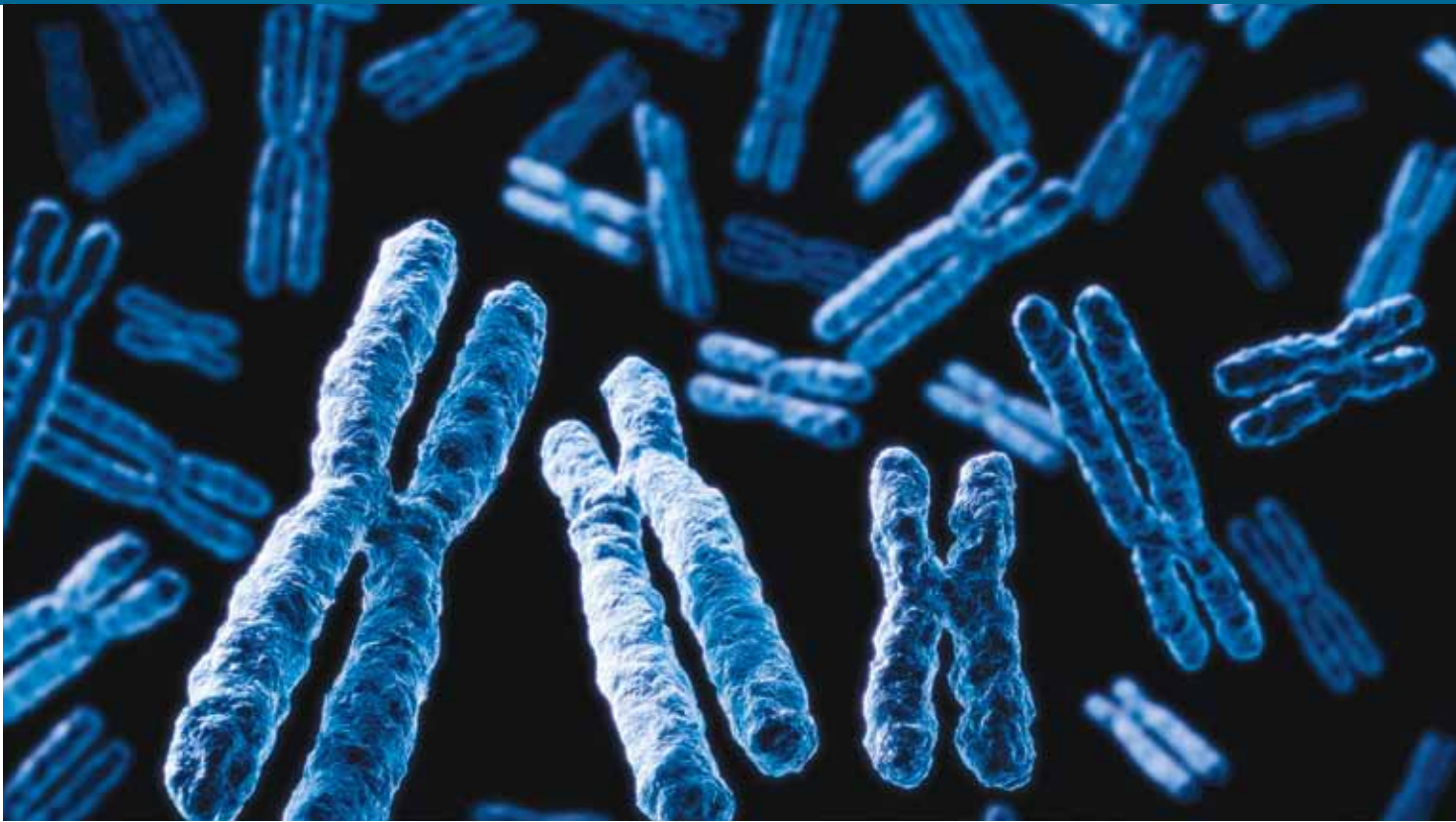




Update

March / April 2011



(Image: fpm, istockphoto.com)

RESEARCH NEWS

Mom vs. dad: Outcomes of genomic imprinting

When mom's and dad's genes compete, whose alleles prevail to make their progeny tall or give her big bones – and more important, why – is a matter of intense interest among evolutionary biologists.

Imprinting, the conditional (on which parent donated it) expression of a gene in an individual, accounts for much of the evolutionary change not adequately described in classical genetic theory. But scientists don't yet have a solid framework for studying the evolutionary role, or long-term outcomes, of genomic imprinting.

