Humans have used the plants and animals in their ecosystems in myriad ways. We’ve eaten them, but we’ve also used them for clothing, tools, landscaping, and more. A group of ecologists, anthropologists, and archaeologists studying pre- and non-industrial human communities in places around the world are working to compile, analyze, and model data about these many types of interactions to see how they vary or stay the same across cultures, ecologies, and environments over time.

The group, which met for the first time last February, gathers again November 6–8. Since February, the working group members have begun compiling and analyzing a wide range of data. Some existing datasets have focused on feeding interactions, like Stefani Crabtree’s recent analysis of ancient Puebloan food webs in the southwestern U.S. Some have focused more on other types of interactions, often in very species-specific ways. “For instance, in the Pacific northwest, ethnographers have spent entire careers studying one thousand and one uses for red cedar bark by First Nations people in Canada,” says Dunne. “This project means collating scattered data sets, often ones that have never been digitized, and combining them with other data sets for more comprehensive, quantitative, big-picture analyses. Dunne hopes that exploring both simple interactions — like a human gathering a mussel from the water, breaking it open and eating it raw — and complex interactions that require multiple species and types of interactions — like a human building a kayak out of wood, hide, and gut and using a bone-tipped wooden spear to hunt and eat sea lions — could provide a “biodiversity-focused” way to understand the dynamics of human technology use and innovation across time and in relation to ecology, climate, and culture.

What are the limits of scientific understanding?

This is the query that will drive a three-day workshop at SFI, which itself aims to understand how well scientific and mathematical reasoning can comprehend complex systems.

“When we went to school and we put down the answer to a question, we always had to explain how we got there,” says SFI President David Krakauer, one of the workshop’s co-organizers. “There was always a concern that we’d cheated or stumbled on the right answer.” With recent advances in machine learning, however, Krakauer says we have no easy way of evaluating the problem-solving process. “Machines are terrible at explaining things,” he says. “We’re now living in an age where we’re confronted with significant limits in understanding. With artificial intelligence, the open question is, ‘Will we ever understand our current understanding, or is this an endgame of technology that only machines can understand?’”

The workshop was conceived by Krakauer, SFI Vice President for Science Jennifer Dunne. “It’s exciting to bring everyone together and see opportunities for new kinds of questions to be asked and new hypotheses to be tested. This is a novel research frontier.”

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SFI launches in-house press

If you search for “complexity” on a university press website, you’ll turn up a dozen or so intriguing titles priced at a median of $49 for paperback, $99 for hardcover.

“The notoriously high price of scholarship books belies their primary purpose — to disseminate knowledge,” says SFI President David Krakauer. “It’s driven academics to read only the volumes they can borrow through their institutional libraries and the wider readership to ignore these writings altogether.”

In order to make SFI scholarship accessible to a wider audience, Krakauer decided last January to launch the SFI Press. He’s envisioned the in-house publishing service as a locus where the best work in complexity science — spanning new and archival SFI-related research — materializes as books that travel quickly through the publication process and cost far less to buy than comparable university press-published SFI volumes.

The SFI Press’ publishing strategy involves releasing titles as e-books and print-on-demand paperbacks that will cost below $15 and below $10, respectively, and can be ordered through Amazon.com.

The Press’ book list debuted with the publication on Apr. 15 of History, Big History, and Metahistory editing, SFI President David Krakauer; John Lewis, Caddis (Yale); and Kenneth Pomeranz (University of California Irvine). The e-book, released in October, is now available through Amazon and iBooks. On deck is The Emergence of Archetypal States: New Perspectives on the Development of Complex Societies (editors: SFI External Professor and Past President Jeremy A. Sabloff and SFI External Professor Paula L.W. Sabloff).

The Press accepts anthologies, papers, monographs, and proceedings of meetings not published before, and is also establishing permissions to re-publish seminal complexity science texts previously published by Addison-Wesley and Oxford University Press.

Jeremy Sabloff says the launch of the press “makes eminent sense.” His research group’s forthcoming anthology will include eight

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Casting a wide net

Working group examines human-centered interaction networks through space and time

Humans have used the plants and animals in their ecosystems in myriad ways. We’ve eaten them, but we’ve also used them for clothing, tools, landscaping, and more. A group of ecologists, anthropologists, and archaeologists studying pre- and non-industrial human communities in places around the world are working to compile, analyze, and model data about these many types of interactions to see how they vary or stay the same across cultures, ecologies, and environments over time.

