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UPDATE

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INSIDE SFI

Welcome to SFI's Tesuque Campus



Eugene Thaw, a retired art appraiser, lifelong art collector, philanthropist, and longtime SFI donor, and his wife Clare have given their former Tesuque, New Mexico, home to the Institute – a gift of land and residences

that constitutes the largest one-time donation in SFI's history.

The 36-acre estate, now referred to as SFI's Tesuque Campus, will become a quiet, contemplative setting for Institute scholars, visitors, and science meetings.

Read about the estate and see photos of the beautiful property on pages 4 and 5 of this issue.

INSIDE SFI

SFI's successful Omidyar Fellowship expands for 2013

SFI's highly successful Omidyar Fellowship is being expanded in 2013, with enhancements designed to sharpen the program's focus on preparing talented early-career scientists to become leaders in complex systems research.

SFI President Jerry Sabloff and the program's longtime sponsors, Pierre and Pam Omidyar, announced the expansion on November 13, 2012.

"Through the SFI Omidyar Fellowship, we want to identify the most promising young postdoctoral scholars working on important problems, and provide them the skills, [> more on page 7](#)

A Q&A with Jerry Sabloff on SFI's status and future

At the turn of the new year, Institute President Jerry Sabloff gave the *Update* his thoughts about 2012 at SFI, and his outlook for 2013.

Update: How would you characterize 2012 for the Santa Fe Institute?

Jerry Sabloff: This was a strong year for us. Given the severe budget constraints and the diminished resident faculty size, our science did very well. We had a number of exciting workshops and working groups, and what's most encouraging to [Chair of the Faculty]

Doug Erwin and me is that we're starting to see a significant increase in the number of meeting proposals compared to a year ago. I think we've had many science visits that were very productive, and we've done extremely well in getting new research grants, both from government agencies and private foundations, which are supporting a lot of new research. The expansion of the Omidyar Fellowship will have a broad and positive impact on the Institute and its research. And philanthropic support for the Institute seems to be on an encouraging trajectory. All those

factors add up to a really good year under very tight budget circumstances. I'm generally feeling quite upbeat, not only about this past year, but also about our prospects going forward.

Update: SFI has received a handful of major new research awards in the last 12 months, some of them in the last few months. What effect do these large new grants have on SFI and the character of its work?

Sabloff: Given the tightness of funding at [> more on page 6](#)

RESEARCH NEWS

DARPA grant supports research to uncover network nuances

When a species disappears from a region, the rest of the ecosystem may flourish or collapse, depending on the role that species played. When a storm rolls across the coast, the power grid might reconfigure itself quickly or leave cities dark for days. A snowstorm might mean business as usual in a hardy city and a severe food shortage in another, depending on the distribution strategies of residents.

Each of these systems is a kind of network, with thousands of members and relationships linking them. Understanding how networks behave is key to ensuring their functioning.

With current network theory, scientists can predict a few simple trends, such as which web pages are likely to get more hits over time. Mostly, current models "flatten" the system to a list of points (nodes) and connections between them (edges). But the features that bestow a network's true cohesion and character – such as the nuanced predator-prey dynamics in an ecosystem, hierarchies in a social community, or critical hubs in a distribution system – have eluded quantification.

A new four-year, \$2.9 million grant from the Defense Advanced Research Projects Agency is supporting SFI research that will, the researchers hope, propel their understanding of networks to the next level.

"If we want to have a power grid that can handle fluctuations in solar and wind power, or know what will happen to the marine food web as the ocean acidifies due to climate change, or see how ideas spread in a social network, we need to understand networks and their dynamics," says SFI Professor Cris Moore, principal investigator for the project.

Nodes and links in real networks are cloaked in details, he says. In an online community, for example, age, ethnicity, language, and location all can influence a person's position and behaviors. In a power grid, each link has a capacity and a cost. But how much do we really need to know about nodes and links to understand their roles in the system? More broadly, how much do we need to know about a system's structure to understand its behavior?

"We're at a very early stage of understanding how structure is related to dynamics," Moore says. The project aims to model the immense variety of network structures and related information, devise methods to fit models to data that cover the intricacy of their patterns, and proffer algorithms that can generalize from patchy information and fill in missing information in massive, complex networks.

SFI is the lead institution for the grant, issued by DARPA's Graph-theoretic Research in Algorithms and the Phenomenology of Social Networks program and the Air Force Office of Scientific Research. Moore joins SFI External Professors Aaron Clauset, a computer scientist at the University of Colorado at Boulder, and Mark Newman, a statistical physicist at the University of Michigan, in approaching the problem using Bayesian inference and machine-learning algorithms. Such algorithms – which refine themselves in response to the results they generate – can be designed to analyze a network and figure out how its communities are organized. [> more on page 3](#)



On NPR’s Science Friday on December 14, SFI External Professor and Science Board member Seth Lloyd explains quantum mechanics, entanglement, Planck’s constant, quantum computing, and the all-around “funkiness” of the quantum world.

Scientific American contributor John Horgan on December 10 cautions against putting too much faith in complexity science because, he writes, a general theory of complex systems might not be achievable.

On the eve of the end of the Mayan calendar, the author of the *Santa Fe Reporter’s* “First (and last) guide to the apocalypse” laments that she wishes she had taken advantage of events featuring SFI’s brainiacs when she had the chance.

In an interview in the December issue of *Alliance* magazine, SFI Distinguished Professor Geoffrey West appeals for a broader, networks-oriented view of problem solving, and philanthropy.

In a *Nature* Q&A on November 26, SFI’s Murray Gell-Mann, a physicist, and USC’s David Agus, a physician and cancer researcher, discuss the value of cross-disciplinary collaboration, and how methods from physics might help further the field of medicine.

Some big names in science are expected to attend a meeting in February at CERN on the origin of life, writes the *Huffington Post’s* Suzan Mazur. Her November 19 article cites work at SFI by two longtime SFI researchers: former SFI professor Stuart

Kauffman and SFI External Professor Steen Rasmussen.

To some scientists, the global financial crisis of 2008 looked a lot like the spread of an infectious disease or the collapse of a coral reef, according to SFI Science Board member Robert May in a November 19 *Albuquerque Journal* interview.

Discovery News on November 15 describes the complex-systems view taken by SFI President Jerry Sabloff and collaborator B.L. Turner in a recent paper on how drought contributed to the “demise” of the classic Maya civilization.

On Public Radio International’s “To The Best Of Our Knowledge” program on October 21,

SFI Distinguished Professor Geoffrey West asked whether cities are like organisms. His answer: yes and no.

At the recent WWW conference at ESRI headquarters in Redlands, California, SFI Distinguished Professor Geoffrey West was among the discussants who explored “creative courage” and what it takes to be an outlier in any field, according to the *Huffington Post* on October 2.

In a September 17 interview in *Wired*, author Fred Guteri cites a remark made by SFI Professor Jennifer Dunne as an inspiration for his book, *The Fate of the Species: Why the Human Race May Cause Its Own Extinction and How We Can Stop It*.

Nonlinearities From the editor

You might have noticed that – like many of us right after the holidays – this issue is a bit, ahem, hefty. But really it’s more big-boned than fat. From major changes to the Omidyar Fellowship to a new SFI campus to fresh research on the chemical origins of life, this issue is overflowing with news. Rounding out the half dozen major announcements is a welcome interview with SFI President Jerry Sabloff, who gives us some perspective on all this madness.

