Science Matters

Humanities as Complex Systems

Maria Burguete and Lui Lam
Editors

Science Matters

Cover photograph

Fishing for knowledge (Lui Lam, Foz do Arelho Beach, 2006)

Artwork

Part I: Rounds (Charlene Lam, 2008)
Part II: Curves (Charlene Lam, 2008)
Part III: Swoops (Charlene Lam, 2008)

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Preface

All earnest and honest human quests for knowledge are efforts to understand Nature, which includes both human and nonhuman systems, the objects of study in science. Thus, broadly speaking, all these quests are in the science domain. The methods and tools used may be different; for example, the literary people use mainly their bodily sensors and their brain as the information processor, while natural scientists may use, in addition, measuring instruments and computers. Yet, all these activities could be viewed in a unified perspective: they are scientific developments at varying stages of maturity and have a lot to learn from each other.

That "everything in Nature is part of science" was well recognized by Aristotle and da Vinci and many others. Yet, it is only recently, with the advent of modern science and experiences gathered in the study of statistical physics, complex systems and other disciplines, that we know how the human-related disciplines can be studied scientifically.

Science Matters (SciMat or scimat) is about all human-dependent knowledge, wherein, humans (the material system of *Homo sapiens*) are studied scientifically from the perspective of complex systems (see Chapter 1). Here, the term "complex systems" means simply "very complicated systems," in the sense adopted by common people. SciMat includes all the topics covered in humanities and social sciences—in particular, art, literature, movie, culture, history, philosophy, science communication and the studies of science.

Traditionally, many of these topics are under the name of "science of x" or "science and x," where x could be culture, art, literature, society, and so on, or even science in the former case. However, x here, from the perspective of SciMat, is already a part of science. These descriptions are thus misleading. For example, by saying "science and culture," it implies that science and culture are two different things, which could be opposing each other. Instead, they are different aspects of the same thing—the effort to understand Nature and a new term "science matters" is called for.

To advance the idea of SciMat, a new discipline, the First International Conference on Science Matters was held in Ericeira, Portugal, May 28-30, 2007, co-chaired by Maria Burguete and Lui Lam. The intention was to bring together experts from art/humanities and sciences, finding out from each other how each person's own discipline is done and exchanging ideas. Hopefully, mutual understanding will be achieved and collaboration across disciplines will result, with the aim to raise the scientific level of the disciplines. This is not easy, but the important first step has been taken.

This book contains contributions from invited speakers of this conference, who are asked to expand their lectures for the general readership of all intellectuals. Two additional articles come from experts who are invited by the editors to contribute, after the conference. The articles, ranging from art to philosophy and history to social science and to physics, are loosely grouped under three parts (see Contents).

We are grateful to the contributors for their professionalism and skills in communicating to the non-experts, and the sponsors of the conference: Centro de Estudos Sociais da Universidade Coimbra, Barclays Bank, Fundação Luso-Americana, Fundação para a Ciencia e Tecnologia, Fundação Oriente, Fundação Calouste Gulbenkian and British Council. Their combined support makes this book possible.

Rio Maior, Portugal — Maria Burguete
San Jose, California — Lui Lam

Contents Summary

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PART II PHILOSOPHY AND HISTORY OF SCIENCE

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Science Matters: A Unified Perspective

Lui Lam

What is science? The answer is that "everything in Nature is part of science." On the one hand, what we called "natural science" is actually the science of (mostly) simple systems; they are human-independent knowledge. On the other hand, humanities/social sciences—human-dependent knowledge—belong to the science of complex systems. Demarcation of Nature according to human and nonhuman systems, and the recognition that complex systems are distinct from simple systems allow us to understand the world differently and profitably. For completeness, the nature of simple and complex systems is briefly presented. The origin of the two cultures (made famous by C. P. Snow), humanities and "science," is traced and some confusing issues clarified. While a gap between humanists and "scientists" does exist due to historical reasons, there is no intrinsic gap between humanities/social science and "natural science." If these disciplines look different from each other, it is because they are at various level of development, scientifically speaking. To *properly* bridge the gap and to advance the search for human-dependent knowledge, a new discipline—*Science Matters* (SciMat or scimat)—is introduced. SciMat treats all human-related matters as part of science, wherein, humans are studied scientifically from the perspective of complex systems with the help of experiences gained in physics, neuroscience and other disciplines. Consequently, all the topics covered in humanities and social sciences are included in SciMat. The motivation and concept of SciMat, and a successful example (*histophysics*, the physics of human history) are presented and discussed. Four major implications of SciMat are described. In particular, a new answer to the Needham Question is offered for the first time. This chapter ends with discussion and conclusion.