The dominant explanation, at least since David Haig published it in 1991, has been "parental conflict hypothesis," often referred to as kinship theory. Haig's theory argues that imprinting is a consequence of oppos-

ing selection pressures on maternal and paternal genomes within an individual.

In other words, mom's genes express in developing offspring for the good of her entire brood – perhaps by conserving resources for the mother so she can reproduce again – while dad's express to make his individual offspring as fit as possible – by hogging maternal resources, for example.

Although most scientists accept kinship theory as a working principle, with just two decades of empirical study behind it, it hardly takes its place among the stalwarts of evolutionary theory.

"Just how prevalent imprinting is among mammals is still controversial," says SFI Omidyar Fellow Jeremy Van Cleve. "Even

murkier is the question of how much new theory is required to account for known cases of imprinting."

In February Jeremy and SFI Professor Jon Wilkins hosted a three-day working group at SFI to take stock of recent experimental and theoretic advances in kinship theory, and to examine situations that seem to fall outside its struggle-for-maternal-resources manifestation.

These special cases, Jon says, provide an opportunity to test the potentially broader explanatory power of the kinship theory.

In one such case, detailed in a recent study published in the *American Naturalist*, Jeremy, SFI Science Board member Marcus > more on page 2

RESEARCH NEWS

At least for Aleuts, switching foods helps stabilize food web

A first-ever effort to quantify where humans fit in the food webs around us suggests a strategy for minimizing our negative effects on the natural world.

SFI Professor Jennifer Dunne and a team of archaeologists and ecologists from Idaho State University are studying Sanak Island, Alaska, where Aleut people lived for 5,000 years before recently moving to the mainland.

Using interviews, ecological observations, and archaeological studies, the team is reconstructing marine and terrestrial food

webs for the entire Sanak archipelago. These complex ecological networks describe "who eats whom," including humans, among the hundreds of species in local habitats. Surprisingly, such a "whole system" study of the human roles in a food web has never been done, Jennifer says.

Jennifer's initial network analyses show that the Sanak Aleut were "super-generalists" and "super-omnivores" who ate a greater variety of plants and animals throughout the food web than other consumer species. In > more on page 2



Jennifer Dunne (InSight Foto)

IN THIS ISSUE

- > Creating a living computer 2
- > Lit Bits 2
- > Achievements 2
- > Women, science, & math 3
- > Frontiers of physics course 3
- > SFI In the News 3
- > Upcoming lectures 3
- > Airline networks 4
- > Phone communities 4
- > Orlando Montoya 4

RESEARCH NEWS

Rhythmic fight schedules tap out social beat

Whether between friends or nations, conflict seems to come in waves. In a recent paper, three SFI researchers suggest that various types of conflicts also tend to occur on regular schedules.

Omidyar Fellow Simon DeDeo and Professors David Krakauer and Jessica Flack analyzed 150 hours of observations Jessica had collected on patterns of conflict in a monkey society to see if monkeys learn better strategies as they gain experience fighting.

Rather than the simple learning trends the trio expected, however, they discovered evidence for a "conflict clock" – a social version of biological clocks like circadian rhythms – that predicts when animals will fight.

> more on page 4

INSIDE SFI

Report: SFI ranks 8th among world's science think tanks

SFI ranks 8th among the world's foremost science and technology think tanks, according to a recently released annual report by the University of Pennsylvania's International Relations Program.

Nearly 5,500 think tanks were nominated in 29 categories. Some 1,500 scholars, journalists, officials, and donors from 120 countries participated in the ranking process.

"This is certainly a great honor," says SFI President Jerry Sabloff. "As a theoretical research center dedicated to the sciences of complexity, SFI is not a think tank in the traditional sense. However, as we gain insights into the complex systems most critical to our > more on page 2

LIT BITS

Segmentation algorithm for non-stationary compound Poisson processes; Toth, B.; **Fabrizio Lillo**; **J. Doyne Farmer**; *European Physical Journal B* 78 (2), November 2010

Evolutionary innovations and the organization of protein functions in genotype space; Ferrada, E.; **Andreas Wagner**; *PLOS One* 5 (11), November 30, 2010

The rigidity transition in random graphs; Prasad Kasiviswanathan, S.; **Cris Moore**; Theran, L.; *Proceedings of the 22nd Symposium on Discrete Algorithms*, 2011