Speaking of big news, you’ve probably heard by now that SFI is offering a MOOC – a Massive Open Online Course – in complexity. See the details on page 7. If you haven’t been paying attention, MOOCs are all the rage. Essentially, lots of people simultaneously take a specially designed college course online. What MOOCs lack in classroom intimacy they make up for in technological connectedness, and, frankly, they offer certain benefits that you simply don’t get on campus. Personally, I think MOOCs might one day redefine higher education. It is fitting that SFI is offering the first MOOC in complex systems.

SFI’s research magazine, the *Bulletin*, began 27 years ago as a mimeographed review of SFI science activities. Since then it has been transformed several times. It has ranged from a quasi journal containing scholarly review articles to an accessible magazine for a diverse audience. This year, it’s adapting again. We now present the *Bulletin* in three ways: as a tablet magazine and as an online publication, with a few printed copies to be found primarily at the Institute. We will publish three issues a year rather than one. Instead of surveying a half dozen research themes in each issue, we’ll now explore a single theme more deeply and from several scholarly perspectives. Interactive illustrations and videos will give you richer insights into each topic.

Our Spring 2013 issue unravels the increasing complexity of human society. Why and how did the earliest states emerge independently? How does the human capacity for metaphor help us imagine new societal structures? What innovations allowed *Homo sapiens* alone to become the “global villagers” we are today? Watch for an email announcing the first issue. I think you’ll enjoy it. ■

– John German, jdg@santafe.edu

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RESEARCH NEWS

Rocks to cells: Piecing together metabolism’s beginnings

Describing how living organisms emerged from Earth’s abiotic chemistry has remained a conundrum for scientists, in part because any credible explanation for such a complex process must draw from fields spanning the reaches of science.

A new synthesis by two SFI researchers offers a coherent picture of how metabolism, and thus all life, arose. The study, published December 12, 2012 in the journal *Physical Biology*, offers new insights into how the complex chemistry of metabolism cobbled itself together, the likelihood of life emerging and evolving as it did on Earth, and the chances of finding life elsewhere.

“We’re trying to bring knowledge across disciplines into a unified whole that fits the essentials of metabolism development,” says co-author Eric Smith, an SFI External Professor.

Creating life from scratch requires two abilities: fixing carbon and making more of yourself. The first, essentially hitching carbon atoms together to make living matter, is a remarkably difficult feat. Carbon dioxide (CO₂), of which Earth has plenty, is a stable molecule; the bonds are tough to break, and a chemical system can only turn carbon into biologically useful compounds by way of some wildly unstable in-between stages.

As hard as it is to do, fixing carbon is necessary for life. A carbon molecule’s ability to bond stably with up to four atoms makes it phenomenally versatile, and its abundance makes it suitable as a backbone for trillions of compounds. Once an organized chemical system can harness and manipulate carbon, it can expand and innovate in countless ways.

In other words, carbon fixation is the centerpiece of metabolism – the basic process

by which cells take in chemicals from their environments and build them into products they need to live. It’s also the link between the geochemistry of Earth and the biochemistry of life.

In a precursor paper earlier this year, Smith and SFI Omidyar Fellow Rogier Braakman mapped the most primitive forms of carbon fixation onto major, early branching points in the tree of life (*PLoS Computational Biology*, April 18, 2012). Now, they’ve drawn from geochemistry, biochemistry, evolution, and ecology to detail the likeliest means by which molecules lurched their way from rocks to cells.

Their 62-page “Logic of Metabolism” paper presents a new, coherent picture of how this complex system fits together.

What started as wonky geochemical mechanisms were sequentially replaced and fortified by biological ones, the authors believe. “Think of life like an onion emerging in layers, where each layer functions as a feedback mechanism that stabilizes and improves the ability to fix carbon,” says Braakman.

Carbon fixing and other chemical sub-processes that together constitute metabolism each comprise dozens of steps; some are quick and easy turnkey reactions with simple molecules, others require highly specific chemical helpers, or catalysts.

The parts of metabolism that guide carbon fixation through its unstable intermediate stages fall into the latter category, requiring help. But these seemingly unlikely reactions are remarkably consistent across all living systems. In fact, says Braakman, their ubiquity and the difficulty with which they are forged make them the chemical constraints

within which all living systems operate – in a sense, the scaffolding for the tree of life.

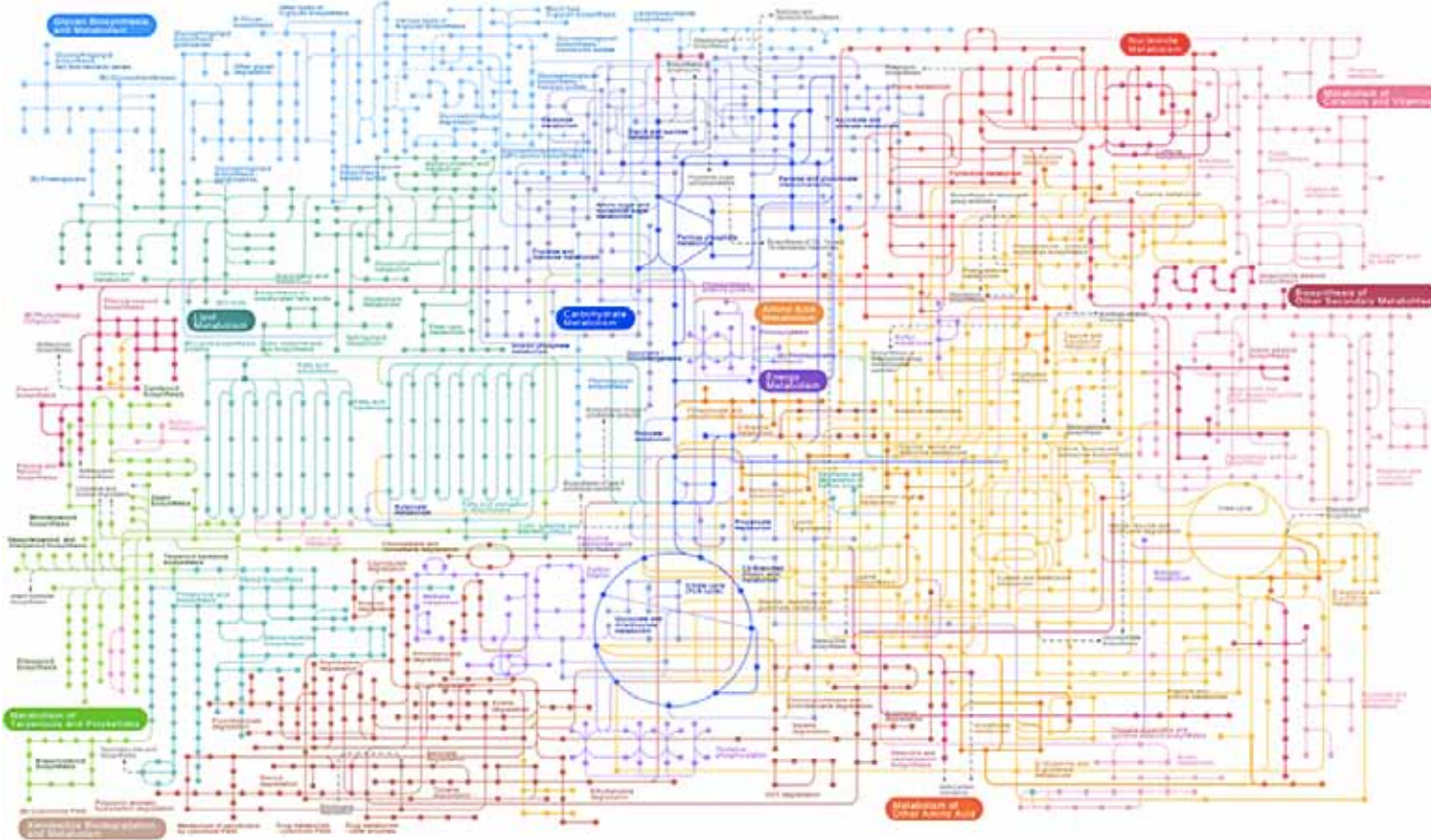
It’s these dependable regularities of hierarchy and modularity, amid the panoply of reactions comprising metabolism, that stabilize the system and enable its complexity.