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> MORE ON PAGE 4
Life is short, evolution is long: Working group tackles temporal challenge

There’s a longstanding challenge in biodiversity research: how can we better understand the interplay between ecological processes—things like birth, death, and migration—and evolutionary processes like speciation, extinction, and long-distance dispersal? Researchers know that these two types of processes feed back on one another, but it’s hard to study because ecological processes happen locally and in short timescales while evolution occurs across landscapes and over long periods of time.

A working group led by SFI Omidyar Fellow Andy Rominger meets November 27 to explore ways to tackle this problem. They’ve tested a uniform approach that combines principles from statistical physics with data from modern ecosystems that have evolved, geographically isolated, in a specific chronology. Much of our understanding of evolution comes from the fossil record. But regions like the Hawaiian Islands and East Africa’s Great Rift Lakes —two examples of geographically isolated eco-systems that evolved in chronological succession—provide a living window into evolution.

You “can almost treat them like a fossil record,” says Rominger.

In Hawaii’s case, as the Pacific Plate glided over volcanic hotspots 65 million years ago, the Hawaiian Islands began to form, one after the next, every million years or so. In that same sequence, they began to support life.

“One of the challenges has been how to go from its biological causes and relate that to opportunities to merge the ecological with the evolutionary,” says Rominger. They could also help us understand how ecosystems move into and then back out of steady states of equilibri- um. Steady states occur when rates of input and output —for instance, energy requirements and production or immigration and extinction—balance each other out. “There are ways to guess about past ecosystems and populations of ext- inct species, but there’s no real way to validate. Using systems along chronosequences is one way we can kind of get at that.”

As human activity rapidly pushes ecosystems into non-steady states today, we’re seeing non-stationary dynamics that we don’t understand, says Rominger. “The ultimate goal of this work is to understand non-stationary from its biological causes and relate that to the kind of impacts humans have on evolu- tionary potential.”

Working group illustrates the seldom-seen side of contagion

When strangers become infected with a complex bacteria, they can no longer experience the world in isolation. Such is the predicament of the characters in Nol Timere, a forthcoming graphic novel based on recent scientific insights into the human microbiome and beneficial epidemics.

The developing graphic novel will show what happens when a contagion carries an unex- pected benefit on its host. Rather than harming the infected, the epidemic facilitates their inter- connection with fellow human beings.

According to Steve Green, the novel’s illustrator: “The infection ultimately gives our main charac- ters a newfound appreciation of the rampant transfer of microbial gene flowing between themselves and everything in their surrounding environment: people, pets, plants, and even inanimate objects in the urban environment. Even though the characters have never met, they understand each other deeply, as they have experienced life each at one; they begin to seek out a single organism.”

Green is working with microbiome researcher and SFI External Professor Jessica Green (Uni- versity of Oregon), storyteller Anira Doron, and the SFI postdoctoral fellows to create the graphic novel. Through Nol Timere, which is Latin for “do not be afraid,” the collaborators hope to infect readers with a deeper understand- ing of how real-world epidemics can confer benefits. Even language could be seen as a beneficial epidemic based on the way it spreads. “In the fictional story, sharing words and ‘the love’ mind as a function of an infection may seem weird and undesirable to us, but was language any different?” asks SFI Omidyar Fellow Vanessa Ferdinand.

Omidyar Fellow Chris Kempe sees the novel as an opportunity to communicate the pressing recent research. “Last year we produced a paper that addressed the idea of spreading beneficial elements in systems ranging from bacterial evo- lution to new concepts in a society,” he explains. “Nol Timere is an opportunity for us to show this seldom-seen side of contagion through top-notch storytelling and graphic art.”

In May, the Nol Timere coauthors met in Santa Fe to outline the scientific and philosophical aspects of the developing novel. During the three-day SFI working group, they decided to structure the novel as co-evolving portions of the fictional narrative, integrated with non-fictional scientific essays. Nol Timere is still under development, and publication details will be announced in a future issue of Parallax.

When the September publication of their intro- ductory economics textbook, the Curriculum Opening Resources for Economics (CORE) project received glowing reviews in *The Economist,* *The New Yorker,* the Independent, and other major media outlets. (See “Books” on page 6.)

