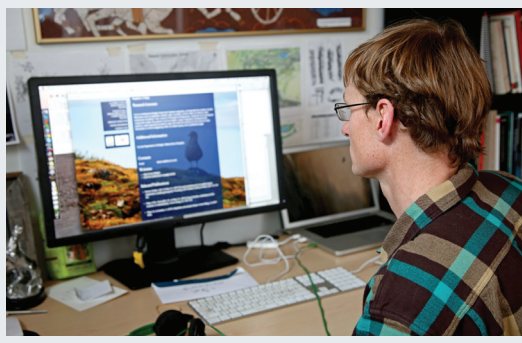
SANTA FE INSTITUTE

March / April 2015

UPDATE



Gabriel Garcia for SFI

Ancient and modern cities aren't so different

Despite notable differences in appearance and governance, ancient human settlements function in much the same way as modern cities, according to new research led by SFI Professor Luis Bettencourt and former SFI Omidyar Fellow Scott Ortman.

Previous research at SFI and elsewhere has shown that as modern cities grow in population, so do their efficiencies and productivities. A city's population outpaces its development of urban infrastructure, for example, and its production of goods and services outpaces its population, with predictable quantifiable regularity – a phenomenon called "urban scaling."

But has this always been the case?

When Bettencourt gave a talk in 2013 on urban scaling, Ortman, now an assistant professor of anthropology at CU Boulder, noted that the trends Bettencourt described were not particular to modern times. Their discussion prompted a research project on the effects of city size through history.

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RESEARCH NEWS

Tracing language histories through sound shifts

A statistical technique that sorts out when changes to words' pronunciations occurred in the evolution of related languages gives researchers a renewed opportunity to trace words and languages back to their earliest common ancestor or ancestors – potentially thousands of years further into prehistory than previous techniques can do with any statistical rigor.

Led by SFI Professor Tanmoy Bhattacharya and SFI External Professor and Science Board member Mark Pagel (University of Reading), the research provides an analysis technique that detects historical "concerted sound changes" – a linguistic evolutionary phenomenon where a specific sound changes to another specific sound in many words across a language simultaneously.

For example, the modern languages of English and Latin descended from a common predecessor called proto-Indo-European. In English, the words *father* and *foot* took on an initial f sound, but in Latin those words retained their p sound, as in *pater* and *ped*. This transition occurred across the English language in many words that had featured a p sound.

The researchers tested their new model on Turkic, a family of at least 35 languages spoken by peoples from Southeastern Europe and the Mediterranean to Siberia and Western China. Their computer analysis automatically considered and evaluated the likelihood (without the potentially biased input of humans) that more than 70 regular sound changes had occurred throughout the 2000-year history of the Turkic languages.

An example is the word *pas* (head in English) in the Khakassian language. In Turkish, Uzbek, and 16 other Turkic languages the initial sound is b instead, yielding *baš*. Similarly, *pel-* (meaning louse) in Khakassian is *bil-* or *bel-* in the other languages. The ubiquity of this sound difference strongly supports the hypothesis that a regular sound shift occurred.

"Computers so far have mainly used the presence or absence of words with a common origin in various languages to stitch together trees that describe the descent of the various languages from a common

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IN THIS ISSUE

RESEARCH NEWS

SFI to seek general theory

SFI has been awarded a three-year, $2.5 million grant from the John Templeton Foundation to support a daring scientific pursuit: developing a general theory of complexity.

The new SFI grant has as its ultimate aim "a concise, parsimonious, and potentially mathematizable framework for understanding complex adaptive systems."

Under the auspices of the grant, SFI will pursue research that seeks to identify and integrate general principles of how complex systems accumulate, store, and process energy and information across scales and domains.

While a general theory of complexity may prove as elusive as the Grand Unified Theory in physics, the search for features essential to the myriad, seemingly disparate systems described as "complex" will almost certainly result in new insights that expand our fundamental scientific understanding, says Jennifer Dunne, SFI Vice President for Science and co-principal investigator on the grant along with SFI Distinguished Professor Geoffrey West.

