the Wohlford Professor of biological sciences at Stanford University, has been named a member of the American Philosophical Society, an honorary society of some 1,000 top scholars from a variety of disciplines. Fellows are nominated by current members and elected annually in April.



During its annual Technology Excellence awards ceremony in Albuquerque on June 3, the New Mexico Technology Council gave one of two Marc Orchant Maximum Impact Awards for 2011 to SFI Project GUTS Principal Investigator Irene Lee. The award is given to the persons or groups that epitomize the best service and impact to the tech industry in New Mexico.

Upcoming public lecture

The ecology of indoor environments: Microbial diversity and sustainable well being. Wednesday, August 17. The vast majority of earth's species are microorganisms. Recent advances in quantifying and visualizing microbial diversity in nature have prompted a new era of microbial exploration, one that builds on the foundations of well established plant and animal biodiversity research. SFI External Professor Jessica Green will explain how microbial biodiversity in the indoor environment influences sustainability and human well being. At the University of Oregon, Green is an assistant professor in the Center for Ecology and Evolutionary Biology and director of the Biology and the Built Environment Center.

Los Alamos National Bank is sponsoring the 2011 SFI community lecture series. All lectures are at the James A. Little Theater in Santa Fe and begin at 7:30 p.m. Admission is free, but seating is limited. ■

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The *SFI Update* is published bi-monthly 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

Clio, Greek muse of history, gets her science on

Researchers at SFI are teaming up with Clio, the ancient Greek muse of history, to construct a new field that seeks to transform the study of historical events and trends into a formal and (largely) quantifiable science. They call the field cliodynamics.

Historians ordinarily study history as a chain of idiosyncratic events, with each event a unique response to unique circumstances. Cliodynamists, on the other hand, seek to understand history as a science, with different circumstances being driven by common, universal forces. They search out the patterns that lie underneath the apparent chaos.

A new journal, *Cliodynamics*, was launched this year, edited by Peter Turchin, a former visiting professor at SFI, and professor of ecology, evolutionary biology, and mathematics at Duke University.

History is a late-comer to the scientific perspective, according to Turchin. "In order to do history, you have to understand anthropology, ecology, political science, economics," he says, "so it almost has to be the last social science to become mathematized."

The tools of complexity science are now beginning to make the task tractable, he says. Researchers are applying mathematical and computational techniques like agent-based models, power law relations, and more classi-



(Image: Gabriel Garcia for SFI)

cal differential-equation models to understand and predict the outcome of historical events.

The second issue of the journal published recently, a special edition titled "History, Big History and Metahistory," was edited by SFI Professor and outgoing Faculty Chair David Krakauer, John Gaddis (Yale), and Ken Pomeranz (UC Irvine). It is rife with contributions from SFI researchers:

- Incoming Faculty Chair Doug Erwin explores how paleontologists deal with the vagaries of preservation and how statistical techniques developed in biology have been applied to textual evidence.
- Distinguished Fellow Murray Gell-Mann illustrates how apparently complex histories and patterns can sometimes be organized using simple models of growth and scaling.
- David Krakauer shows how history often uses analogs of concepts and tools expressed quantitatively in the natural sciences and introduces concepts from non-linear dynamics, statistical physics, and evolutionary biology that he believes should be useful to students of history.
- Distinguished Professor Geoffrey West argues that historians have had trouble finding common patterns because they have focused on individuals; studying collective phenomena, such as urban systems, might lead to surprising new discoveries.

The issue will be published as an e-book by SFI Press.

"A historical chronicle is like a random sequence, with very high complexity," David says. "But if there's a pattern, you can dispense with details and give a more parsimonious description. This parsimonious description can help reveal the general principles of historical dynamics as they apply across fields." ■

INSIDE SFI

SFI appoints inaugural Cowan Chairs

SFI has selected three eminent scholars as the first George A. and Helen Dunham Cowan Chairs in Human Social Dynamics, to be referred to as the Cowan Professors.

George Cowan is SFI's founding president. He endowed the chair to attract leading social science researchers who have applied rigorous scientific methods in their fields, and who offer perspectives that are complementary to existing SFI research, says SFI Professor and outgoing Faculty Chair David Krakauer.

