This past year SFI’s International Program sponsored a Complex Systems Summer School in China. As a research fellow working in Hong Kong, I learned that William Wang, who supervises the work of our language evolution group at the Chinese University of Hong Kong, would be giving a week-long course in evolutionary linguistics at the Summer School. Then I discovered that John Holland, External Faculty member at SFI and professor in the departments of psychology and computer science at the University of Michigan, was to be his co-lecturer. I knew I would apply. Attending the school would be an opportunity for me to meet a new group of young researchers and to further my current work in modeling processes of language evolution.

The school was held at Qingdao University in Shandong Province, located on the coast of China. Organized jointly by SFI and Qingdao University, with the cooperation of the Key Laboratory of Complex Systems and Intelligence Science of the Chinese Academy of Sciences, the school brought together academics and students from around the world, with about sixty percent of the participants coming from China.

Qingdao University is situated just beyond the city center, whose restaurants, bars and beaches provided
ample entertainment throughout our one-month stay. Downtown Qingdao is modern, with newly built office towers and shopping malls. Other parts of the city reflect both the elegant architecture constructed during the European occupation of the city at the beginning of the 20th century and the dilapidated structures of villages that have been engulfed by the expanding city, hinting at an agricultural past. The city even inspired a couple of the projects, with one group modeling the popularity of the city’s bars and another studying the self-organization of individuals moving about in bounded spaces, such as the city’s buses.

The areas of interest of the students attending the Summer School were broad. Significantly, the research interests of the majority of those from China were on complexity theory and computational modeling techniques, whereas the overseas students tended to focus their research on applications in specific fields such as ecology, economics, and linguistics, although there were exceptions in both cases. This complementary blend of foci was, no doubt, deliberate on the part of the summer school organizers to promote both interdisciplinary and international collaboration.

Like previous schools, the Qingdao Summer School consisted of three weeks of lectures and group project work, followed by one week for the completion and presentation of the group projects. The school focused more on a broad coverage of applications of complexity science than on theory, although the school did begin with a one-week intensive course on fundamental aspects of complex systems research.

After opening preliminaries, Dave Feldman, from the College of the Atlantic, kicked off the main business of the school with a series of lectures on complexity science, summarizing a number of important concepts underlying the analysis of complex systems, such as information theory, entropy, and computation theory. These lectures were helpful in providing a guide to some of the general tools that can be used for complex systems analysis, pointing the way to more detailed presentations in the literature.

Also in week one was a discussion by Thomas Peacock, from the

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**Rural/Urban Migration in China Focus of Study**

SFI Science Board member Marcus Feldman from Stanford teamed with Li Shouzhou at Xi’an.

In rural China, where a strict patrilineal family system is dominant, preference for sons is ubiquitous. However, in large cities the extent of son preference has been weakened by the process of modernization and improvement in the social security system (families are no longer as reliant on the son to support them in old age). Migration from the country to the city leads to a dramatic change in lifestyle and social networks, which most probably influences the values and concepts of rural-urban migrants. The original, strongly male-biased culture and the corresponding behaviors are likely to be influenced by the host culture, which is more modern. In particular, marriage and childbearing preferences change, as well as other behaviors, which trickle back to the country, influencing those peasants who later marry in the rural areas. The influence may eventually give rise to a cultural transition within the whole population and even a diminution of son preference.

Using social network analysis and models of cultural transmission and evolution, the new research will incorporate personal social networks, characteristics of regions where migrants flow-in and flow-out, living arrangements and duration of stay in urban areas, frequency of returning to the countryside and duration of stay in rural areas, individual socioeconomic characteristics, mass media, as well as local policies and regulations, etc. The models aim to describe interaction among temporary rural-urban migrants and urban residents in terms of culture and behavior and to simulate the dynamics of transmission and diffusion.

Development and testing of models for the cultural transmission and diffusion during the process of rural-urban migration in China as well as the interaction of these migrants and urban residents is important, both academically and practically. The research will help to predict the social and economic consequences of rural-urban migration in China and perhaps produce corresponding policy formulation for community development.
Department of Mathematics at MIT, on pattern formation in fluid mechanical systems. Peacock’s lectures combined an overview of the mathematics of fluid mechanics, discussing, for example, the Navier-Stokes equations, Rayleigh-Bernard Convection, and Taylor-Couette Flow, with video clips that illustrated vividly the types of patterns that can emerge in such systems. Although his lectures did not provide students with specific tools with which to tackle problems in their own fields, they did serve to highlight the rich behaviors that can emerge from complex systems.

In the second week of the school, the lectures switched to biology and the evolution of agriculture. Eric Smith, a research professor at SFI, and Satoru Miyano, from the Institute of Medical Science at the University of Tokyo, spoke about reaction networks in biology, with Smith providing an overview of the citric-acid cycle and Miyano describing how Petri nets can be used to model interactions among genes. Hao Bailin’s (Institute for Theoretical Physics, Chinese Academy of Sciences) discussion of the K-strings method for characterizing and comparing genetic sequences was particularly interesting to me because the technique might find application in the phylogenetic classification of language, one of my own research interests. The opportunity to learn about such a method for potential use in my own field was, for me, one of the most valuable aspects of the Summer School.

The school also included lectures on the evolution of agriculture, specifically rice domestication and cultivation in China, Southwest Asia, and the Americas. It also had lectures on network dynamics, providing a basic introduction to network-based tools for complex systems research.

In the third week, William Wang and John Holland lectured on my own research area of language evolution. The style of presentation here was a little different from the other talks, with Wang and Holland alternating their discussions between the empirical and theoretical. Wang focused on the empirical, sampling a broad range of features that illustrate the structure and complexity of language. From an overview of FOXP2, the so-called “language gene,” whose role in the phylogenetic and ontogenetic emergence of language has been much discussed in the recent literature, to the historical development of the Chinese language, his lectures served both to provide a stimulating introduction to the theoretical discussions of Holland and to ground them. Holland concentrated on describing a framework, based on the classifier system, for modeling the emergence and evolution of language.

