Omidyar grant funds new research theme

The Santa Fe Institute has received funding for a new five-year research theme on emergent political economies. The theme, funded by a $6.5 million grant from the Omidyar Network, will take up the ethical imperative to develop better theoretical frameworks and methods to understand the social, ecological, and moral inequalities at the core of the modern economy, as well as imagine the role that innovation will play in emergent political economies of the future—both for good and ill.

In the eighteenth century, Adam Smith conceived of capitalism in response to poverty. “Free market theory was an ethical matter, and Smith theorized that the free market would help solve the social ills that mercantilism generated,” explains SFI President David Krakauer.

“What he did not anticipate, however—it could not have anticipated given his toolkit was that capitalism plus technology, under many conditions, can generate externalities that exceed the political-economic damage of mercantilism—from unemployment to climate change. Adam Smith needs to meet complexity economics.”

If the contemporary global economy has made anything clear, it is that the political and theoretical methods and tools that researchers have inherited are insufficient to deal with the emergent patterns, systems, and phenomena that shape global economic life.

SFI’s Omidyar-funded research network will be one of five research centers, each focused on the renewal of political and economic thinking in theory and policy. The four fellow centers, all supported by the William and Flora Hewlett Foundation, are housed at Harvard’s Kennedy School, Howard University, the Massachusetts Institute of Technology, and Johns Hopkins University. The total funding for the network of institutions is $41 million.

In the SFI network, research will be conducted through a series of working groups and workshops and will home in on different emergent properties of economic complexity. One of the first workshops, led by SFI External Professor Ricardo Hausmann, is called “The Study of Technology.” The group will theorize the structure of technology and develop better mathematical frameworks that capture how technology— in all of its diversity—evolves.

Hausmann explains the challenge this way: “Formalizing ideas about technology has always been a form of collective intelligence, a discussion on how the conversation about collective intelligence evolves in an interplay between columns of neurons in the brain and between columns of people in the world. The regulations or incentives needed to ensure that algorithms are working in our best interest; they developed a comprehensive theory.”

Workshops explore individual and collective intelligence

Are ants intelligent? Watching an individual ant carry a bit of leaf back to the anthill, it may not seem that way, but as a group, the colony exhibits a kind of collective intelligence, says SFI’s Melanie Mitchell.

“If you look at the ant colony, each individual ant is not very intelligent and can’t do much on its own, but working together, the hundreds of thousands of different ants in a colony can do all kinds of seemingly intelligent things, like building elaborate structures underground that regulate temperature and humidity,” says Mitchell, the Davis Professor of Complexity at SFI, who conducts research on visual recognition and conceptual abstraction in AI systems.

Insects’ collective intelligence was just one of the topics of a workshop Mitchell co-organized and participated in last August. The gathering, held virtually due to the pandemic, pooled knowledge from biologists, computer scientists, and other experts to further the conversation about collective intelligence and how to inform AI. Some of the questions the group explored were: What mechanisms allow collective intelligence to emerge from a group of individuals or components? Which AI research paths hold the most promise for solving complex collective problems like climate change or epidemics? How can we harness collaborative intelligence to increase fairness and other key values?

Highlights of the workshop, part of SFI’s Foundations of Intelligence project, included a talk by Jeff Hawkins, co-founder of the AI organization Numenta, on how communication between columns of neurons in the brain is a form of collective intelligence, a discussion on resolving semantic ambiguities that hinder learning across fields, a debate about how to improve the study of democracy, and a discussion on the spread of misinformation.

