



Update

August 2008



RESEARCH NEWS

Working group: Foreign affairs meets complexity



Modern nations are, in many ways, complex adaptive systems.

(Image: ©iStockphoto.com/Daniel Cardiff)

International affairs is ripe for its most profound change in several centuries, a revolution in thinking similar to the revolution that has remade physics, economics, biology, and other sciences over the past 50 years.

That's the premise of a working group, "International Affairs and Complexity," scheduled for Aug. 28-31 at SFI that will involve 12-15 invited experts in science, foreign policy, and business.

"Our system of diplomacy was developed hundreds of years ago and was effective when very traditional states with well defined needs interacted with each other," says SFI President and Distinguished Professor Geoffrey West.

Today, nation states are much more complex entities representing many interests, and non-traditional players – alliances, political groups, even terrorist organizations – often

get involved in, or influence, international relationships.

Modern nations are, in many ways, complex adaptive systems, says SFI Science Board Co-chair Simon Levin, who is co-organizing the event with SFI Professor Doug Erwin and Joshua Cooper Ramo, Managing Director of Kissinger Associates and former TIME magazine senior editor, foreign editor, and assistant managing editor.

"This drives a new level of complexity and interconnectedness that requires a rethinking of the way we do things," he says. "Is there an approach to the international system that can take uncertainty as a given, that acknowledges complexity as a first concern, and that looks for stability not in strong central authority but in the sorts of self-organization that makes complex systems stable and resilient?"

The gathering is the first in a series of planned activities intended to apply complexity thought to problems in foreign affairs and to engage influential foreign policy thinkers in complexity science. Its goal, says Levin, is "to air ideas on both sides and begin a dialogue that we hope will grow and persist for years."

During the event, participants will begin by reviewing the classic approaches to foreign affairs. They'll then explore what changes have taken place in recent years and discuss whether complexity science can help.

The seeds for the interaction were set when Ramo, writing a book on revolutionary groups and terrorism, read *Fragile Dominion*, Levin's book based on his Ulam Lectures at SFI a decade ago. Ramo contacted Levin to explore common interests, which turned out to be substantial. ■

RESEARCH NEWS

'Six degrees' revisited: Thinking globally, navigating locally

An SFI working group Aug. 4-6, "Networks and Navigation," draws its theme from a novel take on Stanley Milgram's famous "six degrees of separation" experiment in 1967, according to co-organizer Aaron Clauset, an SFI Postdoctoral Fellow.

Milgram sent envelopes to randomly selected people in Nebraska and Kansas with a bit of information about a target person – call her

Sarah – who lived in Boston. He asked them to forward a letter to Sarah, if they happened to know her. If not, they should instead send the letter to someone they did know who was more likely to know her. The letters that reached Sarah did so in just six steps, on average.

But that's not the only remarkable outcome of the experiment, says Aaron. That any

of the letters made it at all is incredible, because its recipients knew just their own friends and acquaintances while having little information about the shape of the social network as a whole. Somehow, that local information was all they needed to get the letter to Sarah.

If researchers understood how social

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RESEARCH NEWS

Workshop: Why technological innovation occurs

How new technologies come to be is the focus of an interdisciplinary group that will gather at SFI this month. The Aug. 13-15 workshop, "Modeling Technological Innovation," is expected to draw some 25 invited participants.

"We will bring together experts from economics, engineering, sociology, physics, biology, and business to present and compare each discipline's view of technological change," says organizer Jessika Trancik, a Postdoctoral Fellow at SFI. She is joined by co-organizer and SFI Professor Doyne Farmer and collaborators Doug Erwin (Smithsonian /SFI Professor), W. Brian Arthur (Xerox Palo Alto Research Center/SFI External Professor), and

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RESEARCH NEWS

Behavior series prompts ideas

SFI's behavior seminar series began this summer with a July 7 presentation by SFI Professor Doyne Farmer on "Virtues and Vices of Equilibrium."

The seminars, organized by Postdoctoral Fellows Dan Hruschka and Willemien Kets, bring together researchers from different backgrounds to discuss current research in the behavioral sciences both within and outside the Institute, thus stimulating discussion across fields and institutions.