Symbolic dynamics and synchronization of coupled map networks with multiple delays; Atay, F.M.; Jalan, S.; **Juergen Jost**; *Physics Letters A* 375 (2), December 1, 2010

Living on the edge of chaos: Minimally nonlinear models of genetic regulatory dynamics; Hanel, R.; Pochacker, M.; **Stefan Thurner**; *Philosophical Transactions of the Royal Society A-Mathematical, Physical, and Engineering Sciences* 368 (1933), December 28, 2010

Hydraulic trade-offs and space filling enable better predictions of vascular structure and function in plants; **Van Savage**; Bentley, L.P.;

Brian Enquist; Sperry, J.S.; Smith, D.D.; Reich, P.B.; von Allmen, E.I.; *Proceedings of the National Academy of Sciences* 107 (52), December 28, 2010

Optimization of parameters for coverage of low molecular weight proteins; Muller, S.A.; Kohajda, T.; Findeiss, S.; **Peter Stadler**; Washietl, S.; Kellis, M.; von Bergen, M.; Kalkhof, S.; *Analytical and Bioanalytical Chemistry* 398 (7-8), December 2010

Strengthening strong reciprocity; Deng, K.Y.; **Herbert Gintis**; Chu, T.G.; *Journal of Theoretical Biology* 268 (1), January 7, 2010

Distributed biological computation with multicellular engineered networks; Regot, S.; Macia, J.; Conde, N.; Furukawa, K.; Kjellen, J.; Peeters, T.; Hohmann, S.; de Nadal, E.; Posas, F.; **Ricard Solé**; *Nature* 469 (7329), January 13, 2011

Optimal viral strategies for bypassing RNA silencing; Rodrigo, G.; Carrera, J.; Jaramillo, A.; **Santiago Elena**; *Journal of the Royal Society Interface* 8 (55), February 6, 2011

The evolvability of programmable hardware; Raman, K.; **Andreas Wagner**; *Journal of the Royal Society Interface* 8 (55), February 6, 2011

Achievements



SFI Distinguished Professor Geoffrey West spoke February 16 in New York City at *The Economist* magazine's "Ideas Economy: Intelligent Infrastructure" conference. His presentation summarized

recent research into how cities grow and change in predictable, measurable ways, and what indicators are signs of progress and decline.



The NSF-sponsored, SFI-led GUTS y Girls program led by Irene Lee has been selected to receive a \$10,000 Google RISE (Roots in Science and Engineering) Award. The RISE awards promote

K-12 and university education initiatives in science, technology, engineering, math, and computer science.



Jim Rutt, Chairman of SFI's Board of Trustees, kicked off the High Desert Discovery District's "HD3 Presents" lecture series March 3 in Santa Fe, in a rousing talk he calls "Shoot the Puppy:

Real Life Insights on the Journey from Idea to Exit." HD3 and SFI co-hosted the lecture. For more about HD3 visit www.hddd.org.

> Think tanks

continued from page 1

society's future, we increasingly find common ground between science and policy making."

According to the report, the top 10 science and technology think tanks worldwide are:

1. Max Planck Institute, Germany
2. Bertelsmann Foundation, Germany
3. Battelle Memorial Institute, United States
4. Science and Technology Policy Research (SPRU), United Kingdom
5. Center for Development Research (ZEF), Germany
6. Institute for Science and International Security, United States
7. Institute for Future Technology (IFTECH), Japan
8. Santa Fe Institute (SFI), United States
9. Consortium for Science, Policy, and Outcomes (CSPO), United States
10. International Institute for Applied Systems Analysis (IIASA), Austria

To read the full report, visit www.gotthinktank.com.

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The *SFI Update* is published bi-monthly by the Institute to keep its community informed. Please send comments or questions to John German at jdg@santafe.edu.