“One of the things I took away from several of the talks was the need to tune individual agents and the conditions under which they interact in order to enhance their collective intelligence,” says SFI postdoctoral fellow Tyler Millhouse, who also helped organize the workshop along with SFI External Professor Melanie Moses. For example, biologist Anna Dornhaus noted in her talk that in insect colonies, more information-sharing between
In March, The American Prospect highlighted Geoffrey West’s work on city scaling in a story about rural American economies. West’s work is dedicated to an economicist: Jennifer Dunne. Dunne’s research on the ecosystems maintained by the world’s thinnest roots (see below). The Gottlieb talked with Tim Townsend about the latest UC climate change report and its implications for New York City and its coastal communities. After a 16-year hiatus, Cormac McCarthy has two novels slated for publication this fall. The New York Times discussed the upcoming titles, “The Passengers,” and “Stella Maris,” while the LA Review of Books looked back on “Blood Meridian,” published nearly 60 years ago. For the last 400 million years, since plants colonized land, roots have been the true engine of terrestrial ecosystems. The SFIPostdocFellow Mingzhou Lu, the lead author of a new study in the Proceedings of the National Academy of Sciences. “Roots are the foundation of biodiversity” Lu and his team of international collaborators, which included William Bond (University of Cape Town) and Lars Hedin (Princeton University), dug deep to better understand one of the most extraordinary root systems in the world. The researchers conducted a four-year experiment to explore the stark divide between the Fynbos and Afrotemperate Forest species in South Africa’s western cape. Fynbos, a shrubby biome with tremendous plant diversity, abuts Afrotemperate Forest, a woodland dominated by a small number of tree species. The unusual biome boundary is so narrow that within a few steps, one passes from a hot, open shubland into the cool, mossy shade of the forest. The soft delineation is made more even distinct because the two biome shares an underlying geology and are subject to the same climatic patterns — they exist as alternative stable states. In the face of extreme disturbance, the biomes could potentially shift to reflect the neighboring plant communities. "Some systems can exist in different states — like water and ice," explains Hodin. "This makes them especially interesting as models for dramatic change because they can switch from one state to another, which is especially urgent in a world being stressed by climate change." Under this backdrop, the study revealed two significant findings. First, the two biomes exhibited marked differences in their root traits. Second, these root differences allow the Fynbos plant community to deter trees by limiting below-ground nutrient availability. Specifically, Fynbos plants rebuff invasion with the thinnest roots ever identified. “We found that across the world’s ecosystems, these roots are the thinnest of all,” says Lu. “For every 1 gram of carbon — the weight of a paperclip — these plants produce roots.” For Fall founded and worked by Melanie Mitchell as it explored three reasons we still drive man-made cars. Fast Company also spoke with Josh Wolfe about the threat of Russian cybersecurity, and how the US and others might threaten the same, preemptively. Wolfe also discussed his investment strategies in startups with a 3CN. Doyley Farmer spoke with The New Yorker about a forthcoming report on why a decisive shift to renewable energy makes good financial sense. In a February opinion piece about President Biden’s plans to nomi- nate a Black woman to the Supreme Court, The Hill cited Scott Page and Lu Hong’s work showing that diversity is important for groups tasked with solving problems. World’s thinnest roots drive landscape pattern Subtle signals convey meaning in online forums A new paper in the Proceedings of the National Academy of Sciences demonstrates empirically for the first time that people use covert signals in one of their political identity online. The sig- nals are subtle messages that convey meaning to other in-group members and mean little to anyone else, allowing people to communicate with others who share their political identity without risking pile-ons from those who disagree. The study also found that people who covert signaling more often in mixed groups, preferring obvious, overt signals in groups that mostly aligned with their beliefs. These ideas were developed in a theory of covert signaling by Paul Smaldino, associate professor of cognitive and information sciences at UC Merced, but had yet to be tested. “This was very much a need to study this question,” says Van Der Do, a postdoctoral fellow at SF and lead author of the paper. “How do you measure a covert identity signal, given that it’s covert?” She and her coauthors, including SFIPostdocFellow Mirza Cazaleg, puzzled over the question for months until they came up with a clever strat- egy. During the run-up to the 2020 election, they collected tweets from politically extreme Twitter users, on both the left and the right. Indiana University graduate student Zachary Durwin developed a method to download follower networks and determine if the follow- ers were mostly similarly extreme, or more heterogeneous. Then for each tweet, they had four groups of raters guess the political affiliation of the tweeter. Some of the raters were politically extreme, either on the right or the left, and some were moderate. The tweets that generated the most disparate guesses between these groups were selected as the most likely to be covert signals. Finally, the raters played an online game, where they selected from overt and covert tweets to share with groups of audience members who were either strictly politically co-partisan with the rater or mixed co- and cross-partisan. Their goal was to maximize likes and avoid dislikes from the audience members. “We wanted to see: when there are more audi- ence members from the out-group, do partici- pants in the game share more covert tweets?” Van Der Do says. “We were quite mind-blown that it was actually the case!” This research was supported by the Army Research Office Grant W911NF20120011. we “came up with a way to meaning-fully use the intelligence of entire planets,” wrote Krakauer in an essay about the threat of alien beings. On Earth, what we might learn from the inhabitants of another planet — managing to capture many of the challenges that modern political and economic public dialogue seem to have lost — notably an appreciation for the inherent complexity of reality and a deep realization that — and perhaps even axiomatic — rules are ethical principles. As Stewart writes in relation to changing such a sys- tem in order to improve the collective in- terests of life, “The great art of governing is to divest oneself of prejudices and attachments to particular opinions, particular classes, and so above all to particular persons, to consult the spirit of the people, to give way to it in appearance, and to never disagree to turn publics of inspiring those sentiments which may induce them to relish the change, which an abatement of curiosity can barely accomplish.” For Stewart the objective of society—that is any social collective in which the parts become correlated towards synergistic purpose—out- comes—it is a political economy that “can provide food, other necessaries, and every employment to every one of the society.” This then Stewart favored was a mere mercantilism, a position to his most famous, and in several ways more enlightened successor, Adam Smith, made the ject of his criticism. In an inquiry into the Nature and Causes of the Wealth of Nations (1776), Smith introduces a language that is more consonant with our own, placing a greater emphasis on technology and industry and reducing the focus on can and trade favored by Stewart. Smith can often sound like a Polynesian of the modern tech- no-society. “It is the interests of the productions of all the different arts, in consequence of the division of labor, which, under the influence of the most general and universal opulence which extends itself to the lowest ranks of the people,” Smith, however fully aware about the heavy cost of excessive specialization and mechanization. He pos- sesses a very sophisticated sense of human potential and ability, and advocated for extensive education for all: “It is much less than we are apt to conclude from the apparent level of society, that the effect of the division of labor, which has been so much from nature, as from habit, custom, and education.” Much of Wealth of Nations is dedicated to an analysis of the economic exchange—costs and benefits of tech- nology, and their respective markets, as they bear on Stewart as described the complexity of human relations. For Smith,
Science of science workshop: discovery and inequality

