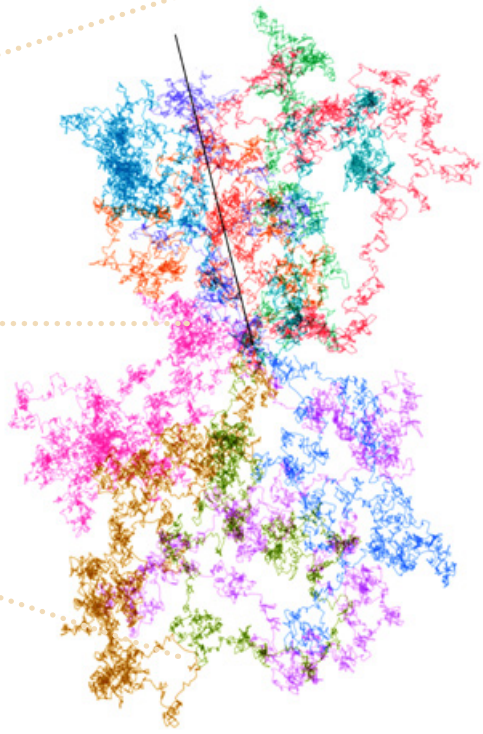
Summer 2016

Parallax

THE NEWSLETTER OF THE SANTA FE INSTITUTE



Kristi Castlin (left) racing against Cindy Billaud at the DecaNation meet in 2014. (Image: Pierre-Yves Beaudouin, Wikimedia, Creative Commons)

What are the limits to human performance?

What cognitive and physiological factors combine in the development of the fine motor skills required to excel at ballet? How many hours of practice should it take to achieve mastery of the long jump? What leads surgical teams to rapidly increase their acumen in a new and difficult procedure?

A unique three-day workshop in Santa Fe in July, the Limits to Human Performance, jointly organized by SFI and Red Bull High Performance, brought together some three-dozen experts from every corner of knowledge related to extreme human endeavor.

The workshop was co-sponsored by Red Bull and the Miller Omega Program, a gift to SFI from Institute Chairman Emeritus Bill Miller.

SFI President David Krakauer and Red Bull High Performance CEO Andy Walshe kicked off the meeting, urging participants to report from the extremes in both individual and team-based activities, from athleticism to intellectual problem solving, and probe the frontiers of science that now illuminates these limits – or might.

The meeting followed an unusual format: each speaker delivered a 15-minute prepared talk followed by Q&A. But there was no agenda; when a speaker felt compelled, he or she added their name to a list on a white board at the front of the room, which served as the queue.

From surgeons to psychologists, military advisors to neurobiologists, nutritionists to stress experts, physicists to choreographers, the speakers trekked to the boundaries of their respective fields and back

Anders Ericsson of the Cognitive and Expertise Lab at Florida State University spoke first, describing the physiological and neurological adaptations that occur in response to extreme physical activity during the complex process of acquiring expert performance.

Culture doesn't seem to play a role, he noted. "Once you start looking at the hours athletes are dedicating [to achieve mastery], you find that it is consistent across cultures even though the starting points can be very different," he said.

Xavier Schelling del Alcazar, applied sports scientist for the NBA's San Antonio Spurs, described the challenges of making team athletes better in a noisy environment, lamenting how little we really know.

It's difficult to isolate the important factors in improving performance, he said; player decision making, skills, emotion, fitness, creativity, coaching, and more all go into the team's model of performance, he said. And that's just for individuals. "Anyone who solves the problem of the interplay between individual and team performance will be a millionaire."

RESEARCH NEWS

Prediction: How good can we get?

Scientists are getting better at predicting the future, but prediction remains an inherently difficult problem. Indeed, there's good reason to believe we will eventually bump against some fundamental limits. What are those limits?

In August, experts will convene at SFI to get a handle on this most fundamental of questions.

The question isn't just about how well we can predict things today using current ideas and technologies, says SFI Omidyar Fellow Josh Grochow, who is co-organizing the workshop with SFI President David Krakauer.

"The idea is that there are limits to prediction – practical, theoretical, and fundamental – and we want to understand what goes into those," Grochow says.