"We want to bring in accomplished scientists to spend significant time at SFI, and who will help link existing research and catalyze interactions with and among of our resident faculty," he says.

The three-year appointments began July 1, 2011, and end June 30, 2014.

Robert Boyd, a longtime SFI External Professor and a professor of anthropology at UCLA since 1986, received his PhD in ecology at UC Davis. He has taught at Duke and Emory universities. Much of his research focuses on population and dynamic models of culture, and he has published on the evolution of social behavior, especially reciprocity and collective action. He brings a game theory and dynamics approach to questions of cultural evolution.

Ricardo Hausmann, director of the Center for International Development and professor of the Practice of Economic Development, both at Harvard, earned a PhD in economics at Cornell University. In addition to positions with the government of Venezuela, he served as the first chief economist of the Inter-American Development Bank and as chair of the IMF-World Bank Development Committee. His research interests include issues of growth, macro-economic stability, international finance, and the social dimensions of development. He brings a networks and statistical mechanics perspective to developmental economics.

Mahzarin R. Banaji, currently the Richard Clarke Cabot Professor of Social Ethics at Harvard, received her PhD from Ohio State University in 1986 and was a National Institutes of Health postdoctoral fellow at the University of Washington in Seattle. She is an experimental psychologist who studies human thinking and feeling as it unfolds in social contexts. She is interested in the sub-conscious nature of assessments of self and other human beings that reflect feelings and knowledge about social group membership. She brings a cognitive science and psychology perspective to existing SFI programs related to behavior and decision-making. ■

> 2011 Ulam Lectures continued from page 1

- **Part two: Invasion of the inferential cell, Wednesday, August 31.** David will recount the evolution of life on earth focusing on the advent of increasingly complex forms of behavior and thought, identifying the common principles of intelligent biological systems, from microbes to mollusks to mammals.
- **Part three: All watched over by machines of loving grace, Thursday, September 1.** David will consider the future of biological intelligence in a world of distributed machine intelligence, where there is a prospect of new cultural mechanisms capable of eclipsing the analytical capabilities of our own species.



David's research is concerned with the evolutionary history of information processing mechanisms in biology and culture, with an emphasis on robust information transmission, signaling dynamics, and their role in constructing novel, higher level features. The research spans several levels of organization, finding analogous processes in genetics, cell biology, microbiology, language, and in organismal behavior and society.

SFI's Ulam Memorial Lecture series is named for Polish mathematician and Manhattan Project contributor Stanislaw Ulam (1909-1984). More information at www.santafe.edu/. ■

LIT BITS (cont.)

The transmission sense of information; **Carl Bergstrom**; Rosvall, M.; *Biology & Philosophy* 26 (2), March 2011

The evolutionary genetics of emerging plant RNA viruses; **Santiago Elena**; Bedhomme, S.; Carrasco, P.; Cuevas, J.M.; de la Iglesia, F.; Lafforgue, G.; Lalic, J.; Prosper, A.; Tromas, N.; Zwart, M.P.; *Molecular Plant – Microbe Interactions* 24 (3), March 2011

The Red Queen theory of recombination hotspots; Ubieda, F.; **Jon Wilkins**; *Journal of Evolutionary Biology* 24 (3), March 2011

Long-term change within a neotropical forest: Assessing differential functional and floristic responses to disturbance and drought;

Brian Enquist; Enquist, C.A.F.; *Global Change Biology* 17 (3), March 2011

Analysis of major failures in Europe's power grid; Rosas-Casals, M.; **Ricard Solé**; *International Journal of Electrical Power & Energy Systems* 33 (3), March 2011

Measuring the hierarchy of feed forward networks; Corominas-Murtra, B.; Rodriguez-Caso, C.; Goni, J.; **Ricard Solé**; *Chaos* 21 (1), March 2011

Principles and promise of Fabry-Perot resonators at terahertz frequencies; **Rogier Braakman**; Blake, G.A.; *Journal of Applied Physics* 109 (6), March 15, 2011

Explosive percolation with multiple giant components; Chen, W.; **Raissa D'Souza**; *Physical Review Letters* 106 (11), March 15, 2011

Differences in accumulation and virulence determine the outcome of competition during tobacco etch virus co-infection; Lafforgue, G.; Sardanyes, J.; **Santiago Elena**; *PLoS One* 6 (3), March 15, 2011