In the late 1800s, a collection of sociologists and philosophers started to try and make sense of the steady yet chaotic progress of scientific discovery, which physicist Freeman Dyson has referred to as “the explosion of logical jumps, improbable coincidences, jokes of nature.” The “science of science,” as the endeavor is now known, turns the scientific method inward on the scientific community and its structure and dynamics. Largely confined to sociology and philosophy for decades, advances in computer technology at the turn of the century broadened the discipline into what is now a field encompassing computer scientists, statisticians, biologists, physicists, and more.

Today’s collaborative and diverse research community reflects SFI’s mission. This May 5-6, the Institute will host a meeting called “A New Synthesis for the Science of Science.” Postponed three times by the COVID-19 pandemic, the workshop will synthesize concepts, models, methods, and data to craft a new vision for the science of science.

“The data and computational tools available today are transforming the field,” says SFI External Professor Aaron Clauset (University of Colorado Boulder). “This workshop aims to articulate the organizing questions that should guide the next five to 10 years of work.”

In addition to Clauset, workshop organizers include SFI Professor Mirta Galesic and former SFI Postdoctoral Fellow Daniel B. Larremore, Assistant Professor of Computer Science at the University of Colorado Boulder. The workshop will focus on the individual and structural inequalities within science that slow the pace and limit the diversity of discovery. Specifically, participants will explore the mechanisms that produce epistemic and social inequality, the removal of which would accelerate and broaden scientific advances.

For example, why do a handful of graduate programs produce 50 percent of all tenure-track faculty across different fields? Or why do women produce fewer papers throughout their careers than their male peers? These questions are even more pressing now, after the global pandemic disrupted all levels of science. “The pandemic has inflated epistemic inequalities, particularly around women,” says Clauset. “The workshop will help us address the current and future causes of pervasive inequalities in science.”