Presentations cover work ranging from finished papers to ideas for new research.

Doyne's presentation – which reviewed the traditional use and limitations of equilibrium models in economic theory, and then suggested alternative

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LIT BITS

Coping with viral diversity in HIV vaccine design: A response to Nickle et. al.; Fischer, W.; Liao, H.X.; Haynes, B.F.; Letvin, N.L.; **Korber, Bette [SFI External Professor]**; *PLoS Computational Biology* 4 (2), February 2008, pp. 175-178

Opinion formation in laggard societies; Klimek, P.; Lambiotte, R.; **Thurner, Stefan [SFI External Professor]**; *EPL* 82 (2), April 2008, pp. 327-332

Solution of the unanimity rule on exponential, uniform, and scale-free networks: A simple model for biodiversity collapse in foodwebs; Hanel, R.; **Thurner, Stefan [SFI External Professor]**; *European Physical Journal B* 62 (3), April 2008, pp. 327-330

Specialization and herding behavior of trading firms in a financial market; **Lillo, Fabrizio [SFI External Professor]**; Moro, E.; Vaglica, G.; Mantegna, R.N.; *New Journal of Physics* 10, April 14, 2008, pp. 111-125

Parsing the evolution of language: Response; Atkinson, Q.D.; Meade, A.; Venditti, C.; Greenhill, S.J.; **Pagel, Mark [SFI External Professor]**; *Science* 320 (5875), April 25, 2008, p. 446

Near intron positions are reliable phylogenetic markers: An application to holometabolous insects; Krauss, V.; Thummler, C.; Georgi, F.; Lehmann, J.; **Stadler, Peter [SFI External Professor]**; Eisenhardt, C.; *Molecular Biology and Evolution* 25 (5), May 2008, pp. 821-830

Revisiting a model of ontogenetic growth: Estimating model parameters from theory and data; Moses, M.E.; **Hou, Chen [SFI Postdoctoral Fellow]**; **Woodruff, William (Woody) [SFI External Professor]**; **West, Geoffrey [SFI President and Distinguished Professor]**; Nekola, J.C.; Zuo, W.Y.; **Brown, Jim [SFI Science Steering Committee Member and External Professor]**; *American Naturalist* 171 (5), May 2008, pp. 632-645

Evolution of mitochondrial gene orders in echinoderms; Perseke, M.; Fritzsche, G.; Ramsch, K.; Bernt, M.; Merkle, D.; Middendorf, M.; Bernhard, D.; **Stadler, Peter [SFI External Professor]**; Schlegel, M.; *Molecular Phylogenetics and Evolution* 47 (2), May 2008, pp. 855-864

Prokaryotic branch of the Tree of Life: A composition vector approach; **Hao, Bailin [SFI External Professor]**; Gao, L.; *Journal of Systematics and Evolution* 46 (3), May 2008, pp. 258-262

A general model for food web structure; Allesina, S.; Alonso, D.; **Pascual, Mercedes [SFI External Professor]**; *Science* 320 (5876), May 2, 2008, pp. 658-661

Characterization of the Arabidopsis heterotrimeric G protein; Wang, S.Y.; Assmann, S.M.; **Fedoroff, Nina [SFI External Professor]**; *Journal of Biological Chemistry* 283 (20), May 16, 2008, pp. 13913-13922

The evolution of modularity in bacterial metabolic networks; Kreimer, A.; **Borenstein, Elhanan [SFI Postdoctoral Fellow]**; Gophna, U.; Ruppin, E.; *Proceedings of the National Academy of Sciences* 105 (19), May 13, 2008, pp. 6976-6981

A closer look at the indications of q-generalized Central Limit Theorem behavior in quasi-stationary states of the HMF model; Pluchino, A.; Rapisarda, A.; **Tsallis, Constantino [SFI External Professor]**; *Physica A-Statistical Mechanics and Its Applications* 387 (13), May 15, 2008, pp. 3121-3128

PCR survey of *Xenoturbella bocki* Hox genes; Fritzsche, G.; Boehme, M.U.; Thorndyke, M.; Nakano, H.; Israelsson, O.; Stach, T.; Schlegel, M.; Hankeln, T.; **Stadler, Peter [SFI External Professor]**; *Journal of Experimental Zoology Part B-Molecular and Developmental Evolution* 310B (3), May 15, 2008, pp. 278-284

AWARDS

Fedoroff awarded honorary doctorate



Nina Fedoroff, SFI External Professor and Science Steering Committee member, in June was awarded an honorary doctorate by The Rockefeller University during commencement ceremonies celebrating its 50th anniversary.

