SANTA FE INSTITUTE

March / April 2014

UPDATE

This map of Tenochtitlan, the metropolis of the Aztecs, was drawn by a Spanish scribe circa 1519 during the expedition of Hernán Cortés.

Modern cities' deep connection with ancient ones

It started with an idea that led to an experiment, then to an SFI-style collaboration, which culminated last month in a significant paper.

The idea, often discussed around SFI, is that based on vast amounts of urban data, modern cities – regardless of their culture or level of development – follow the same mathematical rules: many urban quantities, from average wages to measures of infrastructure, vary predictably with city population size.

Recent theory, published last summer in *Science* and proposed by SFI Professor Luis Bettencourt to explain these intriguing patterns, treats cities generally, as meshes of social and infrastructural networks, and with properties that are not specific to modern cities.

When archaeologist Scott Ortman, a former SFI Omidyar Fellow now at the University of Colorado Boulder, heard these findings from the Institute's Cities & Urbanization team, he was curious whether the same scaling relationships would apply to the settlements of ancient civilizations.

So Ortman did an informal analysis using urban scaling rules and urban data from an archaeological survey done 50 years ago in the Valley of Mexico, the heart of the Aztec Empire. To his amazement, the scaling rules seemed to fit the data from this ancient society that had emerged independent from the influences of European culture.

"This was an intriguing result with potentially deep implications since, let's be honest, about the only things ancient Mexican cities have in common with today's cities is that they were created by humans," says Ortman.

He connected with Bettencourt, who responded with similar amazement. Ortman and Bettencourt soon began to develop urban scaling theory in the context of archaeology to see whether Ortman's initial result stood up to more rigorous scrutiny.

They formed a team to compile and digitize the data from the Pre-Columbian Valley of Mexico and analyze it in greater detail. The team included Jennie Sturm (University of New Mexico) and Andrew Cabaniss (University of North Carolina-Chapel Hill), a former student in SFI's Research Experiences for Undergraduates program.

Their work shows that the ancient settlement system of the Valley of Mexico is not only consistent with urban scaling theory, but also exhibits spatial properties analogous to those observed in modern cities.

Their findings, published February 12 in *PLOS ONE*, suggest that the basic principles that organize human settlements are general and may apply to all human settlements regardless of how far apart they are in time, space, or culture. ■

Sen. Heinrich visits SFI

U.S. Senator Martin Heinrich, D-N.M., visited the Institute on Saturday, February 22, accompanied by retired U.S. Senator Jeff Bingaman, an SFI Trustee. Here Heinrich gets a tour and overview from SFI President Jerry Sabloff. The visit included briefings on several research projects, including the Institute's cities and urbanization project (briefing given by Geoffrey West and Luis Bettencourt), recent work in epidemiological dynamics (Ben Althouse and Sam Scarpino), and studies of inequality in indigenous human populations (Paul Hooper).

(Photo by Ricardo Quinto)

IN THIS ISSUE

RESEARCH NEWS

Better ways to infer relatedness of languages

For decades, linguists seeking to sort out the history of language sifted through words and grammars by hand in search of clues to tongues' shared pasts. SFI Professor Tanmoy Bhattacharya and External Professor Peter Stadler are taking the first steps toward an improved approach during a March working group at SFI on the methods and mathematics of historical linguistics.

"The current standard in this field is you ask which words are cognate [have the same origin]," and then consider the words' grammatical and semantic contexts to infer whether two languages are related, Bhattacharya says. The better approach is to infer the probability that words from different languages are cognate, then "propagate the uncertainty" to determine the probability that entire languages are related, he says.

> more on page 2

RESEARCH NEWS

How adaptation works at the molecular level

A chance mutation or mistake in replication introduces genetic variation, the substrate for evolution. Different genetic variants within a population may be slightly better suited to a task, or may create a ripple effect in gene expression, altering many characteristics of the individual.

"Genes underlying all traits exist in complex webs termed molecular networks," says SFI Omidyar Fellow Sam Scarpino.

> more on page 2

SFI IN THE NEWS

In a *New York Times* opinion piece on February 16, SFI Professor Sam Bowles and collaborator Arjun Jayadev crunch the numbers and find that of the world's advanced industrialized nations, the U.S. has the highest ratio of workers devoted to guarding things; at the regional level, they show, the more guards, the more inequality.