A classic example of where prediction faces fundamental challenges is in chaotic systems. By definition, the future of a chaotic system depends very sensitively on its conditions. Inherent limits on our ability to measure those initial conditions make prediction more difficult.

But even that is a fairly mild challenge compared to situations where evolution, adaptation, and innovation come into play. How, for example, would biologists predict the future evolution of species, where mutation and natural selection combine to produce…what, we don't really know. Likewise, predicting the future of technology even five to ten years out is often little more than a guessing game.

The workshop is a first attempt to understand how much better we might be able to do. "We think that getting at the core issues of prediction in complex adaptive systems will benefit from and possibly require every tool in the tool chest we have for prediction, in every field," he says. "So we want to bring people together, to see what those tools are, where they're going, and how they might be combined to get a better understanding of the limits of prediction."

RESEARCH NEWS

How to detect cyber attackers by thinking like one

Cyber attackers' methods evolve rapidly, and software that worked to detect network attacks yesterday might be ineffective tomorrow.

The best detectors don't focus solely on keeping intruders out: they also help identify intruders that have already broken in, as through a malicious link or email attachment.

"Attackers go from one computer to another and mine for information, looking for system credentials and elevating their privileges," says Justin Grana, an SFI Postdoctoral Fellow.

Security tools designed to find these attackers typically scan a network and search for an anomaly – activity that differs significantly from "normal" behavior. These statistical approaches assume that an attacker will stick out as they move through the network.

That strategy is problematic, says Grana, because it's difficult to know what behaviors are normal. What appears to be an intruder prowling the system might be the benign activities of new employees getting their bearings in a network. "There are a ton of false alarms," says Grana.

In a new paper in the *Journal of Network and Computer Applications*, Grana and his collaborators – including SFI professors David Wolpert and Tanmoy Bhattacharya – take a different approach. Calling on the tools of game theory, they suggest that a better way to stop an attacker might be to think like one.

Rather than assuming it knows how an attacker behaves, the proposed detector assumes attackers will follow near-optimal strategies given their knowledge that defenders are looking for them. This allows the detector to compare the probability that certain activities were generated by normal network behavior to the probability that it originated with an attacker. This ratio – not just the probability that the activities reflect normal network behavior – is used to determine

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Welcome to *Parallax*

SFI President David Krakauer's column, Beyond Borders, will return in the next issue. I wanted to use this space to introduce you to *Parallax*, the Santa Fe Institute's new community newsletter, which you're holding.

Parallax is similar to the *Update*. It's still tabloid sized and colorful, but with a refreshed design. It still brings you an inside look at the forward ideas that are being probed week after week in our scientific meetings and collaborations.

We're publishing the print edition quarterly rather than six times per year. But we're also introducing a monthly email edition, which includes content you won't find in print, including longer think pieces written by complexity scientists. Write subscriptions@santafe.edu to request monthly delivery to your inbox.

Why the change? The *Update's* design was getting dated, and the name, well, let's admit, it was about as exciting as a rice cake. More about the new name below.

First, though, my deep gratitude to SFI Design Coordinator Laura Egley Taylor and to my conspirator for the past 58 issues of the *Update*, graphic designer Michael Vittitow, for their help in bringing you *Parallax*. I am also grateful to SFI Technology Manager Liz Martinez for help with e*Parallax*. As always, we welcome your feedback; send comments or questions to jdg@santafe.edu.

Now the name…

Parallax is the displacement or difference in the apparent position of an object when viewed along two different lines of sight. Due to foreshortening, nearby objects have a larger parallax than more distant objects, so parallax can be used to determine distances. Astronomers use parallax to measure distances to stars.

Stellar parallax is so difficult to detect that its existence was the subject of debate in astronomy for hundreds of years, and its apparent absence was used as a scientific argument against heliocentrism – the onetime revolutionary notion that the planets orbit the sun and not the earth. German astronomer Friedrich Bessel made the first successful parallax measurement in 1838 with his parallax machine.