Braakman and Smith describe specific features of metabolism and subdivide the helper metabolites by their functions. For example, vitamin B9, a complex molecule in the ‘cofactor’ class, facilitates the (otherwise unstable) incorporation of one-carbon compounds into metabolism.

In mapping the chemical pathways of life’s emergence, the researchers also touch on a more existential question: How likely was it for life to have developed at all? Extraordinarily so, says Braakman. “Metabolism appears to be an ‘attractor state’ within organic chemistry, where it was likely to be selected regardless of earlier stages of chemical evolution” in the chaotic, high-energy conditions of prebiotic Earth, he says.

Can it happen elsewhere? Possibly, even probably, he says. Rocky planets usually have cores chemically similar to ours, so if a planet is volcanically (and perhaps tectonically) active and has an ocean, it will probably have hydrothermal vents that spew chemicals, creating the potential conditions for life, Braakman says. In fact, the physics of star and planet formation make the chances of such conditions pretty reasonable.

Smith cautions, however, that we still have much to learn about the chemical and physical conditions that might lead to life-like organization, but he hopes their paper will at least “lead to experimental questions that focus more directly on the key functions that link metabolism to geochemistry.” ■



Detail of a global map of metabolism, courtesy of the Kyoto Encyclopedia of Genes and Genomes developed by Kanehisa Laboratories (www.kanehisa.jp)



SFI Omidyar Fellow Anne Kandler in September joined the faculty of the School of Mathematical Sciences at City University London as an assistant professor. Her two-year term at SFI included work in modeling and analyzing cultural shift processes, including modeling the cultural influences on endangered languages using Scottish Gaelic as a case study.



SFI Omidyar Fellow Jeremy Van Cleve has joined the National Evolutionary Synthesis Center (nescent.org) as a postdoctoral fellow. During his three years at SFI he studied how evolution works in changing environments, how sex-specific

demographic effects create selection for genomic imprinting and other novel phenotypes, and how the architecture of mechanisms of behavior evolve, including the evolution of empathy.



SFI External Professor Jessica Green is a principal investigator for biology in the University of Oregon's new Microbial Ecology and Theory of Animals Center for Systems Biology, funded by a five-year, \$10.3 million grant from the National Institutes of Health. SFI Omidyar Fellow James O'Dwyer is a collaborator. The center is devoted to understanding how animal-associated microbial communities assemble, interact, evolve, and influence human health and diseases.

SFI Online

Multimedia content available at www.santafe.edu



Video: SFI Science Board member Lord Robert May, Baron May of Oxford, in a series of three lectures, considers beauty in mathematics, the complex systems dynamics in banking, and ways to think about our world's biological limits. Source: 2012 SFI Stanislaw Ulam Memorial Lecture Series video



Audio: SFI President Jerry Sabloff takes on pseudo-archaeology, scientific literacy, and the Mayan apocalypse. Source: Santa Fe Radio Café interview



Video: SFI External Professor Doyme Farmer describes how he and

his collaborators are building a high fidelity model of the financial crisis and housing collapse. Source: Institute for New Economic Thinking video interview



Video: Participants in an SFI symposium co-sponsored by the Krasnow Institute discuss financial complexity and why economists didn't see the financial crisis coming. Source: SFI video



Video: Science historian George Dyson explores ideas pursued by the late Stanislaw Ulam (1909-1984) that have become tenets of modern mathematics and physics. Source: SFI lunchtime seminar video

RESEARCH NEWS

Better ways to estimate the diversity of unseen life

Ecologists often rely on the twin standards of the variety and number of species to describe a given region's diversity. But scaling down the size also scales up the numbers: On and in our bodies is a community with ten times as many microbes as there are cells of a human host, which makes counting species and comparing diversity an intractable problem.

SFI Omidyar Fellow James O'Dwyer, SFI External Professor Jessica Green, and Steven Kembel at the University of Quebec at Montreal have developed a new approach, which they detailed December 20, 2012, in the journal *PLOS Computational Biology*.

Using a gene that codes for a scaffolding used in building proteins – whose crucial role in a fundamental process means its sequence has changed little over millennia – they bypassed the ambiguous step of species identification and compared organisms by looking at the degree of change in that gene. In the resulting

tree of relatedness, the longer the branch, the more changes in the gene and the less the organisms are related.

"Traditionally, we look at biodiversity in terms of total number of species, and whether they're rare or abundant," explains O'Dwyer. "Sequence data let us go beyond that."

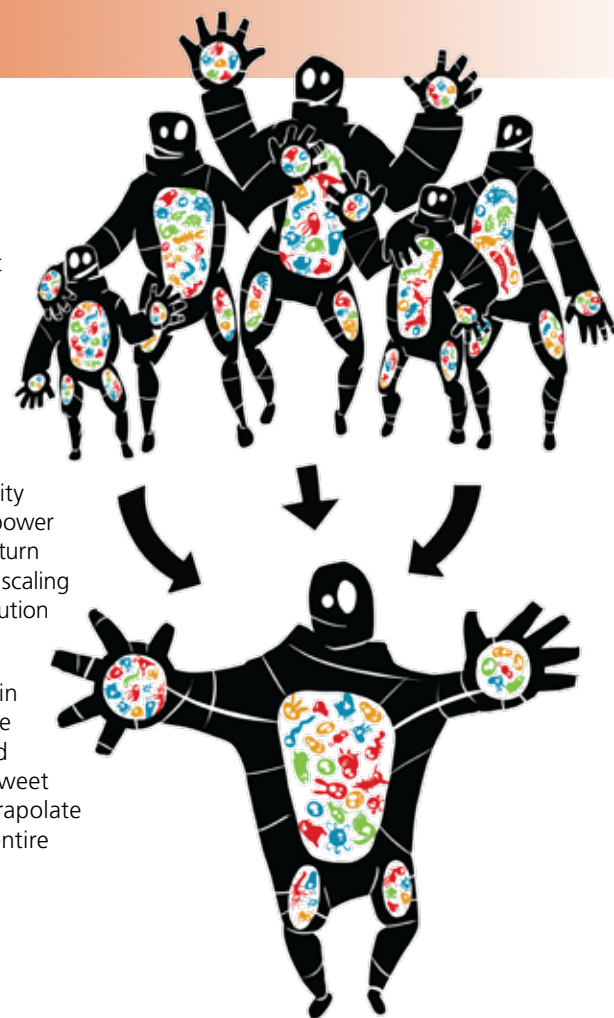
The new idea is looking at and predicting phylogenetic diversity, which takes into account relatedness within community. "Phylogenetic diversity is more tightly correlated with functional diversity – what a community is doing and why – than species diversity alone, and is therefore more informative," he says.

At the center of their new approach is what they call the Edge-length Abundance Distribution, where "edge" refers to the branch length determined by the gene's similarity between species. This quantifies the contribution of different clades – an ancestor and all of its descendents – to phylogenetic diversity.

They tested the approach on a subject with a huge range of habitats: the human body. One round of sampling the subjects' foreheads, forearms, elbows, knees, mouths, noses (both on and in), and guts yielded millions of sequences.

The team found that a habitat's diversity increased with its size according to a power law, and that this boost in diversity in turn arises from an unexpected power law scaling in the Edge-length Abundance Distribution with clade size.