Cultivation of cereals by the first farmers was not more productive than foraging; **Sam Bowles**; *Proceedings of the National Academy of Sciences* 108 (12), March 22, 2011

Did modeling overestimate the transmission potential of pandemic H1N1-2009? Sample size estimation for post-epidemic seroepidemiologi-

cal studies; Nishiura, H.; Chowell, G.; **Carlos Castillo-Chavez**; *PLoS One* 6 (3), March 24, 2011

Niche construction on Bali: The gods of the countryside; **Stephen Lansing**; Fox, K.M.; *Philosophical Transactions of the Royal Society B – Biological Sciences* 366 (1566), March 27, 2011

Gene-culture co-evolution and the nature of human sociality; **Herbert Gintis**; *Philosophical Transactions of the Royal Society B – Biological Sciences* 366 (1566), March 27, 2011

Statistically validated networks in bipartite complex systems; Tumminello, M.; Micciche, S.; **Fabrizio Lillo**; Piilo, J.; Mantegna, R.N.; *PLoS One* 6 (3), March 31, 2011

INSIDE SFI

SFI's new 2011 Omidyar Fellows

The Institute has named two new Omidyar Fellows for 2011, selected from more than 200 applicants. The new Fellows will soon join the current Omidyar Fellows now at SFI.

A gift from eBay Founder Pierre Omidyar in 2008 established the Omidyar Fellowship, which aims to attract to SFI early-career scholars from the social, physical, and natural sciences. Omidyar Fellows spend two to three years at SFI as postdoctoral fellows pursuing the research questions of their choice.



Evandro Ferrada holds a PhD in evolutionary biology from the University of Zurich, where he examined protein evolution, specifically the relationship between protein sequences and their structures and functions.

At the Institute, he will be exploring the evolutionary mechanisms that promote innovation and explain the complexity of natural systems, initially by studying genotype-phenotype maps of macromolecular systems.



Charles Perreault holds a PhD in anthropology from UCLA, where he applied concepts of paleontology to study rates of cultural change in the archaeological record. He will pursue a deeper understanding of cultural evolution while at SFI through the use of

theoretical models and cross-cultural comparisons. As part of this work, he will compare the changes brought by evolutionary forces on both cultural and biological phenomenon. ■

PEOPLE

Science & movies flirt in Thor

Science and magical movie worlds are strange and largely incompatible bedfellows, despite Arthur C. Clarke's adage that "any sufficiently advanced technology is indistinguishable from magic." So when it came to trying to connect the mythological world of the film Thor with modern science, SFI External Professor Jim Hartle had his work cut out for him.

Jim, an physics professor emeritus at UC Santa Barbara, got involved in the film as part of the Science & Entertainment Exchange of the National Academy of Sciences – a program intended to connect entertainment industry professionals with top scientists to create a synergy between accurate science and engaging storylines in film and TV programming.

Before filming, he and other scientists met with the film's director, writer, and others about how to incorporate science into the production, he said.

"They were not so much interested in having things being scientifically realistic, which is

impossible [in the portrayal of a superhero universe], but the director Kenneth Branagh thought it would be a better movie if it made reference to things in science that the audience would know about and be interested in," Jim says.

In that vein, the group suggested that Thor live on a D-brane, an object that is part of Superstring Theory, and that Thor arrived on Earth through a wormhole.

"Of course, in the film the wormhole is in this big golden dome and you can steer it around and point it where you want to go, which is not realistic, but at least it had the right name," says Jim.

He says it was an interesting experience working with Hollywood, and he'd be happy to do it again.

"I think the fact that film makers wanted to make scientific references is an affirmation of the importance and popularity of science today," he says. "Also, having the female heroine [played by Natalie Portman] as a physicist is a nice touch." ■

> Erwin, SFI faculty chair continued from page 1

morphologies and how new niches are constructed to facilitate the persistence of these new inventions. Together with colleagues at SFI he has developed models of biotic recovery that can be tested with data from the fossil record.



Doug Erwin

He is the author or editor of six books, including *Extinction: How life on Earth nearly ended 250 million years ago*, published in December 2008. He has served on the editorial boards of a number of journals and in a variety of advisory capacities to

the Smithsonian, NASA, the National Science Foundation, the National Research Council, and other agencies. (More about Doug at <http://paleobiology.si.edu>)

energy, and ideas have strengthened SFI and significantly helped us advance our mission. It has been great to work with him."

