Humanities Science Scimat

An Interdisciplinary Cross-Cultural Introduction

Lui Lam

Science Matters Series

Lui Lam
Founder and Editor

Scimat (Science Matters) is the new nultidiscipline that treats all human-dependent matters as part of science, wherein, humans (the material system of *Homo sapiens*) are studied scientifically from the perspective of complex systems. 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 evolutionary and cognitive sciences, neuroscience, statistical physics, complex systems and other disciplines, that we know how the human-related disciplines can be studied scientifically. **Science Matters Series** covers new developments in all the topics in the humanities and social science from the scimat perspective, with emphasis on the humanities.

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4. *Humanities, Science, Scimat: An Interdisciplinary and Cross-Cultural Introduction*
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Science Matters Series | No.4

Humanities, Science, Scimat

An Interdisciplinary and Cross-Cultural Introduction

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San Jose State University, USA

World Scientific

NEW JERSEY · LONDON · SINGAPORE · BEIJING · SHANGHAI · HONG KONG · TAIPEI · CHENNAI

Contents Summary

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Prolog

The year was 1990. When NASA's *Voyager 1* space probe was leaving the Solar System, it turned its camera around and took one last picture of Earth. In this rare picture, our dear Earth appears as a pale blue dot. The blue is reflection from the seas while the white comes from the clouds and ice. It is this pale blue dot we share every day. It is on this pale blue dot our joy and sorrow come and go. We are curious about the real world happening on this pale blue dot and beyond. We are curious about the trees, ants, sunset and the stars up in the sky. We are curious about the fate of us humans—past, present and future. And we keep on wondering whether there is a God out there.

These questions were raised systematically about 2,600 years ago by the Greeks in the West and the Chinese in the East. The complete answer did not come, not even today. However, in the past 400 years since Galileo, modern science has prospered and we know much more. We even have the answer to some of the big questions raised by our ancestors.

Our understanding of this pale blue dot and its inhabitants, we humans among them, comes from all branches of science, but especially from the study of complex systems in the last three decades as well as the century-long development of evolutionary science and neuroscience. To understand where we came from, why we humans behave the way we do, and how we can make the world better tomorrow, we have to look back 13.7 billion years in the past. A long look back in time, just like the *Voyager 1*'s long look back in space. In this book, some of these understandings are presented, spanning from science to arts and human history, and to the God question.

1

Introduction

No matter what you study and do in the future, this book contains some fundamental or common-sense knowledge that you should possess. They are essential in helping you to understand properly yourself and the real world out there, and could change your life or career planning. They are prerequisites for a fruitful and happy life, in the university and beyond.

1.1 Learning

This book is a textbook for a general-education course. Its nature is trans-disciplinary and cross-cultural. Its emphasis is not on the detailed knowledge but on the basic concepts and their connections. The materials presented are profound and deep, but never complicated. For details, there are the special courses, and you can easily find them in Wikipedia and Google Scholar.

Part I: Basic forms the core of this course; everyone should read. The rest you read when you feel like it. But you may want to know that those are extremely interesting topics which are not available elsewhere. That is why you buy this book. Every chapter ends with a Summary and Further Reading, which are mostly popular-science books or articles. The Summary is to make your life easy; I am on your side.

As a student, you should read before you enter the classroom and take advantage of it. You pay for them already, anyway. To get the maximum return for your money, use the classroom to engage people, the instructor and fellow students, in discussion and debate—the Socratic Method of gaining knowledge. The second advantage of attending class is that the instructor has prepared a large number of beautiful, colored power-point slides to entertain you, to keep you awake and save you time in collecting them yourself. Ask the instructor for copy of the slides.

The examinations should be easy. No formulas and no calculations. But you can make it as technical as you want, in doing your term paper, assuming there will be a term paper. It is up to you. Aim high. But the important point is to have fun. And make a lot of interesting friends there. After all, it is just a general-education course.

1.2 Teaching

Every university instructor is qualified and *can* teach this general-education course. You may not know everything in this book since the topics span from the humanities to "natural science". But nothing there is technical. You can understand them easily. The tricks are:

- In the first lecture, you admit to the students that you are not the expert in every topic in the course. And tell them you will learn it together with them. Tell them that is the way research is done. That is true. No shame, no guilt.
- Ask volunteers in the class to do an Internet search for any question that you cannot answer. And give the volunteer "extra credit" after the student does a one to three minutes presentation in the next class. Students love extra credits, at least for those in the United States. Tell them this is to train them to do presentations. That is true, too.

