Humans arrived in what is now known as French Polynesia around one thousand years ago. Since then, people have lived sustainably on some islands but not on others. New NSF-funded research led by SFI Chair of Faculty Jennifer Dunne seeks to understand why.

The four-year, $1.3 million project will apply methods from ecology, hydrology, oceanography, archaeology, demography, and economics to study relationships between initial ecological and environmental conditions and subsequent trajectories of human cultural development on four well-studied French Polynesian islands. The researchers will use computational models to test theories regarding long-term human-ecology-environment feedbacks. They are particularly interested in the dual roles humans played as subsistence consumers and market-driven exploiters of resources.

As part of the project, they plan to develop a comprehensive network model of coupled natural-human systems, including their robustness and resilience to external and internal changes; to apply the model to, and test it against, the introduction, persistence, and dynamics of Polynesians on the four islands; and to explore how the development and application of the model might support further advances in our understanding of diversity and complexity and their interactions with ecosystem management. “Such advances are vital for addressing critical problems at the intersection of social and natural sciences, including resource over-consumption, climate disruption, and catastrophic transitions in ecological and human systems,” says Dunne, the project’s principal investigator. Co-principal investigators include Neo Martinez (University of Arizona), Patrick Kirch and Neil Davies (both UC Berkeley), and Jennifer Kahn (College of William and Mary).

The research is among 21 new NSF-funded projects intended to promote a better understanding of how humans and the environment interact.

Innovation in energy technology is booming, according to an October 14 paper in PLOS ONE that examines what factors set the pace for energy innovation. The analysis – co-authored by SFI Professor Luis Bettencourt, SFI External Professor Jessica Trancik of MIT, and graduate student Jasleen Kaur of the University of Indiana (Bloomington) – examines worldwide and regional trends in translating research into technology, and it models the relationship between patent production, funding, and markets.

“Patents reveal early stages of technology development, as they tell of the nature of innovative activity, and who’s doing what where,” explains Trancik, who notes that energy patents are growing faster than patents overall.

To see what’s driving innovation, the researchers examined a dataset of more than 73,000 energy-related patents issued in 200+ plus countries between 1970 and 2009. They used keyword searches of the patents themselves rather than the classifications assigned by patent offices.

Their analysis showed that the number of energy patents has risen dramatically over 30 years; that patenting of renewable energy technologies now outpaces that for most fossil fuels; that regions are beginning to specialize in certain kinds of energy technology innovation; and that both research and market growth are significant factors, acting together to drive innovation.

The team uncovered these results by creating a new model of the relationship between research and market growth. The model revealed that “as the network rearranges itself, hundreds of miles away as the flow of power in the network rearranges itself,” says Moore, who hosted a workshop at SFI September 9-12 to explore ways to adapt network science to better model critical infrastructure networks such as power grids.

Network theorists usually assume blackouts spread the same way diseases do – by close contact – but for power grids the relevant network is not the physical network of lines and towers and transfer stations, says SFI Professor Cris Moore.

The cascade of failures in a blackout can jump from one power line to another line hundreds of miles away as the flow of power in the network rearranges itself, says Moore, who hosted a workshop at SFI September 9-12 to explore ways to adapt network science to better model critical infrastructure networks such as power grids.
On October 14 in the public radio show/podcast Big Picture Science, SFI Research Fellow Simon DeDeo explains how and why emergence abounds both in nature and in human social systems. In an October 14 piece in the Santa Fe New Mexican, SFI Research Fellow Simon DeDeo describes the promise of working with large datasets that capture human experience in an age of computation. An October 14 paper in PLOS ONE co-authored by SFI Professor Luis Bettencourt, External Professor Jessika Trancik, and collaborators attracted coverage in USA Today and numerous other publications. The paper examines trends in and drivers for energy innovation (see story on page 1 of this issue).