PART I

Art and Culture

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Culture Through Science: A New World of Images and Stories

Paul Caro

The relationship between science and society is dominated by the media, which act as the middle man going in between the two. Media have their own literary set of rules which basically are those of traditional story telling recipes such as those used in fairy tales. They can be easily applied to some scientific contents as shown by examples. This practice is as old as science itself as shown by the simultaneity of the birth of modern science in the 17th century and its immediate popularization as texts and images by the "media" of the time. The interplay of the public opinion, shaped by the media, and the conduct of policies in which scientific knowledge is involved, or plain basic culture, is important as demonstrated by history and by contemporary conflicts involving scientific matters. Science is in fact deeply embedded in culture through words and images.

2.1 The Science/Society Dialogue

Scientists and experts very rarely directly dialog with the public. The scientific language is made of four components: a difficult *vocabulary*, mathematical *formulas* and tables, *numbers* (some very large, other very small), and *images* (mostly obtained through instruments which extend human senses to the immense on one side and to the smallest on the other side, and see through human body—not directly understood by people with no training in science) [Caro & Funck-Brentano, 1996]. Moreover scientific specialists from different fields do not understand each other. The dialog should then proceed from indirect ways.

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Physiognomy in Science and Art: Properties of a Natural Body Inferred from its Appearance

Brigitte Hoppe

The historical roots and development of physiognomy are presented. This chapter discusses physiognomy as a method to judge by the outer appearance of the main parts, the so-called "signs," of objects in Nature, including human beings, in order to recognize their properties. The application of this method as described is found in many scientific fields and in the arts, extending from Classical Antiquity through Renaissance Humanism, to Modern Times. In the past, both the scientist and the artist hoped to detect, by observation, the obscure—"mute" but essential—properties of a natural object. The Aristotelian legacy has been retained in popular medicine (see the doctrine of "signatures"), whereas modern sciences give preference to instrumental and experimental analytical methods. Yet from the 17th century onward, physiognomy has been used mainly to discover and represent the characteristics of a human being. The holistic approach remains a heuristic method for interpreting the complex nature of humans.

3.1 What Physiognomy Means and Its Methodological Aims

When observing a natural object, an animal or a human being, for the first time both the naturalist and the artist—in particular an artist of the non-abstract period—each notices the overall constitution and disposition (*habitus* in Latin) of the natural being. They ask: what is its size, its main color, the quality of its surfaces, etc. In addition, they select

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Has Neuroscience any Theological Consequence?

Alfredo Dinis

In Michael Persinger's book *Neuropsychological Basis of Human Belief* (1987), he claimed to have found a causal correlation between the frequency of epileptic seizures affecting the left temporal lobe of human beings, and the frequency of their religious experiences. Rhawn Joseph has argued along the same lines in *The Transmitter to Go: The Limbic System, the Soul, and Spirituality* (2000). More recently, research on the neural correlate of religious experiences, such as Buddhist and Christian meditation, have become an interesting line of research for neuroscientists. The fact that a neural correlation of every religious experience can be identified, has led some authors to put forward the thesis that religion is fully explainable in terms of neural activity. I will try, first, to clarify whether we are allowed to identify the neural correlation of every human experience (its necessary condition) with its causation (or sufficient condition). Secondly, I will discuss the difference between internalist and externalist approaches in the study of the mind in general, and of the neural correlate of religious experiences, in particular. And thirdly, I will attempt to understand whether neuroscience fully explains the complexity of religious experience.