Nina, a prominent researcher in molecular biology and genetics, is the Verne M. Willaman Professor of Life Sciences and Evan Pugh Professor of Life Sciences at Penn State University. She recently received the National Medal of Science, the nation's highest award for scientific research, at a 2007 White House ceremony.

She currently is the science and technology adviser to the U.S. Secretary of State and to the administrator of the U.S. Agency for International Development.

Her current research is directed at understanding the genetic organization and molecular dynamics of plant stress and hormone responses. ■

RESEARCH NEWS

Science paper describes plants' climate climb



Science paper: Climate warming has resulted in an upward shift in the elevation at which plant species thrive. (Image ©iStockphoto.com/Eric Back)

A paper in the June 27 issue of *Science* co-authored by SFI External Professor Pablo Marquet (Pontificia Universidad Catolica de Chile) sheds light on the effect climate warming is having on the elevations at which native plant species thrive.

Pablo's collaborators include Jonathan Lenoir and Jean-Claude Gegout of AgroParisTech, France, and Patrice de Ruffray and H. Brisse, CNRS (National Center for Scientific Research), France.

Spatial fingerprints of climate change on biotic communities are usually associated with

changes in the distribution of species at their latitudinal or altitudinal extremes.

By comparing the altitudinal distribution of 171 forest plant species between 1905 and 1985 and 1986 and 2005 along the elevation range (0 to 2600 meters above sea level) in Western Europe, the researchers show that climate warming has resulted in a significant upward shift in species optimum elevation.

This upward shift, according to the research, has averaged 29 meters per decade, and the shift is larger for species restricted to mountain habitats and for grassy species,

which are characterized by faster population turnover.

The study suggests that climate change affects the distributional range as well as the distributional margins of plant species. ■

> Technological innovation continued from page 1

Woody Powell (Stanford/SFI External Professor).

As a focal point, workshop participants will explore ways technological advancement can facilitate the transition to a low-carbon-emission energy infrastructure.

In a larger sense, the organizers anticipate the forum will provide a way for people thinking about technological innovation from different perspectives to build a more integrated body of knowledge and begin to address important remaining questions. ■

> Behavior series continued from page 1

approaches needed for the field of economics to progress – drew a diverse audience and stimulated a lively discussion, in line with the aim of the series.

“The seminars are a good way of encouraging interaction among the natural sciences and behavioral sciences,” says Willemien, who started her postdoctoral fellowship at the Institute in January.

The schedule is at SFI's Events page (www.santafe.edu/events/). The series is funded by the behavioral sciences endowment of George Cowan, Distinguished Fellow and Founding President of the Institute. ■

Traub elected to Marconi board



SFI External Professor Joseph Traub, the Edwin Howard Armstrong Professor of Computer Science at Columbia University, has been elected to the board of directors

of the Marconi Society, best known for the Marconi Prize, considered the most prestigious award in the field of communications and the Internet. ■

INSIDE SFI

Colloquium: To three R's add thinking computationally

To reading, writing, and arithmetic, let's add computational thinking.

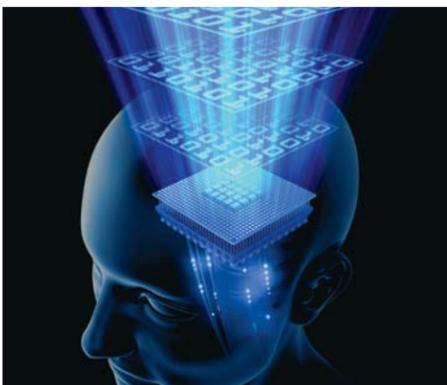
Jeanette Wing, President's Professor of Computer Science at Carnegie Mellon University and Associate Director for Computer and Information Science and Engineering at the NSF, spoke at SFI July 11 about the need for computational thinking to become a fundamental skill used by everyone.

