

IST Breaks New Ground

By Cathy Perlmutter

If physics laid the groundwork for the Industrial Revolution of the twentieth century, information science may be the defining discipline of the twenty-first. And Caltech's pioneering Information Science and Technology (IST) initiative is leading the way.

The \$100 million IST initiative grew out of faculty discussions in 2001. According to Richard Murray, Thomas E. and Doris Everhart Professor of Control and Dynamical Systems and the program's director, an overwhelming consensus emerged: "Information provides a framework by which all large scale, complex systems—whether social, biological, or computing—can be understood."

The faculty saw the information paradigm as a way to move beyond the limits imposed by scientific specialization. And they recognized Caltech's already multidisciplinary environment as ideal for this revolution. "What makes Caltech and IST special," says Murray, "is our ability to work on research directions that are truly at the leading edge." He points to some of the groundbreaking research that has come out of the community in recent months:

Quantum computing. Particle-like structures called "anyons" may lead to the development of powerful quantum computers. The idea, first posed by Caltech's Alexei Y. Kitaev, professor of theoretical physics and computer science, is being explored by Jim Eisenstein, Roshek Professor of Physics. Their work was featured in an April 2006 *Scientific American* article, "Computing with Quantum Knots." Murray notes, "This is a great example of how combining ideas from information science and physics can revolutionize both fields."

Internet congestion control. Steven H. Low, professor of computer science and electrical engineering, uses ideas from game theory, control theory, and computer networking to send packets across the internet at unprecedented speeds. His internet congestion control algorithm allowed an international team of high-energy physicists (headed by Caltech physicist Harvey Newman) to set "land speed records" for internet file transfer at the last three Supercomputing Bandwidth Challenges. Their maximum speed—over 150 gigabits per second—is fast enough to transmit the entire contents of the Library of

Congress in 10 minutes. With the help of Caltech's Office of Technology Transfer, Low recently founded FastSoft, a Monrovia-based corporation that is commercializing his 'FastTCP' technology.

Genetic networks. Organisms have thousands of genes. It would take researchers decades to explore all possible pairings. So Professor of Biology Paul Sternberg and Weiwei Zhong, a biology postdoctoral scholar with a master's degree in computer science, have developed a database-mining method to predict gene interaction outcomes. Their approach, featured in the March 10, 2006, issue of *Science*, may mean that researchers can do 10 to 50 experiments—instead of thousands—to discover which of an organism's genes work together.

IST was formally launched in 2004 as a 10-year academic and research initiative. It has raised over \$52 million in startup funds, including \$25 million from the Annenberg Foundation to build the Walter and Leonore Annenberg Center for Information Science and Technology and \$22.2 million from the Gordon and Betty Moore Foundation.

Six research centers form the core of IST. Four were defined by the original faculty proposal: The Center for the Mathematics of

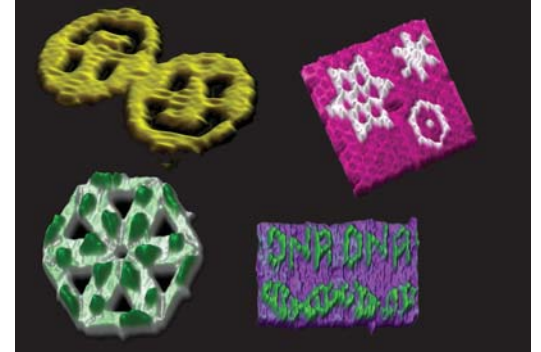
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—IST director Richard Murray, Everhart Professor of Control and Dynamical Systems

Information is developing a common theoretical framework for the study of information across disciplines. The Center for the Physics of Information aims to foster physical insights that pave the way for revolutionary new information technologies, like quantum computers. The Social and Information Sciences Laboratory is looking at social systems such as markets, elections, and committees, to understand how they might work more effectively. And the Center for Biological Circuit Design studies how living things store, process and share information in an effort to design circuits made from biological components—DNA, RNA, protein, and cells.

Two preexisting centers also have joined the initiative: the Lee Center for Advanced Networking, which aims to create robust global wireless communication systems, and the Center for Neuromorphic Systems Engineering, focusing on developing

Paul Rothmund; smiley image, Nick Papadakis and Paul Rothmund



One example of IST nanoscience research is DNA origami, created by Caltech senior research fellow Paul Rothmund. Each shape, about 100 nanometers (1/1000th the width of a human hair) across, is a long, folded DNA strand held together with shorter strands. The DNA origami technique could potentially be used to build smaller, faster computers and many other nanotechnology devices.

machines that can adapt to their environment with the flexibility of living creatures.

Collectively, the six centers have hosted dozens of Summer Undergraduate Research Fellowship students, graduate students, postdoctoral fellows, and visiting investigators. Every week, IST offers a packed calendar of seminars and events, open to all, through its website, www.ist.caltech.edu.

Another key IST goal is to give Caltech undergraduates in all disciplines the tools they need to handle the complex information

challenges of the future. "We want Caltech students to recognize the role that information plays in the world around them, and that it permeates all fields of science and engineering," says Murray. In spring 2007, the project will offer its first two freshman courses: IST 1, Introduction to Information, and IST 4, Information and Logic.

IST's top priority now is to recruit more of the best and brightest—graduate students, postdoctoral fellows, and faculty, who will become involved with one or more of the six centers. "One of our goals is to endow a number of IST fellowships and faculty chairs so that we can attract top students and faculty," says Murray. "This investment in people is critical to IST's success."

For more information about Information Science and Technology, please contact Brian Murphy at 626-395-6349.



Richard Murray,
IST director