Some animals have evolved the use of motion parallax for hunting or defense. For example, some varieties of *Phasmatodea*, commonly known as the "stick bug" (a marvel of evolution for many reasons), sway their heads back and forth to, most biologists think, distinguish nearby objects from background.

Metaphorically, then, parallax is gaining an improved perspective by looking at a problem from a different, or number of, angles, with the possibility of revolutionary insights. Just like the sciences of complexity. Enjoy.

— John German
Editor

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SFI IN THE NEWS

SFI Postdoctoral Fellow Christa Brelsford takes on the complexity of water supply and demand July 13 in "Water, water rights, and water wars," part of SFI's essay series in the *CS Monitor*.

The *Financial Times* on July 5 gets SFI Distinguished Professor Geoffrey West's thoughts on the U.K. and London as urban scaling anomalies.

In the wake of Brexit, Bloomberg news and *R&D* magazine highlight SFI Professor Mirta Galesic's recent paper explaining why larger crowds don't always produce wiser decisions and in what situations smaller-group decision-making makes better sense.

Forbes features Joerael Elliott and his SFI-inspired complexity art in a June 28 profile written by SFI Trustee Josh Wolfe.

On June 23, SFI Professor Sam Bowles explores why incentives sometimes backfire in "The complex economics of self interest," part of SFI's essay series in the *CS Monitor*.

A feature story on the Santa Fe Institute appears in the Summer 2016 issue of *Fine Lifestyles* Santa Fe.

NPR on May 11 describes Geoffrey West's insights into life's laws and unity, as presented at a recent New York Academy of Sciences panel discussion.

MIT Technology Review on April 19 highlights SFI postdocs' new research into beneficial epidemics and how they might spread faster than detrimental ones.

WNYC's *Radiolab* asks what math reveals and misses about cities in an April 17 segment featuring Luis Bettencourt's and Geoffrey West's urban scaling research.

RESEARCH NEWS

Group-navigating species may be vulnerable

Migrating birds flock together and salmon swim upstream in schools because there's a navigational advantage: By traveling in groups, individuals are more likely to get to their destinations – or so a growing body of research suggests.

But the advantages of group navigation often come with strings attached, according to new research published in *Movement Ecology* by SFI Omidyar Fellow Andrew Berdahl and collaborators: populations relying on group navigation could be vulnerable to sudden collapse.

Studies of migrating animals such as cranes only recently confirmed the benefits of collective animal navigation; whether group navigation has other consequences isn't yet well understood.

To start to explore the question, Berdahl, SFI Science Board member Simon Levin, and two others developed models aimed at understanding how group migration affects species' population sizes and structures.

Perhaps their most striking finding is that migratory populations are bistable – that is, group navigation can drive a population to greater size or nearly to extinction, depending on context.

As an example, suppose overfishing is driving down the sizes of Pacific salmon runs. If a population size gets too low to navigate collectively, individuals might no longer successfully complete their travels, leaving the remaining population vulnerable to collapse. It's an outcome that wouldn't happen, Berdahl says, if the animals navigated individually.

The effect could hit populations adapted to local conditions in a more subtle way, too. If salmon numbers are reduced, they'll disperse more readily, and the consequent mixing of fish between streams would result in homogenization of fish populations. If these local populations survive, they might comprise fish that are less well adapted to local conditions and more sensitive to environmental challenges.

Worse, wildlife managers, whose models don't account for these nonlinearities, might not see those effects coming – and if they don't, Berdahl says, they might not make the right choices to sustain already fragile migratory populations.

RESEARCH NEWS

The neurobiology of recognizing smells and faces

Say there's a free concert in the park where you've arranged to meet a friend. You arrive and scan the crowd, glimpsing and dismissing a dozen faces every second. Three minutes later you focus on a face…there she is!

The everyday occurrence of facial recognition involves neural tagging, in which the brain sets a unique combination of synapse strengths in a specific cluster of neurons for each distinct face.

At least three regions of the brain are involved in recognizing complicated objects, says SFI External Professor Charles Stevens, a neurobiologist at the Salk Institute. We know that tags for faces are generated in the dentate gyrus of the hippocampus. But how, exactly, the brain generates and uses these tags is unclear.