“When your daughter goes to school in the morning, she puts in her backpack the things she needs for the day. That's prefetching and caching. Which line do you stand in at the supermarket? That's performance modeling for multi-server systems,” she said.

“We are often too easily swept up with the rapid progress in technology and the surprising uses by society of our technology that we forget about the science that underlies our field,” she said. Accessing the field's scientific drivers to solve problems at all levels will open up new research avenues and educational opportunities.

Wing said computational thinking has already influenced many disciplines, from the sciences to the arts. The NSF's new Cyber-enabled Discovery and Innovation Initiative now is bringing computational thinking to fundamental science and engineering.

“Just as the printing press facilitated the spread of the three R's, computing and computers will facilitate the spread of computational thinking,” she said.



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SFI IN THE NEWS

SFI President and Distinguished Professor Geoffrey West, SFI Distinguished Fellow and Founding President George Cowan, and SFI External Professor Scott Page (University of Michigan) were listed among notable signatories in an announcement of the release of "14 questions the candidates for President should answer about science and America's future." The questions, culled from more than 3,300 submitted questions from the signatories, are available at www.sciencedebate2008.com.

The April 2008 issue of *Harper's* magazine includes an article, "Contagious cancer: The evolution of a killer," that cites the work of SFI External Professor John Pepper (University of Arizona) and collaborators about how the tools of evolutionary biology and ecology are providing new insights into the clinical control of cancer. www.harpers.org

SFI External Professor Daniel Schrag (Harvard) is quoted in the May 6 *Houston Chronicle* regarding the growing body of research that suggests deep sub-sea rock formations may be ideal for carbon sequestration. Daniel says the high pressures and low temperatures found below the sea floor – 10,000 feet or more underwater – provide a nearly foolproof way to keep CO₂ stored. www.chron.com/CDA/archives/archive.mpl?id=2008_4562234

A May 27 *Washington Post* article discussed a \$600 million grant from the Howard Hughes Medical Institute, to be shared among 56 American scientists including SFI External Professor Mercedes Pascual (University of Michigan). The grant will support risky but potentially lifesaving medical research over several years. The selected scientists will continue to work at their institutions but will become employees of the Hughes Institute. Said

the article: "One new investigator is Mercedes Pascual, who...is trying to determine how global climate change affects outbreaks of infectious diseases. Pascual wants to build a mathematical model to help scientists identify when and how cholera, malaria, and other diseases might balloon into epidemics, enabling public health agencies to prepare for, or even pre-empt, deadly outbreaks." www.washingtonpost.com/wp-dyn/content/article/2008/05/27/AR2008052701014.html

An interview with SFI Science Board Chair Emeritus Harold Morowitz [George Mason University, Krasnow Institute] was featured in a June 16 broadcast of the History Channel documentary "How Life Began." From the program's summary: "Earth was teeming with life billions of years before the dinosaurs existed. Single-celled organisms inundated the oceans, and the soil swarmed with living creatures. Where did it all come from

and how do you go from a single-celled organism to a trillion-celled organism like Man? Cutting-edge science is testing out answers about life's origins and how life can be created on new worlds – or even our own." For a schedule of future airings: www.historychannel.com

The July 11 "Captain's blog" by *Fortune* magazine managing editor Andy Serwer included this entry: "I stopped at the Santa Fe Institute, where I attended a lecture by [SFI Professor] Doyne Farmer entitled 'The Vices and Virtues of Equilibrium, and the Future of Financial Economics.' Um, it was heady stuff to say the least. (Amazing hearing the discussion between Doyne and Geoffrey West, for example.) Spoke with Doyne a bit and also Shannon Larsen, executive director. Then, as I was leaving, who do I bump into but Cormac McCarthy!" http://money.cnn.com/2008/07/11/magazines/fortune/serwer_captainsblog.

