



November / December 2015

# UPDATE



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## RESEARCH NEWS

### Why some species adopt complex life strategies

When faced with environmental stressors, some species respond (evolutionarily) by adapting to the new conditions or by evolving into multiple species. Others take a more unusual path, evolving complex life investment strategies with the ability to reproduce into various forms, or requiring multiple environments to complete a lifecycle.

SFI Omidyar Fellows Justin Yeakel and Eric Libby want to know why organisms like brown algae, Pacific salmon, and various parasites go to all the trouble "when there is overwhelming opportunity to choose simpler strategies, or to speciate," Libby says.

In late October, an eclectic group of experts – including ecologists, evolutionary biologists, and even a philosopher – gathered at SFI to explore this question from a number of perspectives and to look for general principles that might explain some organisms' adoption of more complex strategies.

Yeakel, who studies ancient food webs, approaches the question with larger organisms in mind, while Libby, an evolutionary biologist interested in the origins of multicellularity, seeks answers relating to Earth's smaller life.

Philosopher Peter Godfrey-Smith (City University of New York and University of Sydney) brought ideas about what constitutes individuality and how we might make distinctions among individual organisms, super-organisms, and groups of organisms.

Developing deeper understandings of how – and why – life on earth has evolved in the ways it has is important for several reasons, says Libby. "It's incredibly useful for understanding what we might expect if we were to ever find life elsewhere in the universe," he says.

> **more on page 3**



(Image: Laura Chambliss)

## Money and currency: Past, present, and future

Few tools of the modern world are as necessary as money. At its simplest, currency makes exchange possible by overcoming the inefficiencies of barter.

Money also permits individuals the time and space to specialize and create diverse products that can be converted, through the abstraction of value, to the items they need but don't specialize in making.

Money is a form of communication that allows for the operation of fundamental structuring processes in an economy –

including at one end the invisible hand of the market and at the other end the regulatory powers of government.

Money connects local decision making to the global order.

Markets and market prices emerge through individual competition for products and sales.

Thus, currency underlies human economic cooperation and, to a large degree, social complexity, putting money "squarely in the domain of complex systems science," says

SFI President David Krakauer, who is co-hosting this year's SFI Business Network and Trustee Symposium – Money and Currency: Past, Present, and Future – November 12-14 in Santa Fe.

The meeting will explore the history of money, from cowrie shells used for centuries in the trade networks of Africa, South Asia, and East Asia to the diverse and highly regulated currencies of today.

Because modern currencies touch a number

> **more on page 2**

## RESEARCH NEWS

### Cooperating on the puzzle of human cooperation

If there's one puzzle that unites the curiosities of anthropologists, economists, political scientists, archaeologists, biologists, and even policy makers, it's human cooperation. Ironically, they rarely get together to share, in a cooperative setting, what they know.

In September, an SFI working group met to mull over human cooperation across the disparate disciplines whose domains include its study.

"A better understanding of human cooperation is one of the key components in solving the problems the world faces," says Christa Brelsford, an SFI postdoctoral fellow who helped organize the event. The problem is, "different people are working at different parts of the spectrum, and they don't talk to

each other much."

To get them to talk, Brelsford, SFI Omidyar Fellow Caitlin Stern, and colleagues recently gathered 12 researchers – including a political scientist who studies water policy and property rights, an economist who studies consumer behavior, and a behavioral ecologist who studies humans and insects – for two days of presentations and discussions.

Their first aim: get everything out on the table, which revealed some surprising overlaps between disciplines, Stern says. For example, biologists' and anthropologists' ideas were similar to each other, but they shared less with ideas from political science. Likely, that's a matter of scale. Biologists, for example, are often interested in interactions between indi-

viduals, while political scientists are sometimes more interested in organizations or institutions – a difference that's led researchers to explain cooperation in different ways.

That idea connects to one of the working group's most important conclusions, Stern says. Addressing policy concerns such as climate change, for example, means knowing both how governments can coordinate to reach solutions and how individuals will behave in response.

Thus, scientists need a framework that encompasses biologists' understanding of individual cooperation and political scientists' understanding of government interactions. The pair hopes to continue advancing toward that goal in future meetings. ■



SFI Omidyar Fellow Sam Scarpino’s recent breakfast presentation in Santa Fe on poverty and disease was previewed in the October 12 *Santa Fe New Mexican*.