"Identifying whether there are universal principles that transcend the extraordinary diversity, path dependence, and historical contingency of complex systems is a major challenge and opportunity for science over the next several decades," Dunne says. "SFI is uniquely suited to be the center of such high risk, high reward research."

"We are grateful to the John Templeton Foundation for its support of ambitious theoretical research in general, and of this project in particular," says SFI President Jerry Sabloff, the grant's principal investigator. "This grant's goals fit perfectly SFI's mission of interdisciplinary research on complex adaptive systems."

The Institute's ongoing work, including recent research supported under a previous Templeton Foundation grant, has yielded many insights about complex biological and social systems that hold promise as foundations for a general theory. ■

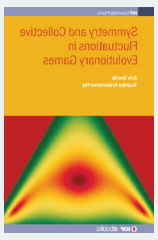
SFI IN THE NEWS

On February 5, *Astrobiology* magazine features the work of SFI Omidyar Fellow Eric Libby on how multicellular life evolved.

SFI Distinguished Professor Geoffrey West's essay "A theoretical physicist's journey from strings and quarks to cells and whales" is among *Physical Biology's* top papers of 2014.

In a January 12 blog post for *Nautilus* magazine, SFI Omidyar Fellow Sam Scarpino explores why Nigeria has fared better in the Ebola outbreak than neighboring Liberia, Sierra Leone, and Guinea despite these countries' similar per-person health-care expenditures.

SFI BOOK NEWS



Symmetry and Collective Fluctuations in Evolutionary Games (IOP Publishing, January 2015) by SFI External Professor D. Eric Smith and Supriya Krishnamurthy posits an evolutionary game theory framework in which the map from individual types and interactions to the fitness that determines their evolutionary success is modeled as a game played among agents in the population. They argue that games are a flexible and reasonably generic framework to capture, classify, and analyze the processes in development and some forms of inter-agent interaction that lie behind arbitrary frequency-dependent fitness models. ■

SFI Online

Multimedia content available at ***www.santafe.edu***

Video: Ginger Rhodes and Richard Rhodes examine the association of violence with mental illness and make an argument for early intervention. 2014 SFI Community Lecture video

Video: Stanford linguist Daniel Jurafsky explores the stunningly complex language of food and what it tells us about our culture and society. 2015 SFI Community Lecture video

Audio: Author and SFI Journalism Fellow Laurence Gonzales talks survival and explains why failure is inherent to the functioning of today's complex machines. Santa Fe Radio Café interview

Audio: SFI Omidyar Fellow Sam Scarpino explains how mathematical epidemiologists can help slow the spread of the Ebola virus by mapping its patterns of transmission. Santa Fe Radio Café interview

Audio: SFI Distinguished Professor Geoffrey West talks with radio show host Richard Eeds on "The theory of almost everything." KVSF radio interview (interview begins at 54:00).

Nonlinearities

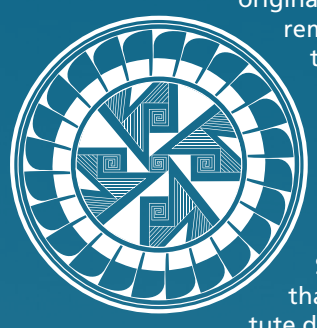
From the editor

Are you Betsy Jones?

Last year, SFI's 30th anniversary year, gave me an excuse to look into SFI's storied history and separate some of the facts from some of the fiction. One investigation stymied me. It has to do with the Mimbres design in SFI's logo, seen below.

In a locked cabinet at the back of our library, I found some of SFI's earliest volumes, which feature this brief passage on their inside covers: "All titles from the Santa Fe Institute Studies in the Sciences of Complexity series will carry this imprint, which is based on a Mimbres pottery design (circa A.D. 950-1150), drawn by Betsy Jones."

At that point, around 1986, the Mimbres was not SFI's seal. The original logo was a starburst, rectangularly cropped. Ronda Butler-Villa, who joined SFI in early 1987, recalls that some felt the original logo was reminiscent of the output of a particle accelerator, which might give people unfamiliar with SFI the notion that the Institute did experimental physics. In March 1987, the Mimbres was adopted as SFI's official logo, and it has remained so since.



