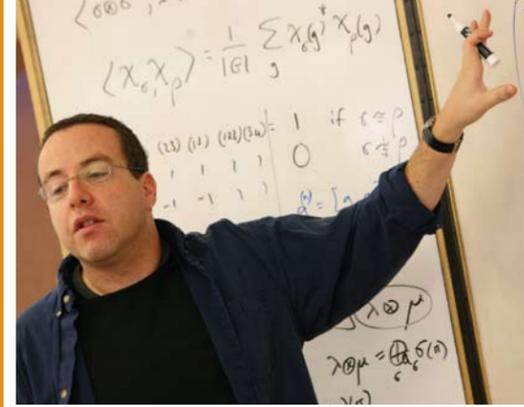




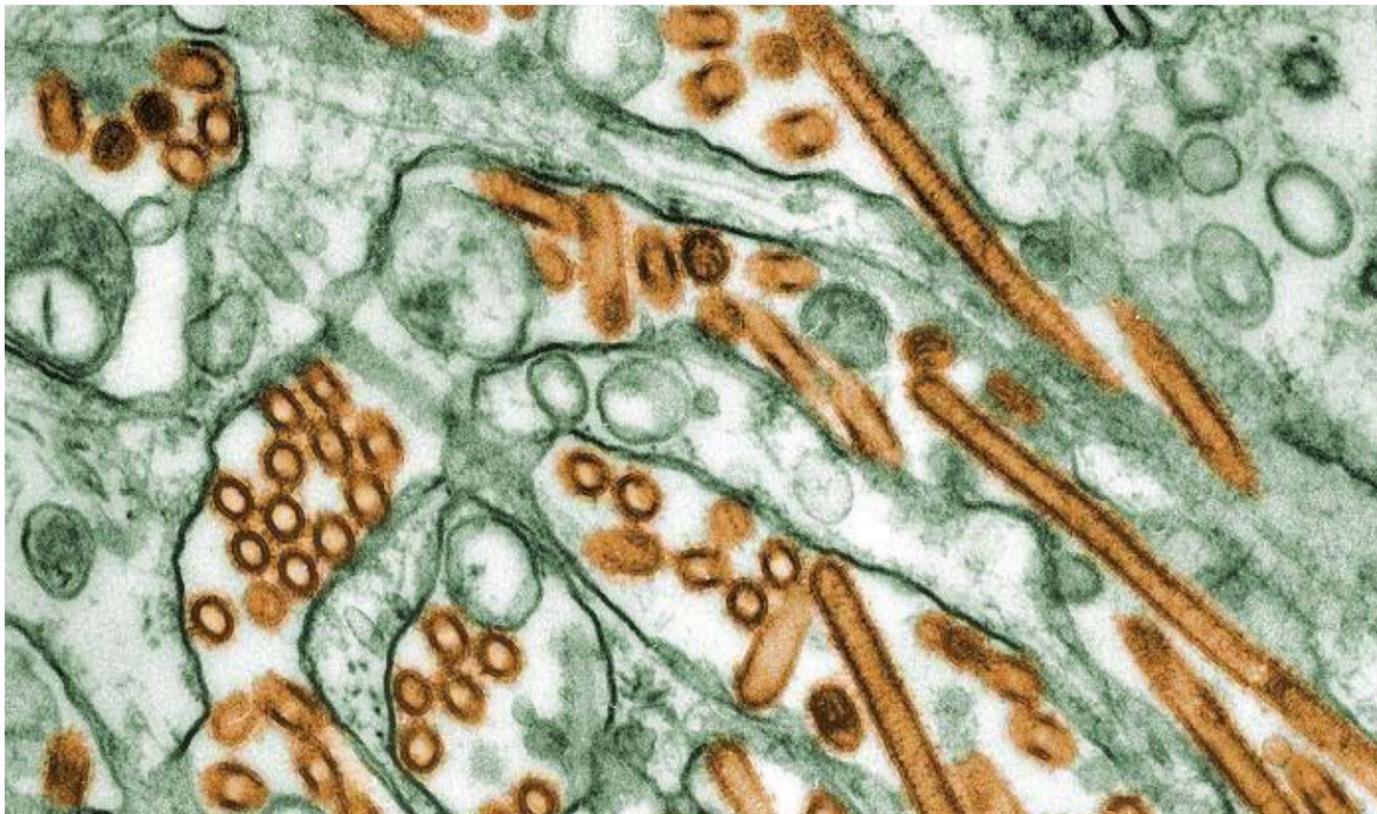
Update

November 2008



RESEARCH NEWS

Stopping flu globally by acting locally



Transmission electron micrograph of Avian influenza A H5N1 (orange) in cell culture (green)

(Image: CDC)

Human health on a worldwide scale may hinge on whether poultry workers in West India get treated for flu symptoms.

Chicken coops are breeding grounds for new varieties of influenza, which can sometimes jump from birds to humans. When this does occur, poultry workers will be the first to get sick.

As part of a grant from the National Science

Foundation, SFI Postdoctoral Fellow Dan Hruschka and collaborators at Emory University will study how and when poultry workers in the West Indian city of Surat go to doctors or healers for treatment of flu-like symptoms.

So far, the avian flu can't efficiently pass from human to human. But many scientists believe the virus is bound to evolve that capability eventually. Preventing a pandemic

could depend on how early scientists realize a flu strain has developed the ability to travel from human to human.

Dan's role in the Surat study will be to gather and analyze social network data showing how people refer one another to health care providers. That data could help the researchers suggest ways to recognize human-to-human spread of a flu strain at the earliest possible moment. ■

RESEARCH NEWS

Fighting modern malware: Whose job is it anyway?

Identity theft: merely aggravating. State-sponsored electronic warfare: potentially catastrophic.

Participants in an SFI workshop October 15-17, "Modern Malware III: Fighting Modern Malware," took a hard look at the range of threats lurking in today's hyperconnected electronic world.

The three-day meeting was the third in an SFI "Modern Malware" series designed to apply SFI-style cross-disciplinary thought to one of modern society's most pressing problems. Its organizers included Matt Williamson of Sana Security, Eric Davis of Google, and Allyn Romanov of Cisco. Google and Cisco are SFI Business Network members.