Says Doug: "David has done a great job over the past few years, bringing new people into the SFI community and advancing our research goals. After more than a decade of association with SFI, as a visitor, external faculty member, professor, and chair of the Science Steering Committee, I am looking forward to working with Jerry, the faculty, and the rest of the SFI community over the next two years."

Adds Jerry: "I am delighted that Doug has agreed to be our new Chair of the Faculty, and I look forward to working with him. I have known him for many years and I am certain he will be a terrific asset for SFI's leadership team." ■

Faculty appointments

Longtime SFI Professors **Jon Wilkins** and **D. Eric Smith** will end their terms as SFI Professors on August 31, 2011. Based on the recommendations of SFI's Science Steering Committee, SFI President Jerry Sabloff has appointed both as SFI External Professors, beginning September 1, 2011. ■

> Complex technologies continued from page 1

improvement," says corresponding author and former SFI Omidyar Fellow Jessika Trancik, assistant professor of engineering systems at MIT. The paper's co-authors are recent SFI Graduate Fellow James McNerney, SFI Professor Dooyne Farmer, and SFI External Professor Sid Redner.

The team also found that certain patterns of interconnection can create design bottlenecks, causing the pace of improvements to come in lurches rather than at a steady rate.

As part of the study, the team tracked how energy generation technologies improve over time, either through reduced cost or better performance, and in the paper develop a theory that

explains why different technologies experience the rates of innovation they do.

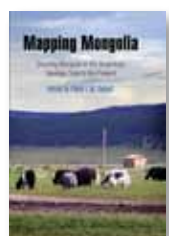
Armed with this theory, they plan to do additional empirical analysis of many different technologies, processes such as supply chains, and infrastructure systems to gauge how effective the model is in practice and how broadly it can be applied.

For now, Jessika suggests, the method is most useful for comparing two different technologies whose components are similar, but whose design complexity is different – two different approaches to next-generation solar cells, for example. ■

SFI BOOK NEWS



In the last decade, the boundary between physics and computer science has become a hotbed of interdisciplinary collaboration. Physicists and computer scientists have a great deal to say to each other, sharing metaphors, intuitions, and mathematical techniques. In *The Nature of Computation* (Oxford University Press, July 2011), SFI Professor Cris Moore and External Professor Stephan Mertens introduce the reader to the fundamental concepts of computational complexity, explain the deep meaning of the P vs. NP question, describe recent results that have not yet appeared in textbooks, and explore the major interfaces between computer science and physics.

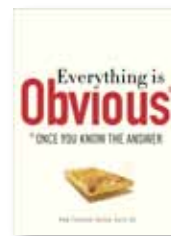


Would marginalized countries such as Mongolia benefit from a reconfiguration of area studies programs or even from another way of thinking about grouping nations? *Mapping Mongolia: Situating Mongolia in the World from Geologic Time to the Present* (University of Pennsylvania Museum of Archaeology and Anthropology, June 2011), by SFI Professor Paula Sabloff, uses Mongolia as a case study to critique the area studies methodology and test the efficacy of the "scapes" method proposed by Arjun Appadurai – which traces individuals' social networks by theme (finance, ethnicity, ideology, media, and technology). Experts from a variety of disciplines contemplate these issues in their chapters on Mongolia through the ages. Their work includes over 30 maps to help situate Mongolia in its geologic, geographic, economic, and cultural matrix.



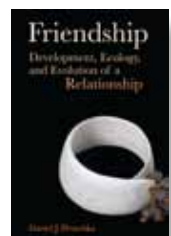
In *A Cooperative Species: Human Reciprocity and Its Evolution* (Princeton University Press, May 2011), SFI Professor Sam Bowles and External Professor Herb Gintis use experimental,

archaeological, genetic, and ethnographic data to demonstrate how human genetic and cultural evolution has produced a species in which substantial numbers make sacrifices to uphold ethical norms and to help even total strangers. They demonstrate that such generous and civic-minded behavior is widespread in human history and cannot be explained by far-sighted self-interest or a desire to help close genealogical kin, contrary to the conventional wisdom in biology and economics.