On February 12, the *Santa Fe New Mexican* and the Santa Fe Radio Café featured interviews with SFI Community Lecture speaker Ross Hammond on complex systems approaches to understanding obesity.

The Santa Fe Radio Café and the *Albuquerque Journal* covered a special Science On Screen event February 11 in Santa Fe, during which SFI Distinguished Professor Geoffrey West and director Mark Levinson introduced the hit documentary film PARTICLE FEVER, the story of the machine and the people who sought, and found, the long-predicted but elusive Higgs boson.

In the *Santa Fe New Mexican* on February 3, SFI Research Associate Eric Rupley tells a story about how declassified U.S. military satellite imagery offered key insights that helped change archaeologists' views of early human societies.

In a January 29 interview on VoiceAmerica Radio, SFI External Professor Peter Peregrine reconsiders population growth and technology as drivers of cultural evolution.

A January 19 *Los Angeles Times* article about the biological basis for human violence mentions research by SFI Professor Sam Bowles on the evolutionary roots of altruism and cooperation.

In *Nature* on January 15, SFI External Professor Herb Gintis remarks on a new paper that examines decision-making organisms' seemingly irrational violations of the rule of transitivity, or the logical ordering of preferences.

The January 14 *New York Times* notes that nearly 200 prominent thinkers responded to The Edge's annual big question for 2014: "What scientific idea is ready for retirement?" Among the SFI-affiliated respondents are Geoffrey West, Seth Lloyd, Daniel Dennett, Martin Rees, Nigel Goldenfeld, and Rebecca Newberger Goldstein.

The *Santa Fe New Mexican* and the Santa Fe Radio Café on January 8 covered an SFI Community Lecture, in which conservation biology pioneer Thomas Lovejoy explored how we might manage both biological and economic systems to reduce the long-term effects of climate change.

Wired on December 25 picked a representation of a food web with and without parasites by SFI Faculty Chair Jennifer Dunne as one of the top 10 scientific visualizations of 2013.

Nonlinearities
From the editor

What is an SFI "founder"? In researching SFI's early history, I've learned it's a question with no easy answer. During the Institute's conception from 1982 to 1984, a group of senior scientists we've chosen to call the "Cowan Collaborative" held dozens of meetings, each with a slightly different cast and each with an increasing focus on the Institute's formation. Everyone who attended contributed in some measure to the DNA of the future Institute. Some contributed more than others. Some participated more often than others. Some who came later contributed more than some who came earlier.

As I note on page 3, what was needed in late 1984, and fast, was a setting, money, and people – people who were remarkably invested in a cooperative vision. George Cowan was highly inclusive in welcoming perspectives to the table. That's probably why many people have considered themselves to be among SFI's inventors. That was Cowan's character. He wanted you to not just feel like an insider, but to *be* an insider, not just to support him, but to join him. And so we have many founding contributors, some mentioned in the last issue. Some mentioned in this issue. Some forgotten, to be sure.

What smallish city can get out well over 800 people on a Tuesday evening in the middle of winter – *while* the Olympics are on television – to watch a movie about particle physics? Santa Fe! I'm referring, of course, to the February 11 SFI/Center for Contemporary Arts screening at the Lensic of the feature-length documentary PARTICLE FEVER, the story of the machine and the people who sought, and found, the elusive Higgs boson. The screening was introduced by SFI's Geoffrey West and the movie's director Mark Levinson. It was the latest in our popular Science On Screen series. I love this town!

If you've visited SFI, you know that food is the glue that holds the Institute together. I want to take this opportunity to thank our hospitality assistant, Beth Kiyosaki, for spoiling us on a daily basis with surprising and tasty culinary delights. Thanks Beth! ■

– John German, jdg@santafe.edu

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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*.

Follow SFI online at **www.santafe.edu**

RESEARCH NEWS

When wild primates, people, and the dengue virus converge

(Image: Ben Althouse)

Despite remarkable human progress in containing infectious diseases over the last five decades, the incidence of one mosquito-borne disease – dengue fever – has increased thirty-fold in that time. Some 390 million people are infected worldwide every year.

