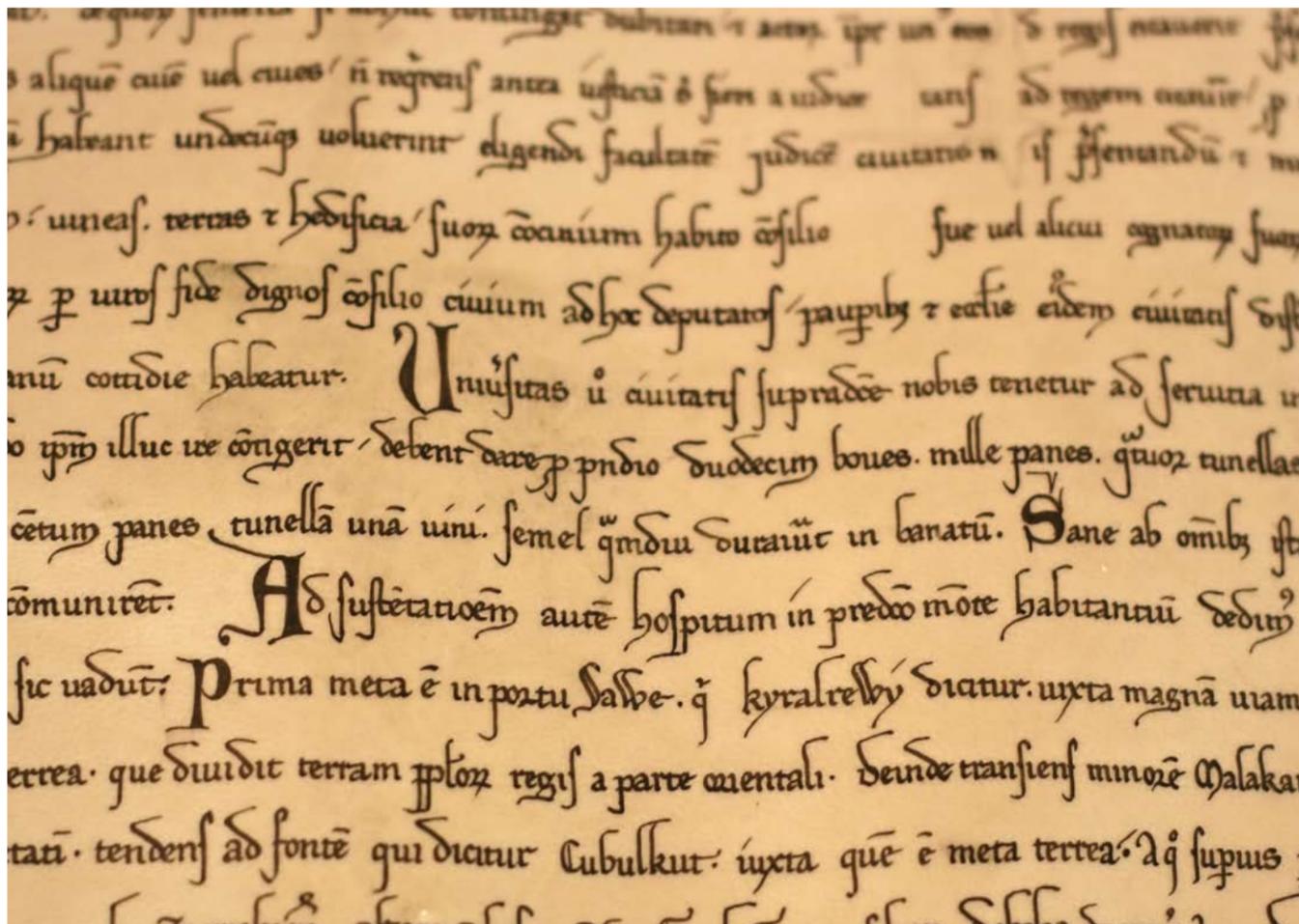
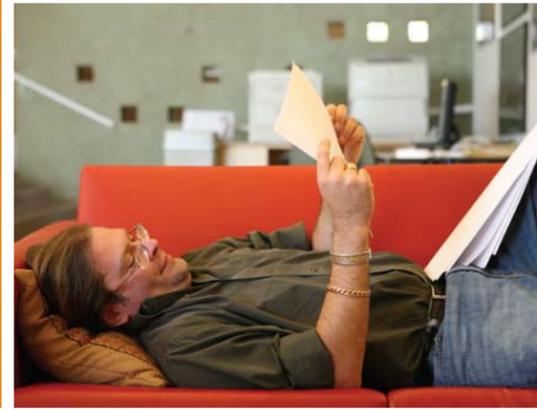