4.1 Neurotheology

How religious experiences correlate to the activation of specific brain areas is a matter of intense debate. Some neuroscientists claim that such experiences are deterministically caused by the activation of some brain areas.

Michael Persinger is certainly one of the best known authors of this group. Since the publication of his book *Neuropsychological Basis of Human Belief*, Persinger has been claiming that religious experiences—

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SciComm, PopSci and The Real World

Lui Lam

A physicist's experience in science communication (SciComm), popular science (PopSci) and the teaching of a Science Matters (SciMat) course *The Real World* is presented and discussed. Recommendations for others are provided.

5.1 Introduction

Yes, yes, I know. I know that I am not supposed to use abbreviations in a chapter title; I should spell out the whole word. But like the French say: rules are set to be broken. And indeed it happened: Newton (1643-1727) broke the rules set by Aristotle (384-322 BC) in dynamics, and replaced them with his own three laws; Einstein (1879-1955) in turn broke Newton's three laws and replaced them with his theory of special relativity. This is called innovation or in rare occasions, revolution. Rules could and should be broken when one has a good reason. And I have *two* good reasons.

My background as a scientist is not atypical. I have been working in physics research in the last 40 years. I am now a professor in California, a job involving both research and physics teaching (with an unbelievable teaching load of 12 credits[1] plus office hours per semester). My research

[1] At San Jose State University, an undergrad lab of 3 hours is counted as 2 credits (*versus* 3 credits in the community college of City University of New York, a great city) as the instructor's teaching load is concerned. I end up teaching 2 courses and 3 labs per week.

PART II

Philosophy and History of Science

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The Tripod of Science: Communication, Philosophy and Education

Nigel Sanitt

Communication in science is not just painted on after the science is finished. It is an essential aspect of both the process and understanding of science itself. This chapter sets out the arguments for enhancing scientists' training to include critical thinking and communication skills, and suggests that all science undergraduates should do at least one philosophy course as part of their curriculum.

6.1 Introduction

A hundred years ago the idea that philosophy was not part of a scientist's toolkit would have been greeted with incredulity. In fact the old term for science—*natural philosophy*—portrayed science as a branch of philosophy. So how did the break between science and philosophy come about? And why does the link need to be restored?

The roots of the divide arose out of the prodigious success of science over the last century, which gave rise to a burgeoning overspecialization and fragmentation into different disciplines. University courses became geared up to catering for new areas within science. The "wood" got lost amongst the "trees" and scientific method, principles and critical thinking became jettisoned. Why this trend must be reversed is the subject of this chapter.

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History and Philosophy of Science: Towards a New Epistemology

Maria Burguete

This chapter discusses a new concept of doing and thinking about chemistry while this scientific field is engaged with new phenomena. The new concept can give new answers to old problems related to the study of receptors. Whereas modern science gives preference to instrumental and experimental as well as analytical methods, a new era has emerged in the field of chemistry—computational chemistry—from the mid-20th century onward; that is, computer- aided ligand design methodology has been used to study and represent the characteristics of dopamine receptor structures. An explanation for the most significant epistemological approach in the change of notions and in basic phenomena discovered by using the method of computational chemistry (similar to a theoretical/philosophical case study) is given. The philosophical interest of this approach is connected with a different way of looking at chemistry, especially in the case of computational chemistry: It is an *epistemological* approach because it deals with language and classification in chemistry.

7.1 Introduction

All the early sciences stemmed from Philosophy. Descartes, Mach, Bohr and Einstein were aware of the philosophical basis of their search for knowledge; before them there was even no distinction at all between science and philosophy. However, from around two hundred years ago the paths of the scientist and the philosopher separated from each other:

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Philosophy of Science and Chinese Sciences: The Multicultural View of Science and a Unified Ontological Perspective

Bing Liu

Many debates and a few new perspectives focusing on Chinese sciences appeared recently in China. Here, after some historical and philosophical ideas are reconsidered, a unified ontological perspective is proposed to explain the existence of and the rationality behind the multicultural view of science.