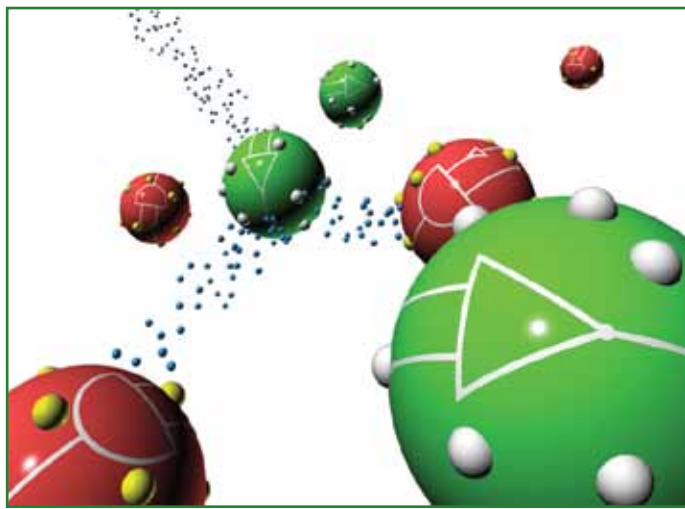


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RESEARCH NEWS

Study: How to create a living computer

Biological systems with decision-making ability can be created using multiple combinations of cells modified by genetic engineering, according to a study published in *Nature* by a research team led by SFI External Professor Ricard Solé (Universitat Pompeu Fabra, Barcelona, Spain).



(Image: Ricard Solé)

The work opens the possibility of distributing biological "computations" over multiple cells that perform different logical functions and communicate with one another through signaling molecules that serve as chemical "wires."

The ability to divide computations among different cells means the cells can be used to build circuits analogous to those in electronics.

"We can use [cells] in a combinatorial way," says Ricard. "Potentially we can generate thousands of different circuits and so implement thousands of different functions."

The researchers published their results online in *Nature* on December 8. Ricard is the corresponding author.

> Genomic imprinting

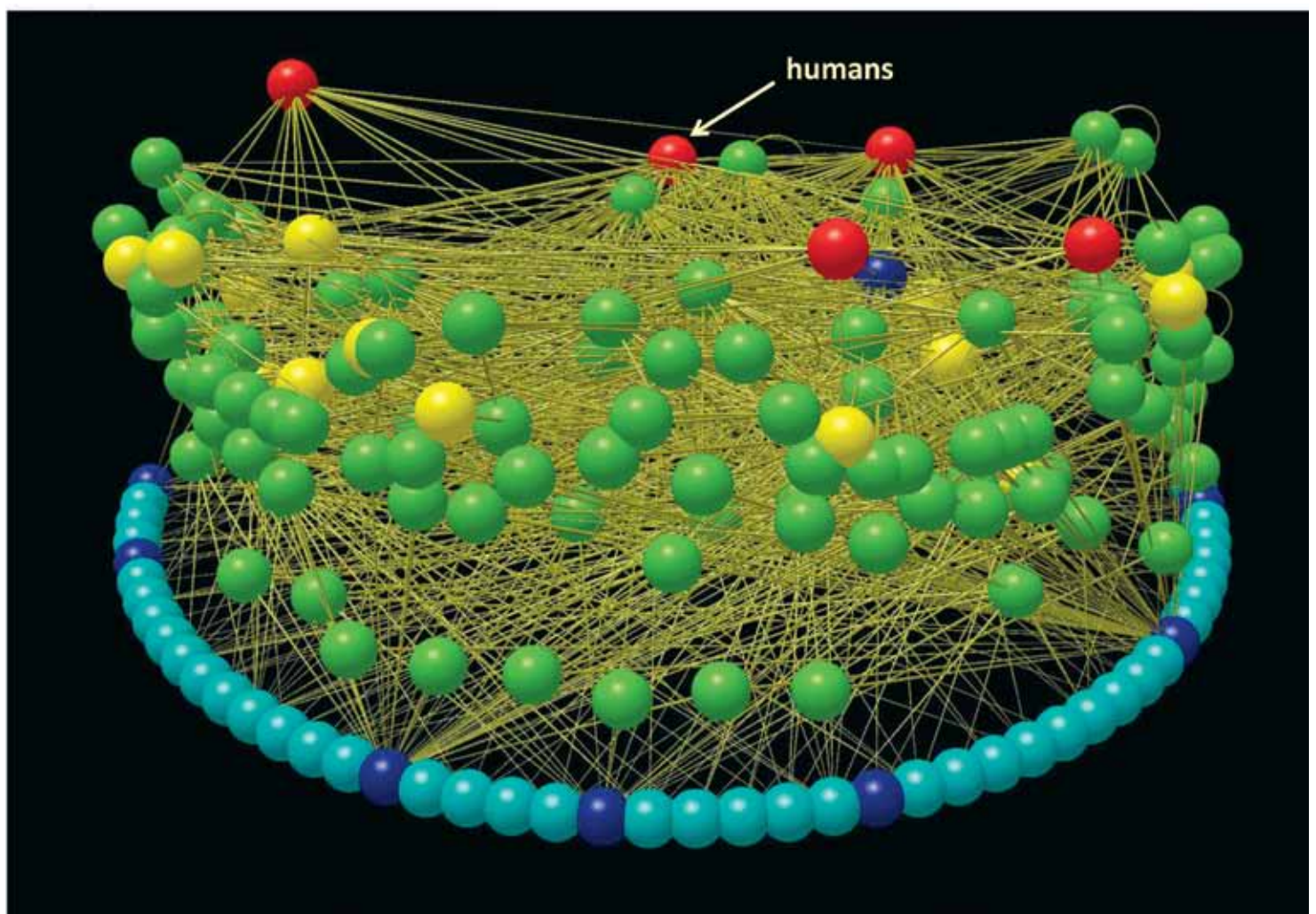
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Feldman (Stanford), and Laurent Lehmann (University of Neuchatel) modeled over many generations the evolution of traits in a notional population of males and females.