With these findings and techniques in hand, O'Dwyer wants to characterize microbial communities on plants and fish, and in buildings, and find the sweet spot of sufficient information to extrapolate trends in diversity from samples to entire communities. ■



RESEARCH NEWS

SFI scientists not settling for slums' bad reputations

With as many as a billion people worldwide now living in slums, understanding what might place these communities and their cities on paths of increasing socioeconomic opportunity is critical.

A new research project now under way at SFI, in collaboration with the nonprofit Slum Dwellers International (SDI) and backed by a \$1,025,000 grant from the Bill & Melinda Gates Foundation, seeks to expand and formalize the scientific study of urban slums worldwide.

"We expect this project to be an unprecedented systematic scientific analysis of the general characteristics of urban informal

settlements," says SFI Professor Luis Bettencourt, a physicist whose research includes studying urban organization and dynamics as a leader of SFI's cities research team.

For years, the groups that comprise Slum Dwellers International have been collecting census-like data on many of the world's slums. These data have been aimed primarily at empowering slum residents in their contacts with city and national governments. Using SDI's data together with other information, the SFI researchers hope to uncover some of the general underlying principles common to rapid urbanization and the emergence of informal settlements.

The first stage of the 18-month research project, Bettencourt says, will be to analyze the existing SDI data using the statistical tools and experience SFI has developed in its scientific studies of cities. The researchers will combine and compare the SDI data across cultures, levels of socioeconomic development, geography, and time to identify common features of informal settlements and test the data for accuracy and potential biases.

The second stage of the project will be to study how the SDI data was collected and find ways to establish its consistency and make it most useful to scientists, policy makers, NGOs, and others interested in urban development.

In the final stage, the project will help design new and expanded data-collection practices and generate new datasets.

"We want to find ways to make the greatest use of the data SDI collects," Bettencourt says. "In this way, the project will help create standards through which informal communities can collect and use data about themselves and develop economic models to sustain these efforts."

This, in turn, should help better articulate the needs of those living in slums, and suggest planning and development solutions that maximize the welfare of resident communities and of their cities and nations. ■

RESEARCH NEWS

Unlearnable games: When game theory breaks down

For decades, economists have relied on game theory as a basis for understanding behaviors in financial markets. But these simplified models of decision-making assume the players fully understand the game and rationally tend toward what is known as the Nash equilibrium point – the sweet spot of optimized win, risk, and tradeoff.

Such assumptions give far too much credit to decision makers in actual financial markets, who are rarely fully aware of either the rules or the other players' choices, and who often make irrational choices. As a result, game theory does a poor job of representing real-life economics. When, then, is it time to abandon game theory and use other approaches?

Tobias Galla, a frequent SFI collaborator at the University of Manchester, and SFI External Professor Doyme Farmer, at the Institute for New Economic Thinking at Oxford, searched for the point at which game theory breaks down in modeling economic behavior. They ran thousands of simulations of two-person

games in which each player had to choose among various moves repeatedly. Each move had many possible payoffs; virtual players chose their best moves based on their successes and their recall of previous experience.

Galla and Farmer found three kinds of behaviors, depending on the complexity of the game. Zero-sum games, where the won and lost amounts sum to zero, lead to stable outcomes. In games with a competitive character, players' strategies vary indefinitely, producing high-dimensional chaotic behavior. And in games of a more cooperative nature, players eventually settle into one of dozens of stable outcomes.

Finally, boosting players' memories changed the outcome, but in a surprising way: the more a player remembered past behavior, the less likely he or she was to repeat move sequences. In such cases, no pattern of response emerged, even with "experience-weighted attraction" – when players keep choosing previously successful strategies and

avoiding bad or dicey options based on what they've learned the hard way. Instead, long memory tends to lead to unpredictable behaviors, and the outcome is what is known in theoretical physics as chaotic attractors.

The researchers conclude that equilibrium is not the right thing to look for in a game, noting that some games are inherently unlearnable. This supports the hypothesis that the real world is frequently not stable, and that equilibrium models are not that relevant for understanding decisions in a financial market.

The pair is looking to expand their study to multiplayer games and to cases in which the game itself changes with time. This is akin to situations in financial markets, where multiple players interact with and react to each other's decision making, and where new strategies become available as time progresses.

Their results were published in *Proceedings of the National Academy of Science* on January 7, 2013. ■

> Networks continued from page 1

Ultimately, the team wants to design algorithms that will analyze a network based on sufficient but incomplete data, make intelligent guesses about gaps in knowledge, indicate which links will form in the future, and note quirks or unusual behaviors in functioning networks.

They have already made progress. In a recent paper, Moore and his students Yaojia Zhu and Xiaoran Yan, along with machine-learning expert Lise Getoor of the University of Maryland, developed a model for categorizing a massive set of research papers. Using both the content of the papers and the links (citations) between them, their algorithm outperforms existing methods – and can run on a laptop.

In addition, Moore, Clauset, and Clauset's student Abigail Jacobs are working with SFI Professor Jennifer Dunne on predicting parasitic links in food webs. And Newman and his student Brian Ball have developed a new model of social networks that takes social status into account. ■



Welcome to SFI's Tesuque Campus

*Largest ever one-time gift to SFI
adds a quiet setting for scholarly
contemplation, research*



When Eugene Thaw first came to New Mexico, SFI's founders were still conceiving a plan to create an independent, interdisciplinary research center to study complex systems.

Almost 30 years later, Thaw spoke at a luncheon in his honor at that Institute, minutes after signing over his former Tesuque, New Mexico, home to SFI – a gift of land and residences that constitutes the largest one-time donation in the Institute's history.

The 36-acre estate, now referred to as SFI's Tesuque Campus, includes five buildings, art, books, furniture, a meadow, a koi pond with a waterfall, and conservation easements surrounding the property.

A short 10-minute drive from SFI's main campus, the estate is a quiet, contemplative setting for SFI scholars, visitors, and science meetings.