A successful dengue vaccine would reduce the incidence of dengue fever in humans. But wild primates can't be vaccinated, so even with a human vaccine the virus would continue to infect both wild and human primate hosts, as the same mosquitoes feed on both populations.

SFI Omidyar Fellow Ben Althouse says it is crucial to understand the dynamics of dengue in wild populations "so we can effectively mitigate the morbidity and mortality that result from a virus whose transmission we have little control over."

That's why Althouse and his collaborators are examining how the virus circulates in the wild — beyond the reach of vaccines — and the relationships among the virus, the mosquitoes that carry it, and the primate hosts (including humans) it infects.

Their most recent paper, published in the March issue of the journal *Virology*, examines results from some 54 different dengue virus-related studies of non-human primates and provides estimates of how long the virus remains in the blood – and how different viral strains behave.

"The longer there's virus in a primate's blood, the greater the chance a mosquito will ingest the virus and then transmit to another host – human or monkey," Althouse explains.

Their analysis finds that the differences among the 11 species of apes and old world and new world monkeys tested are minimal.

Althouse says the new estimates might help improve prediction of dengue epidemics in wild populations – which in turn might help lessen the degree of spillover to people living near their wild primate kin.

Co-authors include Derek Cummings and Anna Durbin of the Johns Hopkins Bloomberg School of Public Health, Kathryn Hanley of New Mexico State University, Scott Weaver of the University of Texas Medical Branch, Galveston, and Scott Halstead. ■

> ***Adaptation*** **continued from page 1**

Moreover, he says, the role of individual genes in the process of adaptation is affected by their positions in these networks.

Scarpino, an integrative biologist investigating the evolution and spread of infectious diseases, co-organized his first SFI working group in late February to explore the role of adaptation in molecular evolution.

The meeting's co-organizer and mathematical ecologist Jesse Lasky of Columbia University, with his background in fundamental ecological and evolutionary processes at the levels of communities and genomes, brought deep theoretical and statistical expertise to the discussions.

Co-organizer and integrative biologist David Des Marais of Harvard University brought an experimental perspective. His research examines how plants adapt to local climates, focusing on the genetic and physiological bases of their stress responses.

Other participants included SFI Omidyar Fellows Evandro Ferrada, who investigates how evolutionary mechanisms operate at various levels of organization, and Eric Libby, who researches how single-celled ancestors transitioned to simple multicellular organisms and what those in-between forms might have looked like.

The group took the first steps in answering testable questions, such as where selection acts within molecular networks, and how the stability of an environment affects molecular evolution as a population adapts to a new location or conditions.

"Our results, we hope, will serve as a foundation for developing new theory and interrogating it with experiments and data," says Scarpino. ■

> ***Language*** **continued from page 1**

It's a problem a number of SFI scientists have worked on, often taking their inspiration from biological phylogenetics – the process of inferring evolutionary history from the genetic similarity of modern-day plants and animals. It's a useful starting point, Bhattacharya says, but language is doing something different from biology. While the basic processes of biology are fixed in time – "a G is a G," he says, referring to the DNA nucleotide guanine – the relationships between phonemes, pronunciation, and word meanings all drift.

With so many moving parts at work in language evolution, the standard mathematical and computational tools researchers use to search for common ancestors in biology won't work.

"We have to have a different algorithm for fitting the data," Bhattacharya says.

Equally important is finding a way to be more objective about what patterns in the data are real. To be sure, linguists have discovered real patterns that can be useful checks on a computer model, but "what we need is an automatic way to find these things." That, he says, "is better done by machines than by humans."

The working group brings together physicists, biologists, anthropologists, and others who have spent years working on the problem. The top question, Bhattacharya says, is: "How do we make real progress beyond what we've done individually?" ■

ACHIEVEMENTS

SFI President Jerry Sabloff has been selected to receive the Society for American Archaeology's Lifetime Achievement Award for 2014. The award is presented annually to an archaeologist for extraordinary, widely recognized lifetime accomplishments that have had lasting scholarly, pedagogical, or institutional impacts. The award will be presented April 25 during the SAA's annual meeting in Austin, Texas.