The problem is that no one can remember who Betsy Jones is. Helene Slansky, the wife of the late Dick Slansky, says she discovered the logo in a coffee table-style book on Mimbres pottery that she owned. She says she thought the design was a good match for the Institute.

"The feathers represented the various disciplines that the institute delves into," she told me. "The crosshatched interwoven pattern represents cross-disciplinary collaboration. It became ours."

A copy of that book – *Within the Underworld Sky: Mimbres Ceramic Art in Context*, by Barbara Moulard – is now on display in the Institute's lobby. Sure enough, right there on page 26 is a shallow bowl with a very similar design. (The primary difference is a rough, quarter-sized hole near its center; such holes are a common feature of Mimbres pottery.)

But what happened between Helene Slansky's epiphany and Betsy Jones's artwork remains a mystery. Naturally the person who can fill in this gap for us wouldn't have a more Google-friendly name like Gertrude Clunkerdinkelhof. Besty, Elizabeth, Beth, Betty, Liz…Jones. I've tried and failed.

If you are Betsy Jones, or you know her, call me. ■

– John German, jdg@santafe.edu

RESEARCH NEWS

Rethinking power supply reliability

Whenever a storm as powerful as Katrina or Irene hits, we expect at least a temporary power outage. Nowadays, though, due to increasing energy demand and aging infrastructure, the reliable supply of power can become a concern even when the skies are clear.

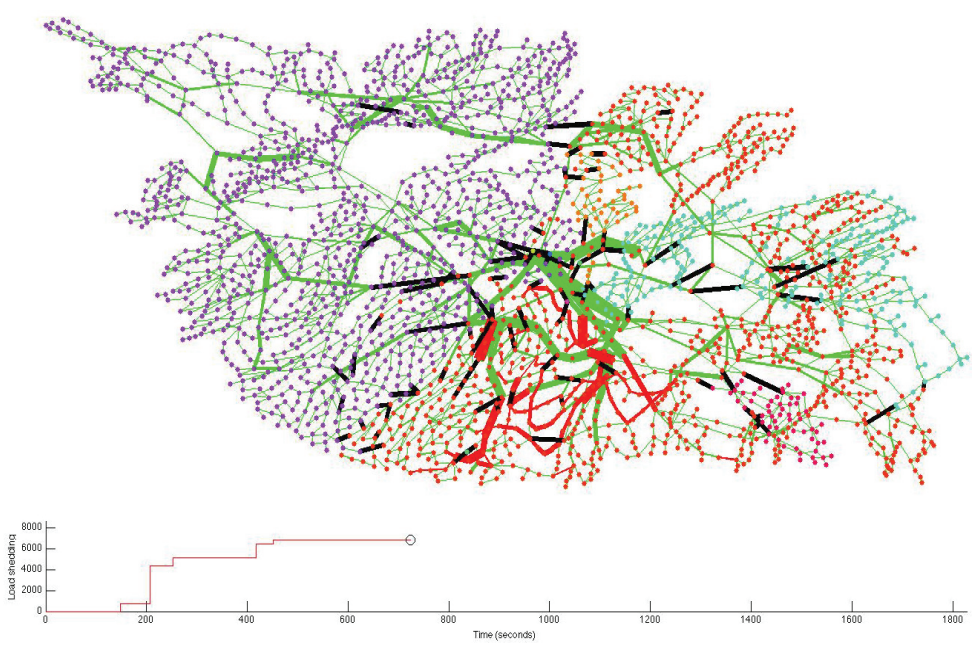
And with the nation's power grid under increasing stress by a number of forces – from heavier and less predictable weather disturbances due to climate change to increased demands for renewable energy and decentralized smart-grid technologies – the business of delivering electricity is in need of a rethink, if not an out-and-out overhaul.

Which is why SFI Professor Cris Moore, along with sabbatical visitors Paul Hines (University of Vermont) and Seth Blumsack (Penn State), put together an upcoming SFI workshop "Reinventing the Grid: Designing Resilient, Adaptive, and Creative Power Systems."

"Traditionally," says Blumsack, "this has been a world characterized by old guys with suspenders. It's been very isolated for a long time. We just want to mix in some new ideas to reinvent the grid. One thing the power grid needs is fresh thinking."

