Symposium explores resilience of complex systems

When Doug Erwin began his appointment as SFI’s Chair of the Faculty in July 2011, he wanted to highlight a common theme he observed across the Institute’s research:

Upsets to systems in sociology, ecology, computer networks, and other areas can have direct consequences for human society, particularly following such disasters as Hurricane Katrina and Japan’s 2011 earthquake and tsunami.

Do those systems’ abilities to recover or renew themselves after a disruption exhibit similarities independent of the systems themselves? What can we learn about resilience of complex systems that will help mankind design better, more reliable systems for the future?

This year’s Business Network and Board of Trustees Symposium, November 1-2 in Santa Fe, explores resilience.

“Our over the last several years, this symposium has been a chance to draw together a broad range of people talking about a common theme,” says Doug. “This year we’ll highlight the emerging issue of whether there’s similarity in resilience in many types of systems.”

In keeping with the tradition of inviting someone not affiliated with SFI as the keynote speaker, foreign policy expert Michael Mandelbaum will kick off the meeting. Mandelbaum, a Johns Hopkins University professor and former Newsday columnist, has written several books on American foreign policy and served as an advisor to President Bill Clinton. His 2011 book, That Used to Be Us, written with New York Times columnist Thomas Friedman, looks at how globalization, information technology, deficits, and energy use have affected the United States’ growth and leadership.

“The theme of the book, on almost a subconscious level, is that of resilience,” says Doug. “Given his backgound, Mandelbaum explores these questions. The session is organized by SFI External Professor John Rundle, a physicist and geologist at UC Davis. John is the founder of the earthquake forecasting company Open Hazards, and he has developed the “Econoquake” model of financial collapse.

“A major assumption that has skewed many investors’ sense of risk was how it is distributed,” he says. “Rather than likelihood of harm following a bell curve with the usual standard deviations, it in fact follows power laws, with huge fluctuations, meaning potential for extraordinary loss, as was the case in the 2008 financial crisis and the 2011 earthquake in Japan.”

One possible strategy in disaster response is to stay small, he says. Neighborhood networks keep resources and expertise easily accessible if nature strikes hard.

Participants in the working group reflect a range of major risk categories. But how do we, as individuals and as a society, manage risk? Do seemingly disparate risks share universal features? Are there means to quantify risk? And how can we best reduce risk or mitigate damage?

Our perception of risk affects every decision we make. Getting out of bed before turning on the light, driving to work, deleting that inflammatory email, investing in mutual funds, and choosing which home to buy each represents a set of real and perceived tradeoffs of convenience, safety, expense, and reward.

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RESEARCH NEWS
Networks helping bring a big-picture view to physiology

SFI Professor Jennifer Dunne’s expertise in ecological networks is contributing to a potentially transformative approach to studying organismal physiology.

Physiology has traditionally taken a reductionist approach, with research focusing on specific organismal subsystems – circulatory, digestive, immune, reproductive, to name a few. But these systems aren’t independent; they interact in myriad complex ways to maintain homeostasis and allow organisms to respond to changes in their environments.

Also, particular molecules often play multiple roles in different physiological subsystems. For example, organism behaviors such as the choice of one prey over another can result in differing amounts of vitamin E uptake, which can trigger interlocking cascades of events within and ultimately beyond the organism.

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The Risk Working Group at SFI on November 1 explores these questions. The session is organized by SFI External Professor John Rundle, a physicist and geologist at UC Davis. John is the founder of the earthquake forecasting company Open Hazards, and he has developed the “Econoquake” model of financial collapse.

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SFI’s CEO Chris Wood, SFI VP for administration and director of the Business Network, says the human component of risk is frequently overlooked.

“Toward a human factor in financial risk

SFI Business Network members and their guests gathered recently at Morgan Stanley World Headquarters in New York for “Risk: The Human Factor,” a Network topical meeting focused on the human element in financial and economic systems.

“I’m looking forward to working with some really bright people to better understand the concept of risk in different arenas,” said Chris Wood.
In a recent paper appearing in PNAS, a team led by SFI External Professor Stefan Thurner examined voting data from a dozen recent elections around the world and found statistical evidence for election fraud in two of them.