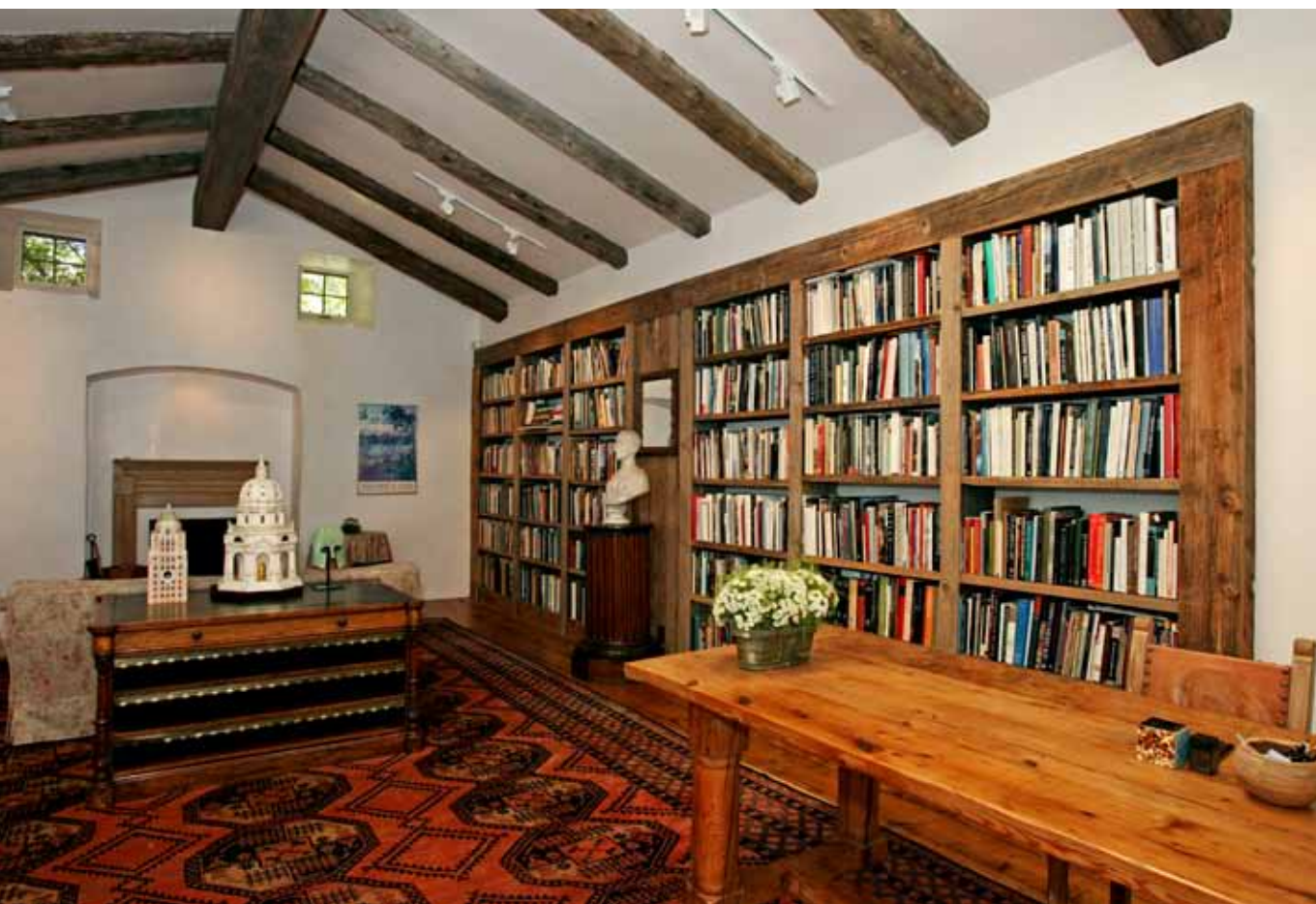
"SFI is deeply grateful to the Thaws for their extraordinary vision and generosity," says Institute President Jerry Sabloff. "This new campus will give us terrific space to host our small working groups and house visiting scientists."

Restarting science from scratch

Why would Thaw, a retired art appraiser, lifelong art collector and philanthropist, and his wife Clare donate their estate to a research center?

He says he's often asked a similar question: why he chose the Morgan Library in New York to receive his collection of master drawings. "I generally say this," he says. "If civilization was ending and you could save one place to start it all over again, it would be the Morgan Library, because it's Shakespeare folios, it's Gutenberg bibles, it's Rembrandt collections, it's the most incredible repository of literary and aesthetic quality that mankind has ever achieved.

"When I think about the world of science,





when everything is going down the tubes and when ignorance is on the rise, if you could save one place that might start discursive thinking all over again, it would be the Santa Fe Institute. They are equivalent intellectual centers.”

He and Clare fretted that selling the property as real estate would have resulted in its quick dismantlement. “There aren’t very many tracts of that size left in the immediate suburbs of Santa Fe,” he says. “It seemed to us that a gift of the property to an organization like the Institute would make more sense. Why not choose to give away the property, before it turns into money, to the right new owners and have it serve a good purpose?”

Land with a colorful history

As a graduate of St. John’s College in Annapolis, Thaw first came to New Mexico in the early 1980s as a member of the board of St. John’s College of Santa Fe. Then, in 1986, he was invited to be an appraiser of the estate of famed painter Georgia O’Keeffe, which included hundreds of her paintings.

He arrived a month after O’Keeffe’s death, and he and Clare spent 10 days at nearby Bishop’s Lodge. “We fell in love with it, and we bought a house the next year,” he says.

The property has a colorful history. The original house, he says, was “a beautiful piece of architecture” by renowned traditionalist New Mexico architect Betty Stewart that had been written up in *House & Garden*. It had previously been owned by World War II aviator and colorful Santa Fean Winnie Beasley.

The Thaws used the place as a vacation home until Mr. Thaw retired from art appraising in 1991, when they made Tesuque their primary residence. The estate grew over the years as they acquired adjoining tracts and residences.

One such acquisition – the lot that now features a meadow, gazebo, and koi pond – had been the site of a vacation home of cult spiritual teacher and software designer Frederick Lenz, who would arrive at the property every so often “in a huge white limousine

with a secretary and two Scotty dogs,” Thaw says. “He had his home filled with stuffed animals, many of them life-sized, including an elephant and a giraffe, and ticker tape machines to follow his investments.”

The guest house, which later became the Thaw residence, had been owned by Walter Mead of the Mead Paper Company.

A gift from the head and heart

In Santa Fe, Thaw took up collecting American Indian art. Through a friend they met Nobel laureate and Institute co-founder Murray Gell-Mann, who introduced them to Geoffrey West, whose work with University of New Mexico professor and SFI External Professor Jim Brown in biological scaling intrigued the Thaws. They began to support SFI’s research in the early 1990s.

Mr. Thaw speaks fondly of the property, and admits to some difficulty giving it up. “It has wonderful trails for walking,” he says. “It has both formal and informal areas. It has great views of the Sangre de Cristo Mountains.

It has views of the most beautiful rainbows you’ve ever seen. It is very special for us.

“This gift is with both my head and my heart,” he adds. “I hope that the Institute finds, by experiment and by living with it, the right way to handle it.

“I’d like it to be a place where they can have gatherings of all sorts, and where individuals, visiting scholars, people of interest, can come and simply spend time and have a very pleasant and physically inspiring place to do their work. And I think work of that sort is often done in that kind of seclusion, in that kind of atmosphere.

“It’s different than this building [the Cowan Campus], which is more of a school and more of a busy place. I think the [Tesuque Campus] can be more of a contemplative area, and it might be useful for the Institute to have both. It was the same – the earth and the grass and the trees – for me as it is for the Institute. But the use you make of it has to do with your own imagination and personality.” ■



the federal level, we've had a very successful year in terms of proposal success rate, not only with the National Science Foundation, which has been a very important source of support over many years, but also with other agencies. We were able to win our first DARPA grant in a number of years [see article beginning on page 1].

The other trend that is encouraging, really a continuation of a trend that started in the past few years, is that some of the major private foundations that had not supported us before, or at least had not in the recent

interdisciplinary science. And the rhetoric of the funding agencies, both on the federal side and among the foundations, and also in the larger scientific world, I think, is beginning to reflect that. That said, the funding reality still lags behind. So I think we have an important role to play in terms of showing how valuable our approaches are.

On the scientific side it's too early to declare success. The goal of building a broad theory that links complex systems at all scales, from atoms to cells to human societies, has not been achieved. We are starting to see some

operating support. The very important gift from the Thaws of their estate in Tesuque, N.M. [see article on page 4] won't have a direct financial impact at this time, but I know it will play a significant role in our everyday lives at the Institute. And I think we're starting to see an improvement in the philanthropic climate. So we're not out of the woods, but our financial picture has started to improve. That's one reason we were able to include in the Institute's 2013 budget a reinstatement of employee salaries that were reduced in August 2010, as well as restoration of SFI's match to employee pension contributions. This brightening revenue picture is combined with the unbelievable work of the staff and faculty in keeping SFI's expenses down. Everyone has pitched in, and we're running as tight a ship as possible. So the confidence we feel now is based both on the improving revenue picture and the austerity we've worked so hard to achieve.