Faculty News

Faculty Extensions

SFI's Science Steering Committee and Appointment & Review Committee recently recommended extensions to the appointments of three SFI Professors, and those recommendations were accepted by President Geoffrey West:

■ **Doug Erwin**, Senior Scientist and Curator of the Smithsonian National Museum of Natural History's Department of Paleobiology, and SFI Science Steering Committee Chair: Doug's research focuses on the history of life and evolution, including ecological and developmental aspects of the origin of animals, the causes and consequences of the great end-Permian mass extinction, and the evolutionary history of really old snails.

■ **David Krakauer**, SFI Science Steering Committee member: David's work is concerned with the evolutionary history of information processing mechanisms in biology, 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, and organism behavior.

■ **Doyne Farmer**, SFI Science Steering Committee member: Doyne has broad interests in complex systems and has done research in dynamical systems theory, time series analysis, and theoretical biology. His current, main interest is in developing quantitative theories for social evolution, in particular for financial markets.

New External Professors

SFI's Science Steering Committee has recommended appointments of nine new SFI External Professors since January, and those recommendations were accepted by President Geoffrey West:

■ **Morten Christiansen**, Co-Director of Cognitive Science and Associate Professor, Department of Psychology, Cornell University: Morten's interests include language acquisition and processing, statistical learning, neural network models of language and statistical learning, neurophysiological (event-related potential) measures of statistical learning and language, language evolution, and genetics of language.

■ **Vincent Danos**, Professor, Computational Systems Biology, University of Edinburgh, U.K., and Director of Research, CNRS (National Center for Scientific Research), France: Vincent's research interests range from mathematical logic and the semantics of programming languages to probabilistic and agent-based models. At Edinburgh he is leading development of an efficient bottom-up simulation platform for cellular signaling that will enable the rapid generation of cellular insight

– including causal information – without requiring significant modeling or quantitative capability from the user.

■ **Andrew Dobson**, Professor, Ecology & Evolutionary Biology, Princeton University: Andrew's research is focused on the population ecology of infectious diseases and the conservation of endangered and threatened species. Over the last eight years he has studied infectious diseases in a variety of endangered and fragile ecosystems, enabling him to develop sections of a larger body of theory that deals with the role of infectious diseases in driving wild animal populations to extinction – a key unsolved problem of conservation biology.

■ **Santiago Elena**, Research Professor, Evolutionary Virology, Instituto de Biología y Celular de Plantas, Valencia, Spain: Santiago's interests are related to the evolutionary biology of microbes, focusing on the study (within the framework of populations genetics) of the mechanisms that generate and maintain the genetic variability of RNA viruses, the potential of digital organisms as model systems for evolutionary studies, and *in silico* and mathematical hierarchical models of the viral infectious cycle.

■ **Jessica Green**, Assistant Professor, Center for Ecology & Evolutionary Biology, University of Oregon: Jessica is an applied and theoretical ecologist interested in biological diversity and patterns in the distribution and abundance of species. Using interdisciplinary approaches at the interface of microbiology, ecology, mathematics, informatics, and computer science, her work aims to understand the forces that organize heterogeneous ecological systems and to apply this understanding to help inform conservation policy and management decisions.

■ **Pablo Marquet**, Associate Professor, Department of Ecology, and member of the Center for Advanced Studies in Ecology and Biodiversity, Faculty of Biological Sciences, Pontificia Universidad Católica de Chile, Chile: Pablo is interested in characterizing, from first principles, the attributes that make ecological systems complex. His approach is focused on the search for general and invariant principles that underlie the diversity and variability of ecological systems. Pablo is a former SFI International Fellow.

■ **Juan Perez Mercader**, Distinguished Research Professor, Higher National Research Council, and Director and Founder, Centro de Astrobiología, Madrid, Spain: Juan's fundamental interest is in the application of theoretical physics to the knowledge of the universe, especially of life. He has hundreds of technical publications and has won numerous awards for his work in theoretical physics and astrophysics. He has served as an advisor

and consultant to NASA and Los Alamos National Laboratory. He is a member of the publishing council of *Astrobiology* and *The International Journal of Astrobiology*.