"What does the next generation of electrical service look like?" asks Hines. "It's wrapped up in a lot of things: It needs to be affordable. It needs to be environmentally benign. Those are the criteria future systems are going to have to meet. And this may need to happen in a more decentralized way than [has been seen in] the entire history of the industry, which is more than a century old."

The mid-April, invitation-only workshop will focus on such issues as resilience, robustness, efficiency, and highly connected versus distributed systems. It will include experts in electric power, ecological systems, network theory – even representatives of the global "maker" movement to motivate creative thinking. ■



Simulated progression of a large blackout in a power grid model (based on the Polish power network). Link (representing transmission lines) thickness indicates the amount of power flowing. Red links indicate an overload. Black links indicate a failed transmission line. Node colors show sections of the network that have separated during the cascade. The progression of the blackout size in terms of how much demand has been disconnected is indicated below the graphic. (Credit: Paul Hines)

> *Language histories* continued from page 1

ancestor," say Bhattacharya. "This has left out the vastly richer data residing in sounds."

In their paper, the researchers developed the mathematics for detecting and evaluating hypotheses concerning concerted sound changes and showed that the technique provided vastly superior dated trees for the Turkic language family than previous methods.

"Regular correspondences between sounds in different languages have long been an important test for establishing linguistic relatedness in traditional historical linguistics," Bhattacharya says. "Being able to detect them automatically and score them within a probabilistic framework is a major step forward. Such a framework may be able to help us detect and evaluate signals of very old regular sound changes that are much weaker than what is possible to determine unambiguously in a manual fashion."

Their paper was published January 5 in the journal *Current Biology*. Co-authors include Dan Hruschka (Arizona State University, former SFI Omidyar Fellow), Simon Branford (Reading), SFI External Professor D. Eric Smith (Krasnow Institute for Advanced Study), SFI External Professor Jon Wilkins (Ronin Institute), and Andrew Meade (Reading). ■

RESEARCH NEWS

Can language statistics unravel human history?

A collaboration between linguists and SFI scientists is using a novel statistical technique to trace the evolutionary origins of a native North American language.

In February, a small group gathered at SFI to experiment with using phonetic shifts in the Athapaskan languages to reconstruct the language group's evolution. Athapaskan languages are spoken by the Dene people, whose native territories cover a large swath of North America from Alaska to the American Southwest. Despite uncanny linguistic and cultural similarities among Dene tribes, details of their ancestry and historical migration patterns are a subject of scholarly contention.

SFI Professor Tanmoy Bhattacharya and External Professor Daniel Hruschka (Arizona State University) arranged the meeting to explore whether a statistical technique their research team has developed could shed light on the linguistic and cultural evolution of the Dene tribes.

Sally Rice, a cognitive linguist from the University of Alberta, presented background on Dene languages and culture, and explained some outstanding mysteries in Dene scholarship. She has developed a comparative lexicon for Athapaskan languages and wanted to see if linguistic classification of Athapaskan provided evidence for her hypothesis that the Alaskan Dene people are ancestors of the Plains Apache people.

To quantify the relationship between two Athapaskan dialects, Bhattacharya and Hruschka's method measures the evolutionary distance between the two languages by statistically analyzing the sound components of words. If, for example, a *t* sound in one language systematically evolves to a *d* sound, the word *tear* in one language would sound as *dear* in its descendant.

In January, the SFI scientists published a detailed classification of the Turkic language group by this method, the results of which agree with widely-accepted history of Turkic language evolution (see article on page 1). They hope their method will prove similarly effective in classifying Athapaskan, whose evolution is less certain.

"Genetically, southern Dene tribes borrow heavily from other cultures," Bhattacharya says. "But linguistically, they are completely northern. There's a lot of dispute over how their migration happened, and analyzing the sound changes should shed some light on that history. We have never tried it, so we don't yet know. That's one of the exciting things about science." ■

Working group to advance computational understanding of matrix multiplication

Among higher mathematical concepts, matrix multiplication is one of the most pervasive operations one can find. It's also one of the least understood.

In an upcoming working group, SFI Omidyar Fellow Josh Grochow and colleagues will try to improve on what mathematicians and computer scientists already know about the subject and, in the process, move toward a deeper understanding of complexity science itself.