In Wired on October 9, SFI Research Fellow Simon DeDeo leads an article on the challenges of analyzing large, noisy, unstructured, dynamic datasets such as those that chronicle human affairs. The article was reprinted from Quanta magazine, and mentioned in the National Review Online and Scientific American. On October 9 on BlogTalkRadio, SFI Research Fellow Simon DeDeo spoke with science journalist Jennifer Ouellette about new ways to study and understand complex social systems.

A September 27 article in the Albuquerque Journal noted that some 200 5th-6th grade girls were sent to a Saturday with New Mexico women who have chosen careers in science, technology, engineering, mathematics, and computing. The hands-on event was this year’s Expanding Your Horizons Santa Fe conference, co-sponsored by SFI’s GUTS y Girls program.

Newsweek on September 20 mentioned an SFI Community Lecture in which Steven Pinker and Rebecca Newberger Goldstein asked whether human moral progress is a gift of empathy and emotion or of reason and logic. In a September 10 column in Forbes, SFI Trustee John Chisholm asks whether the theoretical, scientific study of complex systems can inform the hardworking world of start-up firms. A September 9 article in The Guardian about ways to build sustainable cities offers advice from several experts, beginning with SFI Professor Luis Bettencourt.

SFI Omicron Fellow alumnus Fortunato is among researchers studying changes to language, and creating a Labma, much as biologists study how living organisms evolve, according to a New Scientist cover story on September 5. In a September 2 piece in the Santa Fe New Mexican, SFI External Professor and Science Editor
Wolpert, Lachmann join SFI faculty

Physicist and External Professor David Wolpert joined SFI's resident faculty with a half-time basis on September 9, 2013. Biologist Michael Lachmann will join the Institute's resident faculty on a full-time basis next summer. Both additions were announced in early September, following an August announcement that physicist Sidney Redner will join the resident faculty full time next summer.

Wolpert joins SFI from Los Alamos National Laboratory’s Information Sciences Group. His research extends far beyond the so-called No-Free Lunch Theorems for which he and his collaborator William Macready are best known. Over his 24-year career, Wolpert has studied the foundations of physics, problems in statistical inference and machine learning, methods for distributed optimization, and the intersection of information theory, econometrics, and social science. All topics he continues to study today.

“There’s just too much stunning stuff in all the sciences for me to restrict myself to just one of them,” he says. As a result, he has “worked at the junctions of fields that usually don’t talk with one another,” he says. “That’s where a lot of the breakthroughs of modern science have been, in my opinion, and where lots of future ones will lie. And those junctions are what SFI is about.”

Wolpert left UC Santa Barbara in 1989 with a PhD in physics, having studied neural networks and how best to generalize from the experiments. She has contributed to such publications as Discover, Scientific American, Popular Science, The New Yorker, TIME, and The Atlantic. She plans to spend May through June 2014 at SFI. She plans to spend May through June 2014 at SFI.

Lachmann came to SFI as a postdoctoral fellow and worked with SFI Professor Cris Moore and External Professor Mark Newman, among others. Lachmann left SFI for a postdoctoral fellowship at the Max Planck Institute for Mathematics in the Sciences in 2002.

His interests have broadened, but evolution continues to be a focus. “I am interested in understanding the process of evolution itself — how it gathers information, how it ororogizes, how it creates adaptation and function,” Lachmann says.

In addition to studying the origins and functions of evolution, Lachmann says he plans to continue research on the connections between information and evolution, the evolution of biological differentiation, and the population genetics of early humans.

“We are very pleased to have David and Michael join us,” says SFI Chair of the Faculty Jennifer Dunne. “They both bring unique, needed skills and perspectives that will complement those of our current research faculty.”

An August 27 article in the Science Careers section of the journal Science describes the challenges of cross-disciplinary collaboration, mentoring SFI as a research center that has successfully formalized the practice of working across disciplines.