Adds Galesic, “This research can help us to see how some deeper changes in the system can alleviate structural barriers and inequalities.”

This meeting was supported by the National Science Foundation Grant Number 2018556.

Using organization to counter online hate speech

Hate speech and disinformation have become intractable problems on social media and other online platforms, but there is little agreement on what to do about them. One approach is for companies to monitor and remove hateful or harmful content. Another emerging approach is counter speech, where individual users respond to bullying posts.

But is counter speech effective at curbing online hate and disinformation? It’s a difficult question to address scientifically, largely because so many societal factors are at play beyond the online forums. However, a study published in PLoS Data Science uses a multifaceted approach to begin exploring the question. The study examines nearly 400,000 worth of conversations that played out on German Twitter between two self-identified opposing groups. The results suggest that counter speech may indeed be effective in curbing hateful speech online, especially when done in an organized manner.

Shortly before the 2017 German federal election, a far-right group called Rez匡nta Germanika began to target online campaigns, spreading hate and disinformation against immigrants through various social media platforms and promoting a radical right political candidate. In April 2016, a counter group called Rez匡nta Internet organized coordinated counter-messaging.

In their paper, “Impact and dynamics of hate and counter speech online,” former SFI Postdoctoral Fellow Brian A. Clauset (Max Planck Institute for Mathematics in the Sciences), and Laurent-Hibert Dufrene (University of Vermont), and Jean-Claude Gabriel (University of Vermont) studied more than 16,000 conversations from 2015 — before the formation of Rez匡nta Germanika — through 2018.

“This is the first time anyone has done a longitudinal study of complete conversations at this scale,” says Garland. Because there were self-identified members of both groups, the researchers used a machine learning classifier to recognize speech patterns typi-

cal of hate and counter speech in the conversations.

To get a picture of the effectiveness of counter speech, the authors considered several proxies for effectiveness at multiple scales, from the overall ratios of hate-to-counter speech over time to the dynamics of individual hate and counter-speech posts.

“Across a number of different indicators, we find that organized counter speech appears to contribute to a more balanced public discourse. After the emergence of the organized counter group Rez匡nta Internet (IR) in the late Spring of 2016, the relative frequency of counter speech increased while that of hate speech decreased,” write the authors. Similar to what research on “traditional” bullying shows, these findings suggest that the presence of supporting peers can motivate individuals to stand up against online hate speech. “Our work suggests it is important to encourage citizens to stand up against hate bullying online,” says Galesic. “They will feel empowered, and they can really make a difference.”

The authors are careful to clarify that their study does not identify any causal effects. “There were simultaneous cultural shifts happening in Germany during this time.”

More on Page 4

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More on Page 4
The range of topics—from quarks to food webs, cultural evolution to urban scaling laws, and emergent economics to Gaia—covers many of the most profound ideas of the 21st century.

The inaugural lectures in 1987—“From Chaos: Different Ways of Thinking about the Nature of Life,” presented by Stuart Kauffman, one of SFI’s first program researchers, and “The Zen of Biology: Life Sciences in the Computer Age,” presented by the late George Mason University biophysicist and SFI Science Board Chair Emeritus Harold Morowitz—set the pace for the lectures that would follow. A new electronic archive documents the series from its inception. The range of topics—from quarks to food webs, cultural evolution to urban scaling laws, and emergent economics to Gaia—covers many of the most profound ideas of the 21st century.

We began the series with two lectures that explore biophysics and the origin of life, and we re-emerge, after two years, with a lecture that shows how this fascinating subfield of complexity science has evolved,” says McShea. “It’s a nice bit of serendipity.”

The lecture series is free and open to the public, thanks to generous support from longtime SFI supporters and local philanthropists Ian and Celynn敬al. The lectures are also live-streamed, and required and the event is often filled to capacity. To reserve a ticket, visit www.leninc.org. The lectures are also live-streamed, and made available after the event, on SFI’s YouTube channel.

The SFI Community Lecture series full lineup for the year (Image: SFI)

**POLITICAL ECONOMIES** (cont. from page 1)

The SFI network will also present generative exchanges between SFI scientists and thinkers who are exploring new ways around the idea of “good roads and communications is, no doubt, beneficial to the whole society.”

