Workshop Program

NSF US-Hungarian Workshop on

Large Scale Random Graphs Methods for Modeling Mesoscopic Behavior in Biological and Physical Systems

August 28 – September 4, 2006

Alfred Renyi Institute of Mathematics
Hungarian Academy of Sciences
Budapest, Hungary

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Program in a Nutshell

August 27:	Arrival at Hotel Peregrinus, Budapest
August 28 – 31:	Workshop events at Alfred Renyi Institute of Mathematics, Budapest
September 1:	Workshop Session at KFKI Institute for Physics, Budapest, Hungary
September 2 – 3:	Excursion to Szeged and the South Region of Hungary
September 4:	Departure from Hotel Peregrinus, Budapest

Workshop Venue:	Alfred Renyi Institute of Mathematics
Address:	13-15 Realtanoda utca, H-1053 Budapest, Hungary
Phone:	36-1-483-8300
Fax:	36-1-483-8333
Workshop Hotel:	Hotel Peregrinus ELTE
Address:	Szerb u. 3, H-1056 Budapest, Hungary
Phone:	36-1-266-4911
Fax:	36-1-266-4913
Organizers:	
Program Co-Chairs:	Robert Kozma and Bela Bollobas
Program Committee:	Peter Erdi, Gabor Tusnady, Tamas Vicsek
Local Committee:	Dezso Miklos (chair), Veronika Pandi
Contact:	rkozma@memphis.edu, dezso@renyi.hu
URL:	http://www.renyi.hu/large/

Co-Sponsored by: National Science Foundation, USA, International Neural Network Society INNS, Alfred Renyi Institute of Mathematics, Eotvos Lorand University, Budapest, KFKI/RMKI Research Institute, Budapest, Hungary

Program

Monday, August 28

08:00 - 09:00 am Registration & Refreshments

09:00 - 09:30 am **Opening Address**
Mark A Suskin (Head, NSF European Office, Paris, France)

Welcome Address
Peter P. Palfy (Corresponding Member HAS, Director, Alfred Renyi Institute of Mathematics, Hungary)

Announcements

09:30 - 10:30 am Plenary Talk
Inhomogeneous Random Graphs
Bela Bollobas (University of Cambridge, UK & Univ. of Memphis, USA)

10:30 - 10:45 am Coffee Break

10:45 - 11:30 am Invited Talk
Hamiltonian Cycles in Sparse Random Graphs
Tom Bohman (Carnegie Mellon University, USA)

11:30 - 12:30 pm Panel Session A
Challenges in Large Scale Random Network Theory & Applications.
Panelists: Bela Bollobas, Tom Bohman, Balint Toth, Walter J. Freeman, Reka Albert, Gabor Tusnady

12:30 - 14:00 pm Lunch Break

Session: Theory of Random Graphs and Networks

14:00 - 14:30 pm **Random Trees and General Branching Processes**
Anna Rudas, Balint Toth, Benedek Valko (Technical University, Budapest)

14:30 – 15:00 pm **Random Models for Quantified Boolean Satisfiability Problem**
Yannet Interian (Cornell University, USA)

15:00 – 15:30 pm **Old Methods Wanted: Applications of Deterministic and Stochastic Formal Reaction Kinetics to Systems Biology**

Janos Toth (Technical University, Budapest)

15:30 – 16:00 pm	**Using Citations and Collaborations to Evaluate Papers, Journals, and Scientists** *Michael Stringer (Northwestern University, USA)*
16:00 – 16:30 pm	**Network of Interacting Reactions in Metabolic Networks** *József Bruck, Oliver Ebenhöh, Reinhart Heinrich (Humbold University, Germany)*
16:30 - 18:30 pm	Free Time
18:30 - 20:00 pm	Welcome Reception at Renyi Institute

Program

Tuesday, August 29

08:00 - 08:30 am Refreshments

08:30 - 08:45 am Opening Remarks & Announcements

08:45 - 09:45 am Plenary Talk:
Two Types of Global Neural Field in Forebrains Serve as Targets for Simulation Using Random Graph Theory
Walter J. Freeman (UC Berkeley, USA)

09:45 - 10:00 am Coffee Break

10:00 - 10:45 am Invited Talk:
Large-Scale Cortical Oscillatory Network Graphs
Steven Bressler (Florida Atlantic University, USA)

Session: Networks in Neuroscience and Biology (Part 1)