8.1 Recent Debates on "Chinese Sciences" in China

Recently within China, there are many debates on Chinese sciences. For example, whether Chinese medicine or feng-shui is a kind of science, and debates on pseudoscience. A typical example is that a Chinese philosopher of science wrote a paper to advance "Farewell to Traditional Chinese Medicine and Remedies" [Zhang, 2006]. He argued that Chinese medicine does not belong to the medical sciences and is not exactly a rational medicine. He went on to view Chinese medicine from the perspective of "culture progress," "respecting science," "species diversity maintenance" and "humanitarianism." His paper has provoked a big debate about Chinese medicine, which is still going on in China. In this debate, an academician of the Chinese Academy of Sciences even wrote a paper to advocate that the core theory of Chinese medicine—yin-yang and the five elements—is nothing but pseudoscience. Opinions like these are typical in the recent debates on Chinese medicine.

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Evolution of the Concept of Science Communication in China

Da-Guang Li

The history of the conceptualization of science communication (or "science popularization") in China can be classified into four stages. Apparently, the discussion of science popularization evolved from diversified to governmental instructed and to authoritative, and ended up as the goal of raising the public scientific literacy. The last stage is triggered by the worries of the low percentage of scientific literacy in China when compared with that of other countries, as measured in recent years.

9.1 Introduction

In the 15th century, Christian missionaries introduced science and technology to China. Defeat of the Qing Dynasty in the Opium War made Chinese intellectuals and the public at large to realize the importance of scientific development and industry.

In the late Qing Dynasty and during the New Culture Movement (1900-1920s), Chinese scientists and intellectuals began pushing the themes of "science and democracy" and "human rights," introducing the ideas of freedom and democracy, and the achievements of natural science from Western countries to the Chinese people.

In 1915, the first science organization was established by a group of scientists who had studied science and technology in the universities of USA. With the publication of the journal *Ke Xue* (*Science*), they wanted

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History of Science in Globalizing Time

Dun Liu

Although globalization is quite a fashionable word today, from the standpoint of macrohistory, the migration of human civilization may be traced back to the departure from Africa of the early *Homo sapiens*; while the modern tendency towards globalization was initiated in as early as the 15th century when the great geographic discoveries were made. Similarly, although it was not until the first half of the 20th century that the history of science became a really mature discipline, historical records for a certain branch of natural knowledge and mathematics can be paralleled with relevant intellectual products of early human beings. Adopting dialectic narration, this chapter deals with some hot topics in today's historiography, including globalization, history of science, the Needham Question, the C. P. Snow Thesis and cultural diversity.

10.1 Globalization Today and Globalization in History

In recent years "globalization" has become a fashionable term, referring to the restructuring of the world economic order especially since the 1990s as a result of the onslaught of capital expanding globally. People in favor of globalization believe that it will lead to the blurring of national boundaries and profoundly influence the way people in every corner of the world live.

What is certain is that the ongoing globalization process will inevitably affect the spiritual life of humankind, impacting on different cultures in new ways and profoundly reshaping them. Globalization is an

PART III

Raising Scientific Level

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Why Markets are Moral

Michael Shermer

The new sciences of evolutionary economics, behavioral economics, and neuroeconomics demonstrate how and why markets must be moral in order to function. Trust is the key to understanding market exchange. This chapter discusses the relationship between trust and economic prosperity, as well as the neurochemistry of trust in the form of oxytocin, a hormone that increases trust between strangers in an economic exchange game. Implications for trust, trade, and economic prosperity are considered from this new research.