As SFI Postdoctoral Fellow Elizabeth Hobson was quoted in Forbes on Aug. 9 and in a Na- tional Public Radio blog on Sept. 7 for her re- cent work which builds on a large body of evi- dence suggesting that the need for sodium is what drives Amazonian parrots to eat play. (See “Research News Briefs” on page 6).

Science on Aug. 19, featured new research by SFI External Professor Scott Orman and Tim Kohler (also a member of SFI’s Science Board), which looks to DNA from sunken bones for clues as to where Ancient Puebloans went after abandoning their settlements.

In an article published Aug. 11 in *Forbes,* SFI Pres- ident David Krakauer talked with columnist Robert Wolkost about how the human experi- ence might continue to change with advancing technologies.

In July, Bill Miller, Chairman Emeritus of SFI’s Board of Trustees, was featured in *The Wall Street Journal* and in *Forbes* for weaving the Journal’s quarterly stock-picking contest: his Miller Opportunity Trust (LOOP), which he manages with CIA Samantha McAlmore, gained 85.25% over months, bearing its clos- est to near six percentage points. The Atlantic; on July 1, featured SFI Professor Jessica Flack’s research on biological col- lisions in an article titled “The Countless Com-puterst Embedded in Nature.” The article about Flack’s work with *The Collective Compu- tation Group* (SFI (E)) was originally appeared in *Quanta*.

SFI Miller Scholar Sam Shepard, a legendary playwright and actor, was remembered on the BBC and in *The New York Times,* *Nautilus,* *The San Francisco New Mexican,* *The San Francisco Reporter,* and *The Albuquerque Journal* after his passing on July 27 at the age of 72.

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New Studios deliver ACTION-able insights

Companies are no strangers to complexity. As they interface with complex economies and human social groups, they routinely encounter emergent feedback loops, and other complex systems behaviors. The trick is for staff to spot and manage such phenomena, encourage the beneficial ones and curtail the detrimental ones.

To that end, SFI’s Applied Complexity Network (ACiSNet) is offering a new program for its members. The Studio is a multi-day intensive workshop wherein a group of a few dozen members convene at SFI and meet with SFI scientists to work through aspects of complexity theory that apply to their organization’s specific challenges.

It’s a great way to see how theories developed at SFI are applied to concrete problems,” says SFI External Professor Simon DeDeo’s essay, “Origin Gates and the Eternal Sunshine of the Second Order Pendulum.” Finals in an annual contest run by the Foundation Questions Institute (FQXi). In the essay, DeDeo argues “there are true gaps between life and non-life, mind and mindlessness, and even between functional societies and groups of Hobbesian individuals…[that] emerge from the mathematics of self-reference.”

An ACiSNet-instructed research paper is among the top 10% of most-cited articles in the journal PLOS ONE. “A quantitative theory of solid tumor growth, metabolic rate and vascularization,” was co-authored by SFI External Professor Van Savage (UCLA), Distinguished Professor and Past President Geoffrey West, and former SFI RELX Alex Herman (University of California San Francisco School of Medicine). It has so citations according to Google Scholar.

The National Science Foundation (NSF) has fund

ed an SFI proposal for a research coordination network called “Exploring Life’s Origins,” to be led by SFI Omidyar Fellow Chris Kimpe

s and SFI President David Krakauer. The ongoin

ing SFI research effort will be part of the NSF’s new push to support sustained integration across multiple scientific fields in order to address important problems.

Let us compute: The law

Legal systems generate staggering amounts of text, from judge’s decisions to court orders to lengthy words of regulations, rules, and laws. A recent study from Michael Livermore (University of Virginia School of Law), much of whose research focuses on us

ing computational tools to better understand the law. Together, and with others, they’ve applied techniques from a range of disciplines including network analysis, computational text analysis, and natural language processing to conduct an empirical study of the text. They’ve produced, for example, an online search engine that can both identify legal documents and make recommendations to a user of other useful documents.

Now, they’re bringing together leading research

er’s in the field for a working group at SFI, to be held December 11-14. It’s the first meeting in a new research theme at the institute, The Feld

stein Program on Law, History, and Regulation.

“Our goal is to set the stage and coalesce the work that’s been done in the computational study of law,” Livermore says. The group includes an international mix of leading economists, politicians, legal scholars, and computer scientists.

Livermore hopes the working group will inspire new computational tools that can produce more sophisticated ways of understanding legal systems. These tools would be useful for any system; they also might be used to study relationships between legal systems or track how legal ideas spread over time. “Anywhere the law matters, which is everywhere, the work is appli
cable,” he says.