10:45 - 11:15 am **Predicting Uncharted Connections with Szemerédi's Regularity Lemma in the Cerebral Cortical Network**
Tamas Nepusz, Ference Bazso, Laszlo Negyessy, Gabor Tusdnady (Semmelweis Medical University, Central European University, KFKI/RMKI, Renyi Institute, Hungarian Academy of Sciences, Hungary)

11:30 - 12:30 pm Panel Session B:
Open Problems in Networks of Neuroscience and Biology.
Walter J Freeman, Steven Bressler, Andras Lorincz, Bela Bollobas, Robert Kozma, Peter Erdi

12:30 - 14:00 pm Lunch Break

Session: Networks in Neuroscience and Biology (Part 2)

14:00 - 14:30 pm **Echotron : Critical Network Model of Superfcial Layers**
Marton A Hajnal, Andras Lorincz (Eotvos University Budapest, Hungary)

14:30 – 15:00 pm **Time Constraints and the Evolution of Scale-Free Properties in Associative Networks**
Derek Harter (Texas A&M University, USA)

15:00 – 15:30 pm **Partial Entrainment in the Kuramoto-Sakaguchi model**
Filip De Smet, Dirk Aeyels (Ghent University, Belgium)

15:30 – 16:00 pm **Nicotinic Modulation of Cortical Connectivity in a Working Memory Task Evaluated by Path Analysis**
Clara A. Scholl (NIH/NIDA-IRP/Neuroimaging Research Branch, USA)

16:00 – 16:30 pm **Estimating the Dynamics of Kernel-based Evolving Networks**
Gabor Csardi, Elliot Paquette, Peter Erdi (KFKI/RMKI of Hungarian Academy of Sciences & Kalamazoo College, USA)

16:30 - 18:30 pm Free Time

18:30 - 21:00 pm Cultural Program

Program

Wednesday, August 30

08:00 - 08:30 am	Refreshments
08:30 - 08:45 am	Opening Remarks & Announcements
08:45 - 09:45 am	Plenary Talk: **Uncovering the Overlapping Cohesive Groups of Complex Networks from Molecular to Social** *Tamas Vicsek (Eotvos Lorand University, Budapest)*
09:45 - 10:00 am	Coffee Break
10:00 - 10:45 am	Invited Talk: **Towards Understanding the Structure and Function of Cellular Interaction Networks** *Reka Albert (PennState University, USA)*
	Session: Modeling Large-Scale Networks: Physics, Biology, Society (Part 1)
10:45 - 11:15 am	**Sociodemographic Exploration of Telecom Communities** *Andras Benczur, Karoly Csalogany, Miklos Kurucz, Andras Lukacs, Laszlo Lukacs (Computer & Automation Research Institute, Hungarian Academy of Sciences, Hungary)*
11:30 - 12:30 pm	Panel Session C: **Open Problems in Physics and Modeling of Large Scale Networks.** *Tamas Vicsek, Reka Albert, George Kampis, Andras Lorincz, Andras Lukacs, Steven Bressler, Tom Bohman*
12:30 - 14:00 pm	Lunch Break
	Session: Modeling Large-Scale Networks: Physics, Biology, Society (Part 2)
14:00 - 14:30 pm	**The Dynamics of SIR-type Epidemics in Static Random Networks** *Erik Volz and Steven Strogatz (Cornell University, USA)*
14:30 – 15:00 pm	**Robust Networks from Local Optimization: A Bottom-up Model to Generate Networks with Skewed Degree Distributions** *Laszlo Gulyas (AITIA Inc & Eotvos Unversity, Budapest, Hungary)*
15:00 – 15: 30 pm	**Directed Connectivity Among Fish Populations in a Riverine Network**

	Robert Schick, S.T. Lindley, A.L. Lloyd, P.N. Halpin, D.R. Urban (Duke University, USA)
15:30 – 16:00 pm	**Network Formation and the Structure of the Commercial World Wide Web** *Zsolt Katona, Miklos Sarvary (Technical U. Budapest, INSEAD, France)*
16:00 – 16:30 pm	**A Graph-theoretic Approach for Evaluating Marine Population Connectivity: Ecological Implications and Conservation Recommendations** *Eric A. Treml, Patrick N. Halpin, Dean L. Urban (Duke University, USA)*
16:30 - 18:30 pm	Free Time
18:30 - 20:00 pm	Boat Cruise on the Danube