Update: We've seen some changes recently at the leadership level, with Michael Mauboussin as the new Chair of SFI's Board of Trustees [see article below], and Jennifer Dunne as the incoming Chair of the Faculty.

Sabloff: Yes. We're obviously quite grateful to [former board chair] Jim Rutt for his leadership, and we are delighted that Michael Mauboussin has agreed to replace him. Michael can provide critical leadership both on the financial side and in attracting new board members. Like Jim, Michael understands our business and the nature of our scientific work, so that's an ideal combination. As for the Chair of the Faculty, both David Krakauer and Doug Erwin have really been terrific in that role, and I know Jen will be as well. It's not an easy position. You have to be aware of diverse and often competing interests and keep SFI's science on a steady, aggressive path in the midst of it all. I'm delighted that Jen has agreed to take on this role, and that she's agreed to step in sooner than we anticipated [see article below].

Update: What are the Institute's primary challenges in 2013 and beyond?

Sabloff: The obvious one is still the budget. It's somewhat stronger than it has been in the past, but we still have significant fiscal challenges. There are things we don't have control of, such as the economy, which in turn can impact federal funding and the philanthropic climate, that could negatively impact us, so we have to be very careful and prudent. Controlling expenses and bringing in new revenue are going to remain my main focus and that of the senior staff and faculty. The second challenge is to strengthen our faculty. That's tied to the budget picture. We've been able to maintain a quality scientific atmosphere through all of this with the Omidyar Fellows, our program postdocs, and external faculty visits and so on, but we're still way below what any of us feel we

2013 science meetings

The following science meetings are approved for 2013:

Working Group: Self-Invention in Biological and Societal Systems, sponsors Manfred Laubichler, Doug Erwin, and Sander van der Leeuw, January 25-26, 2013

Workshop: Dynamics of Wealth Inequality Project, sponsors Sam Bowles and Paul Hooper, February 1-3, 2013

Working Group: Gradient-Based Ecological Network Research: Next Generation Data, Models, and Theory, sponsor Jennifer Dunne, March 5-7, 2013

Workshop: Structure, Statistical Inference, and Dynamics in Networks: From Graphs to Rich Data, sponsors Aaron Clauset, Cris Moore, and Mark Newman, May 6-7, 2013

Workshop: Deep Computation in Statistical Physics, sponsor Cris Moore, Jon Machta, and Stephan Mertens, August 7-10, 2013

Workshop: Dynamics of Technological Innovation, sponsors Doyne Farmer and Jose Lobo, August 7-31, 2013

Workshop: Gateways to Emergent Behavior in Science and Society, sponsors David Pines, John Holland, Simon Levin, and Donald Saari, September 23-26, 2013 ■

need in terms of senior researchers who are the foundation for our science. That remains a major priority. Doug Erwin and I are advertising for a new faculty position in the new year.

Update: Why does today's world need a place like the Santa Fe Institute?

Sabloff: Generally, there is still too much emphasis in the world today on short term, linear thinking, and on narrow solutions to a host of critical issues we face as a nation and as a species. It's SFI's focus on complex adaptive systems, on interdisciplinary approaches, and on long-term thinking that makes it valuable in considering these issues. If we are going to tackle the unbelievable problems facing us now, much less those facing future generations, I think the SFI perspective is crucial. The role SFI plays in the scientific community and in the world today is, I believe, more critical than it was 28 years ago at the Institute's founding. ■



past – the John Templeton Foundation, the Rockefeller Foundation, and the Bill & Melinda Gates Foundation [see article on page 3] – are now supporting SFI in very significant ways. The research they are funding is right on target not only with the interests of the principal investigators, but also with SFI's interests.

It's also nice that our two newest resident faculty members, Cris Moore and Luis Bettencourt, have both been very successful on the grant front. These new grants not only support their own research, they bring in new postdocs, new visitors, and new workshops and working groups. That just invigorates and stimulates SFI science and strengthens our scientific community.

Update: Does this increased support from some of the major foundations indicate a more mainstream acceptance of SFI's approaches?

Sabloff: I think if you look at the founding mission of the Institute, in some ways SFI has had terrific success. It's not all SFI's doing, but clearly we have been a driver in promoting a complex adaptive systems perspective, as well as a recognition of the importance of

patterns, and there have been some interesting insights, but there is a long way to go. Whether we can, in fact, realize the initial hopes of having a more encompassing theory of complex adaptive systems is an open question. And we still see a great deal of linear thinking in science and in public policy. While we have not yet won full mainstream acceptance of our approaches, we should be very proud of the Institute's progress in its 28 years.

Update: You mentioned the expansion of the Omidyar Fellowship [see article beginning on page 1] along with some major changes to its structure. Why was this so important to you personally, and how will this affect SFI broadly?

Sabloff: It loomed large to me because it's a really good program, but the program itself was not as well supported as I think either the Omidyars or SFI wanted. We were putting in significant funding from our unrestricted budget and, despite the Fellowship's scientific success, we weren't nearly where we wanted to be financially in terms of the endowment. So I'm just delighted that we could work with the Omidyars to come up with a plan that strengthens the program, improves the science, gives us more Fellows, and gives the Fellows more to work with, and at the same time rationalizes the business plan that underwrites it and lowers the burden on the Institute. It will transform a very good program into an excellent one, and, according to our estimates, extend it out to at least 2030. It's a classic win-win. I'm very grateful to the Omidyar Group for their commitment to its success.

Update: For the last several years, SFI's budget has been your top concern. What's changed, and does SFI have a little breathing room now?

Sabloff: I think we are on a positive trajectory. We're clearly in a stronger position than we were, say, in 2009. I'm encouraged, but we're certainly not where we want to be. Expanding our research grant base from a major reliance on the NSF to a much broader array of government and private foundations, and the success in bringing in large grants across the board, has been a major improvement. The expansion of the Omidyar Fellowship holds a lot of promise for the future. We are very grateful for a major grant from the Delle Foundation for general

Chair of Faculty transition to occur February 1



SFI Professor Jennifer Dunne will succeed Doug Erwin as SFI's Chair of the Faculty and Vice President for Science sooner than previously announced. Her term begins

February 1, 2013 (rather than July 1, 2013) and ends June 30, 2015.

Dunne will serve as Chair of the Faculty on a half-time basis, spending the other half of her time conducting research, as previous chairs have done. She asks members of SFI's community to use sfiscience@santafe.edu for science-related email correspondence for the faculty chair. ■

INSIDE SFI

Board news: Michael Mauboussin elected chair of SFI's Board of Trustees



Michael Mauboussin, former Chief Investment Strategist for Legg Mason Capital Management, has been elected chairman of SFI's Board of Trustees. His three-year appointment began November 4, 2012, following his election at the Board's bi-annual meeting. He replaces Jim Rutt, who served as chairman since 2009.

Mauboussin has been an active member of SFI's Board since 2000 and of SFI's Business Network since 1998. He has contributed extensively to the Network's activities as a speaker, panel member, and co-organizer of Network Topical Meetings and Symposia.

His complex systems-inspired advice on market behavior and dynamics is frequently sought by financial analysts and investors. His new book, *The Success Equation: Untangling*

Skill and Luck in Business, Sports, and Investing, brings a multidisciplinary perspective to the relative roles luck and skill play in individual and business success.

In addition to Mauboussin's election as chairman, the Board of Trustees also made the following appointments:

- J. Leighton Read, M.D., venture partner for Alloy Ventures, has been elected vice chairman (three-year term);
- Reese Jones, a venture capitalist and trustee of Singularity University at NASA Ames, was elected an SFI trustee (three-year term);
- Ross Buhrdorf, chief technology officer for HomeAway, Inc., and former VP of Engineering at Excite.com, was elected an SFI trustee (three-year term);
- SFI Distinguished Fellow Murray Gell-Mann was named a lifetime member of the Board of Trustees. ■



> **Omidyar Fellowship expansion** continued from page 1

opportunities, and freedoms to lead tomorrow's transdisciplinary research programs and companies," says Sabloff.