The *Atlantic* spotlighted research by SFI’s Jessica Green and her collaborators in a September 22 feature on people’s microbial “fingerprints.”

*Smithsonian’s* September 22 “Generation Anthropocene” podcast includes an interview with SFI Professor Luis Bettencourt on cities as potential problems and solutions for sustainability.

SFI’s Science on Screen event in Santa Fe inspired a September 21 *Santa Fe New*

*Mexican* article on fear, vampires, data, and vaccinations.

A lengthy September 16 article on Nature.com titled “How to solve the world’s biggest problems” reviews the history of interdisciplinary science and mentions SFI as one of its pioneers.

The September 15 *Santa Fe New Mexican* noted Jennifer Dunne’s 2015 Ulam Lectures, themed “The Web of Life and the Ecological Human.”

A September 11 article in *Scientific Computing* highlights a study of aggression and rank calculation in groups of monk parakeets by SFI External Professor Simon DeDeo and collaborator Elizabeth Hobson.

A feature article in the September issue of *Scientific American* titled “The most invasive species” covers research of the origins of human cooperative behavior by SFI Professor Sam Bowles and SFI External Professor Robert Boyd and their colleagues.

*Quanta* magazine explored recent research by SFI’s Dan Larremore, Aaron Clauset, and their collaborators in an October 15 article, “Networks untangle malaria’s deadly shuffle.”

SFI’s Murray Gell-Mann makes *National Geographic’s* list of “dissed” scientists based on a view that he is potentially deserving of a second Nobel Prize.



Goldstein



Dunne



May

SFI Miller Scholar Rebecca Newberger Goldstein has been selected for a 2014 National Humanities Medal. She and nine others were honored by President Obama during a September 10 ceremony at the White House.

A review article in the September issue of the journal *Food Webs* named SFI Professor Jennifer Dunne and SFI Science Board member Robert May as two of 14 researchers whose work has expanded the scientific understanding of food webs over the last century.

## Nonlinearities

From the editor

SFI Omidyar Fellow Eleanor Power and I were able to cross “ghost hunt” off our bucket lists in late October after being invited to participate in a séance by local science reporter Staci Matlock, whose task was to write an interesting Halloween story. Never one to take shortcuts, Staci arranged a haunted house, a psychic counselor, and a half-dozen volunteer participants. Elly played the role of objective scientist, providing her perspective as an anthropologist interested in beliefs and rituals.

It went down at a gallery on Santa Fe’s Canyon Road, reportedly built in 1905 as a women’s clinic, and where for decades people have heard slamming doors and soft voices in empty rooms and found things in odd places...the usual ghost hijinks. I come from a thoroughly skeptical point of view, so the spectacle was nothing short of irresistible to me. In the end, the apparitions were no-shows, but as an offbeat science communication opportunity, not too bad. You can read all about it here: <http://bit.ly/1M4CJ5E>.

Chris Wood, longtime SFI VP, director of the Business Network, and resident faculty member, has announced his intention to retire from full-time SFI duties. He’ll stay on until the end of January and join SFI’s external faculty at that time. You may know that for the last year-plus, Chris has been winning a war with cancer, and he still is, decidedly so. But chemotherapy, major surgery, and side effects have prevented him from returning to the 100 percent level he had imagined.

This news hit me harder than expected. His broad scientific training and sharp intellect have many times prevented you, the *Update* reader, from being exposed to errors, both in fact and in theme. More important, Chris is a friend to me, and his generous spirit has touched me routinely and directly, as it has every person at SFI. I know I speak for all of us, Chris, when I say we will miss you in ways we don’t yet comprehend.