Nearly two-dozen participants brought a variety of perspectives to the table; together they represented computer security software developers, internet service providers, domain name registrants, electronic commerce,



(Image: ©iStockphoto.com/Robert Kyllö)

federal law enforcement, and other players in the online community.

Society's dependence on electronic communication and commerce makes the Internet an attractive medium for bad actors, says Institute Vice President Chris Wood, and workshop participants noted that the victims of malware are not necessarily rewarded for combating it.

"The relationship between an individual's or organization's ability to do something about malware and their incentive to do so is absolutely out of whack," he says.

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INSIDE SFI

Symposium explores next 25 years

The Institute is inaugurating its 25th anniversary year by exploring the future.

"Open Questions," a two-day Business Network and Board of Trustees Symposium November 7 and 8 at the Eldorado Hotel in Santa Fe, will focus on the scientific, technological, and organizational challenges facing society in the next 25 years. (See "SFI turns 25" on page 3.)

Morning sessions will address significant questions in various scientific disciplines. Afternoon sessions are designed to provoke discussions on issues that will shape the evolution of business and society.

On Friday morning, November 7, Lee Smolin of the Perimeter Institute for Theoretical Physics will be the keynote speaker during a session on "Open Questions in Science." The afternoon is dedicated to a roundtable discussion of challenges in science education for the next generation.

On Saturday morning, November 8, SFI External Professor Mark Newman of the University of Michigan will address the promises and challenges of network theory as a methodology for integrative science.