They found that minor demographic variables – such as small differences in male-to-female ratios and frequency of movement among individuals – seem to play important roles in which genomes dominate, at least on evolutionary time scales.

"We suggest that the evolution of imprinting, within the context of kinship theory, can arise from demographic conditions in a population," says Jeremy.

At the meeting a small group of collaborators began to develop a framework for what outcomes kinship theory should predict, which will be useful for designing future tests of the theory. The meeting is expected to result in a review paper for the journal *Trends in Genetics*.



The Sanak intertidal food web. Yellow lines indicate feeding relationships – who eats whom – among the 176 taxa.

(Image: Jennifer Dunne)

> Food webs continued from page 1

the intertidal food web, for example, Sanak Aleuts ate more than a quarter of all species at all levels of the web.

Historical and archeological records show that the Aleut also regularly switched what they ate, by hunting sea lions when the weather was good, harvesting salmon when they migrated up the local river, or digging for clams when other food items were unavailable or inaccessible.

Switching made sense – if one thing gets

hard to find, eat another – but also helped keep the ecosystem healthy by giving plant and animal populations a chance to recover. Jennifer's modeling demonstrates the importance of this behavior: a super-generalist can be a part of a stable ecosystem as long as they eat only a few species at a time, she says.

In the modern world, economic pressures can interfere, however. She cites blue fin tuna, which have been in the news recently because their value has skyrocketed as they

have become rare due to over-fishing for the sushi market. People's failure to switch to other more available, but less profitable, species is driving blue fin tuna towards extinction.

Jennifer says this cycle also, and more alarmingly, introduces a potentially destabilizing dynamic: ripple effects in the food web could drive other species to extinction, altering the ecosystem's fundamental structure and function and ultimately affecting what – and how much – food we humans have left.

SFI IN THE NEWS

SFI Distinguished Professor Geoffrey West and his work with External Professor Luis Bettencourt on cities and scaling were featured in the December 17 *New York Times Magazine*.

In a December 27 *Huffington Post* article on the implications for democracy of mega-philanthropy, SFI External Professor Scott Page suggests that in giving, like in most human endeavors, diverse groups make better decisions.

A January 1 *Science News* article summarizes a paper co-authored by SFI External Professor

Aviv Bergman, which suggests that mammals' core body temperatures evolved to about 37 degrees Celsius to ward off fungal infections while minimizing food consumption.

A January 16 *Wired.com* article describes a study by a research team including SFI External Professor Stefan Thurner that found that equations describing earthquake propagation fit the reverberations of topics through the political blogosphere.

On January 24, in the first in a series of

monthly articles by SFI scientists to appear in the *Santa Fe New Mexican*, SFI External Professor Luis Bettencourt described how researchers are developing new measures that quantify what is remarkable about cities, after adjusting for their sizes.

In a February 26 *Science News* article, SFI Professor Jennifer Dunne responded to a Northwestern University study examining how perturbations propagate through a network of organisms, demonstrating that when an ecosystem is off-kilter, removing particular spe-

cies can halt the cascade of destruction that may follow.

The work of Luis Bettencourt and Geoffrey West to develop improved metrics for ranking cities continues to be featured widely, including in the *Albuquerque Journal*, *New Scientist*, WNYC Radio, and hundreds of blogs.

Find these articles and more SFI news – and sign up to receive notifications via Twitter, Facebook, and RSS – at www.santafe.edu.