A fixture of our relationship, mine and Chris’s, has been a friendly sparring over the value of social media in our lives. Thus, I can think of just one way to end this column – hashtag ur1ofakind-myfriend. ■

– John German, [jdg@santafe.edu](mailto:jdg@santafe.edu)

## CREDITS

**Editor:** John German  
**Contributors:** Katie Mast, Krista Zala, Nathan Collins, Jenna Marshall, Devon Jackson  
**Design & production:** Michael Vittitow  
**VP for Science:** Jennifer Dunne

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

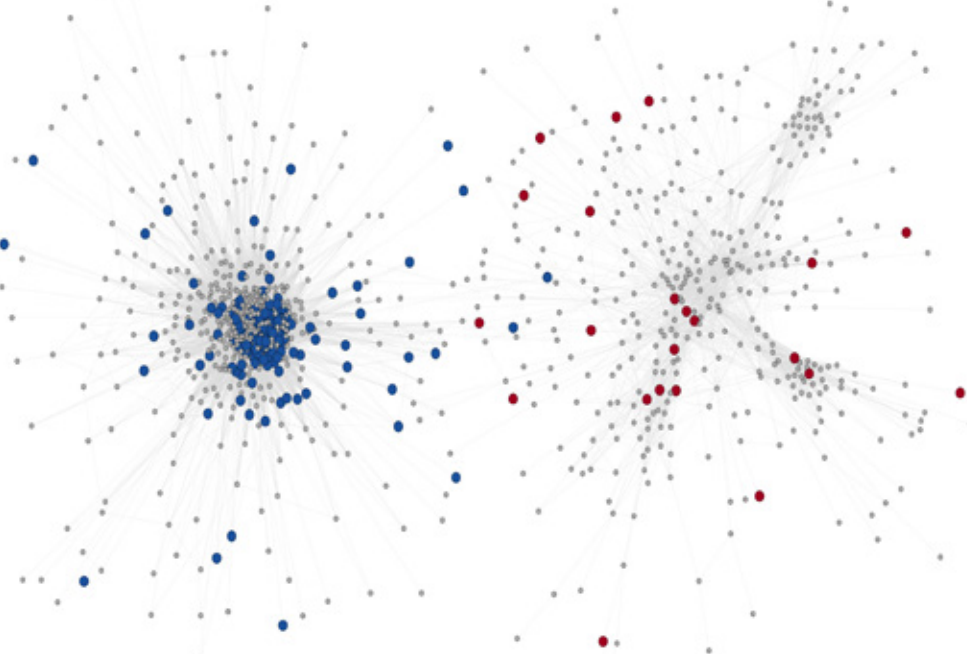
## RESEARCH NEWS

# In gene networks, it’s location, location, location

From appearance to endurance, nature’s adaptations all trace back to complex molecular networks. Improving our understanding of how genes give rise to outward adaptations may hinge on three concepts from network science – location, location, location.

Take the example of the humble winter weed *Arabidopsis thaliana*, the first plant species

It turns out that the genes involved in the weed’s extreme-weather adaptations occupy vastly different spots in the network: cold genes are densely clustered and highly connected in the center, and thus greatly influence genes farther along the expression pathways. Drought genes, in contrast, lie near the endpoints.



The genes involved in *Arabidopsis thaliana’s* extreme-weather adaptations occupy vastly different spots in the network: cold-weather genes (left) are densely clustered and highly connected in the center; drought genes (right) lie near the endpoints. (Image: Sam Scarpino)

to be sequenced. Past experimental attempts to find the genetic origins of the plant’s cold and draught tolerance turned up idiosyncratic results.

In 2014, a working group co-organized by SFI Omidyar Fellow Sam Scarpino, Jesse Lasky, David Des Marais, and Rafael Guerrero helped make sense of the data using network algorithms to analyze *Arabidopsis’s* genetic activation network – the labyrinthine chemical pathways of gene expression.

Simply put, “it’s biology that matters most,” says Scarpino, explaining that knowing gene distribution in a molecular network, rather than just the statistics of gene expression, is crucial in understanding adaptations.

With that established, the groundwork is laid for explaining the role of molecular networks in adaptation. The Molecular Networks and Evolution Across Biological Scales Evolution working group met again in October to develop a general theoretical framework, then test it using reciprocal

transplant experiments of *Arabidopsis* and the wild grass *Brachypodium*.

Joining the group were SFI Omidyar Fellows Josh Grochow and Chris Kempes and SFI Post-doctoral Fellow Laurent Hébert-Dufresne.