The November 8 afternoon session will feature a Business Network roundtable that begins with comments by Eric Bonabeau, founder and CEO of Icosystem and a former SFI Postdoctoral Fellow, entitled "Deep, pervasive, and unbranded: SFI's first 25 years of influence on business thinking."

On Saturday evening, November 8, the Institute will host a gala dinner with the theme "The Road Less Traveled" at the hotel to inaugurate SFI's 25th anniversary. Tickets are nearly sold out at the \$500 and \$1,000 level.

"SFI is known globally for its contributions to science and society," says Shannon Larsen, SFI Executive Director of Development and Corporate Relations. "It is only appropriate

> more on page 4

SFI IN THE NEWS

Past work by SFI External Professor Mark Newman and SFI Postdoctoral Fellow Michael Gastner was referenced in a September 18 *Nature* article about national science indicators. *Nature* created a series of cartograms to illustrate disparities among states in federal science funding per capita and other indices. The maps were made using 2008 data from the NSF. "Perhaps the best-known use of cartograms is the 2004 analysis of U.S. presidential election results by [Mark and Michael] of the Santa Fe Institute in New Mexico, who are experts in social and information networks. Whereas standard maps showed the United States awash in red Republican votes, cartograms that adjusted state and county areas on the basis of their population gave a more accurate picture, with roughly equal areas of red and blue." www.nature.com/news/2008/080917/full/455270a.html (subscription required)

A September 19 *Nature* article about the future of evolutionary theory and the synthesis of thought from genetics and developmental biology quoted SFI Professor David Krakauer. "It's a matter of finally unifying two areas that haven't spoken to one another," he says. "To tackle any modern problem in evolutionary biology, you'll have to use development and the dynamics of the genes that underlie it." He's quite enthusiastic about the possibility of bringing together mathematical theories of pattern formation...and the large body of theory on genetic change between generations used by population geneticists...But at the same time, he can see forces beyond the content of the theories that may keep them apart: "It's not about totally incompatible world views, it's about who holds the torch – who are the legitimate heirs to the Darwinian intellectual estate." www.nature.com/news/2008/080917/full/455281a.html (subscription required)

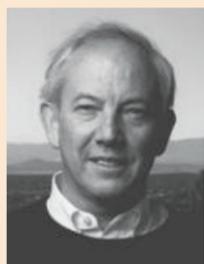
An October 1 op-ed in the *New York Times* by theoretical physicist and author Mark Buchanan cited the work of three SFI-affiliated researchers to better understand financial market performance through agent-based modeling. The article blames day-to-day uncertainty about stock market fluctuation on economists' over-reliance on classical market-equilibrium theory. "Really understanding what's going on means going beyond equilibrium thinking and getting some insight into the underlying ecology of beliefs and expectations, perceptions, and misperceptions that drive market swings. Surprisingly, very few economists have actually tried to do this, although that's now changing – if slowly – through the efforts of pioneers who are building computer models able to mimic market dynamics by simulating their workings from the bottom up...For example, an agent model being developed by the Yale economist John Geanakoplos [SFI Science Board and Science Steering Com-

mittee Member, and SFI External Professor], along with two physicists, [SFI Professor] Doyne Farmer and [SFI External Professor] Stefan Thurner, looks at how the level of credit in a market can influence its overall stability...The model also shows something that is not at all obvious. The instability doesn't grow in the market gradually, but arrives suddenly. Beyond a certain threshold the virtual market abruptly loses its stability in a 'phase transition' akin to the way ice abruptly melts into liquid water. Beyond this point, collective financial meltdown becomes effectively certain. This is the kind of possibility that equilibrium thinking cannot even entertain." www.nytimes.com/2008/10/01/opinion/01buchanan.html?_r=2&ref=opinion&oref=slogin&oref=slogin

The October 2 *Christian Science Monitor* featured a study by SFI External Professor Jim Crutchfield (UC Davis) and Santa Fe-area sound artist David

AWARDS

Arthur wins Lagrange Prize



SFI External Professor W. Brian Arthur is one of two inaugural recipients of the Lagrange Prize for research in the science of complexity. Princeton mathematician Yakov Sinai

also received the inaugural prize.