INSIDE SFI

Education programs: New ways to become a complexity scholar

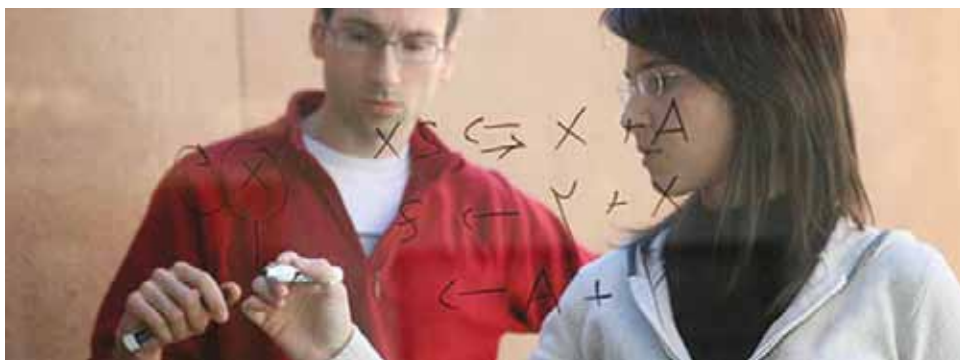
SFI is offering several new education outreach programs in 2011 and making changes to its education programs designed to increase their value and sustainability, says Ginger Richardson, VP for Education and Institutional Outreach.

This summer SFI's signature school for graduate students and postdocs, the 25th Complex Systems Summer School (June 8-July 1 in Santa Fe), will be coordinated and taught by the Institute's resident faculty; past years have relied more heavily on guest instructors.

"We are drawing on the wealth of resources at SFI to make the curriculum more integral to the research the Institute is doing," she says.

To maintain the popular program on a cost-neutral basis to SFI, participants will pay tuition for the first time in 2011. At least one-third of those accepted will be selected to receive scholarships, based on individual need and merit.

SFI also is expanding its summer programs for high school students by partnering with the Groton School in Groton, Massachusetts. The new Summer Complexity and Modeling Program (July 9-23 in Groton) will introduce high school students, from the Santa Fe area



and from national and international applicant pools, to complexity science.

Another new program, GUTS y Girls, is being offered for New Mexico middle school girls (see article at right).

A new summer workshop for high school teachers, offered in partnership with George Mason University, will explore the latest theories on the origins of life. Located on the GMU campus in Fairfax, Virginia, "Origins of Life: From Geochemistry to the Genetic Code" (June 21-July 3) will be taught by faculty from a consortium of educational institutions including SFI.

Professionals, academics, postdocs, and students are invited to attend "Exploring Complex-

ity in Science and Technology from a Santa Fe Institute Perspective," directed by SFI External Professor Melanie Mitchell. Her next two-and-a-half-day course May 23-25 at the University of New Mexico includes lectures and hands-on demonstrations and requires no background in mathematics or science.

"Constantly scaling our programs by way of new formats, new venues, and new audiences is all about building a sustainable educational pipeline for today's and tomorrow's complexity scholars," adds Ginger.

Tuition fees vary; visit www.santafe.edu/education for more information. ■

INSIDE SFI

New GUTS y Girls engages tomorrow's women scientists

The National Science Foundation is sponsoring a three-year, SFI-led program designed to attract New Mexico girls to careers in science, technology, engineering, math, and information and communications technology – fields in which women are historically under-represented.

"Learning technical and computing skills will give young people the background needed to succeed in these fields," says Irene Lee, principal investigator for GUTS y Girls, which will provide extramural curricula for some 300 middle school girls.

Once-a-month Saturday workshops in Santa Fe will offer girls the opportunity to meet women scientists and professionals, participate in hands-on projects, and learn about career options. Two-week summer workshops are being held in Santa Fe, Albuquerque, and Las Cruces.

The program is an outgrowth of the successful 4-year-old, SFI-led Project GUTS (Growing Up Thinking Scientifically), an after-school program designed to encourage young people to ask questions about issues that affect their communities, investigate them through scientific inquiry, and devise potential solutions by modeling and analyzing them as complex systems.

GUTS y Girls includes a research component. Because girls tend to succeed when they see others like them succeeding, the program enlists women scientists as mentors and keeps girls and their mentors connected through a private social networking site. The research will investigate whether these activities promote and sustain girls' interest in science and math over time.