Update

February 2008



Medieval Latin script on parchment

(Image ©iStockphoto.com/Gordana Sermek)

RESEARCH NEWS

February workshop links efforts in language, linguistics, and computation

Dozens of researchers from various fields are gathering at SFI this month to discuss development of computational models that would help linguists understand how languages change and, on a larger scale, possibly address some of humanity's biggest questions.

"Where do we come from and what's our history?" says SFI Postdoctoral Fellow Dan Hruschka. "Language can provide a lens through which to view these questions."

The Feb. 18-20 workshop, Building Integrated Models of Linguistic Change, is organized by Dan, Morten Christiansen (Cornell University), and SFI Professor Steve Lansing. (For more information and a list of speakers: www.santafe.edu/events/)

In recent years researchers have built linguistic models focusing, typically, on narrow aspects of linguistic structure or on individual agents of linguistic change. Models integrating a greater set of linguistic problems would prove useful, says Dan, particularly if they account for processes occurring across time scales and levels of linguistic structure, as well as those resulting from both internal and external influences.

"There is an emerging cohort of computationally trained experts in linguistic evolution," he says. "This is a good place to foster conversation among those people."

Beyond its computational focus, the workshop is a first-of-its-kind opportunity to bring together the many SFI collaborators studying language-related

topics from a variety of fields and perspectives. Speakers represent such fields as linguistics, computation, statistics, genetics, and sociology.

SFI President and Distinguished Professor Geoffrey West says the integration of current and potential future projects in language is the subject of an SFI Science Board analysis in 2008.

One central SFI effort, the Evolution of Human Languages (EHL) project, seeks to investigate degrees of genetic relationship among the world's languages. EHL researchers have begun compiling a comprehensive network of etymological data that could lead to a better understanding of language ancestry dating back many millennia. SFI Distinguished Fellow and Trustee

> more on page 2

IMPACT

Researchers search for patterns in society

Are there rules, akin to the laws of physics, that explain the patterns and regularities that arise in human society?

Participants in a three-day January workshop in Santa Fe, organized by SFI Postdoctoral Fellow Aaron Clauset and Michelle Girvan (former SFI postdoc, now University of Maryland), addressed that question drawing on principles of statistics, physics, computation, chemistry, political science, and sociology.

"The range of typical behaviors in society is narrower than one would expect," says Aaron. "Embarrassment, peer pressure, and other social factors determine much of what I do."

On a population-wide scale, these patterns often manifest themselves as predictable regularities, he says. Recent SFI work, for example, has found scaling laws for cities that suggest group-level behavior of residents of a community often is a function of the city's size.

Much of the workshop discussion explored how social behavior at the individual level aggregates into more predictable group behavior, says Aaron, and how individual choice transitions into population behavior.

"As you increase group size, the range of behaviors narrows," he says. "When do the laws of the group take over? It's an important question."

> more on page 2

IN THIS ISSUE

- > Lit Bits 2
- > SFI In The News 2
- > Three new postdocs 2
- > Statistical archaeology 3
- > Buckley to NCEAS 3
- > Waldrop returns 4
- > Wilkins' book 4

LIT BITS

Component sizes in networks with arbitrary degree distributions; **Newman, Mark [SFI External Professor]**; *Physical Review E* 76, October 2007, pp. 17-20

Unanimity rule on networks; Lambiotte, R.; **Thurner, Stefan [SFI External Professor]**; Hanel, R.; *Physical Review E* 76, October 2007, pp. 49-56

Self-organization versus hierarchy in open-source social networks; Valverde, S.; **Solé, Ricard [SFI External Professor]**; *Physical Review E* 76, October 2007, pp. 185-192

Topology and evolution of technology innovation networks; Valverde, S.; **Solé, Ricard [SFI External Professor]**; Bedau, M.A.; **Packard, Norman [SFI External Professor]**; *Physical Review E* 76, November 2007, pp. 193-199