Scarpino reckons that if their experiments hold up, they’ll be midway to constructing a workable theory of molecular networks in evolution. Even if the experiments fall through, though, “we’ve had a breakthrough in the conceptual understanding of this question,” he says. “If we’re wrong, we’re wrong for the right reasons.” ■

## RESEARCH NEWS

# Working group seeks better cell type classification

Traditionally, cells have been categorized based on location within an organism, structure, function, or even developmental history. But recent advances suggest there might be better and more uniform approaches to cell classification and understanding cell types.

“Ultimately what determines the function of each cell or each cell type are the genes that are turned on in that cell,” says SFI External Professor Manfred Laubichler, President’s Professor of Theoretical Biology and History of Biology at Arizona State University and director of the ASU-SFI Center for Biosocial Complex Systems.

A better theory of gene regulation within cells is needed if we are to understand how cell types have evolved and how they might change in the future, he says: “The emergence of a new cell type represents an evolutionary innovation. This makes it all the more important to clearly redefine what a cell type is.”

As they have made progress in their individual fields and addressed similar questions, experts in cell biology, evolutionary biology, and systems biology have developed different concepts and terminology in their work. Unifying these definitions and approaches could lead to a more robust theory of cell evolution, Laubichler says.

He and colleagues Günter Wagner (Yale University) and Detlev Arendt (European Molecular Biological Laboratory) organized an early-October working group at SFI that brought together experts in these fields to develop a more unified understanding of cell type evolution. Laubichler says participants are working on a synthesis paper that will clarify existing questions and identify the most pressing next questions. ■

## > Money and currency continued from page 1

of concepts familiar to SFI – emergence, networks of exchange, scaling theory, decision theory, the theory of inequality, communication theory, encryption, and computational complexity – the meeting will explore the mechanics of money through the insights of complexity science.

It will then examine how money functions as a mechanism of exchange in the emerging world of cryptocurrencies, peer-to-peer markets, and bitcoins and their implications for business.

Krakauer conceived the topic for the meeting with SFI Board of Trustees Chair Emeritus Bill Miller. They are co-hosting the event with SFI Board of Trustees Chair Michael Mauboussin and SFI VP and Director of the Business Network Chris Wood.

Miller, Chairman and Chief Investment Officer of LMM, LLC, will chair an expert panel discussion on “Money, Currency, and Finance.” SFI Journalism Fellow Kevin Allison, a global resources columnist with Reuters Breakingviews, will chair a panel on “The World of Peer-to-Peer Exchange.” Speakers and panelists include experts in the history of money, investing and finance, digital and cryptocurrencies, and economic theory and public policy.

“This meeting offers an important and timely vehicle connecting ideas central to complexity science with the world of business and finance and the fast-evolving technologies of peer-to-peer communication and exchange,” says Krakauer. ■



# Working group: Grasses, mammals, and their co-evolution

After millions of years of amphibians, dinosaurs, and early mammals ruling the forests and swamps of the hot, humid Mesozoic and early Cenozoic, a new habitat emerged. Small patches of grasslands sprang up and spread as the climate cooled and dried.

These new, grassy expanses brought advantages and challenges. Prey species were safer in groups than on their own, for example, as a herd of grazers needs only one or two members to keep watch for predators while others ate or rested. Grass's scant nutrition meant grazing herd animals had to eat often and travel great distances in their incessant quest for food. The savannah was both easy to move through and tough for predators to surprise prey in.

Many mammalian groups were shaped by these features – like the knee-high, multi-toed herbivore that evolved into today's horse.