The program is a collaboration among SFI, MIT, the University of New Mexico, New Mexico Tech, New Mexico State University, the Santa Fe Complex, the Girl Scouts of New Mexico Trails, the Supercomputing Challenge, and New Mexico schools. ■

INSIDE SFI

Free online course examines today's physics frontiers



"Emergent Behavior in Quantum Matter," an online module created by SFI Science Board member David Pines, is part of Physics for the 21st Century, an 11-unit multimedia course exploring the current frontiers of physics.

Designed for adult learners such as high school teachers, undergraduates, and the interested public, Physics for the 21st Century

was developed at the Harvard-Smithsonian Center for Astrophysics by experimental physicist Christopher Stubbs.

The course presents an accessible overview of the rapidly advancing knowledge front in physics. It begins with an exploration of the basic building blocks of matter and ends with a unit on dark energy.

Two invited scientists also contributed to the quantum matter unit: New York University

professor Paul Chaikin and Rutgers University professor Piers Coleman.

"This is an exciting endeavor," David says. "It enables all kinds of people who are interested in science to learn more about the frontier fields in physics."

Physics for the 21st Century is available free at the Annenberg Foundation website at www.learner.org/courses/physics. ■

INSIDE SFI

Upcoming public lectures: Secret codes & market engineering

■ **Wednesday, April 13 – Sending Secrets: Security and Cryptography In a Quantum World.** The art of sending secret messages has come a long way since Julius Caesar shifted each letter three places in the alphabet. Much of modern computer science was born in the effort to break the Nazi Enigma code. Today we depend on cryptography, to send our credit card information over the Internet, for example. SFI Professor Cris Moore, professor of computer science, physics, and astronomy at the University of New Mexico, will describe how modern cryptosystems work, and how a future quantum computer could break them. He'll then give a personal view about whether quantum computers can be built – and what kinds of cryptography could remain secure even if and when they are built. Underwritten by Joy and Philip LeCuyer.

■ **Wednesday, May 18 – Can Financial Engineering Cure Cancer, Solve the Energy Crisis, and Stop Global Warming?** The important lessons from the spectacular failure of financial technologies could pave the way for some of the most significant achievements of the 21st century. Andrew Lo, Harris & Harris Group Professor at the MIT Sloan School of Management and Director of MIT's Laboratory for Financial Engineering, will provide a brief overview of the origins of the crisis, the key role that mathematics played, and how a deeper understanding of human nature may allow financial engineers to focus the enormous power of global financial markets on some of societies most pressing challenges. Underwritten by Dr. Penelope Penland.

All SFI community lectures are at the James A. Little Theater in Santa Fe and begin at 7:30 p.m. Admission is free, but seating is limited. ■



In SFI's first 2011 community lecture on March 2, SFI Diplomat in Residence Bill Frej of USAID explored the transition from conflict to stabilization to sustainable development in Afghanistan. The lecture was underwritten by Diana MacArthur, an SFI Trustee.

INSIDE SFI

2011 sustainability school in Brunei

The Universiti Brunei Darussalam (UBD) is hosting the 2011 Global Sustainability Summer School in Bandar Seri Begawan, Brunei, co-sponsored by IBM. Although SFI is not a sponsor for the 2011 school, the structure, topics, and lectures for the will be similar to the previous schools held at SFI. It is being organized by Deva Seetharam, an alumni of SFI's sustainability school.

The 2012 school is expected to be held in Germany, at the Potsdam Institute for Climate Impact Research.

For more information about the 2011 school, visit www.sustainability2011.org. ■



PEOPLE

SFI's Orlando Montoya: Keeping the Institute humming for 17 years

Seventeen years ago when the first Institute scientists arrived at what is now Cowan Campus, Orlando Montoya was here. And he's been here ever since.

"I tell people I came with the house," he laughs.

Orlando makes possible the Institute's constant hum of activity by keeping the lights on, keeping the boiler running, and performing (with a smile) myriad other activities critical to SFI's smooth operation. He started working on the property in 1969, when it was owned by the family of Gen. Patrick Hurley, the former U.S. Secretary of War and New Mexico candidate for U.S. Senate.

Though he works half time, Orlando handles about 200 work requests per year. He is the expert on any repair, from plastering walls to unclogging sinks, and is on call for snow

removal and maintenance emergencies.

Ronda K. Butler-Villa, SFI's Director of Publications, Facilities, and Personnel, says he possesses the rare combination of general know-how and an intimate knowledge of the property and its history, as well as SFI's culture and people.