SFI is making the following improvements, beginning this year:

- Increase the number of appointments (increase total number of Fellows by 3-4 to total 11-13);
- Expand leadership training and professional development; and,
- Increase support for travel and scientific collaboration.

The Fellowship's enhancements are designed to optimize what is already a great program, he adds.

A shift in the financial structure of the program, including annual financial support

and dollar-for-dollar matching contributions – now applied to program operations rather than to an endowment – from the Omidyar Group will fuel the enhancements and help ensure the long-term sustainability of the program, says Sabloff.

"Through the imagination and generosity of the Omidyars, this Fellowship has, in just a few years, distinguished itself as the premier postdoctoral appointment in transdisciplinary science anywhere in the world," he says. "That is a singular achievement. But with the program's success comes greater opportunity, and we're ready to take it further.

"These changes will create added opportunities for our Fellows to do great science," he adds. "We are delighted with the Omidyars' vision and their commitment to this important program." ■

BUSINESS NETWORK NEWS

Fellowship offers quality 'SFI time'

A solid block of time to ask deep, relevant questions and explore answers is a luxury not often enjoyed in business. Members of SFI's Business Network have an opportunity to enjoy some quality SFI time as part of the Business Network Fellowship.

Fellows spend up to four weeks over a two-year period at SFI researching a topic that applies complexity science directly to their business interests.

"It's one of the most important benefits to Network members because it provides them the opportunity to become a member of the SFI scientific community for a specific period of time," says Chris Wood, Director

of SFI's Business Network. "If I were a scientist at a member company, you bet I'd be applying for the Fellowship!"

Two Fellows are chosen each year through a competitive application process. To apply,

Network members must submit a written proposal that describes the research project, the scientific benefits of the research, and how the project relates to current SFI research themes. Nine Business Network Fellows have been selected since the program began in 2003.

John Litherland, a Navy officer with The Chief of Naval Command's Strategic Studies Group, began his Fellowship in August 2012. He says SFI's research on the broad issues of complexity and information sciences can be applied to many issues in the military.

"Here at SFI I have the opportunity to interact with physicists, economists, anthropologists – every kind of scholar that's considering the complex issues that can affect us," he says.

During their terms, Fellows are members of the in-house SFI community. "It's hard to imagine that any organization interested in learning about these complex issues would fail to benefit from coming here and enjoying the interactions with the scholars here at SFI," says Litherland. ■



John Litherland



INSIDE SFI

Conference room renamed to honor gift



SFI Trustee Michael Collins has made a five-year, \$500,000 unrestricted gift to SFI. In recognition of the gift, the room previously known as the "Medium Conference Room," located in the main building on the Cowan Campus, is now

known as the "Michael and Sandy Collins Conference Room."

Collins has been President of Collins Capital

since 1982, which is today a group of "fund of funds" and mutual funds invested in multi-manager strategies utilizing alternative, nontraditional investment strategies. He currently serves and has served on numerous boards in finance, venture capital, culture, and the arts. During his nearly two years on SFI's Board of Trustees, he has contributed greatly to the intellectual and fiscal well-being of the Institute.

"We are fortunate to have him with us, and we are very grateful for this generous gift," says SFI President Jerry Sabloff. ■

EDUCATION

Online complexity course debuts soon

More than 3,200 people, from professors and professionals to college students and the just-curious, have signed up to learn more about the first in a series of SFI massive open online courses (MOOCs) in complexity, scheduled to begin in late January.

The first course, "Introduction to Complexity," will be an accessible introduction to the field, with no pre-requisites or course fees. It begins January 28.

SFI External Professor Melanie Mitchell, the course's instructor, says she's heard from many people about the need for an online course in the science of complexity. "There's an increasing number of people, people from all over the world who can't come to one of our events, asking where they can learn about this stuff," she says. "We knew there was going to be a lot of interest."

academic in a field – can teach the course to thousands, and often tens of thousands, of students at once.

In the 11-week "Introduction to Complexity" course, participants will learn about the tools used by complex systems scientists to understand, and sometimes control, complex systems. Topics include dynamics, chaos, fractals, information theory, self-organization, agent-based modeling, and networks.

"Students also will get a sense of how these topics fit together to help explain how complexity arises and evolves in nature, society, and technology," Mitchell says.

SFI's MOOCs will be integrated with the Complexity Explorer, an online education repository that includes computer simulations, background reading, exercises, and other resources. (Development of the Complexity Explorer is being supported by a grant from the John Templeton Foundation.)

As part of the course, an online student forum will be available to participants, "so people can discuss contents of the course with people from all over the world," Mitchell says. Her team will help organize local meetups in some areas, similar to study groups.

"Introduction to Complexity" will be repeated, possibly in Fall 2013. A follow-on "Introduction to Complexity, Part 2" is planned for Summer 2013. Mitchell also hopes to offer a series of more advanced, special-topic future courses related to complex systems.

Mitchell is an SFI External Professor, a professor of computer science at Portland State University, and author of the award-winning book *Complexity: A Guided Tour*.

For more information, visit www.santafe.edu/mooc. ■



Screen shot from SFI's MOOC informational video, featuring course instructor Melanie Mitchell. Watch the video at www.santafe.edu/mooc.

MOOCs are offered by academic institutions in everything from fiction writing to physics, and their numbers are growing, along with the demand for nontraditional education choices. Online courses won't soon replace on-campus courses, Mitchell says, but they do offer certain advantages. "People can go at their own pace, they can focus on topics they're interested in, they can take it in any order they want," she says.

A MOOC can accommodate large number of students, so a single instructor – often a top

Follow SFI's Community Lectures live online

Beginning in March, SFI's Community Lectures will be available to the Institute's worldwide community, live on YouTube (<http://www.youtube.com>).

A Twitter feed (@sfi_live), active during each lecture, will provide links to supplementary information and offer members of both the auditorium and webcast audiences an opportunity to engage in a "backchannel" conversation about the presentation.

Each community lecture includes a Q&A session following the prepared remarks; those watching the live webcast can pose questions via email (sfi_live@santafe.edu) or Twitter (@sfi_live), and a selection of questions from the online audience will be read and answered by each speaker.

"Los Alamos National Bank has long sponsored our lectures in Santa Fe," says Ginger Richardson, SFI's VP for Education and Outreach. "With the Bank's continued support, we're pleased to extend our talks to the world at large."

Here is the 2013 SFI Community Lecture series schedule. For more information about each lecture and to confirm dates and times, please visit www.santafe.edu.)

March 14: Leysia Palen, UC Boulder, "Crisis Informatics: How Online Interaction During Unexpected Events is Changing the World" (Note: This lecture is to be held at the Greer Garson Theater, Santa Fe)

May 9: Alison Gopnik, UC Berkeley, "The Philosophical Baby: What Children's Minds Tell Us About Truth, Love, and the Meaning of Life"

May 30: Barbara Natterson-Horowitz, UCLA School of Medicine and L.A. Zoo, "Zoobiquity: How Jaguar Breast Cancer, Dolphin Diabetes, and Flamingo Heart Attacks Will Change Human Medicine"

June 4: David Eagleman, Baylor College of Medicine, "The Brain and the Law"

June 26: Leonard Susskind, Stanford Institute for Theoretical Physics, "The Cosmic Landscape"

July 31: Michael Crow, Arizona State University, "Complexity and Interdisciplinarity: Reconceptualizing the Academic Enterprise"

August 14: Steven Pinker, Harvard, and Rebecca Goldstein, author and professor of philosophy, "A Conversation: Emotion, Reason, and Moral Progress"

September 10, 11, 12: Stephanie Forrest, University of New Mexico, Stanislaw Ulam Memorial Lecture Series

November 6: George Dyson, science historian, "Turing's Cathedral: The Origins of the Digital Universe"

SFI Community Lectures are free and open to the public, but seating is limited. ■

Crowdfunding campaign offers lessons

Late on the evening of December 14, a generous “fueler” made a \$450 contribution on www.rockethub.com to support SFI’s first crowdfunding campaign. The donation, the last of 62 such acts during the six-week effort, put the total amount raised at \$3,000, the campaign’s goal.