SFI welcomes new External Faculty

AMY BOGAARD

Professor of Neolithic and Bronze Age Archaeology (University of Oxford)

Amy Bogaard works at the intersection of archaeology and archaeometric to explore early farming practices and land use in Europe and western Asia. Collaborating with plant ecologists, isotopic geochemists, archaeologists, and econo

mists, she aims to show how those practices have evolved into present-day traditional farming.

Bogaard is currently leading the European Research Coun

cil’s Agricultural Origins of Urban Civilization (AGRICURB) project, which aims to refine another method of reconstruction: digital crop growth conditions to evaluate the nature and social significance of farming practices in Europe and Western Asia. Her other current projects range from excavations in Knossos, Crete, studying economic integration and cultural survival in Neolithic Turkey; and developing new approaches to paleoecology and agricul
tural reconstruction.

Earlier this year, Bogaard co-taught a graduate/postgraduate short course at Oxford, “Inequality: Archaeological and Economic Perspectives” with SFI Professor Sam Bowles. The course at

tracted wide interest in the School of Archaeology and enhanced the profile of multiscale approaches to social inequality at Oxford.

Bogaard earned her Ph.D. at the University of Sheffield and received the Shanghai Archaeology Forum Research Award for her AGRICURB and paleoecology projects.

ELIZABETH BRUCH

Associate Professor in Sociology and Complex Systems (University of Michigan)

Elizabeth Bruch has explored a broad array of population phenomena where the actions of individuals, families, cou

ples, and neighborhoods drive decisions about where to live and patterns of residential segregation. Bruch is currently developing “sociometric” calculational models that aim to represent individuals’ underlying decision processes using new data sources like mobile de

vices and the Internet along with existing choice models. She uses “big data” to investigate how people explore their environment, engage in novel or habitual behaviors, interact with others, and learn from past experiences.

Working with a treasure trove of data on how millions of individuals search for and pursue mates, Bruch is uncovering new methods and theoretical frameworks for understanding the link between human behavior and sociometric change. Her current project looks at mate preferences and marriage market dynamics in the world of online dating.

Bruch earned her Ph.D. from the University of California Los Angeles, and was a Robert Wood Johnson Health Policy Scholar. Her article on racial tolerance and race-ethnic segregation, Neighborhood Choice and Neighborhood Change, won the Politics, Culture and Society Award.

BARBARA GROSZ

Higgins Professor of Natural Sciences (Harvard University)

Barbara Grosz develops computational theories and meth

ods that enable computer agents to work effectively with people over the long term in complex, dynamic environ

ments. Her current research explores ways collaborative multi-agent systems and collaborative human-computer interaction design can improve the systems and programs people use for health care planning, coordination, and communication. She also investigates uses of models of collaboration for science and math education.

Groz’s contributions to Artificial Intelligence include pioneering research in dialogue process

ing and multi-agent systems, collaboration and their application to human-computer interac

tion. A member of the National Academy of Engineering and the American Philosophical Soci

ety and fellow of several scientific societies, she received the 2009 ACM/AAAI Allen Newell Award, the 2015 IJCAI Award for Research Excellence, and the 2017 Association for Compu

tational Linguistics Lifetime Achievement Award. Known for her role in the establishment and leadership of multidisciplinary institutions, she is widely respected for her many contributions to the advancement of women in science.

Grosz received her undergraduate degree from Cornell and Ph.D. in Computer Science from the University of California Berkeley. A member of the National AI Center before joining the Harvard faculty, she has also taught at the University of Pennsylvania, Stanford University, and Hebrew University.

SRIVIDYA IYER-BISWAS

Assistant Professor of Physics and Astronomy (Purdue University)

Using rapid, iterative feedback between theory and experiments, Srividya Iyer-Biswas works to discover the basic physical laws that govern the probabilistic behavior of single cells, and that transcend detailed specifics of biological systems. Her research uses a top-down physics approach rather than more traditional approaches that focus on the catastrophe of genetic network cascades. Iyer-Biswas and her team have reported predictive scaling laws governing the stochastic growth and division of cells, and have developed a theory that reveals the emergence of
New External Faculty (cont. from page 3)

a scalable, cellular unit of time. Her current work involves extending these results to thermodynamics of organismal computation, time-dependent phenomena involving cellular decision-making, and laws that dictate complex biological and social phenomena.