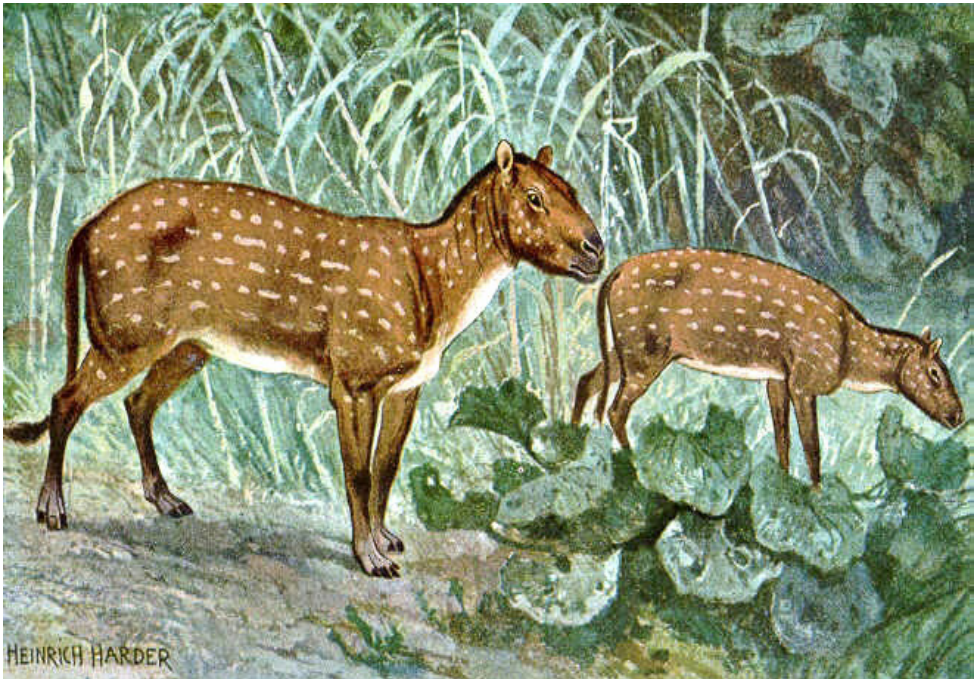
But how, exactly, did these changes happen?

And how did the varying evolutionary pressures influence each other?

“These questions have ignited much interest in paleontological and modern ecological research,” says SFI Omidyar Fellow Justin Yeakel, who co-organized with Dartmouth's Nathaniel Dominy a recent SFI working group, Coupled Grassland and Mammalian Community Dynamics over Ecological and Evolutionary Timescales.

At the two-day meeting, experts in community dynamics, evolution, morphology, anthropology, and climatology explored how grassy plants expanded from isolated patches to dominate the landscape, how they affected mammalian evolution, and how, in turn, mammalian diversification influenced grasslands.

The ecologies of interest were continually in flux, adding special complexity. “One question we asked is how mammalian species might have developed grassland-specific



The small, herbivore *Hyracotherium*, which averaged eight to 14 inches high at the shoulder, evolved into today's horse. (Image: Heinrich Harder, Wikimedia public domain)

traits in ecosystems that are constantly shifting,” says Yeakel.

The participants defined three topics that will shape their near-future research efforts,

and they planned to produce five to six research papers over the next three years. A followup meeting at Dartmouth in May 2016 will cement some of the questions posed at SFI. ■

# Putting humans into their environmental contexts

What if you had access to an online research tool that provided a vast knowledge base about humans and their historical relationships with their physical landscapes?

SFI External Professor and archaeologist Tim Kohler thinks such a tool would be broadly useful, not just to archaeologists but to researchers and policy makers in many fields for which the nexus of humans and their environments are of interest: history, ecology, geography, sustainability, and many more.

Kohler, an anthropologist at Washington State University, and Keith Kintigh, an an-

# Complexity Explorer introduces wave of new offerings

Two new offerings – a course on fractals and a tutorial on random walks – are the first of a wave of new Complexity Explorer content slated to come online over the next year.

The new course, Fractals and Scaling, was College of the Atlantic Professor David Feldman's response to requests for a broad exploration of the subject. It launched this fall.

The new tutorial, Random Walks by SFI Professor Sid Redner, offers a taste of random walks for students with more advanced skills. It is available now.

Gabrielle Beans, SFI Program Manager for Online Education, says new tutorials designed by SFI Omidyar Fellows Eric Libby and Joshua Grochow will be introduced later this fall, as

well as an Introduction to Information Theory tutorial by SFI Science Board member and External Professor Seth Lloyd (MIT). “He's an eloquent speaker, and his tutorial is bound to be a real highlight,” says Beans.