In August, Stevens is hosting a working group at SFI to explore this problem. Because visual recognition is so difficult to study, Stevens and colleagues are drawing from the similar and better-known olfactory sensory system to investigate how mammals recognize complex odors and use them to navigate.

Stevens will be joined by Venkatesh Murthy, a biologist at Harvard who studies olfactory-guided navigation in mice, and Massimo Vergassola, a physicist at UC San Diego who has developed theory for how we navigate with the olfactory system.

During the meeting, the researchers plan to combine experimental data and theory to extend their understanding of the problem for olfaction and set the stage for understanding the problem in other contexts, says Stevens.

Waiting for the Concert, Jerome Myers, December 1920 (Wikimedia Commons)

RESEARCH NEWS

Searching for better search models

One day at SFI, physicist and SFI Professor Sid Redner and computer scientists Melanie Moses and Stephanie Forrest found themselves discussing the difficulties of modeling ant foraging behaviors.

One of Redner's research interests is stochastic search (in which the searcher has no information about the location of the target). In May the trio pulled together a number of experts, including SFI Postdoctoral Fellow Caterina de Bacco, to focus on stochastic search with reset. In these conditions, a search process starts with little information about the target's location and is intermittently stopped and restarted.

An ordinary stochastic search in one or two dimensions will, with infinite time available, find its target. But a search in three dimensions may never find its target, even in infinite time; in this many dimensions, the searcher is too likely to go off on wild tangents.

Counterintuitively, though, in search with reset, the target is found in finite time in any number of dimensions, guaranteed; reset cuts short those fruitless expeditions to nowhere.

Reset not only adds these fascinating qualities to search probabilities, Redner says, it is a practical consideration, too – as when ants or a search-and-rescue teams call it quits for the night, but commence their searches each morning.

Future models might incorporate more realistic considerations, he says.

RESEARCH NEWS

Gathering the pieces of a first-principles-derived ecological theory

Writing in the pages of *BioScience* two years ago, SFI External Professor Pablo Marquet, SFI Professor and VP for Science Jennifer Dunne, and a team of ecologists and physicists made a bold call: It's time, they argued, for a new synthesis of ecological theory based on something they termed "efficient theory."

This September, the scientists will meet at SFI to take some of the first concrete steps toward the sort of theories they outlined.

"We already have our manifesto on what are the salient characteristics of the theories we will focus on," Marquet says. "Now, the exercise would be to trace the point of connection between these theories and see how they can be integrated."

September's workshop will be the second formal meeting of the Network for Ecological Theory Integration (NETI), as the group is now called. NETI traces its origins to a 2006 meeting that brought together leading theorists in metabolic scaling, ecological networks, neutral theory, and other fields of ecology that had been developing largely independently.

Out of that meeting and several more that followed, the people that would form NETI developed the notion of efficient theory – theory that is "grounded in first principles, expressed in mathematical language, simple, and makes a large number of predictions relative to the number of free parameters it contains," Marquet says.

Now NETI's aim is to start putting seemingly disparate theories together to create a more unified understanding of ecology. "There is a sort of algebra for theory integration that we want to develop," Marquet says. That could mean using the predictions of one theory as the inputs for another theory. For example, predictions derived from metabolic theory could be used as constraints in maximum entropy theory, which makes predictions about biodiversity patterns based in part on the metabolic energy available in a region.

"But also it is important to look at cases where different theories make similar predictions starting from different assumptions," he says, or where similar theories with slightly different assumptions reach quite different predictions.

It's early days, he says. "We're in the process of just showing the connections between different theories, and showing you can do this with efficient theories."

RESEARCH NEWS

Replacing ill workers with healthy ones accelerates some epidemics

When disease outbreaks occur, people with essential roles – healthcare workers, first responders, and teachers, for example – are typically up close and personal with infected people. As these front-line workers become infected, healthy individuals take their places.

Mathematical biologist Samuel Scarpino, who creates and analyzes epidemiological models, wondered how this exchange of critical people affects the spread of disease. The practice clearly raises the risk of infection for the replacement individuals – but the population dynamics of this increase are neglected in existing epidemiological models.