The team looked for two kinds of rigging: incremental fraud, where votes for one party are set in the ballot box while those for the other candidates are tossed, and extreme fraud, which shows 100 percent voter turnout in a district, all voting for the same party. By comparing the distributions of votes for the dominant candidates in those two categories, they found that rigged elections show a different voting pattern than fair ones. They also developed a model to detect how much forged or manipulated results affected the outcome, then ran through all possibilities of both fraud types playing 0 percent to 100 percent trickery in an election, and compared those to actual data to determine prevalence.

Among the countries studied, data from recent elections in Russia and Uganda showed both the smear of incremental fraud and the second cluster of extreme fraud, with up to 14 percent of districts being affected in Russia's 2011 vote and 39 percent in 2012. Other countries' data showed little to no such trends.

"It would be cheaper to prevent it for every nationwide election on this planet, the raw data is made available on say a United Nations or OECD database," says Stefan. “One could then think of a set of quality standards and checks for every election – like the ones we presented – or better ones.”

In a review paper published in the September issue of American Economic Review, SFI External Professors John Geanakoplos, Rob Axtell, and Doyne Farmer questioned weaknesses in the current economic models and asked whether forecasters and policymakers need to bestow variables. Their own agent-based model of the U.S. housing market, they wrote, better captures the heterogeneity of agent behaviors.

Drought's effects on societies are defined in large part by how people respond and what other economic and environmental stresses are present, according to a paper that reviewed SFI President Jerry Sabo's recent PNAS paper on the collapse of Classic Mayan civilization.
A Q&A with SFI Chair of the Faculty Doug Erwin

Update: In your time as SFI’s Chair of the Faculty, you’ve pushed for the greater involvement of SFI’s external faculty. What have they been, and are we there yet?

Doug Erwin: I have tried to encourage some things. One is a clearer presentation of SFI’s research on our website and clearer thinking about SFI’s research generally. Both the new website and last year’s annual report presented SFI’s research themes in the three cross-cutting research themes and the three cross-cutting foci that together describe the important lenses through which much of our research is currently carried out. But this is more than presentation. The three themes and three foci convey more of the transdisciplinary approach that is key to how SFI operates. We aren’t “anthropologists and physicists and biologists. We are looking at broad problems across disciplines.” And it’s not that I am trying to impose this structure on SFI. I wanted to come up with something that reflected what was already going on, and I thought it was important to convey in more clear terms how we think about ourselves. And I think some of the meetings we’ve had – the theme week in August on “information theory meets game theory,” which brought together a pretty diverse group of people, and the annual Business Networks and for several changes. Symposium on resilience – are good examples of broader topics and why SFI should be addressing problems and bringing together projects on the Principles of Complexity are also fairly broad, and these are all good steps toward what SFI is about.

Another thing I had hoped to encourage is the greater involvement of SFI’s external faculty in our science activities. The Science Steering Committee, which reviews proposals for SFI science meetings, is seeing more proposals from external faculty or involving external faculty, and that’s good. But it’s always a process and we still have a way to go.

Jennifer Dunne to be SFI’s 2013-2015 Chair of the Faculty

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“David Krakauer and Doug Erwin have set a high standard for this key position, and I am certain that Jen will successfully build on the momentum they have begun to build in their recent internal announcement. Jen’s research interests are in analysis, modeling, and theory related to the organization, dynamics, and function of species interactions. Most of her work focuses on trophic interactions, which provide the basic architecture for the flow of energy and resources through ecosystems. She has been an active member of SFI’s resident faculty for five years, and she is a successful grant writer. She began her career at SFI as a postdoctoral fellow.

SFI Online Multimedia content available at www.santafe.edu
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SFI Science Board member Eric Maskin, a Nobel laureate whose work has had widespread impact on economics and political science, has been named a SFI Research Professor, Harvard’s highest honor for a faculty member.

The National Institutes of Health has selected SFI External Professor Elchanan Borenstein to be among 81 winners of its high-profile 2013 New Innovators Award.