The property has been more than a workplace for Orlando; he and his wife lived in the gatehouse at the bottom of the drive for 10 years and raised two of their three children there. In heavy snow the driveway became a sled run, where his son and daughter spent hours hurtling down the hill on inner tubes.

In his spare time Orlando enjoys restoring vintage cars. His current projects include a 1951 Ford Custom Victoria and a 1946 Ford pickup truck, which is often seen and appreciated around SFI. ■



RESEARCH NEWS

Certain airline networks are more resilient

Southwest Airlines' lack of a hub-and-spoke network makes it more resilient to a number of disruptions, from weather problems to terrorism. But it's easy to make the other airlines' hub-and-spoke networks more robust.

Using network simulations, SFI External Professor Raissa D'Souza and collaborators Daniel Wuellner and Soumen Roy, all of UC Davis, show that while hub-and-spoke networks are more economically efficient on good days, they are more susceptible to random interruptions (such as bad weather) and local interruptions (such as airport security shutdowns).

Flight networks with large, densely connected subnetworks called "k-cores" – like Southwest's network – remain better connected when specific flights or airports are removed. Southwest's average travel time increased only 4 percent in the simulations after removing a targeted 10 percent of its airports, while travel times for the next-best airline, American, increased 25 percent.

Fortunately, the authors argue, it's easy to make the whole network more robust by concentrating on small subnetworks and adding routes there.

Their paper was published November 2 in *Physical Review E*. ■

RESEARCH NEWS

Study: Phone communities coincide with political boundaries

Analyzing a database of 12 billion British telephone calls, three researchers affiliated with SFI have found that phone interactions among people coincided remarkably well with regional administrative boundaries established by governments.

Their algorithm also detected a new "region" west of London, around a growing center of high-tech industry – the British version of Silicon Valley.

The research team included former SFI

External Professor Steven Strogatz (Cornell University), former SFI postdoctoral fellow Michelle Girvan (University of Maryland), and SFI External Professor Mark Newman (University of Michigan).

Communities and political boundaries probably evolved together over many centuries, the researchers suggested recently in *PLoS One*, with "cohesive patterns within society promoting change in administrative boundaries and the latter, in turn, affecting human interaction." ■

> Rhythmic fight schedules continued from page 1

Using a technique borrowed from astrophysics, they found that fights broke out on several more or less regular schedules, ranging from hourly to daily to weekly. And different kinds of monkeys used different clocks – for example, younger females tend to get involved in fights every few days, whereas younger males get involved in fights more regularly. A few animals who serve in policing roles by impartially breaking up skirmishes show up in fights about every hour.

The hourly schedule, the authors surmise, might reflect the cyclical need for conflict management: a rowdy group forms, police come to break them up and then leave, and the group forms again.

"Having an hour-long policing clock reminds everyone that police are present and so they better not get too out of line," Jessica says. "It's an interesting, perhaps more efficient way of managing conflict than simply intervening only after a fight gets really big and hard to control."



(Image: Irwin Bernstein)

Biological clocks are ubiquitous; they are seen in the daily cycle of sleep and waking, and from the long, yearly cycles of species migration down to the millisecond fluctuations seen in "gamma" waves of the human brain. The results of this study suggest that social clocks might also be ubiquitous and might play a critical role in making social interactions orderly and predictable, David says.

The results, published February 16 in *Proceedings of the Royal Society B - Interface*, might eventually help scientists understand how complex societies with roles and a division of labor evolve, adds Simon. ■

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Multimedia and supplementary content available at www.santafe.edu



Audio: 'Cityness' and how it is measured

On WNYC public radio, SFI researchers Geoffrey West and Luis Bettencourt discuss their attempts to find universal laws and constants governing cities and city life everywhere.



News release: Plotting a contagion's spread

An NSF news release describes a study co-authored by SFI Science Board member Marcus Feldman in which the researchers tracked person-to-person interactions at a high school and used the resulting data to develop a network structure of the population, examining the frequency and distribution of contacts and their relationship with disease-spreading events.



Audio: What ants tell us about complex systems

In an online radio interview with Newstalk, a talk radio program in Ireland, SFI Science Board member Deborah Gordon discusses her work monitoring the movements of individual ants within colonies and describes what she has learned from them about the evolution of complex systems.



Audio: How science can serve diplomacy

AAAS President and SFI External Professor Nina Fedoroff kicked off the 2011 AAAS annual meeting in Washington, D.C. with an NPR Science Friday radio interview about how science can be used by policy makers for improved diplomacy.