Iyer-Biswas began her career as a theoretical physicist, then transitioned to experimental biophysics as a postdoc at Princeton University and the University of Chicago. Through her interdisciplinary work — combining theory and application, and spanning physics and biology — her goal is to ultimately advance the fundamental physics of living systems. Iyer-Biswas was named a 2017 Scialog Fellow for Molecules Come to Life.

ANDREW LO

Charles E. and Susan T. Harris Professor, Sloan School of Management; Director, Laboratory for Financial Engineering (Massachusetts Institute of Technology)

Andrew W. Lo draws on finance, economics, evolutionary biology and ecology, computer science, and engineering to tackle problems related to investment strategies, investor behavior, risk management, regulatory policy, and how research ideas can be be applied to real world situations.

Much of his research over the past two decades has been devoted to understanding the impact of human behavior on financial markets and policy, culminating in his new book, Adaptive Markers: Financial Evolution at the Speed of Thought.

Lo’s current research expands on this work, including developing new methods for measuring and managing risks in the financial system and researching new business models and financial structures to support scalable and profitable biomedical research and drug development. He is also applying machine-learning and natural language processing to develop real-world solutions to common financial industry challenges.

Lo received his Ph.D. in economics from Harvard University, and has taught finance at the University of Pennsylvania’s Wharton School. He is currently co-chair of the Annual Review of Financial Economics and an associate editor of the Financial Analysts Journal, the Journal of Portfolio Management, and the Journal of Computational Finance. He holds the AlfreP. Sloan Foundation Fellowship, a Guggenheim Fellowship, and awards for teaching excellence from both Wharton and MIT.

SONJA PROHASKA

Professor and Group Leader, Computational EvoDevo (University of Leipzig)

Sonja Prohaska studies gene regulation, from the theoretical considersation of the gene concept to the evolutionary history of special genetic regulatory mechanisms.

Drawing from both her computer science and genetics backgrounds, she seeks to investigate whether epigenetic regulation — setting “on top of” the DNA — can be understood as a computation device. And using modeling and computer simulation, she is working to uncover the causes of cell differentiation.

Working across multiple disciplines at SFI, Prohaska will explore evolution — a central theme of her research — as it relates to technology, culture and language. She hopes to introduce more theory to the life sciences and to go beyond individual models toward universal theories.

On a recent visit to SFI for back-to-back workshops on the thermodynamics of computation in chemical and biological systems, Prohaska was part of a team working to collect and review ideas on what it is that biological systems compute.

Prohaska is a professor and project leader for Evolution and Development at Leipzig University’s Interdisciplinary Center for Bioinformatics and leads Computational EvoDevo at the University’s Institute of Computer Science, where she earned her Ph.D. in Bioinformatics.

GEORGE STAROSTIN

Linguistics Researcher (Russian State University of the Humanities)

George Starostin has spent over a decade at the Center of Comparative Studies and the Department of Far Eastern Philology of the Russian State University for the Humanities, where he advances the work of his late father, Sergei Starostin, formerly Russia’s leading specialist in comparative linguistics.

As co-director of the SFI-coordinated international Evolu- tion of Human Languages project, initiated by Dr. Muray Gell-Mann, Starostin has made important contributions to the study of the linguistic prehistory of humanity, working toward a global phylogenetic classification of the approximately 6,000 languages spoken today, similar to the classification of biological species. He has also been instrumental in the development of The Tower of Babel, an online system of etymological databases for the worlds languages started by his father.

Starostin is currently focused on the languages of Africa, including hypothetical language families such as Nilo-Saharan and Khoisan (formerly known as Bushman-Hottentot) of South Africa. This field remains particularly challenging due to the extreme complexity and unique features of these languages, including the Khoisan “click” phonemes, which do not occur in any other language family.

Starostin received his Specialist degree in theoretical and applied linguistics and defended his Candidate thesis in comparative Dravidian linguistics at the Russian State University of the Humanities in Moscow.

Real-world problem solving comes to online complexity learning

Participants in SFI’s online education platform, Complexity Explorer, now will be able to test their new knowledge on a tangible, real-world problem.

“At the end of the day, it doesn’t matter how much book learning you have or how many problem sets you solve,” says SFI External Professor John Miller “Creative, interdisciplinary complex systems thinking is best tested when applied to the real world.”