The program recognizes innovative health researchers who have taken risks in areas of research where the potential impact in biomedical and behavioral sciences is high. Elchanan, an assistant professor of genome sciences at the University of Washington, researches the human microbiome, which has a tremendous impact on human health and is altered in various disease states. He and his team developed a computer algorithm to predict which microbiomes can be manipulated to treat various health issues. They are now using their computer to predict which microbiomes can be manipulated to treat various health issues. They are now using their computer to predict which microbiomes can be manipulated to treat various health issues.
Ian White: Putting on a strategic hat

Ian White is fascinated by SFI’s research toward a theory of cities—which makes sense, because his company, Urban Mapping, offers embedded geographic technology to create maps that combine geographic information with statistical data in thousands of categories in any city. This information helps clients in a variety of industries make business decisions.

White says his involvement in SFI’s Business Network has given him access to people like SFI’s Geoffrey West and Luis Bettencourt, who have taught him to approach problems in novel ways. Network meetings also have broadened his thinking on issues that affect the future of his company. “Those issues are exciting because they help me put on a strategic hat, which I don’t do day-to-day running a business,” he says.

Business Network members have the opportunity to participate in (and sometimes help organize) Network topical meetings and SFI symposia, short courses, and summer schools.

White recently hosted a Business Network “birds of a feather” event for Network members and guests at Urban Mapping’s San Francisco office. Typical of the informal breakfast meetings, the event featured a talk by SFI External Professor Raisa D’Souza of UC Davis, who summarized her recent work on mathematical models of interdependent networks such as the power grid and the Internet.

Seven new grants to SFI investigators

The Defense Advanced Research Projects Agency and the Air Force Office of Scientific Research have awarded SFI Professor Cris Moore and External Professors Aaron Clauset and Mark Newman a four-year, $1,106,911 grant to develop statistical models and methods to automatically identify complex structural and dynamical patterns in real-world networks and highlight anomalous or low-probability structures or events.

The National Science Foundation has awarded SFI Professor Cris Moore a two-year, $216,644 grant to use nonabalian Feurer analysis to find new ways to “derandomize” algorithms; study the extent to which high-dimensional structures can be embedded in low-dimensional spaces with limited distortion; show that certain problems require a long time even for quantum computers to solve; and study whether new cryptography algorithms will remain secure if and when quantum computers are built.

The National Science Foundation (NSF) has awarded SFI Professor Cris Moore a three-year, $88,048 grant to examine ways Markov chain Monte Carlo (MCMC) algorithms are used by theoreticians and practitioners, and to bridge the divide between these two camps.

The NSF has awarded SFI Professor Sam Bowers and SFI Omidyar Fellow Paul Hooper a one-year, $47,100 grant to examine social network structure, political hierarchy, and economic inequality and to hold a workshop and training program on the topic.

The NSF has awarded Laura Fortunato (an SFI Omidyar Fellow) and Anne Kandler (an SFI Omidyar Fellow alum), a one-year, $31,581 grant to develop an agent-based model of urban dynamics in New York—based on data from geographic and cultural factors on cultural diversity.

Science On Screen encore leads with Memento

The popular Science On Screen series returned to Santa Fe October 17, with neuroscientist Chris Wood exploring the compelling depictions of human memory in the 2000 art-house crossover Memento. The series is a joint collaboration of SFI and the Center for Contemporary Arts (CCA) in Santa Fe. During each showing, an SFI scientist presents a favorite film, offering personal perspectives from the world of science. SFI and CCA presented four Science On Screen events early in 2012.

The encore series, presented in conjunction with the Coolidge Corner Theater and the Alfred P. Sloan Foundation, offers six classic films (including Memento) selected by SFI scientists.

Still to come:

Raiders of the Lost Ark with SFI External Professor George Guernsey, November 28, 2012, 7:00 p.m., CCA

The Gods Must Be Crazy with SFI Distinguished Fellow Murray Gell-Mann, December 13, 2012, 7:00 p.m., CCA

Primer with SFI Professor Cris Moore, February 20, 2013, 7:00 p.m., CCA

Never Cry Wolf with SFI Professor Paula Sabloff, March 13, 2013, 7:00 p.m., CCA

Sneakers with SFI Omidyar Fellow Simon DeDeo, April 24, 2013, 7:00 p.m., CCA

Dates subject to change.

Visit SFI online at www.santafe.edu for more about these events. Advance tickets are recommended for tickets and prices, call the CCA Box Office at 505-982-1388. All showings take place at the Center for Contemporary Arts, 1050 Old Pecos Trail, in Santa Fe.