An SFI Omidyar Fellow Roger Braikman, in an August 1 commentary in Proceedings of the National Academy of Sciences, reviews two scientists’ recent progress in simulating prebiotic chemistry at deep-sea hydrothermal vents and puts the research in the context of what we know, and what we still need to learn, about life’s beginnings.

A model based on a two-stage process that captures how new technology emerges and gener-
Sande Deitch: Life infused with science

An artist by training who studied at Juilliard and the Santa Fe University of Art and Design, Deitch was for two decades affiliated with the Pittsburgh Center for the Arts, first as an artist, then as director of exhibitions and programs, and finally as executive director. Later, as executive director for the Bayer Foundation, she was the architect of its award-winning science literacy outreach program for children called Making Science Make Sense. Her goal was to help kids see that science is infused in everyday life.

“Science is something people think is so highfalutin,” Deitch says, laughing, “yet it’s all around us.”

After a five-year sojourn in Mexico, she moved to Santa Fe in 2003, where she settled just down the road from the Institute. Her daughter suggested that she attend an SFI Community Lecture that fall at the Linnicott, and with that Deitch was enthralled.

“I wanted to know more about what they were doing up there,” she says. She is excited to be more involved with SFI and is particularly interested in the Institute’s new Science Club for President’s Circle donors. Deitch also sits on the board of SITE Santa Fe and is a commissioner with the Santa Fe Arts Commission.

> Power grid continued from page 1

Rethinking such critical infrastructure networks as “virtual or effective networks of dynamic connections” is a promising approach, he says, with possible insights to come from studying other highly dynamic networks such as food webs.

“A lot of what we were focusing on in the workshop,” says workshop co-organizer Matthew Koehler, MITRE’s Complexity Sciences Area Lead and a member of SFI’s Business Network, “was trying to figure out what is the next step in the development of the tools and techniques of network science to get it past its current limitations.”

Participants, including co-organizer Paul Hines of the University of Vermont, agreed that the next step was overcoming four challenges:

1. Getting more data to better understand the complexity and heterogeneity of critical infrastructure systems, understanding tradeoffs between detailed but slow physics-based models and abstract and quick network-based models of such systems, validating models once they are identified, and translating the output of validated models into information that is useful to decision-makers.

This was the second recent SFI workshop on the topic organized by Moore. He says he is pleased with the workshop’s results but recognizes the problems of protecting critical infrastructure as long-term challenges. He adds that he is hopeful that the coming year will bring sabbatical visitors to SFI “so we’ll have critical mass in-house to make some major progress.”

SFI is re-offering its popular massive open online course (MOOC) in complex systems science, “Introduction to Complexity.” The course session opened on September 30; you can begin taking the class at any time says SFI External Professor Melanie Mitchell, the course’s instructor. For registration information, visit http://complexityexplorer.org.

> Emergence continued from page 1

Pines, who organized the meeting with fellow SFI Science Board member John Holland, Simon Levin, and Donald Saari.

A diverse cast of participants focused on identifying what Pines calls “gateways” – concrete scientific principles that explain how a particular system’s behavior emerges from its constituent parts – and whether those gateways might have relevance across traditional scientific boundaries.

Pines says the workshop’s goals required both young and established scientists from many fields that included biology, physics, mathematics, and ecology. “We all know that almost all of the exciting problems in emergent behavior we work on require input from a number of disciplines,” he says. “You begin breaking barriers down by exposing people to a wide variety of exciting perspectives from different disciplines.”

In addition to expanding SFI’s and ICAM’s network of researchers interested in gateways, another outcome will be to engender a Gateways Registry: a Wiki-based repository where members of the scientific community can describe approaches to emergence that have proved successful in their own research.

The workshop also addressed ways to use the gateways concept in science education. ICAM has developed a website, emergentuniverse.org, aimed at younger adults, Pines says, and a number of workshop participants agreed that emergence would be a good way to introduce middle schoolers to science.

> Emergence continued from page 1

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