# CEU Summer University

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## *Complex Systems*

*Co-organized with the Santa Fe Institute, Santa Fe, New Mexico, USA and Loránd Eötvös University, Budapest, Hungary*

**July 8 - August 2, 2002**

**Course directors:** **John Pepper**, Santa Fe Institute, USA
**Imre Kondor**, Eötvös Loránd University, Budapest, Hungary

**Resource persons:** **Chris Adami**, California Institute of Technology, USA
**Albert-László Barabási**, University of Notre Dame, USA
**Jim Crutchfield**, Santa Fe Institute, USA
**Skye Bender-deMoll**, Bennington College, USA
**Jean-Louis Deneubourg**, Université Libre de Bruxelles, Belgium
**Dirk Helbing**, Dresden University of Technology, Germany
**Cristopher Moore**, University of New Mexico, USA
**Béla Novák**, Technical University of Budapest, Hungary
**Beata Oborny**, Eötvös Loránd University, Hungary
**Wim van Saarloos**, Leiden University, The Netherlands
**Jonathan Shapiro**, Manchester University. UK
**Eörs Szathmáry**, Eötvös Loránd University, Budapest
**Gábor Vattay**, Eötvös Loránd University, Hungary
**Tamás Vicsek**, Eötvös Loránd University, Hungary
**Geoffrey West**, Los Alamos National Laboratory, USA
**Andy Wuensche**, Santa Fe Institute and Discrete Dynamics, Inc., USA

**Guest lectures:** **John Casti**, Technical University of Vienna, Austria

**Course objectives**
The goal of the summer school is to provide an intensive introduction to the study of complex behavior in mathematical, physical, and living systems, with particular emphasis on mathematical and computational modelling techniques. The school presents the core concepts and techniques of complex systems, together with the work in progress of researchers applying these ideas to specific problems. This training is designed to provide a solid understanding of traditional disciplines combined with a new view of complexity. In this way the school is intended to attract, stimulate, and educate the best young scientists as they begin to define their own research programs.

**Course level, target audience**
Applications are solicited from graduate students and postdoctoral fellows in any discipline, but with some background in science and mathematics at least at the undergraduate level (including calculus and linear algebra). Women, minorities, and students from developing countries are especially encouraged to apply.

**Course Content**
During the four weeks of the school, participants are introduced to the basic ideas and techniques central to research in complex systems, as well as current research frontiers.

*Week 1* will consist of an intensive series of lectures and laboratories introducing fundamental ideas and tools of complex systems research. The topics will include non-linear dynamics and pattern formation, statistical mechanics and stochastic processes, information theory, theory of selection and adaptation, computer modelling tools, and specific applications of these core topics to various disciplines.

*Weeks 2 and 3* will consist of lectures and panel discussions on current research in complex systems. The topics are:

- Foundations of Complex Systems (including nonlinear dynamics, information and computation theory, and evolution and adaptation)
- Network Structure and Dynamics
- Adaptation in Natural and Artificial Systems
- Universal Scaling Laws in Biology
- Collective Behavior and Self-Organization

*Week 4* will be devoted to completion and presentation of student projects.

**Syllabus**

*Foundations of Complex Systems*

Introduction to Complex Systems – Kondor
Stochastic processes and statistical inference
Dynamical systems theory – Wuensche, Crutchfield
Discrete dynamics software - Wuensche
Statistical mechanics – Moore
Measures of complexity – Moore
Information theory – Crutchfield
Theory of computation - Moore
Darwinian selection dynamics - Pepper
Collective Behavior and Self-organization
Jean-Louis Deneubourg – self-organization in social insects
Dirk Helbing - traffic jams, pedestrian flows, and escape panics
Tamas Vicsek - statistical physics of collective behaviour
Wim van Saarloos - nonequilibrium pattern formation

*Adaptation in Natural and Artificial Systems*

Chris Adami – evolution in digital and biological organisms
Jonathan Shapiro - evolutionary computation
Eörs Szathmáry – origin of life, molecular evolution

*Network Structure and Dynamics*

Albert-László Barabási – self-organized networks
Béla Novák – DNA regulatory networks
Gábor Vattay – internet traffic

*Scaling Laws in Biology*

Geoffrey West

Applicants may wish to visit the web site of the Santa Fe Institute Summer School at **http://www.santafe.edu** as well as the web site of CEU SUN at **http://www.ceu.hu/sun/sunindx.html** where more detailed course information will be available.