Now, no matter what you do, make sure you cover Part I: Basic before the course ends. You can expand any part of it according to your personal expertise or interest. That can be done easily with Internet search, use of the library, and reading some of the materials suggested in the Further Reading section at the end of each chapter.

The book can be used for a short course, or a one to two units course. (In America, one unit is a 50-minute class per week, for about 14 weeks that include examination sessions.) There are enough materials in the book to cover that. The course is suitable for undergrad or grad students of any major. Here are four different ways of conducting the class.

1.2.1 *Closed Teaching*

Closed teaching means the traditional way of teaching, suitable for a large class—any class with more than 15 to 20 students, say. The instructor lectures, with power-point presentations. For a full-term course, the examinations could consist of two mid-terms and a final. Each mid-term exam could be multiple choice and worth 25 points, with questions to test whether the students actually read the book and grasp the important points. The final exam could be a term paper and worth 50 points, written individually with 1,500-2,000 words, say.

Closed teaching is boring, for both the instructor and the students, but is still the practical way to go for a large class. However, you can make the class more interesting and enlightening by leaving a lot of time for class discussion.

1.2.2 *Open Teaching*

Open teaching is very educational, for both the instructor and students. It is the preferred mode of teaching for a small class; the optimal class size is 15 students. A particular mode I tried before in my course *The Real World* is recommended here (Fig. 1.1). It is actually two intertwined courses: a research-training course and a regular course on scimat. (See Section 4.5.1 for a quick introduction to scimat.)

The course is made up of lectures and seminars, student projects, and oral presentation and writing trainings. For a full-term course, the grading could be: presentation (25%), mid-term exam (25%), term project and report (40%), participation (10%). The course consists of three parallel components:

1. The instructor will introduce the proper relationships between humanities and "natural science"—from the perspective of scimat—and new developments (especially those using the bottom-up approach) in history, arts and philosophy. Outside speakers could be used.
2. Students will form teams of 1-3 persons each. Each team will work on a (research) project of their choice which is approved by the instructor, to investigate what has been done scientifically on that topic, with the help from the web, library and experts around the world. Students will present progress report in class. Make sure every team member will deliver at least one presentation. The team will hand in a joint written report at end of course. And organize a half-day or one-day workshop for them to present them to the public. Mix it with prominent speakers invited from your university or outside. That will make the students and your department happy.
3. The teams will be treated and guided like research teams. Pretend that they are your research groups for a funded project called "Understanding the World". The teams do not compete with each other, but compete with other research groups outside of your university. Have a group picnic; that will raise everybody's spirit (you or your department pays for it, of course). The students will learn how to do good research, do oral

presentation and write research papers in English. (The high-quality papers could be published in international research journals.)