Scarpino, while he was an Omidyar Fellow at SFI, set out to quantify that risk and understand its influence. He enlisted the help of theoretical physicist Laurent Hébert-Dufresne, a James S. McDonnell Fellow at the Institute, and Antoine Allard, Hébert-Dufresne's longtime collaborator from the University of Barcelona. Both study complex patterns in networks.

The trio integrated this "human exchange" into network models of disease and found that replacing sick individuals with healthy ones can actually accelerate the spread of infection.

Scarpino and Hébert-Dufresne tested their ideas on 17 years' worth of data on two diseases: influenza and dengue. Their analysis, just published in *Nature Physics*, reveals that human exchange likely accelerates outbreaks of influenza, which spreads via human contact. But it has no effect on the spread of dengue – which makes sense, as dengue spreads via mosquitoes.

"We didn't see a strong signal in diseases where we didn't expect it," says Hébert-Dufresne.

Scarpino, now an assistant professor at the University of Vermont, says he hopes to see this effect integrated into future epidemiological models. "Models where you start to incorporate slightly more realistic human behavior are essential if we're going to make high-fidelity public health and clinical decisions," he says.

EDUCATION NEWS

New online course: Agent-based modeling

Ever wonder how a flock of birds collectively makes a turn? How people surf the web for news? Agent-based programming languages allow users to explore such questions through simulation. Beginning in August, programmers and nonprogrammers alike can learn to model by enrolling in Complexity Explorer's new massive open online course.

The new MOOC, Introduction to Agent-Based Modeling, begins August 1 and runs 11 weeks. William Rand, an SFI alum and professor of business management at North Carolina State University, will guide students through the ins and outs of creating agent-based models (ABMs), from programming the individual agents to analyzing the collective phenomena that result. Students will learn why and when to use agent-based models and will build their own simulations from the ground up.

"In agent-based modeling you work forward from an individual agent's rules to observe the pattern that is created," Rand says. "This makes ABM a natural method for exploring complex systems. Students will be able to build and construct their own agent-based models to understand phenomenon of interest to themselves, and analyze the results of those models in a rigorous, scientific fashion so they can make clear generalizations of the results."

The course's first module will be open to everyone, and a modest tuition is requested for those interested in continuing through the course and receiving a certificate of completion. Video materials, quizzes, and homework from the course will be freely available after the course is closed.

EDUCATION NEWS

First accredited SFI short course

Medical professionals interested in attending SFI's upcoming short course, Exploring Complexity in Health and Medicine, can now earn Continuing Medical Education (CME) credits when they take the course.

Through a joint providership with CHRISTUS St. Vincent Regional Medical Center in Santa Fe, SFI has planned its three-day course, October 12-14, to meet the accreditation requirements of the New Mexico Medical Society.

The short course offers a review of many of the ways health and medicine intersect with, and are being influenced by, complexity science, says SFI Director of Education Juniper Lovato.

This course is SFI's first accredited course. If there is strong interest for courses offering continuing education credits, Lovato says, SFI might offer more accredited courses in the future.