Though the name "matrix multiplication" may not be familiar, the idea and its applications likely are. In simplest form, matrices are ways of representing systems of equations as rectangular arrays of variables.

Matrix multiplication refers to methods of manipulating such arrayed systems of equations by taking the solutions of one equation system and using them as the inputs for another system. It turns out that "multiplying" matrices is computationally equivalent to solving such equation systems manually – but offers additional mathematical structure that aids in understanding their complexities.

Biologists use matrix multiplication to study species' population dynamics; economists use it to predict market behavior; and graphics processing systems use it to play videos, edit photographs, and generate 3D simulations in a variety of applications.

Computationally speaking, matrix multiplication turns out to be a flagship question in complexity theory, Grochow says, in part because of its ubiquity and the surprise 1969 discovery of a way to beat the brute-force approach of solving equation systems variable-by-variable and equation-by-equation.

"Once people realized they could multiply matrices faster than the naive algorithm," he says, "it opened up new horizons for computer scientists and engineers."

In spite of both practical and theoretical progress, however, deeper truths about why the algorithms researchers were discovering worked remained a mystery. Beginning in 2003, Henry Cohn and Christopher Umans proposed using a field of mathematics called group theory to link many of the algorithms together, an idea they realized with help from Robert Kleinberg (Cornell) and Balasz Szegedy (University of Toronto).

"What we've been trying to do now is take that framework and push it further," Grochow says. "Can we use it to get some explanatory power?" If so, it could lead to better algorithms for matrix multiplication, though "the real goal is a better understanding of computational complexity" and complexity science, he says.

Cohn (Microsoft Research and MIT), Umans (Caltech), and mathematician Jonah Blasiak (Drexel University) will join Grochow for the working group. Mathematician Thomas Church (Stanford), who has worked with the group before, will join in future discussions. ■

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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*.

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Frontiers in ecological network research

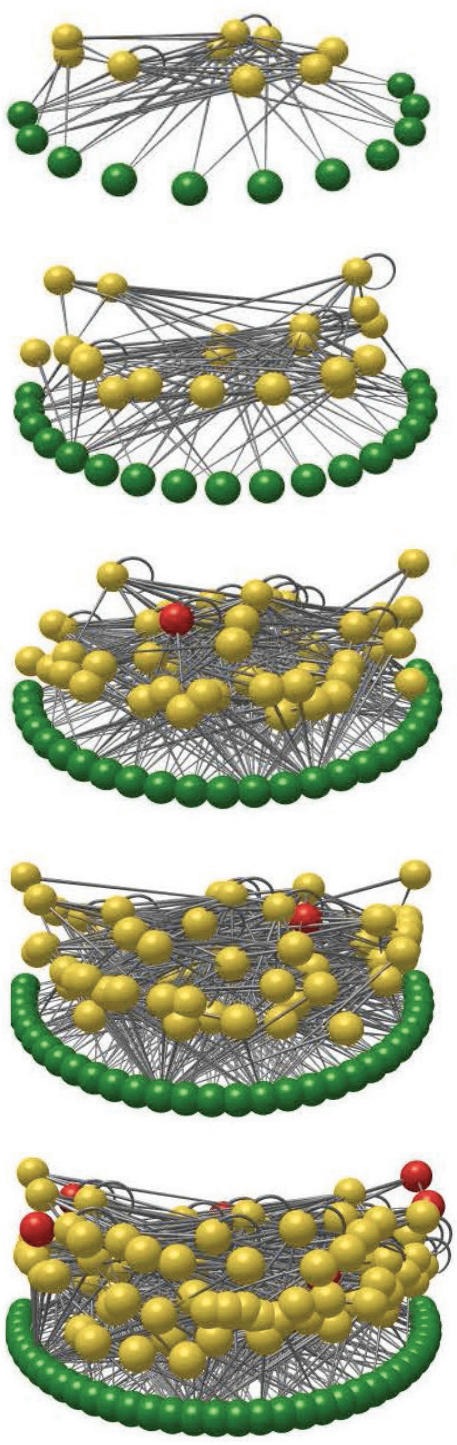
A few decades ago, ecologists used cartoonish data and models to describe species interactions in ecosystems. Now, with advances in empiricism, computing power, and modeling, the complex structures and nonlinear dynamics of highly interconnected ecological networks can be simulated and assessed, allowing researchers to characterize how energy flows through ecosystems in far more sophisticated ways than was previously possible.