Awarded by the Institute for Scientific Interchange Foundation (<http://www.isi.it>) and CRT Foundation (<http://www.fondazionecri.it>) of Turin, Italy, the 75,000 Euro prize is given for "outstanding scientific contributions to the field of complexity and complex systems in all disciplines."

In addition to his SFI External Professorship, Brian is a past member of SFI's Board of Trustees and Science Board. He currently is a visiting researcher at the Palo Alto Research Center's Intelligent Systems Lab.

His research interests include technological evolution, nonequilibrium models of economics, and theoretical frameworks for economic allocation. He has authored three books and is a noted speaker. ■

PEOPLE

Ladau leaves SFI for UCSF

SFI Postdoctoral Fellow Josh Ladau's last day at the Institute was October 10. He is now a Postdoctoral Fellow with the Gladstone Institutes at the University of California, San Francisco, where he is working on iSEEM, a metagenomics project funded by the Moore Foundation. ■

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RESEARCH NEWS

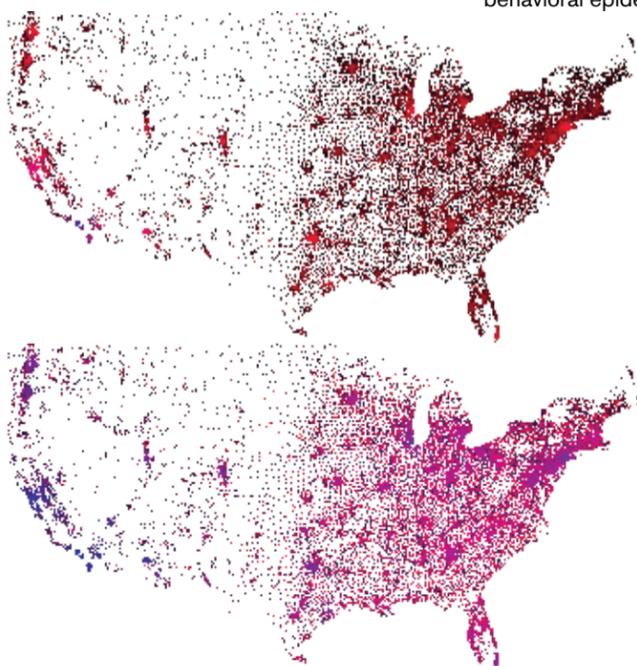
Model citizens: Preventing flu by understanding behavior

Influenza spreads as people travel. Vaccines can work only if people choose to take them. Sexually transmitted diseases can be stopped only if people adopt safe sex practices.

"Behavior matters a lot in disease," says Josh Epstein, an SFI External Professor, "and mainstream epidemiology hardly considers it."

So Josh is inventing a whole new field: behavioral epidemiology. Recently he

received a 2008 National Institutes of Health Director's Pioneer Award, a \$2.5 million grant over five years, to support his work.



Josh and his colleagues have developed an agent-based model of the U.S. population so they can watch how influenza spreads. The model approximates the lives of 300 million people traveling in realistic patterns among zip codes as they go from work to school to home. As they move from place to place, their maladies move too – infecting new people.

Simulations show how a flu virus can spread across the U.S. Black dots indicate people who are healthy and susceptible. Red dots show people with active cases. Blue dots show those who have had it.

The researchers also have used a global version of the model to study how travel restrictions affect a flu's

spread. As they expected, restricting air travel between large cities tended to delay its spread from country to country.

Surprisingly, though, the researchers found that in some situations such restrictions could make a flu epidemic worse in particular areas. For instance, delaying the spread of a new flu virus that originates in Asia could cause it to hit the U.S. during winter instead of summer, greatly increasing its wallop.