RESEARCH NEWS BRIEFS

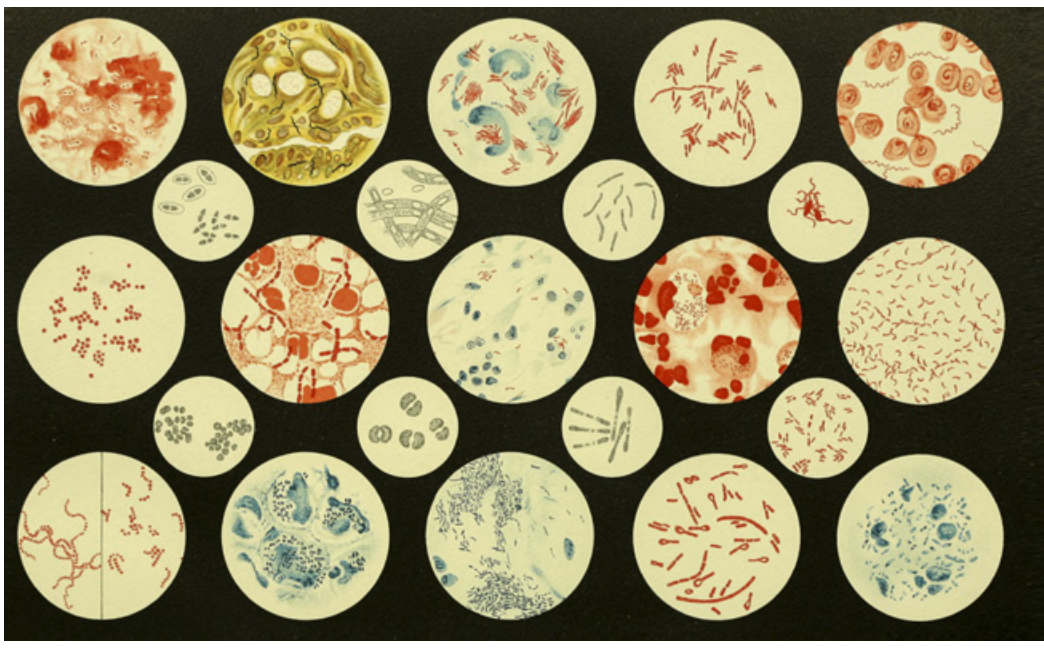

Image: Otto Warburg, Wikimedia Commons

BACTERIA MUST MAKE EVOLUTIONARY SIZE VS. FUNCTION TRADEOFFS

In *ISME*, the journal of the International Society for Microbial Ecology, SFI Omidyar Fellow Chris Kempes and co-authors analyze the components of bacterial cells and the corresponding physiological functions and metabolisms of various bacterial species. The smallest bacteria are dominated by DNA and proteins, they say, and the sizes of these structures means the smallest bacteria are at the lower limit of possible cell size. For the largest bacteria, any larger and the number of ribosomes they would need to sustain their metabolisms would exceed available cell volume. Between these two extremes, cellular components closely follow trends predicted by biological scaling laws, they find.

DOES NATURE FAVOR COOL COMPUTATIONS?

Any highly precise computation requires energy, but imprecise, noisy computations can actually cool a system, writes SFI Professor David Wolpert in an analysis in the journal *Entropy*. This has major implications for biological systems. Computations that affect an organism's survival require extreme precision and, therefore, more energy. Other computations can be imprecise, requiring less energy, and thus, less food. In the first analysis of its kind, Wolpert has modeled the pressure of natural selection on organisms to perform computations that are as noisy as possible, reserving precise calculations only for times when it is fitness-relevant.

APPLIED COMPLEXITY IN THE CITY DIFFERENT

With the support of the federally funded MetroLab Network, SFI Professor Luis Bettencourt and officials from the City of Santa Fe are exploring ways to use complexity science to tackle challenging urban issues. By analyzing real-world data, they are looking for innovative ways to address complex issues like sustainability and carbon neutrality, management of emergency services, low high school graduation rates, and high criminality rates among the city's youth. For Bettencourt, engaging with policy makers is one way for researchers to test their ideas.

WHY WE CAN'T SEEM TO GET OUR HEADS AROUND CLIMATE CHANGE

An article in *BioScience* explores four psychological barriers that drive our lack of "foresight intelligence" regarding climate change – that is, to recognize, diagnose, plan, and act to address its perils. The normal short-term, seasonal, and regional variability of weather patterns, for example, contributes to what the authors call "the noisy-signal problem" that obscures the gradual temperature increases characteristic of climate change, leading to a perception of non-urgency. Among the article's 14 co-authors are SFI Professor and VP for Science Jennifer Dunne and Science Board members Kenneth Arrow (Stanford) and Marc Feldman (Stanford).