■ **Kazuo Nishimura**, Director, Institute of Economic Research, Kyoto University, Japan: Kazuo focuses on information processing and computation in complex systems, and dynamics and quantitative studies of human behavior as they relate to economic theory.

■ **Rajiv Sethi**, Professor, Barnard College, Columbia University, Department of Economics: Rajiv's work in Dynamics & Quantitative Studies of Human Behavior focuses on economics and inequality. This summer he co-authored a book, *International Trade and Labor Standards: A Proposal for Linkage*, which proposes international trading system reforms that could support poor countries in promoting the well-being of their peoples in ways that are acceptable to both rich and poor nations.

New International Fellows

The Institute in July appointed two new International Fellows:

■ **Eric Goles**, Science Director, Institute for Complex Systems, Valparaiso, Chile: Eric, a mathematician and computer scientist, is best known for his work on cellular automata. In 1993 he was awarded the *Premio Nacional de Ciencias Exactas* (Chilean National Science Prize). He also was President of CONICYT (the Chilean equivalent of the U.S. National Science Foundation), as well as an advisor on science and technology to the Chilean government.

> Thinking globally continued from page 1

networks are organized to make such connections possible, that understanding could benefit an entirely different network: the Internet.

Internet routers have to store enormous amounts of information about the other routers around them to send information in the right direction. But that method doesn't scale.

"If you were to put all six billion people in the world online today, the Internet would crash," says Aaron. "Maybe we can use this navigability property of social networks to design a new, more robust structure for the Internet."

The meeting is co-organized by Aaron, Dmitri Krioukov and KC Claffy (UC San Diego), and SFI Professor Cris Moore (University of New

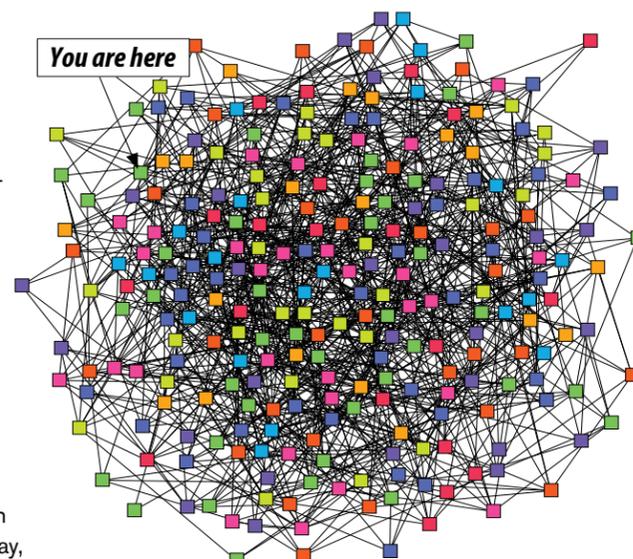
■ **Virgilio Almeida**, Professor of Computer Science, Federal University of Minas Gerais, Belo Horizonte, Brazil: Virgilio's research interests include performance evaluation and modeling of large scale distributed systems. He has held visiting professor positions at Boston University and Polytechnic University of Catalunya, as well as visiting appointments at Xerox PARC and Hewlett-Packard Research Laboratory. He is a recipient of a Fulbright Research Scholar Award and is a full member of the Brazilian Academy of Sciences.

SFI's International Fellowship Program aims to foster interdisciplinary research in targeted countries by identifying outstanding researchers affiliated with an academic institution in India, China, former Soviet countries, or countries in Africa, Eastern Europe, or Latin America.

Selected International Fellows have demonstrated experience in the study of complex adaptive systems in an interdisciplinary environment. They continue to do research in their home institutions while participating in collaborative research with SFI researchers. Fellowships are awarded for a two-year term.