Unlike other popular online education platforms, like EdX and Coursera, which offer a diversity of stand-alone online courses, SFI's online learning platform focuses exclusively on complex systems topics, providing both broad overviews of the field and detailed explorations of specific topics, along with news and interviews with instructors. “We want to create a network of information and resources that anyone can follow as deeply as they want,” says Beans.

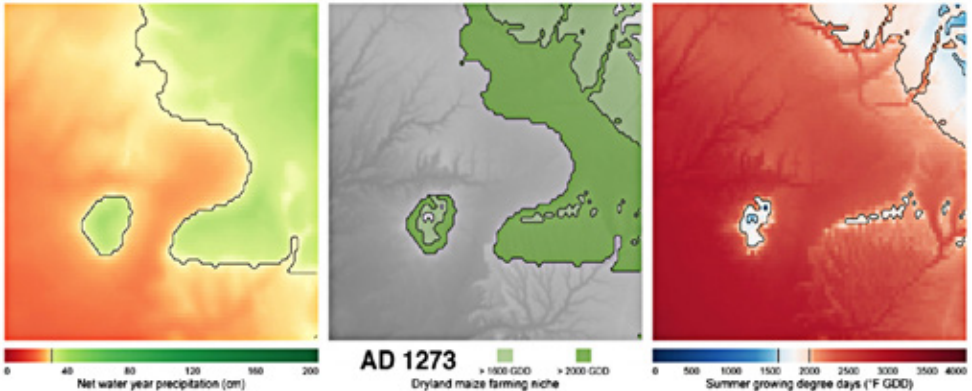
When courses are active, students can interact

with one another and professors. Archived courses do not allow the interactive component of the course but are available any time, as are existing tutorials.

Best of all, Beans says, all of Complexity Explorer's content is free. More at [complexityexplorer.org](http://complexityexplorer.org). ■

## Current and upcoming courses

- Nonlinear Dynamics: Mathematical and Computational Approaches, September 1 -December 1, 2015, enroll now
- Agent-based Modeling, enrolling in 2016
- Complexity Economics, enrolling in 2016
- Information Theory and Network Biology, enrolling in 2016



Network of tree-ring chronologies and other data allow reconstruction of spatio-temporal climate indicators that might have influenced Mesa Verde migrations in the late 13th century AD. (Image: Bocinsky, Kohler, et al.)

thropologist at Arizona State University, are developing just such a tool, which they call SKOPE, for Synthesized Knowledge of Past Environments.

Although the project has, to date, focused on the American Southwest, the long-term aim is to provide integrated information about the environment experienced by humans in many places and times, past and present. The project's furtherance was the subject of an October working group at SFI.

Having grown, in part, out of the 2002-14 Village Ecodynamics Project, SKOPE could lead to a broader understanding of the

mutual dependency of human societies and their natural environments.

“SKOPE could be useful for research in other areas,” says Kohler, “from political science and sociology to sustainability. It can find data and synthesize it for people who are not experts.”

SFI, because of its modeling work, is the perfect venue for deciding how to implement it, Kohler says. Plus, he adds, SKOPE “could get some cross-talk going between the archaeologists and the non-archaeologists at the Institute.” ■



# Mental math helps monk parakeets find their places in the pecking order

In *PLoS Computational Biology*, SFI External Professor Simon DeDeo (Indiana University) and Elizabeth Hobson of the National Institute for Mathematical and Biological Synthesis examine how dominance hierarchies are established in monk parakeet societies. Unlike other animals that use visual cues (such as size) or perceptual clues (such as spatial location) to determine rank, monk parakeets appear to rely on past patterns and outcomes of aggression, from which they infer their own rank and the ranks of others and make decisions about future interactions. Their ability to determine rank and influence the status hierarchy is an indicator of social and cognitive complexity, the researchers say.

## Complex behaviors can arise from simple brains

How much brain power is required to control a body? Not that much, according to new research from SFI Professor Nihat Ay and colleagues published in *PLoS Computational Biology*. Bodies have to obey certain rules – the laws of physics and biomechanics, for example – and that constrains and simplifies the control problem. They tested this idea using computer simulations of an insect-like robot. Despite the complexity of walking in a particular way with six legs, it took a brain with the equivalent of just 65 neurons to tackle the goal. The traditional, non-constrained approach to programming would have required a whopping 10<sup>14</sup> neurons to effect the same walk, they estimate. Their minimal brain size estimation is a first in the field of artificial intelligence and may contribute to the design of future robots. ■

> **Life strategies** continued from page 1

It's also important in making decisions about managing life on earth. If an organism has multiple life stages and something happens that interrupts one of those stages, that change could have implications not only for that organism but for other species that have evolved alongside it.