Program

Thursday, August 31

08:00 - 08:30 am	Refreshments
08:30 - 08:45 am	Opening Remarks & Announcements
08:45 - 10:00 am	Meetings of Working Groups: **Open Questions & Challenges in Large Scale Networks in Various Research Areas** *Math/graph theory: Coordinator Tom Bohman* *Neuroscience/biology: Coordinator Steve Bressler* *Physics/modeling: Coordinator Andras Lorincz & Andras Lukacs*
10:00 - 10:30 am	Coffee Break
	Integration Session:
10:30 - 11:00 am	**Presentation of the three group's findings (10 min each)** *Tom Bohman (Carnegie Mellon University), Steve Bressler (Florida Atlantic University), Reka Albert (Penn State University)*
11:00 - 12:30 am	**Open discussions on the significance of findings in broad areas** *Panelists: Bela Bollobas, Peter Erdi, Walter J Freeman, Robert Kozma, Andras Lorincz, Andras Lukacs, Mark Suskin, Balint Toth, Gabor Tusnady*
12:30 - 14:00 pm	Lunch Break
	Round Table Discussion Session
14:00 - 16:00 pm	**Perspectives & Recommendations** *Reka Albert, Tom Bohman, Bela Bollobas, Steven Bressler, Peter Erdi, Walter J Freeman, Yannet Interian, Robert Kozma, , Andras Lorincz, Andras Lukacs, Dezso Miklos, Anna Rudas, Mark Suskin, Balint Toth, Gabor Tusnady, Tamas Vicsek & all interested attendees*
16:00 - 18:30 pm	Free Time
18:30 - 21:00 pm	Conference Banquet

Program

Friday, September 1

Workshop Session at KFKI Research Institute

09:00 - 16:00 pm **Cortico-Hippocampal Dynamics: Navigation and Neuromodulation**
Coordinator: Peter Erdi (KFKI Neuroscience Group, Budapest)

Location: KFKI Research Institute, Csilleberc (Buda Hills)
URL: http://cneuro.rmki.kfki.hu/events

September 2-3: Excursion to Szeged & Hungarian countryside

Saturday, September 2

09:00 am: Vans leave from Pelegrinus Hotel, Budapest

12:00 am: Lunch at Szeri Csarda, Opusztaszer

01:30 pm: Visit Opusztaszer Hungarian Millenium Historical Site

05:00 pm: Arrival at Szeged, visit/wreathe statues of Hungarian mathematicians

06:00 pm: Check in to Hotel Novotel Szeged
http://www.accor-pannonia.hu/novotel_szeged_szalloda.php

07:00 pm: Dinner

Sunday, September 3

09:30 am: Visit Szeged University

10:30 am: Attend Szeged Paprika Festival and Fish Soup Contest

12:00 am: Lunch in Szeged

01:30 pm: Leave Szeged

02:30 pm: Visit Bugac traditional horse riding attractions

06:30 pm: Dinner at Mizsei Csarda

08:00 pm: Arrival at Hotel Peregrinus in Budapest

Monday, September 4

Morning: Departure from Hotel Peregrinus, Budapest

Book of Abstracts

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Alfred Renyi Institute of Mathematics
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August 28 – September 4, 2006

Plenary Talk, 9:30 am, Monday August 28

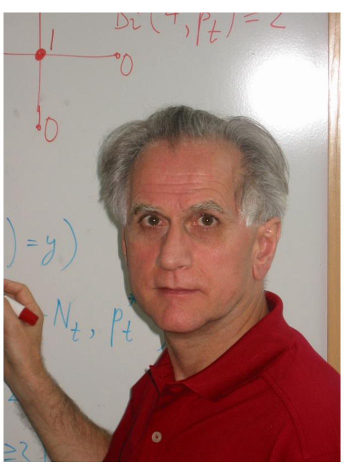
Inhomogeneous Random Graphs

Bela Bollobas
University of Cambridge, Cambridge, UK and
University of Memphis, Memphis, TN, USA

Abstract

The 'classical' random graph models, in particular G(n, p), are 'homogeneous', in the sense that the degrees (for example) tend to be concentrated around a typical value. Many graphs arising in the real world do not have this property, having, for example, power-law degree distributions. Thus there has been a lot of recent interest in defining and studying 'inhomogeneous' random graph models.