In August, Miller and SFI’s Education team introduced the Complexity Challenges, exclusive events where Complexity Explorer participants in opened real-world problem-solving.

Here’s how a Challenge works: SFI teams up with a partner institution (often a member of the Applied Complexity Network) to identify a problem or business obstacle. Miller abstracts that problem into an open-ended puzzle for participants to solve any way they want.

Participans have one month or seven days to create and deliver written articles and three-minute video presentations. They then review each others’ submissions. Mentors and partner-institution reps rank the top-scoring submissions.

“We don’t have some ‘right answer’ in mind,” Miller says. “What we care about is good solid scientific thinking that uses the various tools and ideas from complex systems science to derive novel solutions.”

For the inaugural challenge, which began August 16 and ends September 30, SFI teamed up with the Multidisciplinary Center for Evolution and Complexity (MCEC) in Boston, which has a long history of bringing together scientists from across the physical, mathematical, and social sciences to tackle problems in these disciplines.

The complexity challenge, which was cosponsored by SFI’s Adaptive Markets and Complex Systems programs, focused on the evolution of real-world systems and how we can apply, or even invent, new solutions that are more robust to changing situations.

“The problem is to find out how to change conventional delivery — think warehouse organization, package delivery, airline routing, or self-driving ride services,” says Scott Auvil, MCEC’s Program Director. “In this case, the problem is abstracted as a giant checkerboard, with the challenge of getting checkers from varying starting and ending points using only simple rules and local information.”

The best two solutions will win the $5,000 prize.

In the future, successful Complexity Challenges may form the basis of capstone projects for online certificate or degree programs offered by SFI, she says.


List of attendees (cont. from Beyond Borders, page 2)

John Beggs (Indiana University); ASU-SFI Center Postdoctoral Fellow Bryan Daniels, SFI External Professor Simon DeDeo, (Carnegie Mellon); SFI External Professor Doug Erwin, (Smithsonian Institution); SFI Professor Jessica Flack, SFI President David Krakauer, (Princeton University); and SFI Professor and Past President Geoffrey West attended the Future of Computational Social Science working group, held August 9-10 at SFI.
The Diversity Bonus: How Great Teams Pay Off (Princeton University Press, 2017) by SFI External Professor Scott Page (University of Michigan) investigates how businesses and other organizations can improve their performance by tapping a variety of cognitive repertoires. Page traces a causative path to the benefits that arise when teams composed of different kinds of thinkers come together to think, solve, and create. These “diversity bonuses” include improved problem solving, increased innovation, and more accurate predictions — all of which lead to better performance and results.

The Economy (Oxford University Press, 2013) is a textbook designed for a first course in economics. Available in paper back format and as a free, online interactive text, the book aims to address the gap between complex, real-world economic problems and the topics traditionally taught in first-year courses. Several SFI co-authors contributed to its content as part of the Curriculum Open-access Resources and Education (CORE) project with international collaboration of economists, teachers, and students led by Wendy Carlos (University College London) and SFI Professor Sam Bowles.

Maya E Groups (University Press of Florida, 2007) is an anthology edited by David Fredel (Washington University), Arlen Chase (University of Nevada), Anne Dowd (ArchaeoLOGIC USA, LLC), and SFI Trustee Jerry Mintuck. The book results from an ongoing series of SFI meetings exploring ancient Maya culture. E Groups, named after “Group E” at an archaeological site in Uaxactun, are some of the earliest permanent public structures that were ritual centers and astronomical observatories.

New books by SFI authors

SFI welcomes new Postdoctoral Fellow

Deepak Bhat seeks to understand systems in nature that have remained unsolved by classical statistical approaches. Such systems — biomolecules such as motor proteins, bacteria exhibiting chemotaxis, and fluctuations in stock markets, to name a few — are often characterized by a noisy environment, and are out of equilibrium.

To better understand the macroscopic properties of these systems, Bhat uses tools from the fields of nonequilibrium statistical mechanics. In recent years he has studied the statistics of a molecular motor transport process that organizes structures inside a cell. He has also been exploring the connection between information theory and thermodynamics — a typical way of thinking about the physical world in a statistical way.

What do you lose by moving to the suburbs?

A lot, according to an SFI working group examining human settlements over thousands of years. Cities are “social reactors” — accelerators of human interactions and their outcomes. And this is something that can and did evolve from marketplaces and sewage systems to moral philosophy and cell phones.