Reaching that goal meant SFI postdoc Marcus Hamilton and his two collaborators at the University of Missouri will be able to start a small but important research project they had long imagined. Their project will test the use of small satellite tracking devices, each the size of a cell phone, for gathering data about how indigenous people use the landscapes on which they depend.

Anthropologists believe there are some 100 uncontacted, indigenous human groups remaining in the world today; most live in remote parts of the Amazon Basin, where deforestation, agriculture, illegal mining, and encroaching modernization press in on their horizons, threatening their forager-hunter-gatherer way of life.

Uncontacted groups have had no verified contact with the modern world other than through indirect trade with neighboring indigenous groups. Many live within large reservations, but little is known about how they move through and use their landscapes. Contacting such groups for study is risky; newly contacted people often become exposed to diseases to which they have no immunity. In addition, many of these groups actively resist interaction with the outside world; any attempt by scientists to make contact must be under controlled, government-sanctioned circumstances.

Hamilton and his collaborators want to record the movements of such groups without having to go through the dangerous process of first contact, so policy makers can make better-informed decisions about conserving their habitats.

The successful campaign allows the researchers to purchase 10 GPS units so they can

work with the well-studied Ache of northern Paraguay to test the devices – incorporated into pots, baskets, and tools – keeping records of their movements by satellite. If the pilot project is successful, the researchers want to propose a way to study the movements of uncontacted groups, through indirect trade, for example.

SFI’s use of Rockethub was also a test, of sorts. Today, crowdfunding is an increasingly common approach to philanthropic fundraising, and for raising seed money for projects in the arts. Essentially, many individuals, often engaged through social networks and word of mouth, contribute small amounts online toward a funding goal. Increasingly, scientists are using crowdfunding as a way to generate financial backing for needed but underfunded scientific research.

SFI collaborated with the SciFund Challenge, a nonprofit that promotes science crowdfunding, and Rockethub to conduct the campaign.

During the six-week giving window, much of SFI’s staff and faculty appealed to their own social networks for support. Hamilton made appearances at SFI events and on a local radio program. Members of SFI’s crowdfunding team handed out fliers. Posts to SFI’s Facebook page and Twitter feeds promoted the campaign.

“This project gave us a sense of how engaged our community of supporters is,” says Juniper Lovato, SFI Education and Outreach Program Coordinator, who led the campaign.

“The campaign got people talking about an important social issue that science and SFI can uniquely address,” says John German, SFI Director of Communications.

“This was an interesting and novel approach to funding,” says Hamilton. “It was very gratifying to see how interested people were in our research project, and we are extremely pleased about the support. Hopefully campaigns like this can help raise awareness of SFI and the diversity of its research to a new crowd.” ■



In *The New Economics of Inequality and Redistribution* (Cambridge University Press, July 2012), SFI Professor Sam Bowles incorporates the latest results from behavioral economics and the new microeconomics of credit and labor markets to show how escalating economic disparity is not the unavoidable price of progress. Rather it is policy choice – often a very costly one. Drawing on his experience both as a policy advisor and an academic economist, he offers an alternative direction, a novel and optimistic account of a more just and better working economy.



In *The Emergence of Organizations and Markets* (Princeton University Press, November 2012), John Padgett, a former SFI researcher, and SFI External Professor (Walter) Woody Powell combine biochemical insights about the origin of life with innovative and historically

oriented social network analyses to develop a theory about the emergence of organizational, market, and biographical novelty from the co-evolution of multiple social networks. The book was developed at SFI under a co-evolution of states and markets project.



Ecological interactions are exchanges of energy and materials between organisms and their environments. Metabolic rate affects ecological processes at all levels: individuals, populations, communities, and ecosystems. In

Metabolic Ecology: A Scaling Approach (Wiley-Blackwell, April 2012), Richard Sibly, SFI External Professor Jim Brown, and Astrid Kodric-Brown lay out a conceptual framework for metabolic scaling and ecology. Each chapter focuses on a different process, level of organization, or kind of organism. Together, the chapters provide an integrated framework that holds the promise for a unified theory of ecology. It is intended for upper-level undergraduates, graduate students, and senior scientists. ■

Pass it on: SFI summer education program deadlines approaching

Know a high school student who uses computers to understand the world? An undergraduate who might benefit from some one-on-one time with a complex systems scientist? A grad student interested in practical applications of complexity?

Planning for SFI’s 2013 lineup of education programs is in full swing, with application periods now open, and soon to close, for SFI’s schools, internships, and mentorships. Pass these dates on:

Summer Complexity and Modeling Program (CAMP) for current high school students: SFI and Groton School – leaders in complex systems and college preparatory education – offer this intensive two-week residential summer program July 28-August 9, 2013, on the Groton School campus. Participants conduct research on current ecological topics in the fields and woodlands of northeastern Massachusetts using computer modeling, collection and analysis of field data, discussions and seminars, and team collaborations. Application deadline is May 1, but apply now; space is limited and slots might be filled sooner.

Edward A. Knapp Undergraduate Fellowship (formerly known as Research Experiences for Undergraduates): Focusing on the computational and mathematical modeling of complex systems, this residential fellowship June 3-August 9, 2013, in Santa Fe trains aspiring scientists to gain quantitatively derived theoretical insights into complex systems. Techniques range from rigorous theorem-proof, to physics-style calculations, to computational



experiments and simulations. Application deadline is February 8, 2013.

Graduate Workshop in Computational Social Science Modeling and Complexity for grad students: This residential workshop June 16-29, 2013, in Santa Fe brings together a small group of advanced graduate students and SFI faculty for an intensive two-week study of computational social science modeling and complexity. The workshop comprises lectures and topical seminars and presentations of research in progress by participants. The program’s primary goal is to assist graduate students pursuing research agendas that include a computational modeling component. Application deadline is February 15, 2013.

Complex Systems Summer School for grad students and postdocs: The application period has closed, but SFI’s signature residential summer program in complexity science for grad students and postdocs is scheduled for June 3-29, 2013, in Santa Fe.

For more information and to apply, visit www.santafe.edu. ■

January / February 2013

UPDATE

SANTA FE INSTITUTE



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Science On Screen series returns February 6

The popular Science On Screen series returns in 2013, with Cris Moore – a computer scientist, mathematician, physicist, and author – providing a window into Shane Carruth’s twisty and unforgettable 2004 cult film *Primer*, in which two young inventors, working after hours in a garage, craft a machine that opens up a universe of possibility...and consequences.

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 seven Science on

Screen events in 2012.

The 2013 encore series, presented in conjunction with the Coolidge Corner Theater and the Alfred P. Sloan Foundation, offers three classic films selected by SFI scientists.

Upcoming Science on Screen events:

Primer with SFI Professor Cris Moore, February 6, 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

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 505-982-1338. All showings take place at the Center for Contemporary Arts, 1050 Old Pecos Trail, in Santa Fe. ■