For distinguishing conjugate hidden subgroups, the pretty good measurement is as good as it gets; **Moore, Christopher [SFI Professor]**; Russell, A.; *Quantum Information & Computation* 7 (8), November 2007, pp. 752-765

The origin of the RNA world: Co-evolution of genes and metabolism; Copley, S.D.; **Smith, Eric [SFI Professor]**; **Morowitz, Harold [SFI Science Board Chair Emeritus]**; *Bioorganic Chemistry* 35 (6), December 2007, pp. 430-443

SFI IN THE NEWS

SFI External Professor Scott Page was featured in the Jan. 8 *New York Times*. His recent work reveals the value of a diversity of perspectives in organizations. "In the long-running debate on affirmative action, Scott E. Page, a professor of complex systems, political science and economics at the University of Michigan, is a fresh voice," said the article. "His recently published book, *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools and Societies* (Princeton University Press), uses mathematical modeling and case studies to show how variety in staffing produces organizational strength." Later in the interview Scott said: "Breakthroughs in science increasingly come

from teams of bright, diverse people. That's why interdisciplinary work is the biggest trend in scientific research."

Another Jan. 8 *New York Times* article commemorating the 50th anniversary of the landmark 1957 *Physical Review* paper "Theory of Superconductivity" mentioned the role SFI Science Board Member David Pines played in advancing the scientific understanding that led to the paper. "In 1955, David Pines...came up with the first breakthrough. Negatively charged electrons generally repulse each other, but Dr. Pines showed that vibrations in the lattice of nuclei could generate a minuscule attraction. When an electron

CREDITS

Editorial staff

John German
Ginger Richardson
Della Ulibarri

Contributor

Howard Kercheval

Design and production

Michael Vittitow

The SFI Update is published monthly by the Institute to keep our community informed about current work and activities. Please send comments to Ginger Richardson at grr@santafe.edu.

ON & OFFS

For SFI's schedule of workshops, lectures, and colloquia:
www.santafe.edu/events/index.php

COMINGS & GOINGS

For a schedule of SFI visitors:
www.santafe.edu/events/calendar-visitors-week.php

> Language workshop continued from page 1

Murray Gell-Mann leads the project with Russian collaborators Iliia Peiros and George Starostin.

In other work, Mark Pagel and colleagues are quantifying the varying rates at which related words are replaced by other forms during the cultural evolution of languages. In a paper published in the November 11, 2007, issue of *Nature* they postulate a relationship for word change that appears to hold over millennia – namely that frequency of use in part determines replacement rate.

Morten Christiansen and collaborators have hypothesized that the human capacity for language might be partially or wholly the result of the adaptation of language to human abilities. The work challenges a long-held tenet of linguistics that the human endowment for language use evolved to fit a universal grammar or language construct.

Several other language- and linguistic-related projects are under way by researchers affiliated with the Institute.

> Patterns in society continued from page 1

SFI External Professor Rob Axtell (Brookings Institution) described the use of two agent-based models to understand firm formation as a social phenomenon. One model depended on individual choice, and the other abstracted away individual behavior completely. Both methods produce the same results. In other words, says Aaron, some social phenomena can be viewed in two ways, one where individual choice matters, and one where it doesn't.

David Gibson (University of Pennsylvania) discussed how the human desire to fit in socially with others can shape the range of acceptable individual choices, in conversation or when standing in line, for example. "Thus, in some contexts, you might not even need that large a group before social constraints cause people to behave in highly predictable ways," says Aaron.

Workshop participants also noted similarities and differences – methodologies, language, and level of investment, for example – between physics and

sociology. One important difference is the relative difficulty in obtaining high quality data in sociology, although computing and microelectronic technologies are increasingly benefitting sociologists, says Aaron.

Matthew Salganik (Princeton University) described research to understand fads in music, with results suggesting that the perception of the success of a pop culture product can become a self-fulfilling prophecy. The study is an example of large scale research made possible by the internet.

The workshop was successful because it brought together natural and social scientists, who, says Aaron, "had a productive and wide-ranging discussion about the scientific, cultural, and institutional factors impinging on our ability to answer the question of whether there is a physics of society."

One outcome of the workshop, he says, might be a summary piece for *Science or Nature*, written by a small but interdisciplinary group of workshop participants, about the prospects and future of physics of society research.

