Introduction to the 2002 Special Issue of *Complexity*, v.7(6), on:

Networks and Complexity

Understanding complex phenomena as part of a broad systems-level framework in the life, physical and social sciences has turned in recent decades to issues of networks and the dynamics and complexity which they entail. Although network analysis has matured over many decades, as in the field of social networks, for which several textbooks exist[1], it is only recently that broad classes of mathematical and statistical models have been developed powerful enough to accommodate more unified theories as well as foundational questions of dynamics and emergent structure. To identify sources of similarity in structural properties, for example, Skvoretz and Faust[2] showed how new statistical models (as discussed in this issue) could be used to compare hundreds of network datasets collected across species, e.g., whether differences vary by classes of relations, such as influence, grooming, and agonistic encounters. The growth of the World Wide Web, the staggering advances in computing power and diminishing computational complexity of network algorithms as well as the attention received by the findings of robustness and ubiquity of small world networks, as identified by Watts and Strogatz[3] in their two-parameter model of clustering and distance, helped spark much of the recent cross-disciplinary explosion of interest in network analysis and modeling.

The focus of this issue is on substantive research, using the powerful tools and theoretical parameters of network models. Researchers from a broad spectrum of scientific inquiry—including mathematics, physics, chemistry, biology, environmental science, behavioral ecology, neuroscience, computer science, sociology, anthropology, history and political science—were asked to reflect on the role of networks and complexity in each of their primary research areas. The contributions reflect emerging confluences of ideas and characteristic findings across the scientific disciplines, demonstrating that network structure and network dynamics are keys to understanding complexity. Moving among different kinds of network architectures, such as the metabolic pathways that Andreas Wagner studies to understand the origins of life and the operation of biological processes, and the market networks that Harrison White studies to understand the organization and operation of the modern economy, we find broad theoretical conclusions about effects of network structure and the dynamics that produce them. These articles can only begin to reflect the vast scope of research initiatives being conducted worldwide on network dynamics and phenomena that emerge out of multi-level interactions. We hope they will help promote further cross-pollination of ideas and further demonstrate the power of network-based analyses and explanations. Given the focus on substantive findings, no attempt was made here to reference the enormous amount of work on simulation and formal modeling, but major advances in this area will also be found in the reviews and citations, and might well foster further issues on Networks and Complexity.

This issue grew in large part out of the August 2000 Founding Workshop for SFI's Network Dynamics Program, directed by James Crutchfield (Program Director, SFI) and Duncan Watts (Sociology, Columbia; also the workshop organizer) and funded by SFI Business Network member, Intel Corporation. A number of resources on networks and dynamics are found at the workshop site: discuss.santafe.edu/dynamics. Many of the papers and contributors to the initial workshop are already well known to the community of complexity researchers, so the organization of the present issue, at the invitation of Harold Morowitz, was intended to bring in new contributors as well as some of those from the workshop.

—— Douglas R. White, Guest Editor

[1] e.g., Alain Degenne and Michel Forsé, *Introducing Social Networks*. London: ISM. 1997.
[2] John Skvoretz and Katherine Faust. Relations, Species, and Network Structure. *Journal of Social Structure* 3(3). 2002. http://zeeb.library.cmu.edu:7850/JoSS/skvoretz/index.html
[3] Duncan J.Watts and Steven Strogatz. Collective Dynamics of 'Small-World' Networks. *Nature* 393: 440-442. 1998.