**FYNBOS ROOTS** (cont. from page 4)

**HATE SPEECH** (cont. from page 5)

Germany,” says Garland. “We can’t say that organized counter speech caused something to occur, but we can look at the correlation between hate and counter speech.”

While this study focuses on the specific scenario of hate and counter speech on German Twitter, the findings offer insight for addressing other types of online disinformation. “Harmful messaging is really a subset of disinformation,” says Garland. “It’s disinformation about a person or group of people. Our paper shows that organizing matters to fight against disinformation. It might be scary to stand up against a narrative that is perceived as true, but one can post on a platform where I have support, it’s easier to stand up against the bully.”

In subsequent work, the authors plan to explore which specific strategies—from humor to counterfactuals to befriending—might be the most effective types of counter speech.

**ALGORITHMIC JUSTICE** (cont. from page 4)

that would lead algorithms to be more robust and adaptive, and they looked for ways that algorithms could be designed with feedback loops that would break down existing biases rather than reinforcing them.

“What I think is unique about SFI,” Moses says, “is the ability to bring together scholars from different disciplines to have a productive discussion. We learn from one another and chart a path forward where artificial intelligence advances justice rather than exacerbates or accelerates injustices.”

**INTELLIGENCE** (cont. from page 4)

individuals isn’t necessarily beneficial to the colony as a whole. “These biologically inspired ideas are, in an emerging domain called collective AI that might not have been obvious otherwise.”

This workshop was part of the ongoing Foundations of Intelligence project, which has included Foundations of Intelligence in Natural and Artificial Systems (March 15–19, 2021), Frontiers of Evolutionary Computation (July 21–25, 2021), Can Algorithms Bend the Arc Toward Justice? (March 30–4, 2022), and Embedded, Situated, and Coevolved Intelligence: Implications for AI (April 12–16, 2022).

**BEYOND BORDERS** (cont. from page 4)

the enterprise of political economy was the betterment of society as a whole, and while an unwatched advocate for free markets, advanced technology, and capitalism, he concluded his book by writing, “The expense of maintaining good roads and communications is, no doubt, beneficial to the whole society.”

**ALGORITHMIC JUSTICE** (cont. from page 4)

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In a time of upheaval, what does it mean to be useful?

In a time of climate change, inequality, polarization, and pandemic, what does it mean to be “useful”? This question from SFI President David Krakauer kicked off SFI’s live online course Complexity Interactive, which ran January 10-28, 2022. Is it better for complex systems scientists to keep their advice simple and be understood, or to advocate for complexity and nuance yet risk not being one who will listen?

This year’s Complexity Interactive focused broadly on sustainability. Participants represented six continents and 38 countries, with interests as diverse as space weather, regenerative agriculture, and computational therapy. The curriculum gave participants an overview of current research at SFI, engaged them in transdisciplinary thinking with colleagues, and inspired ideas and approaches for future research using the tools of complexity science.

A series of seminars and discussions throughout the three-week program uncovered how complex systems reveal real patterns and explanations across a variety of systems, and explored how complex-systems approaches could inform solutions to global challenges.

SFI Professor Geoffrey West used his work on scaling up to explain why people in cities don’t, and why the unbound growth of cities may not be good news. “Everything comes at a price,” he said. “This means, too, that everything comes at a price.”

For others, energy consumption, genetic information, and pandemic, what does it mean to be useful? “I think bad things lie ahead for humans and society for sure,” said O’Connor. “But the threat, the threat is not the planet is not going to implode, or disappear. The planet is not going to shut down, the planet goes on and on and on. But the things we’ve accustomed to—biologically, ecologically—will carry on. I personally find that sobering.”

Along with sustainability, the course emphasized fundamental principles of complex systems, such as measures of sameness and the limits of computability, along with forays into algorithmic fairness, cascading failures in the power grid, and the power of Big Tech and its threat to democracy.