*Everything Is Obvious: *Once You Know the Answer* (Random House, March 2011) by Duncan Watts reviews recent research and experimentation in social science and social networking and reveals

how commonsense reasoning misleads us into believing we understand more about the world of human behavior than we really do, thus undermining our ability to address complex issues in business, government, and life. A former SFI External Professor, Watts is a principal research scientist at Yahoo! Labs, where he directs the Human Social Dynamics Group.



Former SFI Omidyar Fellow Dan Hruschka's book, *Friendship: Development, Ecology, and Evolution of a Relationship* (University of California Press, September 2010) explores why friends are more generous and cooperative with each other than evolutionary benefit seems to dictate. *Friendship* synthesizes recent cross-cultural, experimental, and ethnographic data to argue that friendship is a special form of reciprocal altruism based not on tit-for-tat accounting or forward-looking rationality, but on mutual goodwill that is built up in human relationships. Dan, an assistant professor at Arizona State University's School of Human Evolution and Social Change, researched and wrote much of the book while at SFI from 2006 to 2009. ■

SFI IN THE NEWS

In two recent columns in the *Santa Fe New Mexican*, SFI Omidyar Fellow Laura Fortunato describes her research of the evolutionary implications of marriage and monogamy, and SFI External Professor Dan Rockmore offers insights about style in art, literature, and music from the emerging field of stylometry.

In an April 29 book review in *Science*, SFI Professor David Krakauer reviews *SuperCooperators*, a new book by Martin Nowak and Roger Highfield about recent research of the evolutionary implications of altruism in human behavior.

In *Scientific American's* "Too Hard for Science" feature on May 10, SFI External Professor Luis Bettencourt describes the

difficulty, and promise, of simulating the human brain.

America needs bold new thinking about growth and markets rather than simplistic rereads, according to a May 20 *National Journal* article that includes remarks from SFI External Professor W. Brian Arthur.

Interactions among people of diverse racial and ethnic groups might help drive the creativity that propels metropolitan economies, according to a June 12 *Boston Globe* article that mentions the work of SFI External Professor Scott Page.

Theorists at SFI are piecing together a model for how the same genes from mothers and fathers behave differently as a child grows, according to a June 13 *Albuquerque Journal* article

describing the work of SFI Professor Jon Wilkins and Omidyar Fellow Jeremy Van Cleve.

The June 20 *Albuquerque Journal* quoted Albuquerque teacher Ashley Ivins about her plans to attend an SFI-George Mason University teacher workshop on the origin of life this summer at GMU.

SFI Distinguished Professor Geoffrey West was among experts at the recent Urban Sustainability R&D Congress in Singapore who pointed out that living smaller and closer are the keys to sustainability, according to *Today Online* on June 28.

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> *Evolving software* continued from page 1

The research is part of an emerging field that aims to create self-repairing programs – known as automated software repair. Most methods fix only certain kinds of bugs or rely on ongoing, built-in checks that make software run slowly.

Evolutionary computation needs a few additional tricks to make it scalable, but unlike other approaches it works for a wide range of programs, and it's surprisingly fast. The researchers looked at 16 programs and about 120,000

lines of code with a range of problems from infinite loops to buffer overflows. They found they could repair a program in under six minutes, on average. Humans would take considerably longer – they would "at least have to read the code" first, Stephanie says.

The DARPA grant will fund, among other projects, research on how hackers' methods and evolutionary repairs of security vulnerabilities might co-evolve, Stephanie says. ■

INSIDE SFI

SFI awards go to 11 students, teacher

SFI has honored 11 Santa Fe-area high school seniors and one teacher with its annual Awards for Scientific Excellence, co-sponsored by the Santa Fe Alliance for Science.

The winning teacher for 2011 is Diane Catron, a science teacher at Santa Fe Preparatory School.

Winning students are Steven Mora, Santa Fe Indian School; Nina Lindsay, Desert Academy; Mitzi Florian, SER/SFPS Career Academy; Mariah Salyer, Santa Fe Waldorf; Benjamin Clark, Monte del Sol Charter School; Brian Lewis, Santa Fe Preparatory School; Deepu

Jose, Academy for Technology and the Classics; Andrew Wilder, Santa Fe Secondary School; Josh Catanach, Santa Fe High School; Meaghan Martinez-Palmer, St. Michael's High School; and Myra Sandoval, New Mexico School for the Deaf.