SFI Trustee John Chisholm has been named president-elect of the MIT Worldwide Alumni Association and *ex officio* member of the MIT Corporation (Board of Trustees). Chisholm earned BS and MS degrees in electrical engineering/computer science from MIT. He currently chairs the MIT Club of Northern California and serves on the MIT Corporation Development Committee.

Mirta Galesic selected as next SFI Cowan Chair in Human Social Dynamics

Mirta Galesic has been selected as SFI's next Cowan Chair in Human Social Dynamics. Galesic plans to join SFI in January 2015 as a full-time resident professor for a five-year term.

Currently a research scientist with the Center for Adaptive Behavior and Cognition at the Max Planck Institute for Human Development, Galesic holds a PhD in psychology from the University of Zagreb, Croatia, and an MS in survey methodology from a joint program at the University of Maryland and the University of Michigan.

"Galesic will extend SFI's intellectual landscape in new, exciting directions," says SFI Chair of the Faculty Jennifer Dunne. "Her expertise and research in psychology, social cognition, decision making, and uncertainty will synergize with the types of research currently pursued by our resident faculty, postdocs, and external faculty."

In 2010, SFI's founding president George Cowan endowed the George A. and Helen Dunham Cowan Chair in Human Social Dynamics to attract leading social scientists to SFI who have applied rigorous quantitative methods in their fields and who offer perspectives that are complementary to existing SFI research.

Three inaugural Cowan Professors will end their three-year, part-time appointments with SFI in 2014: Mahzarin Banaji, Robert Boyd, and Ricardo Hausmann.

"Bringing these three scientists to SFI has been a great success," says Dunne. "Their research agendas address a diversity of interesting topics – experimental psychology, the evolution of social behavior, and economics and development – and they have brought new ideas and methods to SFI."

Galesic's selection marks a shift in the focus of the program. "In the past we looked to bring eminent, later-career scholars to the Institute for shorter periods of time," Dunne says. "For this next period of Cowan Chair funding, we decided to bring a promising early-career scientist to be a full-time resident professor, someone who will both augment our research and be immersed in the daily life of the Institute." ■

1984-2014 SFI@30

New Science. New Horizons.

Something from nothing: SFI emerges and synthesizes

Editor's note: This is the second in a series of articles recounting the history of the Santa Fe Institute. Special thanks to SFI Co-Founder In Residence David Pines for his recollections and perspectives. For a more detailed version of this article and more stories about the Institute's past, please visit www.santafe.edu/sfi30.

By John German

It was November 1984. The fledgling Institute had just held a pair of workshops during which some 60 invitees had heard the "game plan" for a completely new kind of research and education center.

The two workshops, themed "Emerging Syntheses In Science," featured a roiling discussion and an abundance of enthusiasm. "There was a sense of excitement, a sense of exploration, and sense of being at the cutting edge," says Pines. "We believed our game plan had been validated."

Perhaps more important, he says, the meetings "attracted a lot of people who would later become important contributors."

The founders began to delineate the important details – people, money, and space – that would give the Institute a tangible presence in the world of science.

The new Institute would need a board of directors. In March 1985 during the Institute's first board meeting, Murray Gell-Mann was elected Chairman of the Board, with Ed Knapp (former head of the NSF) as Vice Chairman. Predictably, George Cowan was confirmed as SFI's first president; Pines was vice president.

"We aspired to a good building and a lot of funding," says Pines.

The reality was more sobering. By the end of 1986, the Institute's total annual budget had grown to just $97,000.

Participants in SFI's founding workshop, second session, November 1984 (Credit: Helene Slansky)

Members of the board, led by Cowan and his friend Art Spiegel, took to their phones and typewriters, connecting with potential donors through their personal networks.

Some support trickled in from individuals and local corporations. But the majority of gifts were from one to five thousand dollars." Most of us weren't any good at fundraising," says Pines.

Six-figure support

In late 1986 and early 1987, the hard work began to pay off. Cowan knew Al Trivelpiece, head of research at the U.S. Department of Energy, who arranged for $250,000 in annual funding for four years. Following a visit to Santa Fe, NSF Director Eric Bloch matched Trivelpiece with another $250,000 in annual funding.