Participants brought their openness and creativity to the course, and a dynamic group of colleagues emerged. “Complexity Interactive was the missing piece of my journey as it built a vibrant community of complex systems researchers with whom I expect to keep learning, sharing, and collaborating,” said participant Tamar Shimoni, a postdoctoral fellow from the Federal University of Rio Grande do Sul (Brazil). Collaboration, many students concluded, is at the heart of what it means to be useful.

Complexity science is a powerful toolbox, but to apply it meaningfully to climate change mitigation and sustainability policies requires domain-specific expertise. Program Director, SFI External Professor Miguel Fuentes, explained, “The idea is not that the complexity scientist will do the policy thing. Rather, they will be there on the team.” Through such teamwork—with fellow researchers, policymakers, governments, educators, journalists, and the public—complexity scientists are not only useful, but essential.

Bridging the dogma divide in the origins of life

Ask a PI — the principal investigator leading a science grant — studying the origins of life about how she begins to get some of the most useful answers. But exactly which answers depend on the intellectual camp the PI belongs to. For example, what are the origins of life researches work in an “information-first” framework, in which genetic information plays the leading role. For others, energy acquisition or “encapsulation” are the characteristics of life that likely arose first.

To an outsider, these ideas might seem like different parallel tracks, each with the same elephant, but the divisions have become deep enough that early career researchers often worry about winding up in the wrong camp.

Complexity Postdocs come together after pandemic-induced hiatus

After a two-and-a-half-year pause, the eighth bi-annual SFI–Complexity Postdocs in Complexity Conference reconvened at SFI April 6-8. The meeting included 34 James S. McDonnell Foundation Fellows from around the world and 13 Postdoctoral Fellows from the Santa Fe Institute.

“This meeting brings together early career complexity scientists who are at the top of their field and provides them with an opportunity to build a network for their future careers,” says Hilary Skolnik, SFI’s longtime Complexity Postdocs Program Manager. “The collaborative, interactive nature of the conference wasn’t something we could easily replicate over Zoom. The short monthly virtual meetings over the past two years meant that a lot more of the participants met online, but Skolnik says, “the whole focus for this conference was interactivity and networking.”

In a two-part session called “You never know when to expect the Spanish Inquisition,” journalists and media experts Sandy Blakeslee, Alex Witze, Mary-Charlotte Domandi, and Ned judge provided guidance on how to handle any kind of interview. Then, following a COMPASS science communication training with participants, they provided improvisation to conduct mock interviews.

“This offered a way for them to practice their newly acquired interview skills with real journalists,” says Skolnik. “It’s about communicating their science effectively and more strategy.”

The postdocs participated in another form of science communication through discussions with SFI Fractal Faculty member Stuart Firestein (Columbia University), who is writing his third book. Through back-and-forth conversations, the postdocs got a window into the process of writing a popular science book — this one on optimism — and Firestein received input from scholars from a range of disciplines.

Across-discipline dialogues are part and parcel of meetings at SFI, but many of the Complexity Postdocs have worked primarily at universities with traditionally bounded departments. Any complexity scientist must know how to work across disciplines and to handle conflicts and differences of opinion when they invariably arise. During the three-day gathering, the fellows worked with SFI’s Director for Education Carrie Cowan and Research Development Director Susan Carter to practice negotiation and public dialogue.

At the heart of the postdocs’ Complexity conferences is a quest to build best practices in complex systems research and an active, networked community, says Skolnik. “We’re exploring what it means to do it in a complex systems science?”

At SFI, that often means creative collaboration across expertise. Through Protein Engineering, the postdocs had the opportunity to propose a working group, if accepted, would be fully funded and held at SFI.

The meeting was funded by the James S. McDonnell Foundation Grant Number 220020541.

Wheat from chaff: looking for real patterns

To advance research on topics from climate change to machine learning, scientific models are crucial. These models often reveal patterns, but humans also tend to see patterns everywhere, even where there are none. How can researchers recognize which patterns are real and which are spurious? What kinds of real patterns are most useful?

These are some of the questions that philosophers and scientists from various disciplines explored in a virtual SFI workshop on “Real Patterns in Science” held February 28-March 4. The workshop was supported by National Science Foundation Grants 2020103 and 2139983.

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At SFI, that often means creative collaboration across expertise. Through Protein Engineering, the postdocs had the opportunity to propose a working group, if accepted, would be fully funded and held at SFI.