INSIDE SFI

Institute welcomes three new Postdoctoral Fellows

Three new researchers joined the select group of SFI Postdoctoral Fellows exploring independent projects that lie at the boundaries of traditional academic disciplines and create new fields of inquiry.

SFI Vice President Chris Wood says that, unlike more traditional postdoctoral positions in which the postdoc works exclusively with a single faculty member, SFI Postdoctoral Fellows are encouraged to pursue research questions of their own design and develop collaborations with SFI faculty and other researchers from around the world.

"We are delighted to have them here and look forward to the intellectual vigor they will bring to the Institute's community," he says. "This year's postdoc cohort continues to expand the breadth of research at SFI."

The new fellows:

Caroline Buckee recently received a PhD from the University of Oxford. She researches the emergence, organization, and



Caroline Buckee

dynamics of living systems, focusing on the evolution and maintenance of pathogen diversity and population structure and evolutionary dynamics of the malaria parasite.

"Part of my work is experimental, measuring immunological responses of children from East Africa to different parasite antigens," she says. "More generally I am interested in the evolution of antigenic variation as an immune evasion strategy and the effects of immune selection on the evolution of pathogen species."



Nathan Eagle

Nathan Eagle focuses on machine perception and learning of complex social systems within the research areas of dynamics and quantitative studies of human behavior; emergence, organization and dynamics of living systems; and robustness in biological and social systems.

"Much of my research involves applying machine learning and network analysis techniques to large human behavioral datasets," he says. "The data I am



Under some conditions, as group size increases the range of behaviors narrows. (Image ©iStockphoto.com/Rafael Ramirez Lee)

For a complete list of workshop speakers and their presentation abstracts, visit SFI's events page at www.santafe.edu/events.

currently working on ranges from movement and communication data collected on individual mobile phones to social network and product adoption data of entire nations."

Nathan earned his doctoral degree from the Massachusetts Institute of Technology.



Willemien Kets

Willemien Kets joins SFI from Tilburg University in The Netherlands. She researches dynamics and quantitative studies of human behavior and robustness in

biological and social systems, focusing on game theory, networks, learning, and financial markets.

"My research focuses on the interplay between strategic interaction, networks, and incomplete information in social and economic settings," she says. "Current projects include work on the formation of diverse groups and on the effect of social structures on income inequality. I am also interested in information diffusion in financial markets and in learning processes."

passes near a positively charged atomic nucleus, the opposite electric charge slightly pulls the nucleus toward the electron. The electron flits away, leaving behind a positively charged wake, and that, in turn, attracts other electrons. Dr. Pines's result showed why the weight of the atoms mattered – heavier atoms accelerate more slowly."

A Dec. 19 article in *The Telegraph* (U.K.) described the work of a team of scientists that studied death rates in England and Wales during the 1918-1919 influenza pandemic. The article quoted from results of a study appearing in *The Proceedings of the Royal Society, Biological Sciences*, which concluded that

rural inhabitants were much less likely to die of the flu than those who lived in towns and cities, where death rates were 30-40 percent higher. SFI External Professor Luis Bettencourt (Los Alamos National Laboratory) was second author of the paper, "The 1918–1919 influenza pandemic in England and Wales: Spatial patterns in transmissibility and mortality impact." SFI was included in a list of research institutions having study contributors.

The Israeli daily newspaper *Haaretz* reported on an artificial intelligence system that "studies the treatment decisions made by good physicians and can use that information to help inexperienced physicians make correct

treatment decisions." The computer program was created by Dr. Ronen Tal-Botzer (Bar-Ilan University) under the tutelage of SFI External Professor Dr. Avidan Neumann (Professor of Life Sciences at Bar-Ilan University). The article said Tal-Botzer created the system last year as part of his doctoral dissertation. He said the system performed well when it was tried with European patients suffering from Hepatitis C. The system is being evaluated for possible commercial applications.

The Santa Fe New Mexican's Pasatiempo section on Jan. 10 featured the work of performance artists David Stout and Cory Metcalf (College of Santa Fe) to incorporate

computers, sensors, and human movement into elaborate onstage biomimetically inspired performances. "Stout and Metcalf are now collaborating with the Santa Fe Institute to find funding for a huge network of autonomous graphic worlds," the article said. "Using computers in many parts of the world, artists would design systems that encourage the evolution of graphics that behave like life forms." The November 2007 issue of the *Update* reported on the project. SFI Research Fellow Jennifer Dunne is co-director of the project.