One way to protect people from emerging flu viruses is to develop techniques to quickly create new vaccines.

"That's a laudable and important goal," he says, "but the assumption is that if they produce a vaccine, people will take it. I think that's very questionable."

He points to a study that showed that more than half the surveyed residents of Washington, D.C., and New York wouldn't accept a smallpox vaccine even during a confirmed smallpox attack.

These and other examples convince Josh that "behavior is a central frontier in epidemic modeling." ■

AWARDS

Hartle wins APS Einstein Prize



James Hartle, SFI External Professor and Professor of Physics Emeritus at UC Santa Barbara, has been awarded the 2009 Einstein Prize by the American Physical Society.

James's award citation reads: "For a broad range of fundamental contributions to relativistic stars, quantum fields in curved spacetime, and especially quantum cosmology."

His scientific work is concerned with the application of Einstein's theory of general relativity to realistic astrophysical situations, especially cosmology. He is currently focusing on the earliest moments of the big bang where quantum mechanics, quantum gravity, and cosmology overlap. ■

The biennial award recognizes outstanding accomplishments in the field of gravitational physics. It is open to scientists worldwide.

PERSPECTIVES

What the candidates say about science

The U.S. presidential candidates' positions on climate change and 13 other issues in science are detailed at Science Debate 2008 (www.sciencedebate2008.com), an online compilation of the candidates' answers to questions posed by the nation's science community.

Leading researchers initially submitted more than 3,400 questions they wanted the candidates to answer. The questions were pared down to the top 14 by groups representing the AAAS, the National Academies, and other organizations. The final list of questions covers

issues from energy and health care to scientific integrity and government interference.

More than 38,000 leading scientists and engineers have signed on in support of Science Debate 2008, including several researchers affiliated with SFI.

Another site sponsored by Science & Engineers for America tallies congressional delegates' voting history on, and candidates' responses to, key scientific issues (<http://sharp.sefora.org/>). ■

> Modern malware continued from page 1

An individual PC user, for example, could keep his or her system up to date with the latest security software but has little incentive to do so because the software is frequently expensive and requires effort, and the damage the malware causes to the individual – perhaps a small performance setback – is relatively minor compared to the potential system-wide or society-wide damage of unknowingly participating in organized malware such as "botnets."

Likewise, internet service providers are technically capable of identifying and blocking suspicious activity but typically view their role as providing the paying user connectivity and bandwidth – not malware protection.

Each player in the online world faces a similar tradeoff, such that no player views fighting the problem as a worthwhile endeavor.

Participants hope to bring attention to these tradeoffs and generate a discussion of the need to revise the incentive structure for fighting malware.

"It's a multifaceted problem," says Chris, "involving software engineering, economics, social networks, the law, and criminal justice systems – exactly the kind of problem to which SFI can productively contribute." ■

SFI IN THE NEWS

Dunn to “listen to the ultrasonic complaints of drought-stricken, beetle-infested piñon pines, yielding new insights into the trees’ plight...The two found that trees stressed by drought emit sounds pitched too high for human hearing. The researchers suspect that bark beetles detect these sounds and thus locate weakened trees to attack. The beetles also emit ultrasounds with which they communicate among themselves. This, too, may attract more beetles to a tree under attack...If true, it may be possible to use ultrasound to divert and confuse the beetles and thus protect vulnerable trees.” <http://features.csmonitor.com/innovation/2008/10/02/can-we-save-forests-by-listening-to-trees/>

The October 6 *Christian Science Monitor* reviewed the conclusions of a research team that includes SFI Postdoctoral Fellow Michael Gastner showing that closing off certain streets can relieve traffic

congestion. The researchers’ study of transportation patterns as networks has been widely cited. <http://features.csmonitor.com/environment/2008/10/06/does-closing-roads-cut-delays/>