For thousands of years, humans were mobile hunter-gatherers. When we started staying in the same place for longer periods, things began to change — and fast. “It appears that everything since then is just the playing out of a series of relationships that emerged when people started settling down,” according to the working group’s organizer, SFI External Professor Scott Ortman (University of Colorado).

By quantitatively analyzing human settlements from ancient times to the present, Ortman’s group has found that the more things change, the more they stay the same. In fact, says Ortman, “in our framework, there’s not much difference between a Neolithic farming village and a modern city.”

The researchers work with a variety of archaeological measurements such as the density of postholes, or size of monuments, as well as historical records and ethnographic studies of contemporary hunter-gatherer societies.

Still, the archaeological record presents thousands of long-term “experiments” in which human groups have tried to harness these social networking processes — and they do so in ways that differ from our typical experience.

Our concept of commuting, for example, assumes that cities have one “downtown.” But the Pueblo people’s traditional social and economic system involves evokes in different villages on different days — essentially creating many city centers. This “polycentric commuter flow” allows them to gain the benefits of larger scale despite the smaller size of individual communities.

So, is your commute worth it? In exchange for your big backyard, you’ll spend part of the day traveling. It’s hardly novel — but sacrificing that for most modern living, a car, a home, innovating with other humans has, arguably, fueled the modern world, the researchers say.

More at http://www.colorado.edu/socialturces/project-news

When species compete, it’s a colossal game of rock-paper-scissors

Organisms competing for contested resources like nutrients, light, and space play an important role in biodiversity. A recent paper co-authored by incoming SFI Omidyar Fellow Jacob Grift finds that the number of competitors may matter. “The authors’ model potentially offers a better understanding than that provided by previous models of how diverse communities are maintained in nature, where it has often been hard to explain the high levels of biodiversity observed,” writes former SFI Omidyar fellow James O’Dwyer (University of Bologna), in a review of the paper.

Think of two saplings seeking to exploit the advantages of light streaming through a new opening in the forest canopy. One will emerge the winner in this simple pairwise contest.

But add a third sapling and predicting a winner is no longer straightforward. Predicting who will win in a three-person game of rock-scissors-paper. Rock smashes scissors, but when paper covers rock, it also awakens to scissors. Now imagine the game with hundreds or thousands of different competitive moves. In their model, Grift and co-authors did just that. They also show how communities can “hedge” increasing the probability of having multiple winners.

When species compete, it’s a colossal game of rock-paper-scissors — a phenomenon that Pomeranz (University of California Irvine), the researchers say, is something to look for in real systems, and the model at least makes it more tractable to study these effects.

The intersection of Grilli and O’Dwyer’s work — and their common SFI pedagogy — is no coincidence. Both are ecologists with backgrounds in physics. About five years ago, Grilli read one of O’Dwyer’s papers and was drawn in by its physics-inspired approach — one Grift had already been thinking about. Grift had not heard of SFI, but his interest in O’Dwyer’s paper eventually led to his application for the fellowship.

“One of the greatest advantages of this program is that it gives fellows a chance to constructively build on and challenge each other’s thinking,” says Grilli.

When winning wars was a matter of marrying well

For rulers in pre-modern states, marrying the right wife was often a path to military victory. In a paper published in the Journal of Archaeological Method and Theory, SFI External Professor Paula Sabloff looked at several pre-modern states to uncover the strategies their rulers used to win wars — or at least, reduce the risk of losing them. Sabloff found that, with remarkable consistency, marriage alliances helped pre-modern rulers form networks of military support. By giving and receiving royal titles, rulers sustained patron-client relations — contracts of obligation between unequal parties that laced the life of the marriage, and often beyond — that might have been established through conquest or other means.

MORE NEWS BRIEFS ON PAGE 6
Energy and matter at the origin of life: SFI Community Lecture, Nick Lane, Tuesday, November 7, 7:30 p.m., The Lensic Performing Arts Center

All living things are made of cells, and all cells are powered by electrochemical charges across lipid membranes — the "proton motive force." We know how these electrical charges are generated by protein machines at virtually atomic resolution, but we know very little about how membrane bioenergetics first arose. By tracking back cellular evolution to the last universal common ancestor and beyond, scientist Nick Lane argues that geologically exalted electrochemical charges across semiconducting barriers were central to both energy flow and the formation of new organic matter — growth — at the very origin of life.