RESEARCH NEWS

Proposed archaeological approach relies on correlation methods to track pottery types

Glazed pots made by Southwest Indian tribes from around 1300 to 1600 were a lot like the Amazon.com shipping boxes of today. They were used to transport items to and from locales all over today's Southwestern United States, and they often were reused many times.

"The classic view that each woman made and used her own pots just isn't right," says SFI Professor and Science Steering Committee Chair Doug Erwin. He says glazed pottery shards from a broad region often are found at a single archaeological site. (Doug is Senior Scientist and Curator of Paleobiology at the Smithsonian Institution.)

Doug, Peter Sadler (UC Riverside), Linda Cordell (School of American Research), and a small group of researchers from paleontology and archaeol-



Shards from a pottery vessel that is one of the earliest ceramic types found within Bandelier National Monument (est. AD 1175-1325). (Image Bandelier National Monument Museum Collections)

ogy are firing up interest in applying correlation methods to questions about the social and trade networks among the Pueblo Indian groups from the 14th to the 17th century.

A January 17 working group meeting at SFI brought together eight interested researchers to discuss whether data sets about glaze ware unearthed during archaeological digs in the northern Rio Grande region could be analyzed to improve archeologists' understanding of such interactions. It was the second such meeting on the topic.

Sadler, a geologist, applies probabilistic algorithms to find optimum solutions



The designs on this Puebloan food serving or storing bowl may represent dragonflies, important because of their relationship to water (est. AD 1400 - 1650). (Image Bandelier National Monument Museum Collections)

in large search spaces, resulting in high resolution temporal frameworks of the fossil and archaeological records.

Pottery styles and painting methods have beginnings and ends, explains Doug. The idea is to feed large data sets about the pottery types found at individual archaeological sites, as well as tree-ring and carbon-14 dates, into Stadler's computer program to identify relationships and chronological overlaps and divide archaeological time into smaller chunks.

Traditional archaeology considers time in relatively long intervals, often several centuries. If researchers can use pottery evidence to divide time into narrower intervals, a richer investigation of trading networks and possibly

migration pathways can be accomplished, he says.

"Once you do that, you might be able to look at 50-year windows, and you can do a network analysis and begin to look at interaction networks between pueblos and people," Doug says.

"If you had three locations, that would be easy," he adds. "As you get more and more sites, it becomes much harder to handle the data."

Sadler's group is adapting constraint-optimization algorithms developed at UC Riverside to simultaneously analyze multiple data sets to find best-fit solutions. The heuristic search methods are borrowed from the traveling salesman problem – finding the shortest route between many cities by visiting each city only once. As the number of cities grows, the number of possible sequences grows exponentially.

Because pottery artifacts are preserved only sporadically within their true time and space ranges, the archaeological record has many holes and disagreements.

"Our challenge is to find the global sequence of ancient events that best fits the evidence from all the local excavations," says Sadler.

So far there is great interest in and energy around the approach among the participants, says Doug. Much of the early discussion has focused on construction of archaeological data sets, he says.

Future workshops are expected to build on this discussion and lead to the formation of a modeling network.



Sankawi'i carrying jar found in the detached portion of Bandelier National Monument located near the town of White Rock, N.M. (est. AD 1525 – 1650). (Image Bandelier National Monument Museum Collections)

PEOPLE

Lauren Buckley joins NCEAS

Lauren Buckley says her post-doc time at SFI was valuable preparation for the next stage in her studies of complex systems – at the National Center for Ecological Analysis and Synthesis (NCEAS), a research center of the University of California, Santa Barbara.



Lauren Buckley

NCEAS uses existing data for multidisciplinary research in ecology and related fields.

"I once thought that multidisciplinary research entailed subgroups of biologists and geographers," Lauren says, "but my time at SFI challenged me to expand my sense of feasible multidisciplinary research to include engineers, economists, historians, computer scientists, and physicists, among others.

"Environment changes interact with natural and social systems in complex ways," she says. "I have come to realize how crucial a multidisciplinary perspective is to understanding how systems will respond to environmental change."