ISLANDS AS MICROCOSMS OF HUMAN-ECOSYSTEM DYNAMICS

One way to better understand the complex interactions between humans, biodiversity, and ecosystem services of any particular place is to develop and run computational models that integrate ecological, environmental, and social system dynamics. SFI Professor and VP for Science Jennifer Dunne and colleagues recently published a description in *GigaScience* of one such approach – a modeling framework they call the Island Digital Ecosystem Avatars, or IDEA. Because of their defined and isolated borders, islands like French Polynesia's Mo'orea are ideal places to begin using an IDEA framework to simulate relationships and feedbacks between human activity and local ecosystems, they say.

ANCIENT GENOMES SHED LIGHT ON HUMAN ADAPTATION AND GENETIC VARIATION

In *Nature Communications*, SFI Professor Michael Lachmann and colleagues compare DNA from modern human populations with DNA from a bone of Ust'-Ishim, an ancient Siberian male who lived at a critical juncture after the African migration but before traits unique to European, Asian, and other populations began to become established. Although Lachmann says the results of the paper aren't particularly shocking – the most functional variations identified were in pigmentation of skin and eye color, and local adaptations such as a mutation for the ability to digest lactose – the research lays the framework for a process of understanding the roots of genetic variation in humans.

RESEARCH NEWS

Predicting microbiome response to a changing world

Unseen but all around us – on and in our bodies, homes, cities, rivers, oceans, and forests – live complex communities of bacteria, fungi, and viruses. We now know that these "microbiomes" are critical to public and ecosystem health.

Scientists have begun to compile large, detailed datasets that describe the species within many microbiomes, their functions, and how their members interact. These data have allowed us to observe how microbial communities change when disturbed, but there are still few models to effectively predict microbiome response to stress.

If we are to prepare for large-scale disturbances such as global climate change, urbanization, or the decline in immune system function we need to "be able to make predictions about how biological, chemical, and physical systems will change as the world is changing," says SFI External Professor Jessica Green of the University of Oregon.

Experts in microbiology, computational biology, and theoretical ecology will meet at SFI in August to begin developing models for predicting how the microbiomes we are immersed in might change as the world changes, using publicly available datasets to test the models.

"Dysfunctional microbiomes are associated with a lot of issues, from diabetes and the hypoxic zone in the Gulf of Mexico to agricultural productivity," says Ashkaan Fahimipour, a postdoc in Green's lab who is co-organizing the three-day SFI working group. "A theory of how microbiomes come apart and how they re-assemble is going to be important for understanding how they impact humans and the environment."

ACHIEVEMENTS

At the International Conference on Network Science in Seoul, Korea, Aaron Clauset, an SFI external professor and former Omidyar Fellow, received the 2016 Erdős–Rényi Prize in Network Science. One awardee under 40 years old is selected annually by prominent scientists for outstanding contributions to the interdisciplinary progress of network science.

Jerry Sabloff, an SFI external professor and past president, will receive the American Anthropological Association's Alfred V. Kidder Award for Eminence in the Field of American Archaeology during the Association's annual meeting in November. Past SFI recipients include Tim Kohler (2014) and the late Linda Cordell (2001).

SFI External Professor Scott Ortman has been awarded the 2017 Linda S. Cordell Prize for his book, *Winds from the North: Tewa Origins and Historical Archaeology.* The award from the School for Advanced Research recognizes innovative books in archaeology and honors the memory of Cordell, the late archaeologist and SFI external professor.

SFI Science Board member Marc Feldman has received the Kimura Motoo Award for his contribution to the field of human evolution. Dedicated to the memory of evolutionary geneticist Motoo Kimura, the annual award given by the Motoo Kimura Trust Foundation honors four outstanding scientists for advancing the field of evolutionary biology.

Thinking like a cyber attacker
(cont. from page 1)

whether or not to sound the alarm. This better solves for what a smart attacker would do, says Grana.

"We want to use that information to refine our detector without assuming we know how the attacker will achieve their goals, only what those goals are," adds Wolpert.

The researchers' model has outperformed simple anomaly detectors under many network scenarios. To ensure their results scale up to real-world conditions, the team tested the model on network data from Los Alamos National Laboratory.

Grana says the paper represents a first step toward integrating game theory ideas into smarter detectors.

RESEARCH NEWS

Networks + AI + social psychology = social change

Influencing social change on a broad scale is a chronically difficult problem. But what if you could identify – and then target and train at exactly the right time – those members of a population most likely to have the greatest influence on their peers?