Lane is a professor of evolutionary biochemistry in the Department of Genetics, Evolution and Environment at University College London (UCL). His research focuses on how energy flow constrains evolution from the origin of life to the traits of complex multicellular organisms. He is a co-director of the new Centre for Life's Origins and Evolution (CLOE) at UCL, and author of four celebrated books on life's origins and evolution. His work has been recognized by the Biochemical Society Award in 2015 and the Royal Society Michael Faraday Prize in 2016.

SFI's 2017 Community Lectures are made possible through the generous underwriting of Thunburg's Investment Management, with additional support from The Lensic Performing Arts Center. Tickets for this event are free, but reservations are required to reserve tickets, visit http://tickets.ticketatlantagroup.org. Watch lectures live on SFI's YouTube page.

RESEARCH NEWS BRIEFS (cont. from page 5)

WHAT ALGAE CAN TELL US ABOUT POLITICAL STRATEGY

A new study by SFI Researcher Caitlin Stern and Oren Kolodny (Stanford University) explores the ecological dynamics, life history, and population size, is published in the Journal of Economic Perspectives, "Evolution of risk preference is determined by reproduction," where the researchers used metagenomic analysis to map the different gut bacterial strains may determine which strains will stick around and competition between different bacterial species play an important role in shaping the human microbiome. According to a new research published in Nature Scientific Reports, general principles may begin to explain how different strategies play out where groups compete for resources. SFI Omidyar Fellow Eric Libby and SFI Research Fellow Laurent Hébert-Dufresne wondered if understanding how algae evolve different competing ideologies squared off with offensive strategies, both parties would persist. When both were more defensive, the less competitive group disappeared entirely. But when a third party was added to the mix, the winning strategy used a level of offense higher than one opponent but lower than the other.

WHY DO PERU’S PARROTS EAT CLAY?

Amazonian Parrots in southeastern Peru gather along the clay banks of the Tambopata River to scoop up baits of soil. It’s confounding behavior — clay contains no proteins or carbohydrates. Researchers have tossed around two leading theories about what drives this geophagy: that clay helps protect the birds from dietary toxins, or it’s a nutritional supplement. In a paper published in Nature Scientific Reports, the team hopes their work will help open broader discussions about the benefits of using simpler models to understand complex ecosystems.

BIRDS CHOOSE MATES WITH ORNAMENTAL TRAITS

A recurring theme in nature documentaries is that of choosy females selecting brightly colored males. But in monogamous mating systems, males don’t select their lifelong mates in much the same way. In a fresh look at evolution by SFI Research Fellow Caitlin Stern. Some traits, such as the tuft of feathers atop a crested auklet, signal attractiveness to the other sex and competitive rank within the same sex. Research has traditionally focused on male competition for access to females or territory and on females choosing males based on their feathers and fights. But recent investigations suggest that females not only compete with each other, but also rely on such traits in deciding whether to engage or defer.

THE ROLE OF COLLECTIVE MEMORY IN PRIMATE CONFLICT

In a recent paper published in the Journal of the Comparative Cognition Group @SFI (Ca), the role of collective memory in managing length and severity of fights between primates. While studying the dynamics of conflict in a primate society, researchers Edward Lee (Cornell University), ASU-SFI Center Postdoctoral Fellow Bruce Dantzig, SFI President and Founder Edward Lee, and SFI Professor Jessica Flack found evidence that it is the number of individuals who control the length of fights (as in a corral model), but the relationships between pairs of individuals: Because statistical variation in the observed fights strongly suggests that conflict duration is set by the first interaction, the researchers propose that “the duration of the conflicts is not driven by individuals independently deciding whether to continue fighting or drop out, but through their joint memory for the past and subsequent collective decision-making.”

BACTERIA COMPETE TO SHAPE YOUR MICROBIOME

A new paper by SFI External Professor Elifran Borenstein (University of Washington) and colleagues shows that competitive interactions between bacterial species play an important role in shaping the composition of the human gut microbiome. The researchers used metagenomic analysis to map the landscape of taxa and affinity factors from the type VI secretion system — a pathway that mediates interbacterial competition — in the gut microbiome. Examining this landscape and the presence of different bacterial strains in adult and infant microbiomes, they first evidence that competition between different gut bacterial strains may determine which strains will stick around and which may be competed away. The paper, published in Cell Host and Microbe, is part of Borenstein’s ongoing work to understand systems-level dynamics of the human microbiome.