While today's technologies are advanced enough to quantify and predict complex food web structures and dynamics, researchers have traditionally had only a few idiosyncratic datasets with which to do so. Novel, emerging databases comprised of tens to hundreds of replicate networks along spatial, temporal, and environmental gradients are providing researchers new ways to study such influences as spatial scaling, habitat change, re-colonization after disturbance, and natural and anthropogenic climate variability on food web structure, dynamics, and function.

SFI Professor and VP for Science Jennifer Dunne organized a working group at SFI March 2-4 to take this type of research a step further. "Gradient-based research presents unique opportunities and challenges, both in terms of ecological dynamics and fundamental network theory," she says.

The working group, a follow-on to a 2013 meeting, brought together ecologists with expertise in ecological network data, experiments, and modeling with researchers who have expertise in network theory to further solidify this as coherent research agenda, to advance particular research projects, and to take on the hard question of how to compare the structure of dozens of networks that include enriched node, link, and system data, she says.

Several earlier-career colleagues "who are doing very cutting-edge research in this area" brought new dimensions to the working group, Dunne says. They include SFI Omidyar Fellows Josh Grochow and Justin Yeakel, postdoctoral fellows Fernanda Valdovinos (University of Arizona) and Luis Gilarranz (Estación Biológica de Doñana EBD-CSIC), and Ph.D. student Ashkaan Fahimipour (UC Riverside). ■



Example intertidal food webs from Alaska, sampled at increasingly large spatial areas from 0.25 m² (top) to 24 km² (bottom). Spheres represent taxa and lines between them represent directional feeding links. Primary producers, invertebrates, and vertebrates are shown in green, yellow, and red, respectively. The vertical axis indicates short-weighted trophic level. (Images: Jennifer Dunne)

RESEARCH NEWS BRIEFS

A hospital worker at a USAID Ebola response unit in Liberia takes a break. (USAID photo by Morgana Wingard)

Ebola transmission occurs more often among small social clusters, not pairs

Transmission of the Ebola virus occurs most often in small social clusters, a finding that has ramifications for case reporting and public health, according to the 11 co-authors of a new study in *Clinical Infectious Diseases*, including SFI Omidyar Fellow Sam Scarpino (a first author) and SFI External Professor Lauren Ancel Meyers. Prior studies of Ebola transmission were based on models that assumed the spread of infection occurred between random pairs of individuals. The researchers found evidence for clustered transmission, most often in hospitals, households, and funeral settings. The findings underscore the importance of rapid contact tracing and quarantine of symptomatic individuals – and for an integrative approach to outbreak response – the researchers note.

How superconductivity emerges in heavy-electron materials

In *PNAS*, SFI Co-founder in Residence David Pines and co-author Yi-feng Yang present a quantitative model for a long-standing challenge for quantum physicists: explaining how superconductivity emerges in unconventional materials. Previous theories of superconductivity do not provide a simple quantitative account of how it arises in a class of materials known as "unconventional superconductors." The Pines-Yang model offers an accounting for superconductivity in a subset of unconventional superconductors called heavy-electron materials.

University hiring biased toward graduates of similarly prestigious institutions

In *Science Advances*, SFI External Professor Aaron Clauset (CU Boulder) and co-authors examined faculty hiring in academia – using data from computer science, business, and history – to get a cross-field representation of the roles played by an institution's prestige factor in faculty hiring. Their network analysis finds that generally, institutions at the top of the prestige heap hire each others' graduates, promoting their collective prestige and restricting the availability of prestigious faculty positions to degree holders from less-prestigious institutions. Ultimately, the inequalities inherent in this paradigm can hinder the flow of ideas and the formation of new fields, Clauset says.

