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 the SFI’s journal, Science Advances, suggests that the basic principles that may apply to all human settlements regardless of how far apart they are in time, space, or culture.
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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 mosquitos that carry it, and the primate hosts (including humans) it infects.

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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 Ricardus 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.”

By John German

I n 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 rolting 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, and 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.

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 Citect, 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 Philip 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 supersymmetric 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 translucent aura, was the ideal setting for cerebral voyages into scientific territory that had never been explored.

In the May/June issue of the Update, SFI@30 continues with “Transcendence: A Place to call home.”

SFI SCIENCE BRIEFS

Tracing the metabolic chemistry of early life

To better understand the emergence of life, former SFI Omidyar Fellow Roger Braakman and External Professor Eric Smith are taking a careful look at Aquifex aeolicus. Being restricted to extreme environments, this single-celled bacterium is fascinating to researchers as it provides a window into how 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 phylogeny) 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 Proceedings of the National Academy of Sciences, 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 available 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 factor’s 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

A study by SFI researcher Dr. Eric Althouse and his collaborators provides one fascinating example of the unexpected links seen 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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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

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.