In August 1986, John Reed, the soon-to-be-CEO of Citicorp, visited Santa Fe for a discussion on the economy as a complex system. Reed agreed to fund a workshop to be led by economic Nobel laureates Phil Anderson and Ken Arrow. Following the workshop, Reed committed $1 million over four years to support the new complexity economics program at SFI.

On the science front, the focus for 1985 and 1986 was to "hold as many proof-of-concept workshops as we could, find some kind of campus, and gain enough support for a research faculty," recalls Pines.

Those workshops – on superstring theory; evolution, games, and learning; adaptive neural networks; complex adaptive systems; computational approaches to evolutionary biology; and other topics – further expanded the Institute's circle.

A place to call home

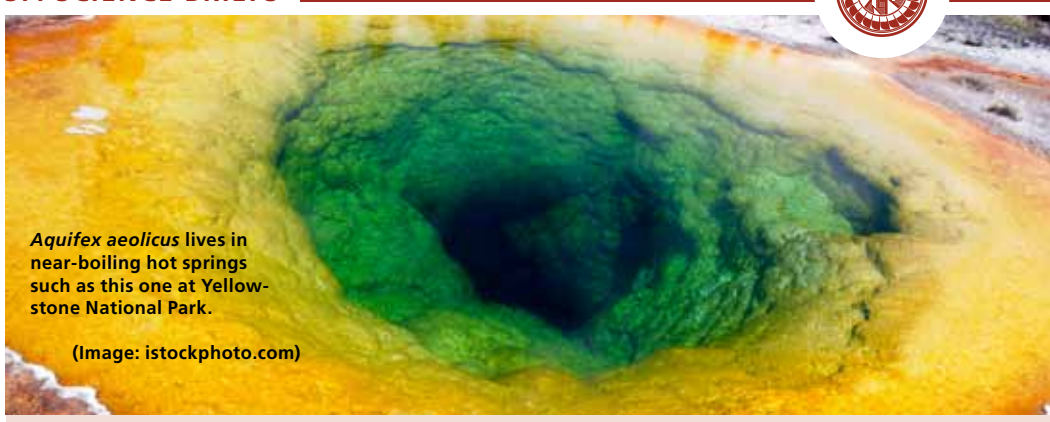
In August 1986, Cowan rented a small office on the third floor of a drab bank building in downtown Santa Fe. But SFI continued to grow, and in 1987 the Institute moved into a former convent off of Santa Fe's famed art gallery row, Canyon Road.

The Cristo Rey Convent, with its thick plastered walls, central courtyard, and transcendent aura, was the ideal setting for cerebral voyages into scientific territory that had never been explored.

Says Pines: "By the end of 1987 we were in the convent, we had funding from NSF, funding from DOE, and funding from Citicorp. We were a healthy infant about to enter nursery school."

In the May / June issue of the Update*: SFI@30 continues with "Transcendence: A place to call home"* ■

SFI SCIENCE BRIEFS



***Aquifex aeolicus* lives in near-boiling hot springs such as this one at Yellowstone National Park.**

(Image: istockphoto.com)

Tracing the metabolic chemistry of early life

To better understand the emergence of life, former SFI Omidyar Fellow Rogier Braakman and External Professor Eric Smith are taking a careful look at *Aquifex aeolicus*. Being restricted to extreme, boiling hot spring habitats (a consistent feature of Earth's geology) means the unusual bacterium's metabolic network has evolved less than those of other species. This makes it a great model system for studying the early evolution of metabolism, they say.

The pair is using a technique called phylometabolic analysis, which combines the building of gene-based family trees of relatedness (called phylogenies) with reconstruction of chemical metabolic networks. This lets the researchers "see not just what information is changing, but how specific driving forces are changing the underlying chemical networks encoded by those genes," explains Braakman.

Their research, published February 5 in *PLOS ONE*, highlights three main drivers of evolution: optimizing kinetics, either by replacing generalist enzymes with multiple, specialized enzymes or by fusing successive enzymes in a pathway together to minimize diffusion; and optimizing thermodynamics by choosing pathways that use less energy. These drivers, they say, evoke a major tradeoff in evolution – speed versus efficiency – and suggest that early ancestors probably started with a smaller assortment of enzymes, each of which could weakly catalyze many different reactions.