Sharing of food across generations contributes to humans' long life histories

New research led by former SFI Omidyar Fellow Paul Hooper explores the evolutionary implications of food sharing across generations in Amazonian forager-farmer societies. The paper, published in the *Proceedings of the Royal Society B*, shows that "the contributions provided by parents and grandparents to younger generations – far greater in humans than in any other primate – are essential for the human way of life," Hooper says. "These contributions explain how we are able to remain dependent longer, and live longer, than any of our primate cousins." Hooper, now an assistant professor of biological anthropology at Emory University, carried out the research while he was at SFI. ■

> *Ancient and modern cities* continued from page 1

To test their ideas, the team examined archaeological data from the Basin of Mexico (what is now Mexico City and nearby regions). In the 1960s – before Mexico City's population exploded – surveyors examined all its ancient settlements, spanning 2000 years and four cultural eras in pre-contact Mesoamerica.

Using this data, the research team analyzed the dimensions of hundreds of ancient temples and thousands of ancient houses to estimate populations and densities, size and construction rates of monuments and buildings, and intensity of site use.

Their results, published February 20 in the new open-access journal *Science Advances*, indicate that the bigger the ancient settlement, the more productive it was.

"It was shocking and unbelievable," says Ortman. "We were raised on a steady diet telling us that, thanks to capitalism, industrialization, and democracy, the modern world is radically different from worlds of the past. What we found here is that the fundamental drivers of robust socioeconomic patterns in modern cities precede all that."

Bettencourt adds: "Our results suggest that the general ingredients of productivity and population density in human societies run much deeper and have everything to do with the challenges and opportunities of organizing human social networks."

Though intrigued by the results, the researchers see the discovery as just one step in a long process. The team plans to examine settlement patterns from ancient sites in Peru, China, and Europe and study the factors that lead urban systems to emerge, grow, or collapse. ■

'So many dimensions coming together'

SFI has always gravitated to those ideas that transcend the confines of scientific disciplines. That's what drew Tim and Mary Mitchell to the Institute.

"SFI is a really worthwhile organization," Tim says. "There are too many that specialize in only one thing…and find exactly what they're looking for. SFI has an interdisciplinary element. There's nobody else doing what they do."

The Mitchells moved to Santa Fe in 2013. Tim is retired from the insurance business. Mary's work history defies categorization; she jokes that she changes careers "every five years on the button," having worked in political fundraising, stock analysis, environmental advocacy, garden design, and now yoga instruction.

She appreciates that SFI's research is similarly not easy to categorize. "At SFI you have so many dimensions coming together," she says.

Tim adds that "because SFI draws from different disciplines, the answers they come up with will be more complete. It is a bright light in Santa Fe with a global reputation."

In addition to donating to SFI and volunteering at the Institute, the Mitchells recently hosted an SFI Science Club meeting in their Santa Fe home. Two dozen-odd participants conversed over wine, cheese, and green chili meatballs, then were treated to an informal presentation by SFI Professor Michael Lachmann on new research relating to Neanderthal DNA.

"Santa Fe has an ability to attract people who are intellectually curious and have the energy to pursue their curiosities," Mary says. "SFI has that same specialness." ■

Facts about SFI's Science Club

- Science Club meets quarterly for cocktails and conversation in the home of an SFI patron and includes a discussion with an SFI researcher.
- Prior to the meeting, members read several articles relating to the scientist's work to prepare for a lively conversation.
- Science Club is a benefit for patrons giving at least $1,000 annually. Patrons are encouraged to bring guests.
- For more information, call 505.946.3678.

NSF grant to bolster women's participation in computer science

Young women in New Mexico will have a new, potentially transformative opportunity to pursue careers in computer science.

The National Science Foundation recently awarded a three-year, $144,054 grant to SFI's Learning Lab Director Irene Lee and New Mexico State University to collaboratively establish a computer science education program in New Mexico called YO-GUTC: Young women Growing Up Thinking Computationally.

The YO-GUTC mission is to increase and sustain women's participation in computing by training young women in computer science. YO-GUTC will also investigate and address the factors that contribute to the underrepresentation of women, particularly Latinas, in computing fields.

"YO-GUTC is unique in aiming to advance young women's skills and knowledge in computer science to a level beyond that of their male peers, so they will not succumb to doubt and intimidation when encountering computer science concepts in coed settings in high-school or college," Lee says.