In a very long paper that has just been completed, Svante Janson, Oliver Riordan and I introduced a very general model of an inhomogeneous random graph with (conditional) independence between the edges, which scales so that the number of edges is linear in the number of vertices. This scaling corresponds to the p = c/n scaling for G(n, p) used to study the phase transition; also, it seems to be a property of many large real-world graphs. Our model includes as special cases many models previously studied. In the talk I shall describe some of the results concerning our general model.



Béla Bollobás - Hardin Chair of Excellence in Combinatorics at the University of Memphis, and for over thirty years has been a Fellow of Trinity College, Cambridge. He is corresponding member of Hungarian Academy of Sciences. He is an expert on probabilistic and extremal combinatorics, and has done fundamental work on extremal graph theory, random graph theory, especially phase transitions in random combinatorial systems, and on random graphs modeling real-life networks. He has written almost three hundred research papers and several research monographs.

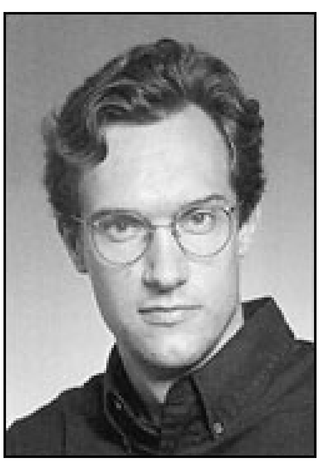
Invited Talk, 10:45 am, Monday August 28

Hamiltonian cycles in sparse random graphs

Tom Bohman, Department of Mathematics
Carnegie Mellon University, USA

Abstract

We discuss an approach to finding Hamiltonian cycles in sparse random graphs that was developed to prove that the sparse random graph known as 3-out has a Hamiltonian cycle with high probability. The methods introduced have the potential to establish Hamiltonicity for several other sparse random graph models. We also note connections with the Karp-Sipser algorithm (which is a randomized algorithm for finding a matching in a graph).



Tom Bohman – Professor of Mathematics at Department of Mathematical Sciences, Carnegie Mellon University, PA. His field of research is extremal and probabilistic combinatorics, and I work on discrete mathematical problems inspired by a diverse collection of perspectives. These include mathematical disciplines as well as information theory (which has a very strong connection with extremal set theory), statistical physics and theoretical computer science. Recently, I have been interested in the Shannon capacities of odd cycles, 'guided' versions of the standard random graph model, randomized network algorithms, list-coloring problems for graphs, and hypergraph discrepancy.

Plenary Talk, 8:45 am, Tuesday August 29

Two types of global neural field in forebrains serve as targets for simulation using random graph theory

Walter J. Freeman

University of California at Berkeley
101 Donner Hall, Berkeley, CA 94720
drwjfiii@berkeley.edu

Abstract

Fields of neural activity are seen in synchronized oscillations that are detected at mesoscopic scales in syntheses of multicellular recordings of action potentials and electroencephalograms (EEGs) over broad areas of cerebral cortex. The waves often have large-scale, highly textured spatial patterns of cortical activity that form in the context of associative learning under classical and operant conditioning in rabbits. The patterns show spatial amplitude modulation of shared oscillations of carrier waves in the beta and gamma ranges of the EEG, with recurrence at frame rates in the alpha and theta ranges. The frames also show spatial phase modulation that is inconsistent with driving of the oscillations by focal pacemakers. The hypothesis is developed that the synchronization manifests continuous distributions of activity in cortical neuropil that modulate firings of selected neural networks embedded in the neuropil. Five interactive agencies have been postulated to explain the mechanism for the field synchrony: electric fields; magnetic fields; electromagnetic fields (radio waves); diffusion chemical gradients; and order parameters that control self-organization of large populations of neurons by widespread synaptic interaction constituting negative and positive feedback. Only the last fits the data. The points are emphasized that these field patterns in frames require interactive neural dynamics that is modulated in respect to global operations mediating arousal, attention, selective emotional stance, wake, sleep, learn, habituate, dishabituate, etc., and that these operations require differing but complementary fields that form by massive parallel feed-forward architectures of brainstem neuromodulatory nuclei. An example is given using histamine of the neural discharges of brainstem nuclei that do not require fine spatiotemporal texturing of their firing; they operate by nonsynaptic release of neuromodulators that effect changes in background state, such that textured patterns of cortical activity can form and update in flexible adaptations of brains to their environments. These systems instantiate volume transmission by nonsynaptic diffusion transmission, in concert with the self-organization of the textured neural activity that supports cognition.