By identifying how the chemical subsystems of metabolism have changed, researchers might infer phenotypic features of the universal common ancestor, notes Braakman, and even link the competition for resources across different branches of the tree of life to the evolution of the major elemental cycles in the biosphere.

At the gene level, robustness and evolvability go hand in hand

In a February 20 study in *Science*, SFI External Professor Andreas Wagner and postdoctoral fellow Joshua Payne, both of the University of Zurich, argue that at the gene level, robustness and evolvability, which might seem incompatible, are two sides of the same coin.

Their study focused on 104 mouse and 89 yeast transcription factors – proteins responsible for regulating gene expression. To do their jobs, transcription factors interact with DNA sequences called binding sites. Payne and Wagner found that the more sites a transcription factor can bind to — and the more one can "hop" from one compatible site to the next through single mutations — the more robust the transcription factor's function.

That robustness makes it easier for a population of, for example, mice or yeast to find new, potentially useful mutations. When their transcription factors are robust, each member of a group can perform the same biological functions despite great diversity in the underlying binding-site DNA. In turn, their offspring as a group will have an even greater diversity, most maintaining the original transcription factors' functions, some with harmful mutations, but some with new, valuable functions.

Modern archaeology's 25 defining challenges

A recent paper in *PNAS* spells out the 25 defining challenges now before archaeology. The paper is the outcome of an NSF-funded program led by Arizona State University archaeologist Keith Kintigh.

Kintigh and his team solicited suggested challenges from professional archaeologists around the world in the academic, consulting, and government sectors, then assembled a group of scholars to augment, vet, and prioritize the suggestions. This expert group met during a two-day working group at SFI in summer 2012 to develop the final challenges. SFI co-authors include Tim Kohler, Peter Peregrine, Jerry Sabloff, and Henry Wright.

Recession web searches suggest health & wealth closely linked

Some 200 million more Google searches than expected for certain stress-related ailments during the Great Recession suggest that health and wealth may be more strongly connected than previously thought, according to a recent study in the *American Journal of Preventive Medicine* by SFI Omidyar Fellow Ben Althouse and his collaborators.

By monitoring health-related search terms, Althouse says, public health officials might recognize burgeoning epidemics and direct resources to precautionary measures. This technique is quicker, cheaper, and more efficient than traditional survey-based methodologies, he adds. ■

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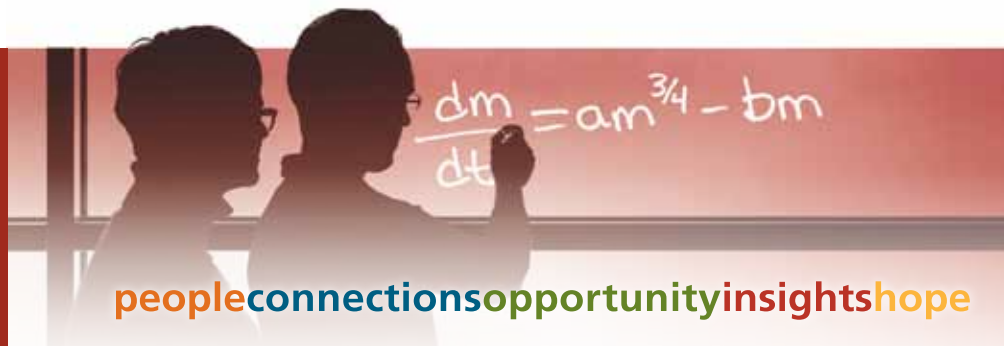

Above: Mathematical description of the growth of an organism incorporating Kleiber's Law

SFI@30: Providing opportunity since 1984

For 30 years the Santa Fe Institute has provided creative scientists a place to study, think, and connect. Here, diverse people, fields, and curiosities come together in a kind of "ideas reactor," producing bursts of insight that can shake the foundations of science and, perhaps, suggest innovative solutions to some of humankind's most perplexing problems.

Insights generated at the Santa Fe Institute have helped change the course of economics, immunology, and education, to name a few. Our researchers have made foundational contributions to emerging fields, too, from network science and information theory to cultural evolution and wealth inequality.