Though computer science is the fastest-growing occupational category, women are notably underrepresented in the field. Fewer than 20 percent of computer science degrees are awarded to women, in contrast to other STEM fields like mathematics and biosciences, where women now participate in equal or greater numbers. ■

New ASU-SFI Center for Biosocial Complex Systems launched in Tempe

During a January 16 signing ceremony and day of panel discussions in Tempe, Arizona, SFI and Arizona State University launched a major new research and education collaboration. Here ASU President Michael Crow (at the lectern) and SFI President Jerry Sabloff formally establish the new ASU-SFI Center for Biosocial Complex Systems. More at http://bit.ly/1G4Ky9u.

MY STORY

Michael Lachmann
Professor,
Santa Fe Institute

"I worked on the origin of life even before I entered university. I would leave a program running on my C64 for weeks, then come back and analyze the results. As an undergraduate, I discovered that this important problem had been mostly solved when I encountered the amazing proceedings of the first A-life conferences in Santa Fe. At the same time I had heard about a graduate student, Cris Moore, who discovered that a 3D billiard 'table' is computationally complete. James Gleick's book *Chaos: Making a New Science* combined with these to create a dream of coming to SFI, which I did — first to the SFI summer school, and then as a postdoc. In 2012 I attended an excellent theme week on information and game theory. That meeting was so exhilarating and inspiring, I realized that I just have to come back — that SFI is an amazing place for thinking and creativity."

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UPDATE
SANTA FE INSTITUTE

Upcoming community events

Science On Screen, Monday, March 16, 7:00 p.m., CCA (1050 Old Pecos Trail) – "Young Frankenstein" with Eric Libby. "What hump?" SFI Omidyar Fellow Eric Libby introduces Mel Brooks' classic 1974 comedy – ranked as one of the funniest films of all time. Libby, a biologist fascinated by how organisms change form, also presented "Alien" in November 2014.

Science On Screen is a collaboration of SFI and the Center for Contemporary Arts. During each showing, an Institute scientist presents a favorite film, offering personal perspectives and insights from the world of science. It's an idea-rich spin on the movies. For tickets and prices, call the CCA Box Office at 505-982-1338.

SFI Community Lecture, Wednesday, March 11, 7:30 p.m., James A. Little Theater (1060 Cerrillos Road) – Ties that Bind: The Goodness of Social Networks. Social networks have proven to be fertile ground for understanding human behavior. MIT's Alex Pentland discusses how studying patterns of information exchange in a social network – even without any knowledge of the actual content – can help us predict with stunning accuracy how productive and effective that network is. Pentland was named one of the world's seven most powerful data scientists by *Forbes* in 2011. His latest book is *Social Physics: How Good Ideas Spread – Lessons from a New Science.*

SFI Community Lecture, Wednesday, April 8, 7:30 p.m., James A. Little Theater (1060 Cerrillos Road) – Adaptive Intervention: Healing with Data. Why are treatments for chronic disease and addiction so often ineffective? Susan Murphy believes that generalized treatment approaches simply don't take into account critical individual differences like patient response, risk, burden, adherence, and preference. Murphy shows how, by implementing a sequence of decision rules that dynamically adapt treatment to each individual's response over time, adaptive intervention can maximize treatment efficacy, avoid over-treatment, and provide increased treatment only to those who need it. Murphy is a 2013 MacArthur Fellow, a teacher of statistics at the University of Michigan, and a principal investigator at the Methodology Center of Pennsylvania State University.

SFI Community Lecture, Wednesday, May 6, 7:30 p.m., James A. Little Theater (1060 Cerrillos Road) – The Accidental Universe: The World You Thought You Knew. Can science prove the existence of God? Is this universe we inhabit the only one? Can a religious experience be scientifically proven? Novelist, essayist, physicist, and educator Alan Lightman ponders these timeless, unanswerable questions using his training as both a scientist and a novelist, always careful to include historical and contemporary perspectives. Lightman is MIT's first professor to receive a joint appointment in the sciences and the humanities. He is author of the international bestseller *Einstein's Dreams*, which has been adapted into more than two-dozen independent theatrical and musical productions.

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.