Walter J Freeman studied physics and mathematics at M.I.T., electronics in the Navy in World War II, philosophy at the University of Chicago, medicine at Yale University, internal medicine at Johns Hopkins, and neuropsychiatry at UCLA. He has taught brain science in the University of California at Berkeley since 1959, where he is Professor of the Graduate School. He received his M.D. *cum laude* in 1954, the Bennett Award from the Society of Biological Psychiatry in 1964, a Guggenheim in 1965, the MERIT Award from NIMH in 1990, and the Pioneer Award from the Neural Networks Council of the IEEE in 1992. He was President of the International Neural Network Society in 1994, and is Life Fellow of the IEEE. He has authored over 450 articles and 4 books: "Mass Action in the Nervous System" 1975, "Societies of Brains" 1995, "Neurodynamics" 2000, and "How Brains Make Up Their Minds 2001.

Invited Talk, 10:00 am, Tuesday August 29

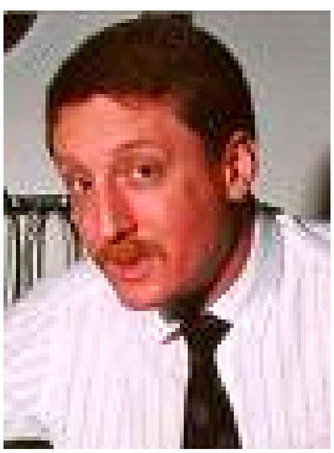
Large-Scale Cortical Oscillatory Network Graphs

Steven L. Bressler

Center of Complex Systems and Brain Sciences
Florida Atlantic University

Abstract

The mammalian cerebral cortex has a highly complex pattern of large-scale anatomical connectivity. This anatomical structure provides a huge combinatorial space of possible functional arrangements of distributed neuronal assemblies. My colleagues and I have developed an approach to the analysis of cortical functional activity that reveals an oscillatory network structure that coordinates distributed assemblies in relation to specific cognitive microstates. This analytic approach involves the use of power spectra to identify distributed cortical assemblies generating oscillatory activity in specific frequency ranges. These assemblies represent nodes of large-scale network graphs. Significantly synchronized assemblies are then identified using spectral coherence analysis. Pairs of synchronized assemblies represent edges of large-scale network graphs. Finally, significant directed causal influences are identified using spectral Granger causality analysis. The causal relations between assembly pairs represent directed edges of large-scale graphs. Our analytic approach has made possible new insights into the functional organization of the cerebral cortex in relation to specific cognitive functions.



Dr. Steven Bressler is Professor of Cognitive Science at the Center for Complex Systems & Brain Sciences at Florida Atlantic University, where he directs the Cognitive Neurodynamics Laboratory. He is a leading innovator in the field of cognitive neuroscience. With broad experience in neuroscience, cognition, and computation, his work transcends many of the disciplines that contribute to cognitive neuroscience. He has considerable cross-species experience, having published studies of rodents, non-human primates, and humans. Dr. Bressler received his graduate training in behavioral neurophysiology and neuroanatomy at UC Berkeley, and his postdoctoral training in cognitive science, experimental design, digital signal processing, and multivariate time series analysis at the EEG Systems Laboratory in San Francisco. Dr. Bressler is a principal contributor to the rapidly growing field of large-scale neurocognitive networks. His studies have had an important impact on thinking in cognitive neuroscience, demonstrating the role of coordination dynamics in cortical information processing during cognitive function. His papers have been cited over 1600 times in leading research journals. His seminal 1993 Nature paper established a precedent for a flood of experimental reports that followed on long-range cortical interactions in cognition. His 1995 Brain Research Reviews paper was also highly influential on subsequent theoretical investigations into the neural basis of cognitive function. His 2003 Neuropsychopharmacology paper has been cited as providing a strong theoretical underpinning for an increasing number of experimental reports that point to discoordination of brain rhythms as a major factor in schizophrenia.