11.1 The Neurochemisty of Trust

"There's an old English proverb that says *It is an equal failing to trust everyone and to trust no one*." So begins Paul Zak, a professor of economics at Claremont Graduate University who is taking the study of economic behavior down to the molecular level in his search for the neurochemistry of trust and trade, which he believes is grounded in oxytocin, a hormone synthesized in the hypothalamus and secreted into the blood by the pituitary. In women, oxytocin stimulates birth contractions, lactation, and maternal bonding with a nursing infant. In both women and men it increases during sex and surges at orgasm, playing a role in pair bonding, an evolutionary adaptation for long-term care of helpless infants. "We know that trust is a very strong predictor of national prosperity, but I want to know what makes two people trust one another," Zak explains as we sit down in his Center for Neuroeconomics

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Towards the Understanding of Human Dynamics

Tao Zhou, Xiao-Pu Han and Bing-Hong Wang

Quantitative understanding of human behaviors provides elementary but important comprehension of the complexity of many human-initiated systems. A basic assumption embedded in previous analyses on human dynamics is that its temporal statistics are uniform and stationary, which can be properly described by a Poisson process. Accordingly, the interevent time distribution should have an exponential tail. However, recently, this assumption is challenged by extensive evidence, ranging from communication to entertainment to work patterns, that human dynamics obeys non-Poisson statistics with heavy-tailed interevent time distribution. This chapter reviews and summarizes recent empirical explorations on human activity pattern, as well as the corresponding theoretical models for both task-driven and interest-driven systems. Finally, we outline some open questions in the studies of statistical mechanics of human dynamics.

12.1 Introduction

Human behavior, as an academic issue in science, has a history of about one century since the time of Watson [1913]. As a joint interest of sociology, psychology and economics, human behavior has been extensively investigated during the last decades. However, due to the complexity and diversity of our behaviors, the in-depth understanding of human activities is still a long-standing challenge thus far. Actually, up to now, most of academic reports on human behaviors are based on clinical records and laboratorial data, and most of the corresponding

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Human History: A Science Matter

Lui Lam

Human history is the most important discipline of study. The complex system under study in history is a many-body system consisting of *Homo sapiens*—a (biological) material system. Consequently, history is a legitimate branch of science, since science is the study of Nature which includes *all* material systems. A historical process, expressed in the physics language, is the time development of a subset of or the whole system of *Homo sapiens* that happened during a time period of interest in the past. History is therefore the study of the past dynamics of this system. Historical processes are stochastic, resulting from a combination of contingency and necessity. Here, the nature of history is discussed from the perspective of complex systems. Human history is presented as an example of Science Matters. Examples of various scientific techniques in analyzing history are given. In particular, two unsuspected *quantitative* laws in Chinese history are shown. Applications of active walks to history are summarized. The "differences" between history and the natural sciences erroneously expressed in some history textbooks are clarified. The future of history, as a discipline in the universities, is discussed; recommendations are provided.

13.1 What is History?

Human history is the most important discipline of study [Lam, 2002]. Yet, human history, or history in general, as a science is rarely discussed [Lam, 2002; Krakauer, 2007].

Science is the study of Nature and to understand it in a unified way. Nature, of course, includes all material systems. The system investigated in history is a (biological) material system consisting of *Homo sapiens*. Consequently, history is a legitimate branch of science, like physics,

Contributors

Maria Burguete received her Ph.D. in History of Science (contemporary chemistry) from Ludwig Maximilians University at Munich, Germany (2000). She was the very first biochemist to graduate from the Faculty of Sciences in Lisbon (1982), after completing a Bachelor Degree in Chemical Engineering (1979) at the Lisbon Higher Institute of Engineering (ISEL). She is a scientist with teaching and research experience in a wide variety of scientific fields. This diversity enhanced the development of both her interdisciplinarity and a transdisciplinarity. She is now a scientist at Bento da Rocha Cabral in Portugal. She has published five scientific books and five poetry books, and over 20 scientific papers mostly in history and philosophy of science. *Email: mariabuguete@ gmail.com*

Paul Caro is a former (retired) Director of Research at CNRS who has worked for many years in inorganic chemistry. He is a rare-earths specialist. In the 1980s he became interested in science popularization through newspaper articles (in "Le Monde" and magazines), radio broadcasts (France Culture, Radio Classique, mostly), television shows (TF1), exhibitions in Museums and some books. He was until 2001 in charge of "scientific affairs" at the Cité des Sciences et de l'Industrie in Paris. He has served as an adviser for several DG Research European programs in the field of education and is also a scientific adviser for the Portuguese Program "Ciència Viva." He is a Corresponding Member of the French Academy of Sciences and a Member of the French Academy of Technology. *Email: paul_caro@hotmail.com.*