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Understanding how classes of enzymes that perform different functions scale in different organisms on Earth could help researchers predict and identify life elsewhere in the universe. If the methods are very different from life as we know it, says SFI External Professor Sara Imari Walker. In a new study published in PNAS, a team of researchers that includes Walker and SFI External Professor Chris Kempes, identifies universal patterns in the chemistry of life that do not appear to depend on the molecules we find in Earth life. The team discovered various scaling laws between the number of enzymes in different enzyme classes and the size of an organism’s genome. These kinds of patterns might be one of life’s mathematical signatures.

Read the paper at doi.org/10.1073/pnas.2006655109

INFORMATION & SCALING THRESHOLDS IN HUMAN SOCIETIES

At certain points in human history, societies experience revolutions in collective computation — the methods for storing and sharing information that shape decisions in collective behavior. Those revolutions, in turn, can shape the scale of societies that adopt them. In a recent paper in the Journal of Social Computing, SFI Professor David Wolpert, SFI External Professor Tim Kohler, and their colleague, Darcy Bird built on past research to explore patterns of change to collective computation that occur in human history. They identified two significant thresholds that relate scale to changes in collective computation. First, they observed a scale threshold before information systems, such as writing systems, emerge; societies must grow to a certain scale. Second, they found an information threshold, which, when crossed, enables societies to grow in scale.

Read the paper at doi.org/10.23919/JSC.2021.0020

Enzyme classes across the life spectrum. Understanding how classes of enzymes that perform different functions scale in different organisms on Earth could help researchers predict and identify life elsewhere in the universe. If it looks very different from life as we know it, (image: from Figure 1 in “Scaling laws in enzyme function reveal a new kind of biochemical universality,” PNAS)

LIFE’S MATHEMATICAL SIGNATURES

In the quest to define life, the primary reference point is life on Earth. Yet astrobiologists suspect that the search for life may require that we look beyond the lifeforms we know. We need new tools for predicting and identifying features of life as we don’t know it, says SFI External Professor Sara Imari Walker. In a new study published in PNAS, a team of researchers that includes Walker and SFI External Professor Chris Kempes, identifies universal patterns in the chemistry of life that do not appear to depend on the molecules we find in Earth life. The team discovered various scaling laws between the number of enzymes in different enzyme classes and the size of an organism’s genome. These kinds of patterns might be one of life’s mathematical signatures.

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SCALING MATTERS FOR PREDICTING INFECTIOUS DISEASE BEHAVIOR

What’s the best scale to use to study the spread of disease? With COVID-19, we’ve seen that it’s not at the scale of a country or even a state — the variation from county to county makes that clear. A new study in Nature Communications shows that we may have to go all the way down to the scale of a single city block, and that the key feature is to choose areas with a similar population density.

SFI External Professors Aaron King and Mercedes Pascual and collaborators studied the spread of a new variety of dengue fever over two years in Rio de Janeiro. They analyzed the size of the second peak of transmissions relative to the first. In areas with both particularly high and particularly low densities, the ratio of the second peak to the first was not as high. Their findings contribute to understanding the fundamental drivers for vector-borne diseases like dengue, as well as for other infectious diseases like the seasonal flu and COVID-19.

Read the paper at doi.org/10.1038/s41467-022-28231-w

SCALING OF HUNTER-GATHERER CAMP SIZE AND HUMAN SOCIALITY

From hunter-gatherer encampments to modern cities, permanent human settlements tend to densify as the population grows, while mobile human settlements do not. New research in Current Anthropology by SFI’s Luis Bettencourt and Scott Ortman, with coauthors José Lobo, Todd Whitehall, Polly Wiessner, and Michael E. Smith, explores these dynamics and the conditions that might lead impermanent, spread-out communities to transition to denser, stationary settlements.

“‘This paper represents an extension into the hunter-gatherer lifestyle of the analytical framework we have used to study cities and urbanization,’ says Lobo. ‘The transition from the hunter-gatherer lifestyle to sedentism is one of the most important transitions in the history of our species and a very active area of research.’

Read the paper at doi.org/10.1086/719326

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