SFI Distinguished Fellow and Trustee Murray Gell-Mann was quoted in an October 7 *Scientific American* profile of Japan-born American physicist Yoichiro Nambu (University of Chicago). “Over the years, you could rely on Yoichiro to provide deep and penetrating insights on very many questions,” said Murray. Nambu was awarded the 2008 Nobel Prize in Physics for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics. The article is a reposting of a *Scientific American* article first published in February 1995. www.sciam.com/article.cfm?id=profile-yoichiro-nambu&page=2

An October 10 *New Scientist* article mentioned the work of political scientist and SFI Postdoctoral Fellow Nathan Collins describing the tendency of people to misunderstand or misrepresent a politician’s stance or record based on how the person making the judgment categorizes that candidate – as Republican or Democrat, for example. “The categorizing process, which has been shown to help explain how we learn and remember things, has now been modeled for political beliefs by Nathan Collins, a political scientist at the Santa Fe Institute in New Mexico. In a paper being considered for publication by *The Journal of Politics*, he finds that voters are more likely to misremember a candidate’s position if it conflicts with the party line. And that, says Collins, opens the door to deceptive campaigning.” www.newscientist.com/article/mg20026774.400-our-psychology-helps-politicians-bend-the-truth.html

SFI Professor Sam Bowles was quoted in an October 14 segment of PBS NewsHour with Jim Lehrer focused on inequality in New Mexico. The piece, part of a series on New Mexico as a political battleground state, explored the implications of sharply contrasting levels of prosperity in Northern New Mexico, between nearby cities Los Alamos and Espanola, for example. Sam discussed the effects, and failures, of trickle-down economic policies. “America is distinct in the extent to which inequality is inherited from generation to generation,” he said. “The kids of rich parents have a strong tendency to be rich. And the kids of poor parents are very, very likely to be poor, to a far greater extent than is true of any other country, except for England. That’s a huge discrepancy from what we think of as the land of opportunity.” www.pbs.org/newshour/bb/politics/july-dec08/nmeconomy_10-14.html

RESEARCH NEWS

Seeking quantum-sized problems

SFI External Professor Joseph Traub has been awarded a National Science Foundation grant to continue his work on quantum and classical complexity of continuous problems.

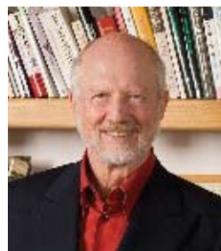
Joe works on continuous problems because so much of science – including molecular dynamics, quantum mechanics, and general relativity – uses continuous mathematical models. An example of such a model is Schrödinger’s equation, which describes how the quantum state of a physical system changes in time.

But classical means of computing answers to such complex problems can often take a long

time. Joe and colleagues hope to find continuous problems for which quantum computation leads to big wins over classical computation.

To prove that quantum computing can solve a problem faster than classical means, one must know both the classical and quantum computational complexity of a problem. Joe and his collaborators have invented arguments to establish both.

For example, one common application in physics and chemistry involves computing the ground state energy of a system. For decades, scientists have found it much harder to solve for a large number of particles. One of the



goals of the project is to prove that a quantum computer would solve the problem exponentially faster than by classical means.

Joe is the Edwin Howard Armstrong Professor of Computer Science at Columbia University. He says he always aims to explore new areas – or, as he puts it, “I like to walk along picking up diamonds. I don’t like to do strip mining.”

His approach works: Every one of his proposals to the NSF has been funded since he joined academia in 1970. ■

PEOPLE

SFI Trustee Esther Dyson begins training for spring 2009 launch

Institute Trustee Esther Dyson is heading for space...maybe.

Esther, a longtime tech pundit and investor, announced October 7 she will begin cosmonaut training this winter in hopes of a March 2009 trip to the International Space Station aboard a



(Image: www.edventure.com)

Russian-built Soyuz spacecraft. She’ll serve as a backup crew member to American software developer Charles Simonyi.

She estimates her chances of making it into orbit this spring at about 1 in 20.