SFI Departures

Statistical physicist and former SFI Postdoctoral Fellow **Michael Gastner's** last day at the Institute was May 9; Michael now is at the Institute for the Chemistry and Biology of the Marine Environment, Carl-von-Ossietzky Universität, Oldenburg, Germany. Statistical physicist and former SFI Postdoctoral Fellow **Thimo Rohlf's** last day at SFI was May 27; Thimo is now at the Max Planck Institute for Mathematics in Leipzig. ■



Can understanding social networks improve the Internet's performance? (Image Aaron Clauset)

Mexico). For more information, www.santafe.edu/events/. ■

CSSS students hear from *Numb3rs* creators and author Mitch Waldrop

Julie Hébert and David Zucker – writer/director and producer, respectively – of the CBS television series *Numb3rs* gave a joint presentation June 25 as part of the 20th anniversary celebration for the Complex Systems Summer School.

They described to an audience gathered at St. John's College, location for lectures during this year's CSSS, the delicate process of incorporating high-end math into a television show understandable to non-scientists while maintaining scientists' satisfaction that their work is not being dumbed down to absurdity. "That's our aim," they said, although "we don't always hit the mark."

Mitch Waldrop, an editor at *Nature*, talked about "Communicating Complexity" during another CSSS session. He is nearing release of a second edition of his 1992 book *Complexity*, which was a best-selling account of the birth of the new sciences of complex systems and the development of the Santa Fe Institute. The second edition contains a new chapter, based on a visit to the Institute in January, in which Waldrop reviews the Institute's development from 1992 to the present.

SFI External Professor Dan Rockmore, Professor of Computer Science at Dartmouth College, was director of the 2008 CSSS in Santa Fe, which ran June 1-28.



CSSS Santa Fe 2008 participants

CSSS is SFI's signature summer school, now in three countries, for graduate students and postdoctoral fellows pursuing interdisciplinary

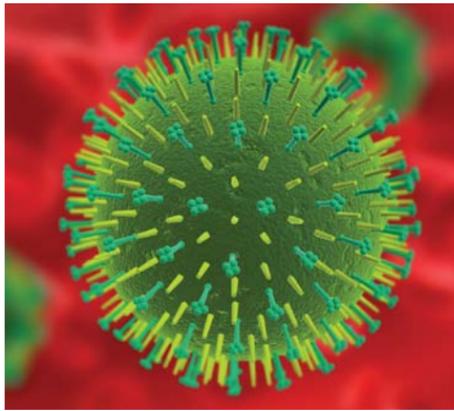
research. Sixty one students participated in this year's Santa Fe program. ■

PEOPLE

Former SFI Graduate Fellow Derek Smith is tracking influenza's every move

It's the case of the missing flu virus. When the flu isn't making people sick, it seems to vanish. Yet, every year it reappears and starts its attack anew.

So where does it go when it disappears? Does it hibernate, lying dormant in a few people and



Three-dimensionally-rendered influenza virus (Image ©iStockphoto.com/Sebastian Kaulitzki)

preparing for its next onslaught? Does it bounce around from the Northern hemisphere to the Southern hemisphere and back, following the seasons?

Neither, it turns out. Former SFI Graduate Fellow Derek Smith, now at Cambridge, led a crew of virus hunters that traced the virus's breeding grounds to Asia. New flu varieties almost always evolve in Asia and then hitch a ride each year with travelers, spreading to Europe, Australia, North America, and finally to South America, where they die away.

The team's work may help make the flu vaccine better. Because the flu virus is constantly evolving, scientists meet at the World Health Organization twice a year to decide on a vaccine formulation, but they must make a choice a year in advance of the targeted flu season to allow time for the vaccine to be manufactured and administered.

Asia, the study suggests, is the best place to look for up-and-coming strains.

The team published its findings recently in *Science*.

The roots of the project extend back to when Smith was a graduate fellow at SFI from 1992 through 1997. During that time he collaborated with Stephanie Forrest and Alan Perelson, and later with Alan Lapedes, Robert Farber, and Terry Jones, all of whom were affiliated with SFI, to develop the methods and software to build antigenic maps.

"This work is highly multidisciplinary, with epidemiologists, computer scientists, computational biologists, mathematicians, virologists, immunologists, geneticists, veterinarians, and MDs," Smith says. "It was made possible by collaborations with people from all of these disciplines. The Santa Fe Institute is one of the



Derek Smith

few places that could have gestated such work and I am immensely grateful for the five years I spent at SFI." ■



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