The Prize was established in 1996 to honor outstanding science students and encourage them to pursue careers in science and technology. The teacher award was begun in 2005 to acknowledge the creativity, rigor, and professionalism of an area teacher of math, science, or computer science. ■

INSIDE SFI

Students, SFI mentors assess water quality

SFI Omidyar Fellows James O'Dwyer and Jeremy Van Cleve and Postdoctoral Fellow Bryan Daniels recently mentored four Santa Fe-area high school students: Andres Gonzalez, Krishan Bhakta, Arlo Barnes, and Noah Kwicklis.

The students attend the MASTERS Program, a new Santa Fe charter school with an emphasis on science, technology, engineering, and math education.

During the fall semester, the students interacted individually with their mentors, and in the spring, all four students and their mentors worked as a group on a community service project, analyzing various datasets related to water quality and availability in Santa Fe-area wells.

Overall, the students developed technical capability in scientific data analysis, in com-



Bryan Daniels works with Krishan Bhakta.

bination with the more intangible but equally important skills of working in a team on a research project and reaching out to members of the community, says James.

The mentoring program will continue in fall 2011 to include additional students. ■

DONOR PROFILE

David Z. Robinson: Accidental pioneer



As an industrial researcher and vice president of the Carnegie Corporation, David Z. Robinson did not set out to change the process of scientific thought when he joined SFI's Board of Trustees in 1986. He had enjoyed a research career that was unfettered by the silos of mainstream academia, and he wanted to be involved in an institution where others could enjoy similar freedoms.

Yet he hesitated when friends (and SFI founders) Phil Anderson, Murray Gell-Mann, and David Pines approached him about joining the board. He felt that SFI including a graduate program focused on interdisciplinary research would not be good training for the students' future careers.

He agreed to serve as a trustee and stayed on until 2008, where he helped oversee the evolution of SFI's education program from

one focused on graduate students to today's programs that nurture scholars of all ages interested in the sciences of complexity, from middle schoolers to postdocs.

An enthusiastic learner, Robinson's own career varied widely, from chemical physics at Harvard, to optics and electronics research in private industry, to the White House Office of the President's Science Advisor, to Vice President for Academic Affairs at New York University, to Carnegie.

His transdisciplinary scientific interests are what drew himself to SFI, and why he remains involved as a donor. "SFI has had a transformational effect on the way science is done in society, and that's a rare thing," he says. "They were among the first to recognize the importance of computers in transdisciplinary research, and the possibilities of using computers to get a better understanding of complex adaptive systems. That's a transformational success in my view, and it deserves support." ■

SFI Online

Multimedia content available at www.santafe.edu/news.

- Interview with SFI Omidyar Fellow Laura Fortunato** on the ancient origins of monogamous marriage, Miller-McCune's "Curiouser and Curiouser" podcast
- MIT's Andrew Lo** on re-applying financial innovations for the common good, SFI Community Lecture
- Interview with MIT's Andrew Lo** on re-applying financial innovations for the common good, KSFR's Santa Fe Radio Cafe
- Interview with SFI Science Board member and External Professor Melanie Mitchell** on the sciences of complexity and what they offer humankind, KSFR's Santa Fe Radio Cafe
- SFI Omidyar Fellow Simon DeDeo** on computation in natural systems, SFI Science Board Symposium presentation
- SFI Omidyar Fellow Scott Ortman** on steps toward a cognitive science of prehistory, SFI Science Board Symposium presentation
- SFI Omidyar Fellow Laura Fortunato** on the evolution of the human family, SFI Science Board Symposium presentation
- SFI Omidyar Fellow Jeremy Van Cleve** on prosocial preferences and the evolution of behavior within and among groups, SFI Science Board Symposium presentation
- SFI Omidyar Fellow James O'Dwyer** on how field theory can help solve problems in ecology, SFI Science Board Symposium presentation
- SFI Postdoctoral Fellow Hyejin Youn** on bigger, denser, greener cities, SFI Science Board Symposium presentation
- Duncan Watts** on the revolution in computational social sciences, SFI Science Board Symposium keynote address

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