“If, for some reason, he doesn’t go, I get to go instead,” she wrote in her Flight School blog (<http://www.edventure.com/flightschool/blog/>), where she will record her training during the next several months.

Esther is an investor in Space Adventures, a Virginia-based company that arranges space flights for paying private citizens. This would be Simonyi’s second time in space. He paid \$25 million for his first trip last spring.

Esther will spend much of this winter at

Russia’s Star City training facility near Moscow. By the end of her training she will be certified as a trained cosmonaut and assigned to the space crew as Simonyi’s backup.

An author, prognosticator of IT advances, and investor in emerging technologies and companies, Esther founded the Flight School conference in 2007 for entrepreneurs engaged in air and space ventures.

Her father, physicist Freeman Dyson, participated in Project Orion in the late 1950s, an effort to develop a spacecraft powered by nuclear pulse propulsion.

She says once she is trained, her chances of making it into space improve greatly – if not this spring, eventually.

“I have always assumed I will go into space myself,” she says. ■



A Soyuz spacecraft approaches the International Space Station during a November 2005 mission. (Image: NASA)

INSIDE SFI

First-ever SFI summer school in Latin America begins Dec. 1

Organizers of the Institute’s first Complex Systems Summer School (CSSS) to be held in Latin America hope to capture the spirit of SFI’s contribution to complexity science, emphasizing the fundamental ideas and leading edge research in complex systems.

The school, themed “Foundations and Frontiers of Complex Systems,” will begin December 1 on the scenic fringes of Patagonia, in San Carlos de Bariloche, Argentina.

During the two-week session, instructors want to offer participants an intensive experience, says SFI Postdoctoral Fellow Miguel Fuentes, the school’s co-director with former SFI International Fellow Pablo Marquet of Pontificia Universidad Católica de Chile.

In lectures by distinguished speakers, discussions, and hands-on projects, 40 graduate and postdoctoral students representing physics, biology, and mathematics will focus on interdisciplinary studies in nonlinear dynamics, pattern formation, dynamics of living systems, scaling, and network theory.

Christine Lamanna, a PhD student at the University of Arizona whose current field is ecology and global change, will be one of the students attending the school.

“I will be able to interact with other scientists who care about similar issues as I do, but approach them from different angles,” she says. “I can’t imagine what amazing insights people could bring to climate change ecology from the disciplines of network theory, nonlinear dynamics, and more.” ■

SFI TURNS 25



Recollections of SFI’s past: George Cowan

When a small group of Los Alamos National Lab senior fellows, during lunch meetings at the lab cafeteria, first dreamt of a place where interdisciplinary thought could be nurtured, none could have predicted that today, 25 years later, complexity science would have its own, secure place in mainstream scientific thought.

Nor could they have predicted that the seeds they planted in those early days would sprout a dozen or so institutes and university research departments around the world similarly dedicated to the field.

George Cowan, Lifetime Trustee Emeritus, Distinguished Fellow, and Founding President of the Institute, says the group “enthused” immediately about the idea of an institute run by scientists. It was late 1982.



The idea came together a few months later when Murray Gell-Mann, now SFI Distinguished Fellow and Trustee, came to the group to describe what he had in mind. “That’s when we decided we could do it,” says George.

By early 1984, two challenges stood in their way. The name “The Santa Fe Institute” was owned by a local drug and alcohol rehabilitation clinic.

And they had no funding.

Problem one was solved when the clinic went out of business and the group registered the name. Problem two required more effort.

Philanthropist Art Spiegel (of the Spiegel catalog), who had just moved to Albuquerque from Chicago, helped secure a handful of investors, while Murray eked a couple of grants from foundations such as the John D. and Catherine T. MacArthur Foundation.

Some of the Institute’s principals were able to stay on the lab payroll while the fledgling effort grew its wings.

