Evolution from Cellular to Social Scales

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Evolution from Cellular to Social Scales

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Preface

This volume comprises the proceedings of a NATO Advanced Study Institute (ASI) held at Geilo, Norway, 10–20 April 2007, the nineteenth ASI in a series held every two years since 1971. The objective of this ASI was to bring together researchers with various interests and background including theoretical physicists, soft condensed matter experimentalists, biological physicists, molecular biologists and social scientists to identify and discuss areas where synergism between modern physics, biology and social sciences may be most fruitfully applied to the study of various aspects of evolution ranging from cellular behaviour to social phenomena including globalization and terrorist networks.

Evolution is a critical challenge for many areas of science, technology and development of society. Emerging areas of science such as "systems biology" and "bio-complexity" are founded on the idea that phenomena need to be understood in the context of highly interactive processes operating at different levels and on different scales. Similarly, there is an increasingly urgent need to understand and predict the evolutionary behavior of highly interacting man-made systems, in areas such as communications and transport, which permeate the modern world. The same applies to the evolution of human networks such as social, political and financial systems, where technology has tended to vastly increase both the complexity and speed of interaction, which is sometimes effectively instantaneous. Better understanding, appreciation and prediction of the behavior of such systems will require the development of tractable methods for addressing evolution. On one hand, this implies deep analysis of particular evolutionary systems. On the other, there is clearly a need to develop general methods of analysis by investigating the similarities and commonalities between evolutionary systems in diverse areas in order to understand, for example, the phenomena in terrorist networks that are common to all networks, or at least to a large class of networks. Many fields of research are confronted with responses to evolutionary pressure in networks. Genetic and metabolic networks have evolved as a result of the interactions of proteins, substrates and genes in a cell. Social networks quantify the interactions between people in the society. Ecological systems are best described as a web of species, and terrorist networks have evolved through political and market pressures. The Internet is a complex web of computers

increasingly used by terrorists and increasingly vital to almost all human activities. In many cases the interacting networks manifest regulation and adaptation and so-called emergent properties that are not possessed by any of the individual components. This means that the detailed knowledge of the components is insufficient to describe the whole system.

The starting point in the proposed ASI was a thorough discussion of general evolutionary facts like origin of life and evolution of the genome and clues to evolution through simple systems. This is where physics meets complexity in nature, and where we must begin to learn about complexity if we are to understand it. The next focus was on evolution at different scales and evolution of complex networks in nature and society. Finally, focus was placed on the possible universality of network structures and how this knowledge can be combined to attack the urgent problem of counter threats of security and terrorism.

The scientific content of the school was timely and these proceedings should provide a useful definition of the current status. The Institute brought together many lecturers, students and active researchers in the field from a wide range of countries, both NATO and NATO Partner Countries. The lectures fulfilled the aim of the Study Institute in creating a learning environment and a forum for discussion on the topics stated above. They were supplemented by a few contributed seminars and a large number of poster presentations.

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December 2007

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