Alfredo Dinis graduated in Philosophy at the Catholic University of Portugal (1979) and in Theology at the Gregorian University of Rome (1985). He obtained an M.Phil. and a Ph.D. in History and Philosophy of Science from the University of Cambridge, UK (1986 and 1989). Since 1989 he has been lecturing in Philosophy of Science, Logic, and Cognitive Science at the Faculty of Philosophy of Braga (Portugal), where he is also at present the Faculty Dean. He is the President of the Portuguese Society for the Cognitive Sciences. His present research is centered upon the philosophical, ethical and theological consequences of recent developments in biology and in the cognitive sciences. *Email: adinis@braga.ucp.pt*.

Xiao-Pu Han, master degree graduate student at the University of Science and Technology of China, obtained his B.Sc. from Shandong University. He has published 15 scientific papers in research journals and conference proceedings since 2004. His current research interest focuses on human dynamics and complex networks. *Email: hxp@mail.ustc. edu.cn*.

Brigitte Hoppe obtained her state diploma in pharmaceutical sciences at the University of Freiburg (Breisgau); she earned the degree of Dr. phil. nat. in the History of Natural Sciences at the University of Frankfurt (Main) in 1964. Her research on epistemological changes in biology in Early Modern Times was the basis of the habilitation thesis at the University of Munich in 1972. As an Associate Professor at this university (1980), she was responsible for a working group in the History of Life Sciences. Dr. Hoppe published 7 books and more than 200 papers. She is an Effective Member of the International Academy for History of Sciences and member of national and international societies in this field. Her current research is in the history of biological sciences from 17th to 20th centuries, and on explorations in the field of natural history in overseas countries. *Email: B.Hoppe@lrz.uni-muenchen.de*.

Lui Lam obtained his B.Sc. (with First Class Honors) from the University of Hong Kong, M.Sc. from University of British Columbia, and Ph.D. from Columbia University. He is Professor of Physics at San Jose State University, California and an Adjunct Professor at both the Chinese Academy of Sciences and the China Association for Science and Technology. Prof. Lam invented bowlics (1982), one of three existing types of liquid crystals in the world; active walks (1992), a new paradigm in complex systems; and a new discipline called histophysics (2002). Lam published 11 books and over 160 scientific papers. He is the founder of the International Liquid Crystal Society (1990); cofounder of the Chinese Liquid Crystal Society (1980); founder and editor-in-chief of the Springer book series Partially Ordered Systems. His current research is in histophysics, complex systems and science matters. *Email: lui2002lam@yahoo.com.*

Da-Guang Li, a professor at the Graduate University of Chinese Academy of Sciences, is the Executive Director of the 1996, 2001 and 2003 Surveys of Public Understanding of Science of Chinese Adults, and the Chinese translator of the popular science book *The Demon Haunted World* by Carl Sagan. *Email: ldaguang@yahoo.com*.

Bing Liu obtained his B.Sc. from Peking University and M.Sc. from the Chinese Academy of Sciences. He is now Professor of History and Philosophy of Science, in the STS Institute, School of Humanities and Social Sciences, Tsinghua University, Beijing, China. Prof. Liu has published more than 20 books and over 170 papers in history and philosophy. His current research is in history of science, and science communication. *Email: liubing@tsinghua.edu.cn*.

Dun Liu, the former Director of the Institute for the History of Natural Science within the Chinese Academy of Sciences (1997-2005), is the incumbent President of the Chinese Society for the History of Science and Technology. Among his numerous publications, the book *How Great Math Is* (Shenyang, 1993) and several treatises on Chinese mathematics/astronomy within the social context of the Ming to Qing period (ca. 16^{th}-17^{th} centuries) are most appreciated by researchers. He is editor-in-chief of the bimonthly journal, *Science & Culture Review*. His current focus is on historical and cultural issues of science. *Email: liudun@ustc.edu.cn*.