Plenary Talk, 8:45 am, Wednesday August 30

Uncovering the overlapping cohesive groups of complex networks from molecular to social

Tamas Vicsek*
Eotvos University, Budapest, Hungary

Abstract

Many complex systems in nature and society can be described in terms of networks capturing the intricate web of connections among the units they are made of. A fundamental question of great current interest is how to interpret the global organisation of such networks as the coexistence of their structural sub-units (called modules, communities, clusters, etc) associated with more highly interconnected parts.Ê Identifying these unknown building blocks (e.g., functionally relatedÊ proteins, industrial sectors, groups of people) is crucial to the understanding of the structural and functional properties of networks. The existing deterministic methods used for large data sets find separated communities, while most of the actual networks are made of highly overlapping cohesive groups of nodes.

Here we introduce an approach to analyse the main statistical features of the interwovensets of overlapping communities making a much needed step towards the uncovering of the modular structure of complex systems. After defining a set of new characteristic quantities for the statistics of communities, we apply an efficient technique to explore overlapping communities on a large scale. We find that overlaps are indeed very significant, and the distributions we introduce reveal novel universal features of networks. Our studies of many kinds of networks, including mobile phone call, collaboration, school friendship, word association, protein interaction graphs demonstrate that the web of modules has highly non-trivial correlations and specific scaling properties.

*This work was carried out in collaboration with G. Palla, I. Derenyi and I. Farkas

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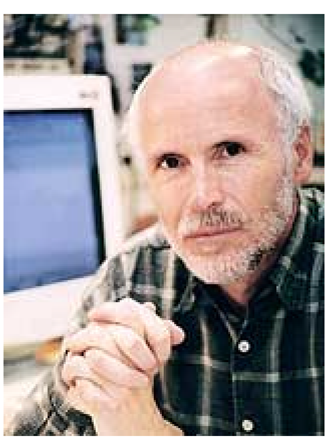

Dr. Tamas Vicsek is Professor of Biological Physics at Eotvos Lorand University, Budapest. He is internationally know expert in numerical studies of dense liquids, percolation theory, Monte Carlo simulation of cluster models, aggregation phenomena, fractal growth, pattern formation (computer and laboratory experiments), collective phenomena in biological systems (flocking, oscillations, crowds), molecular motors, cell locomotion in vitro. He has published 5 books on fractals and scaling, and over 140 journal papers. He is the recipient of numerous awards, member of the Hungarian Academy of Sciences and Academia Europea.

Invited Talk, 10:00 am, Wednesday August 30

Towards understanding the structure and function of cellular interaction networks

Reka Albert, Huck Institutes for the Life Sciences
Pennsylvania State University, PA

Abstract

A cell's behavior is a consequence of the complex interactions between its numerous constituents, such as DNA, RNA, proteins and small molecules. Cells use signaling pathways and regulatory mechanisms to coordinate multiple processes, allowing them to respond to and adapt to an ever-changing environment. The large number of components, the degree of interconnectivity and the complex control of cellular networks are becoming evident in the integrated genomic and proteomic analyses that are emerging. It is increasingly recognized that the understanding of properties that arise from whole-cell function require integrated, theoretical descriptions of the relationships between different cellular components. Recent theoretical advances allow us to describe cellular network structure with graph concepts, and have revealed organizational features shared with numerous non-biological networks. This presentation will focus on three important questions (i) How do we quantitatively describe a network of hundreds or thousands of interacting components? (ii) Does the observed topology of cellular networks give us clues about their evolution? and (iii) How does the cellular networks' organization influence their function and dynamical responses? Throughout the talk, I will illustrate how graph theory can aid in formulating predictive models of biological systems.

Reka Albert is an Assistant Professor of Physics, and a member of the Huck Institutes for the Life Sciences, at the Pennsylvania State University. She received her Ph.D. in Physics from the University of Notre Dame (2001), and did postdoctoral research in mathematical biology at the University of Minnesota. Dr. Albert is a theorist who works on elucidating biological regulatory networks at the molecular and cellular level. Before turning to modeling biological networks, Dr. Albert's research focused on the structural properties of complex networks, and she co-authored a series of influential articles on the subject. Dr. Albert is a member of the American Physical Society and the Society for Mathematical Biology. She serves on the Advisory Board of the journal Chaos (2004 - 2007), on the Board of Governors of the Mathematical Biosciences Institute at the Ohio State University (2006 - 2008) and as a peer reviewer for more than 35 journals. She was a recipient of an Eli and Helen Shaheen Graduate School Award (2001) and a Sloan Research Fellowship (2004 - 2006).