Since we formed the first complexity institute in 1984, more than 60 similarly focused institutes have arisen around the world. We're proud that a significant number of them were founded or influenced by scientists who are part of our ever-expanding circle.

We're also proud that in 30 years, thousands of bright young minds have been introduced to complexity thinking at our summer schools, camps, and after-school programs, helping ensure that our signature approach to science is perpetuated well beyond the walls of our campuses and far into the future.

Without the opportunity created at SFI, we might not have learned to use cell phone data to track and predict the spread of malaria in the developing world. We might not have gained a deeper understanding of our recent global financial crisis, insights that can help our leaders prepare for future economic instabilities. We might not know that all the world's cities, regardless of size, are the product of the same underlying human social processes, an insight that is suggesting new ways to make our rapidly urbanizing world more sustainable.

By contributing to SFI, you are providing opportunities for scientists to explore the frontiers of emerging fields, discover new truths, and improve our world for future generations. You're helping bring abundant curiosity and new ideas together in bright sparks of insight. It's a reaction we can all be proud of. Please join us by making a gift to our 30th anniversary campaign.

Warm regards,

Nancy Deutsch, Vice President for Advancement

SFI@30 MY STORY

Eric Bonabeau
Member, Business Network
Former Postdoctoral Fellow
Santa Fe Institute

"My own company, Icosystem, is a spiritual spin-off of SFI, and our mission is to spread the value of complexity science to new businesses around the globe every day. My first exposure to the Business Network was in 1992, when I was working on research at the Institute. Even in those early days, a core set of companies and leaders was passionate about SFI's mission and committed to translating complexity science into real-world opportunities. Some of the discussions we had were early predictors of today's peer-to-peer networks. Others have sparked ground-breaking commercial and social opportunities, like former Omidyar Fellow Nathan Eagle's Jana, which is using big data to provide employment and address inequality in the developing world."

New Science. New Horizons.

As part of SFI's 30th anniversary, the Institute is seeking to raise $30 million in a comprehensive fundraising campaign. As of February 2014, we've raised over $20 million toward that goal. We're offering unique giving opportunities all year. **Won't you join our campaign now by providing a transformational experience to an outstanding high school student.**

Send a young scholar to CAMP

SFI's CAMP (Complexity and Modeling Program), held at the Groton School in Groton Massachusetts, immerses selected high school students in complexity science through instruction, field research, and extracurricular activities. The two-week residential program is an intensive introduction to complexity for young scholars who are passionate about science.

SFI works to provide financial assistance for promising students who could not otherwise attend CAMP, but we need your help. This year, 11 academically excellent applicants have requested assistance. These students from around the country have already excelled at magnet, public, and charter schools in advanced placement and honors courses; many have participated in SFI's GUTS and GUTS y Girls programs or similar after-school science programs.

We're confident these students can become the scientific leaders of the future, and we need your help to bring them this opportunity. Your contribution of $3,500 provides tuition and travel expenses for one student to participate in the program this summer. Gifts of any amount will help to offset their expenses.

Please meet some of these outstanding students now at www.santafe.edu/supportcamp.

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UPDATE
SANTA FE INSTITUTE

EDUCATION NEWS

'Majesty of Music & Math' goes global with new multimedia website

In April, a new online resource for investigating the connection between math and music will be available on SFI's website. The site will offer video segments from the Majesty of Music and Mathematics concert – a November 2013 special event in Santa Fe created by SFI and the Santa Fe Symphony. The site, intended for teachers, students, or anyone interested in the mathematics of music, includes lesson plans and project ideas for 6th-12th grade classrooms.

SFI Education and Outreach Program Coordinator Juniper Lovato, who is leading the project, has worked with local musicians, the Symphony, Big Sky Learning, and Institute faculty to develop the site's content. Students from New Mexico Highlands University are designing and building the site, and Santa Fe High School students will test the curricular content.

"I think it helps students who are interested in either music or math talk about these things and collaborate with each other, and it's great to see how other institutions in Santa Fe are getting excited about this," Lovato says. "The project really embodies the Institute's interdisciplinary and collaborative spirit."

The website is made possible through generous support from the Sydney and Andrew Davis Foundation. ■

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