“[Former Los Alamos Director] Sig Hecker was instrumental in getting us off the ground,” George says. ■

Institute Postdoctoral Fellow search closes November 14

The Institute is wrapping up its annual search for SFI Postdoctoral Fellows. Appointed for up to three years, SFI postdocs explore independent projects that lie at the boundaries of traditional scientific fields, often pursuing research questions of their own design.

Fellows are encouraged to invite speakers, organize workshops and working groups, engage in research outside their fields, and collaborate with SFI faculty, other postdocs, and researchers from around the world. Funds are available to support their activities.

"We hope everyone in the SFI community will help by bringing this opportunity to the attention of talented students in their fields," says SFI Professor Jon Wilkins, who is heading up this year's search.

Applications are being accepted through November 14. Appointments begin in fall 2009.

Information about the application process can be found at www.santafe.edu/postdoc. ■

Economics Nobel goes to Krugman

Princeton economist and *New York Times* columnist Paul Krugman has won the 2008 Nobel Prize in economics for his analysis of how economies of scale work in concert with population levels and transportation costs to affect global trade.

Krugman contributed a chapter, "How the Economy Organizes Itself in Space: A Survey of the New Economic Geography," in the SFI book *The Economy as an Evolving Complex System II*. The book is part of the SFI series, Santa Fe Institute Studies in the Sciences of Complexity (Addison Wesley Longman, 1997). ■

Language diversity of measured quantum processes; Wiesner, K.; **Crutchfield, Jim [SFI External Professor]**; *International Journal of Unconventional Computing* 4 (1), 2008, pp. 99-112

Strong reciprocity and the roots of human morality; **Gintis, Herbert [SFI External Professor]**; **Henrich, J.**; **Bowles, Sam [SFI Professor]**; **Boyd, Robert [SFI External Professor]**; **Fehr, E.**; *Social Justice Research* 21 (2), June 2008, pp. 241-253

Data completeness – The Achilles heel of drug-target networks; **Mestres, J.**; **Gregori-Puigjane, E.**; **Valverde, S.**; **Solé, Ricard [SFI External Professor]**; *Nature Biotechnology* 26 (9), September 2008, pp. 983-984

Smithsonian acquires portraits of SFI icons

The Smithsonian National Portrait Gallery has acquired the portraits of two Institute icons – SFI Distinguished Fellow, SFI Trustee, and Nobel laureate Murray Gell-Mann and Pulitzer Prize-winning author Cormac McCarthy – to add to its permanent collection of famous Americans.

The Smithsonian acquired the paintings, by acclaimed artist Andrew Tift, from Andreeva Portrait Commissions of Santa Fe (www.luxuryportraits.com).

The images are part of a series of 23 commissioned in 2003 by gallerist/owner Tatiana Andreeva as a millennial portrait record of Northern New Mexicans. The eclectic collection, "New Mexico Faces," includes portraits of scientists, activists, artists, musicians, flea market sellers, a Vietnam veteran, and a waitress, among others.

Tift, winner of the prestigious BP Portrait Award Best of Show 2006 at London's National Portrait Gallery, visited the Institute to meet both men before painting them. ■



Murray Gell-Mann



Cormac McCarthy

(Images courtesy of Andreeva Portrait Commissions)

> Annual symposium continued from page 1

that the events of our silver anniversary be focused on the future – where is the world going and how will SFI's multidisciplinary approach help us understand and shape the next 25 years?"

Other selected speakers and topics:

- "The challenge of complexity from the perspective of a mathematician," Donald Saari, SFI Science Board Member, UC Irvine
- "Science diplomacy," Nina Fedoroff, SFI External Professor and Science and Technology Advisor to the U.S. Secretary of State
- "Why we must all be scientists at heart," Laurence Gonzales, author, *Deep Survival* and *Everyday Survival*
- "Individualized medicine for the sick and the healthy," Avidan Neumann, SFI External Professor, Bar Ilan University
- "The future of archeology: Why the past matters now," Henry Wright, SFI External Professor, University of Michigan



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