Complex strategies are also fundamentally interesting, says Libby. “If all the [additional effort] has payoff, it's absolutely fascinating to understand what the payoff is, to understand why it's being done, and why we might expect it to exist in other parts of the world.” ■



# Author Neal Stephenson named an SFI Miller Distinguished Scholar



Stephenson

Scholar Hampton Sides, who is currently in residence at the Institute.

Stephenson is best known for his works of speculative fiction. His novels have been variously categorized as science fiction, historical fiction, cyberpunk, and postcyberpunk. They explore such subjects as mathematics, cryptography, philosophy, currency, futurism, and the history of science. He is the author of *The Big U*, *Zodiac*, *Snow Crash*, *The Diamond Age: or a Young Lady's Illustrated Primer*, *Cryptonomicon*, *The Baroque Cycle series*, *Anathem*, *Reamde*, *Some Remarks: Essays and Other Writing*, and, most recently, *Seveneves*.

He also writes for publications such as *Wired* and has written novels with his uncle, George Jewsbury, under the collective pseudonym Stephen Bury.

He is an advisor for Blue Origin, a company developing a manned sub-orbital launch system, and he is a cofounder of Subutai Corporation, whose first offering was the serialized, interactive, app-distributed fiction project *The Mongoliad*, which he co-wrote. He is currently the chief futurist at Magic Leap, a U.S. startup working on a head-mounted augmented-reality retinal display that superimposes 3D computer-generated imagery over real world objects.

He will be the sixth SFI Miller Scholar since SFI

Author Neal Stephenson has been named an SFI Miller Distinguished Scholar. He will visit SFI periodically through the end of 2016.

Stephenson joins author, narrative historian, and 2015 Miller

Board Chair Emeritus Bill Miller conceived the program in 2010. Stephenson follows philosopher of science Daniel Dennett (2010), quantum physicist Seth Lloyd (2010-2011), actor/author/playwright Sam Shepard (2010-2011), philosopher/author Rebecca Goldstein (2011-2012), and Sides (2015-2016).



Sides

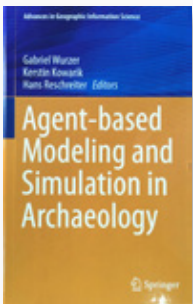
*Ghost Soldiers*, *Blood and Thunder*, *Hellhound on His Trail*, and, most recently, *In the Kingdom of Ice*.

An editor-at-large at *Outside* magazine and a frequent contributor to *National Geographic*, his journalistic works have been frequently anthologized and have twice been named finalists in the National Magazine Awards. He is also a partner of Atalaya Productions, an independent film company that develops non-fiction and historical stories for the screen.

The Miller Distinguished Scholarship is the most prestigious visiting position at SFI, awarded to highly accomplished, creative thinkers who make profound contributions to our understandings of society, science, and culture.

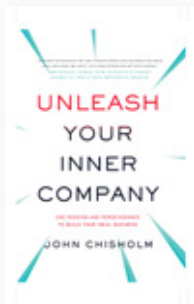
Miller Scholars are internally nominated and may have backgrounds in the humanities, arts, or sciences. During their appointments with SFI, they are encouraged to interact and collaborate with resident and visiting scientists. ■

Sides began his residency at SFI in September. He is best-known for his gripping nonfiction adventure stories depicting epic expeditions of discovery and exploration. He is the author of the best-selling histories



*Agent-based Modeling and Simulation in Archaeology* (Springer, 2015) is an up-to-date overview of agent-based simulation as a tool for understanding the past. The volume's introductory chapter describes the Artificial

Anasazi Project, originated at SFI. The chapter's authors – including former SFI External Professor Alan Swedlund and External Professor George Gumerman – are longtime SFI collaborators.