SFI Professor Mirta Galesic, a social scientist, and Harvard's Barbara Grosz, a computer scientist and member of SFI's Science Board and Science Steering Committee, hope to take some early steps during an August working group at SFI: Social Network Interventions: Combining Network Science and AI Decision-Making with Social Influence Theories.

As part of the effort, the duo is joining forces with researchers from the University of New Mexico's Prevention Research Center, the University of Southern California (USC), and Microsoft Research to design, implement, and evaluate a social network intervention to encourage parents in disadvantaged areas of New Mexico to promote healthy nutrition and physical activity in their children.

The collaborators will build on experiences from USC researchers Milind Tambe and Eric Rice, who have undertaken a pilot study among homeless youth in Venice Beach, California. Tambe and Rice found that a network algorithm for identifying the most influential members of the youth's social circles and recommending sequenced interventions was useful in designing interventions to spread information about sexually transmitted diseases and increase the rate of STD testing.

"The algorithm used in the Venice Beach project was very effective," says Galesic. "We will discuss whether we can augment the algorithm and the overall intervention by incorporating findings about social influence from social psychology."

Based on these discussions, Galesic, Grosz, and their colleagues plan to collect preliminary data to gauge whether their approach will work in New Mexico, then seek a broader implementation of the method.

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UPCOMING COMMUNITY EVENTS

SFI Community Lecture, Tuesday, August 30, 7:30 p.m., The Lensic Performing Arts Center (211 W. San Francisco Street) – Surprises at the Intersection of Human Emotion and Wearable Tech. How will future computers, robots, and smartphones acquire the emotional intelligence they need to be truly useful to humans? Rosalind Picard highlights some of the world's first technologies that recognize human emotion and reveals unexpected findings about how wearable techs might help treat autism, anxiety, depression, epilepsy, and more.

Picard is the founder and director of the Affective Computing Research Group at the MIT Media Lab and a pioneer in human-computer interaction.

Stanislaw Ulam Memorial Lecture Series, Monday & Tuesday, September 26 & 27, 7:30 p.m., The Lensic Performing Arts Center (211 W. San Francisco Street) – The Information Edge: Creation and Destruction in Life, the Economy, and the Universe. Using accessible examples from cosmology, quantum physics, and biological and financial systems, Seth Lloyd explores the profound role information plays in both the creation and destruction of our universe's complex structures.

Lecture I - Monday, September 26, 7:30 p.m. Birth. The Information Edge, which occurs when one system gains an advantage in collecting and processing information, is behind all creation, from the formation of stars, planets, and galaxies in the early universe to the generation of wealth emerging from interactions among economic agents.

Lecture II - Tuesday, September 27, 7:30 p.m. Collapse and Re-birth. The Information Edge has a darker side. It's not only responsible for the collapse of stars and the formation of black holes, it's also behind mass extinctions, the unraveling of ecosystems, and financial collapse. Lloyd explores this destruction and describes how stars, ecosystems, and economies can regain productive balance in its aftermath.

Lloyd is a professor of mechanical engineering at MIT and a member of SFI's Science Board and external faculty. His research focuses on the interplay of information with complex systems.

SFI Community Lecture, Tuesday, October 18, 7:30 p.m., The Lensic Performing Arts Center (211 W. San Francisco Street) – Mining Math's Gray Areas: Uncertainty and Contradiction. Math is often thought of as a discipline of certainty and consistency. But mathematicians know their work is riddled with uncertainty and contradiction. Jordan Ellenberg asks how math's gray areas provide us with powerful avenues for thinking about the seemingly nonmathematical matters that dominate our lives.

Ellenberg is the John D. MacArthur Professor of Mathematics at the University of Wisconsin-Madison and in 2015 was named a Guggenheim Fellow. His 2014 book *How Not to be Wrong* was a *New York Times* bestseller.

SFI's 2016 Community Lectures are made possible through the generous underwriting of Thornburg 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.ticketssantafe.org. Watch lectures live on SFI's YouTube page.