That view meshes with NCEAS's education and outreach programs, as well as its core research function. The center offers training at levels ranging from elementary school through graduate programs and continuing education for professionals, with the goals of increasing public understanding of science and fostering interest in ecology and technology professions, among others.

"There is a tendency for researchers within a discipline to adopt similar approaches to a problem with time," Lauren says. "Interacting with researchers from diverse disciplines at SFI helped me out of disciplinary ruts to apply fresh tools and approaches."

Lauren earned BAs in biology and mathematics at Williams College in 2000 and a PhD in biology at Stanford in 2005. Her postdoc fellowship at the Institute was from 2005 to 2007.

Author Mitch Waldrop revisits Institute, complexity science

Mitch Waldrop, author of *Complexity: The Emerging Science at the Edge of Order and Chaos* (Simon & Schuster, 1992), spent a week in January at SFI getting reacquainted with the Institute's people and its work.

His mission: To write an afterward to his book describing the course complexity science has taken since the book's publication. The new chapter will appear in a reprinting of the book planned for this year.

"The publication of *Complexity* was an important event for the Institute," says SFI Vice President Chris Wood. "It was the first popular treatment of the emerging sciences of complexity and brought SFI to the attention of many

around the world. It's still the first book people pick up when they are curious about complexity science."

Waldrop's book was a narrative incorporating the research and personalities of several key characters at the Institute at the time. Through the people, Waldrop described the growing complexity field. The resulting book was accessible both to scientists and laypersons interested in ideas at the frontiers of science.

Since 1992, says Chris, Waldrop has continued his science writing. He published the widely regarded *The Dream Machine: J.C.R. Licklider and the Revolution That Made Computing Personal* (Penguin Books, 2001). He



Mitch Waldrop

also served as a National Science Foundation public affairs officer. He now is an independent communications consultant and freelance writer.

"His visit was a chance to get reacquainted with the Institute, explore how the ideas of complexity science have evolved, and see how far the Institute has come since the early 1990s," says Chris.

During the January visit Waldrop had discussions with dozens of SFI's researchers about the state of com-

plexity science and the state of the Institute in 2008.

"I believe the Institute has changed significantly since 1992 while maintaining a clear continuity with the Institute of that time. I'll be interested to learn about Mitch's impressions following this visit," Chris says.

Beginning this month Waldrop is joining *Nature* as its editorials editor in charge of official *Nature* opinion and commentary.

He is expected to be the keynote speaker at the June 21-22 Complex Systems Summer School alumni event in Santa Fe.

IMPACT

Book edited by Jon Wilkins examines genomic imprinting research

A book edited by SFI Professor Jon Wilkins, *Genomic Imprinting* (Springer and Landes Bioscience, co-publishers), is scheduled to be published this month.

Genomic imprinting refers to a recently discovered phenomenon in which the expression pattern of an allele depends on whether that allele was inherited from the mother or the father. Approximately 100 imprinted genes have been discovered to date.

"The various clinical disorders associated with imprinting – as well as the

mechanistic complexity involved in the establishment, maintenance, reprogramming, and interpretation of imprinted gene expression – mean that imprinting poses an interesting set of questions for a broad array of biologists," notes Jon in the book's introduction.

Most imprinted genes affect fetal growth, but recent work has begun to focus on other contexts – flowering plants, for example, and cognition and behavior in mammals. The book's nine chapters, each written by geneticists at the frontiers of imprinting research, "give some

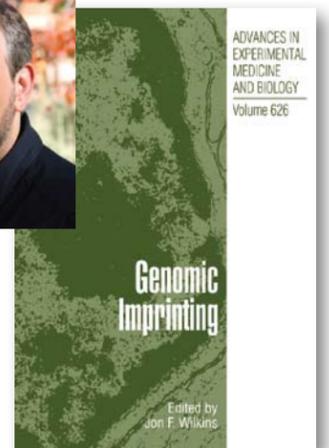
indication of the puzzles that we will be faced with," he says.

In selecting the materials for the book, Jon says he favored depth over breadth. "For some of these questions, we already have a reasonable idea of the answers; for others, we are just beginning to know how to formulate the questions," he says.

More at www.landesbioscience.com/books/intelligence_unit_id/945.



Jon Wilkins



SANTA FE INSTITUTE

1399 Hyde Park Road
 Santa Fe, New Mexico 87501
 T 505.946.3678
 F 505.982.0565
www.santafe.edu