The Echo system, described in Holland’s book *Hidden Order*, was originally derived to study the dynamics of complex adaptive systems. It is an agent-based, rule-based system consisting of heterogeneous, interacting agents that evolve by building up rules to encode beneficial behaviors. This system is a situated model: agents must interact with an environment and survive in it by filling reservoirs, measures of the extent to which they are able to fulfill certain basic requirements, such as acquiring food, finding shelter, and so on. Whenever a reservoir is low, a bridging rule, e.g., a rule stating “I’m hungry!” is activated and stays on until the reservoir is refilled; bridging rules act to keep the agent focused on an important task, such as finding food. New rules are
Last May, SFI co-sponsored an International Workshop on Biocomplexity with Fudan University, one of China’s leading universities with an international reputation for academic excellence. The workshop also served as the 40th Eastern Forum for Science and Technology sponsored by the Shanghai Municipal People’s Government, the Chinese Academy of Sciences, and the Chinese Academy of Engineering. The organizers were SFI International Fellow Hao Bailin, academician of the Chinese Academy of Sciences and professor at the T-Life Research Center at Fudan, and Eric Smith, research professor at SFI.

The meeting was topically broad, including, but also reaching beyond familiar fields in biocomplexity such as genomics and proteomics, bioinformatics, and the genetic reconstruction of phylogenetic (inheritance) trees. Also represented were ecosystem and microbiology, scaling and invariance principles, and the mathematical structure of evolutionary theory and information transmission across generations. Important new directions that are reshaping classical fields were presented, including quantitative and computational modeling of the emergence of civilizations, and the study of network structure and dynamics. Finally, intrinsic system-level phenomena were discussed, from the structure of inheritance to the emergence of neural maps.

Presenters at the workshop came from China, Taiwan, Korea, India, Germany, and the U.S. Their primary research interests ranged from laboratory synthesis and database creation and mining, to public health and agriculture, to fundamental mathematical and computational representations of living systems.

What held such an eclectic meeting together was a shared sense among the participants that there are organizing principles characteristic of life that transcend these application domains. What we learn about the roles of hierarchy and autocatalysis at the molecular level may also predict constraints on the emergence and succession of forms of civilization. Network dynamical principles discovered to make protein and gene regulation comprehensible continue to be relevant to the structuring of ecologies, epidemics, and immunology. As we understand better the principles that underlie the amazingly diverse yet resilient natural world, we can work to integrate engineering and medical practices within that framework, discovering elegant ways to restore functions that integrate smoothly into the living processes responsible for creating it.
The common interest of our group was extinction, albeit from different perspectives, such as ecology, paleontology, and linguistics. We soon agreed to form a team to model extinction processes, a project that would support my research into the dynamics of language extinction. The range of topics considered in the projects was wide, from the formation of biofilms, the layer of microbial organisms that grows, for example, on one’s teeth when left unbrushed; to the modeling of conflict and warfare. Given the short duration of the summer school, the aim of the project work was less about carrying out new research and more about gaining experience with using methodologies that will be useful in future research.

Taking part in the Qingdao Complex Systems Summer School proved to be a rewarding experience, both for the broadened perspective to research in different fields that it offered and for the opportunity to work in mainland China. The different general approaches of the Chinese students—theory-based—and the overseas students—application-based—made for a constructive blend. It is to be hoped that complexity science teaching and research can continue to blossom in the coming years so that the flow of knowledge between nations and across disciplines can grow.

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Chinese Dignitary Visits SFI

Jiang Mianheng, son of former Chinese President Jiang Zemin, visited SFI on February 28th and participated in a round table discussion with SFI researchers. Dr. Jiang is a successful entrepreneur instrumental in the development of the information technology industry in Shanghai and also a vice president of the Chinese Academy of Sciences. A guest of the New Mexico Economic Development Board, he requested to visit SFI to learn how the Institute fosters interdisciplinary research and maintains an environment of academic creativity and freedom. This trip followed visits to the MIT Media Labs and Harvard University, where he explored how to ensure standards of academic excellence and how to evaluate the success of a bottom-up organized institution. He explained that the Chinese Academy of Sciences has been undergoing many changes and is committed to building world-class research institutions.

SFI researchers Jessica Flack, John Holland, David Krakauer, John Miller, Eric Smith, Geoffrey West, and Henry Wright participated in the discussion with Jiang, who was especially curious about why the researchers chose to work at SFI over other academic institutions. The group also discussed many SFI/China initiatives, ranging from research collaborations to the upcoming Complex Systems Summer School in Beijing. The discussion also touched on the SFI Business Network, with Ann Stagg, manager of Marketing and Business Relations, explaining how the Network contributes to the environment of scientific entrepreneurialism and innovation, in addition to providing valuable research revenue for SFI. The visit culminated in a tour of the Institute and informal discussions with various researchers.

2005 Complex Systems Summer School in Beijing

This summer, the second Complex Systems Summer School to be held in China will be hosted in Beijing by the Institute of Theoretical Physics and the Academy of Mathematics and Systems Sciences of the Chinese Academy of Sciences. The school, which will run from July 11 through August 5, will focus on both theory, with lectures on the fundamental principles and tools of complexity science research; and application, including biological systems, social aspects of language evolution, and population dynamics. The Summer School at Santa Fe, held from June 6 to July 1, will focus more on theory, although it too will deal with such applied topics as the modeling of food webs, the evolution of cancer, and the structure of the World Wide Web.