Nigel Sanitt obtained his B.Sc. in Physics from Imperial College, London and Part III of the Mathematics Tripos and Ph.D. from Cambridge University, where he trained as an astrophysicist at the Institute of Astronomy. He is founder and editor of *The Pantaneto Forum*, a journal which aims to promote debate on how scientists communicate, with particular emphasis on how such communication and research skills can be improved through a better philosophical understanding of science. His book *Science as a Questioning Process* was published in 1996, and he has edited a collection of articles from the first five years of The Pantaneto Forum under the title: *Motivating Science. Email: nigel@ pantaneto.co.uk.*

Michael Shermer is Publisher of *Skeptic* magazine (www.skeptic.com) and a monthly columnist for *Scientific American* (www.sciam.com). He is the author of *Why People Believe Weird Things, How We Believe, The Science of Good and Evil*, and *Why Darwin Matters*. His new book is *The Mind of the Market: Compassionate Apes, Competitive Humans, and Other Tales from Evolutionary Economics* (Henry Holt/Times Books). *Email: mshermer@skeptic.com.*

Bing-Hong Wang, graduated from Theoretical Physics Specialty, Department of Modern Physics, University of Science and Technology of China (USTC), Beijing, in 1967, did his Post Doctoral Research in Department of Physics, Stevens Institute of Technology, USA during 1982-1985. His current occupation: Professor, Ph.D. Doctor's Adviser of Theoretical Physics, USTC; Director, Institute of Theoretical Physics, USTC; Head, National Key Important Specialty of Theoretical Physics, USTC; Director, Institute of Complex Adaptive System, Shanghai Academy of System Science, Shanghai, China; Executive Director, Nonlinear Science Center, USTC; and President, Nonlinear Science Society of Anhui Province, P. R. China. His recent research interests focus on traffic flow, statistical physics, nonlinear dynamics,

econophysics, complex networks and complex adaptive system theory. He has published more than 200 research papers in scientific journals. *Email: bhwang@ ustc.edu.cn.*

Tao Zhou obtained his B.Sc. from the University of Science and Technology of China (USTC) in 2005, and is a Ph.D. student majoring in theoretical physics at USTC now. He has published over 100 papers in refereed journals, with more than 70 of them included in *Web of Science* (SCI Index). His publications together obtained more than 500 citations according to *Web of Science*. His current research interests include complex networks, human dynamics, econophysics, statistical mechanics of information systems, and collective dynamics of self-driven particles. *Email: zhutou@ustc.edu*.

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All earnest and honest human quests for knowledge are efforts to understand Nature, which includes both human and nonhuman systems, the objects of study in science. Thus, broadly speaking, all these quests are in the science domain. The methods and tools used may be different; for example, the literary people use mainly their bodily sensors and their brain as the information processor, while natural scientists may use, in addition, measuring instruments and computers. Yet, all these activities could be viewed in a unified perspective—they are scientific developments at varying stages of maturity and have a lot to learn from each other.

That "everything in Nature is part of science" was well recognized by Aristotle and da Vinci and many others. Yet, it is only recently, with the advent of modern science and experiences gathered in the study of statistical physics, complex systems and other disciplines, that we know how the human-related disciplines can be studied scientifically.

Science Matters is about all human-dependent knowledge, wherein, humans (the material system of *Homo sapiens*) are studied scientifically from the perspective of complex systems. Science Matters includes all the topics covered in humanities and social sciences.

This book contains contributions from knowledgeable humanists, social scientists and physicists. It is intended for those, from artists to scientists, who are curious about the world and are interested in understanding it with a unified perspective.

Maria Burguete is a scientist at Scientific Research Institute Bento da Rocha Cabral in Portugal. She has published five scientific books, five poetry books, and over 20 scientific papers mostly in history and philosophy of science.

Lui Lam is Professor of Physics at San Jose State University, California. He invented bowlic liquid crystals (1982), active walks (1992) and histophysics (2002). He is the editor in chief of the book series *Partially Ordered Systems*, the editor of *Introduction to Nonlinear Physics* and *Nonlinear Physics for Beginners*, and the author of *This Pale Blue Dot.*

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