*Unleash Your Inner Company: Use Passion and Perseverance to Build Your Ideal Business* (Greenleaf Group Book Press) by SFI Trustee John Chisholm lays out a step-wise process for starting a business and achieving results, from concept

through development. Chisholm draws insights from his three decades of experience as an entrepreneur, CEO, and investor...and incorporates several key ideas from complexity science. ■

## RESEARCH NEWS

### Getting our arms around obesity

If there's an ultimate complex social problem, obesity might be it, with its interrelationships in genetics, neurobiology, demographics, agriculture, economics, environment, social norms, education, public policy, healthcare, and much more.

"Obesity, in general, has very real and very unfortunate outcomes for health in terms of chronic diseases like diabetes, asthma, and various cancers," says SFI External Professor Ross Hammond, a senior fellow in economic studies at the Brookings Institution.

Individuals, communities, and governments around the world have, for decades, sought ways to curb the growing rate of childhood obesity. Some of the most successful efforts have happened at the community level. No one is sure exactly how or why such interventions work better than others, at the national policy level, for example.

Hammond co-leads with Matthew Gillman of Harvard Medical School an ongoing project called Childhood Obesity Modeling for Prevention and Community Transformation, or

COMPACT – a transdisciplinary collaboration funded by the National Institutes of Health. The collaboration seeks the best childhood obesity prevention approaches across many communities and conditions.

"The effort is really a cutting-edge application of complex systems science to obesity prevention, and seems likely to have high impact in both scientific and practical policy terms," says Hammond.

In late October the COMPACT team met at SFI for the third in a series of in-person meetings. Using data collected from two successful community-based initiatives, the collaborators have developed a generalized mathematical model to inform future interventions. During the meeting, they further tested this model and used it to design a new public health campaign, which they will pilot next year.

"Increasingly, communities are concerned about obesity and don't want to wait for a coherent national policy," says Hammond. "Part of our job is to help them figure out how to address it effectively." ■

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# UPDATE

SANTA FE INSTITUTE



1399 Hyde Park Road  
Santa Fe, New Mexico 87501  
505.984.8800

[www.santafe.edu](http://www.santafe.edu)

## APPLY NOW FOR THESE SFI EDUCATION PROGRAMS

### SFI Short Course: Exploring Complexity in Social Systems and Economics

Faculty, postdocs, grad students, & professionals  
January 5-7, 2016 in Santa Fe. Registration open, space limited.

### Research Experiences for Undergraduates (REU)

Undergraduates  
June 5-August 13, 2016 in Santa Fe. Apply by January 4, 2016

### Complex Systems Summer School

Graduate students & postdocs  
June 12-July 8, 2016 in Santa Fe. Apply by January 23, 2016

### Graduate Workshop in Computational Social Science, Modeling, & Complexity

Grad students  
June 26-July 8, 2016 in Santa Fe. Apply by February 14, 2016

### Global Sustainability Summer School on Urban Sustainability

Postdocs, grad students, scientists, policy makers, & professionals  
July 25-August 5, 2016 in Santa Fe. Apply by February 23, 2016

## Upcoming community events

**SFI Community Lecture, Wednesday, November 18, 7:30 p.m., James A. Little Theater (1060 Cerrillos Road) — The Self as Brain: Neural Workings of Identity.** What shapes our personalities? How do we account for near-death experiences? How do we make decisions? And what happens when we accept that everything we feel and think stems not from an immaterial spirit but from electrical and chemical activity in our brains? Neurophilosopher Patricia Churchland grounds the philosophy of mind in the essential ingredients of biology, offering lucid explanations of the neural workings that underlie identity. She then explores how the latest research into consciousness, memory, and free will can help us reexamine enduring philosophical, ethical, and spiritual questions.

Patricia Churchland is a Canadian-American philosopher and author of *Touching a Nerve: Our Brains, Our Selves*. Churchland was a 1991 MacArthur Fellow who currently teaches at UC San Diego and at the Salk Institute.

SFI's 2015 Community Lectures are made possible through the generous support of Thornburg Investment Management. Lectures are free and open to the public, but seating is limited. To watch a lecture as it happens, visit SFI's YouTube page; participate in the discussion live on Twitter at @SFIlive.