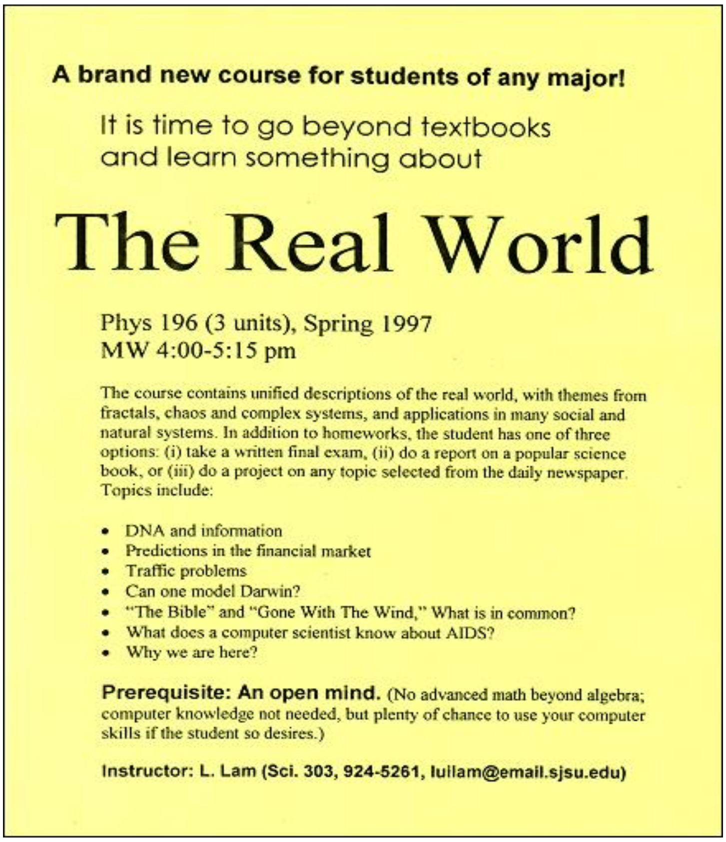


Fig. 1.1. The upper-division course *The Real World* created and taught by Lui Lam in Spring 1997 at San Jose State University. In Fall 2002, a general-education course of the same name was taught by Lam as one of the 100 incoming-freshmen MUSE courses. (MUSE means Metropolitan University Scholar's Experience.)

The scimat lectures are presented to fill in the gaps between student presentations, which are plenty in the beginning but less so near the end. (See Appendix A for a teaching report.)

1.2.3 *Mixed Teaching*

In this mode, only one or two research teams are formed. Each team has about 5 students. Other students each picks a topic from a section of the textbook (selected by the instructor from Chapters 3-7; introduction and conclusion sections are excluded in the list). They will prepare and teach that section when the time comes, and write up a paper based on that. This mode is less stressful for the instructor and those students who choose not to do a team paper. (See Appendix B for a teaching report.)

1.2.4 *Collective Teaching*

In this mode, there are no teams—an extreme case of the mixed-teaching mode. Each student picks a section like in the mixed-teaching case, teach, and write a paper at the end. This mode is most relaxing for the instructor and serve the purpose of training students to do research, teaching and writing papers *without* team works. It could also be used in teaching any GE course and most humanities courses which do not involve too technical and mathematical materials.

1.3 The Book

The book, in the form of a textbook, is designed also for self-study. It is suitable for everybody to read. As a textbook, only a few references are given. But the reader can find the relevant references from the author's articles listed in the Bibliography. The literature listed in Further Reading can be consulted, too. Note that the references listed in Further Reading are all by other authors and serve as background materials only.

There are a few Chinese names in this book; the conventions are:

1. All Chinese names in text are written with family name *first*, with first name's characters (if more than one) connected by a hyphen.
2. All Chinese names from mainland China are spelled out in pinyin.
3. For those who made their career in the US, whether they settled later in mainland China or not, their name's old spelling is adopted, i.e., *not* in pinyin. For example, Yang Chen-Ning in this book is Chen Ning Yang in the US (which would be Yang Zhengning if he made his career in mainland China but not in the US).

4. Lui Lam made his career in both places, outside and inside China. The name Lui Lam is the only exception of the three rules above. Lam is the family name.

1.4 Summary

1.5 Further Reading

- Gary Miller's *The Meaning of General Education* (1988) is the only book that discusses the history, concept and impact of general education, which started in the 1920s and 1930s as a curriculum movement in the United States.

PART I

Basic

2

Humans

The universe as we know it starts with the Big Bang 13.7 billion years ago. Humans, like other animals, plants and nonliving systems (such as a table or ping pong ball) on Earth, are made up of atoms coming from the stars. There are about $5x10^{12}$ cells in a person's body, with 10^{11} neurons in the brain. Both genes and epigenes can pass on from generation to generation. It is through the evolutionary process that we become the way we are today.

2.1 We Came a Long Way

It all began with the Big Bang, or earlier, about 13.7 billion years ago (bya). At 10^{-5} seconds later, "long" after the cosmic inflation (which happened about 10^{-37} seconds after the bang), protons and neutrons appeared. They combined to form nucleus at 0.01-300 seconds after the bang, with *atoms* formed 380,000 years later. Stars appeared 13.4 bya; our Solar System, of which Earth is a member, 4.7 bya (about 1/3 the universe's age); life on Earth, 3.7 bya. The important point is that *all living systems on Earth are made up of atoms*, the same atoms that make up nonliving systems. All atoms came from the dying stars, except that hydrogen and helium appear soon after the Big Bang in the universe. Consequently, humans are "stardust", but what a stardust! (See Fig. 2.1.)

While the origin of life on Earth is an unsolved problem, we do know from Darwin's evolutionary theory (1859) that humans were evolved from simpler lives. However, we are not descendants of the monkey, but of fish (Fig. 2.2). In fact, six million years ago, the chimp and human lineages split. We *Homo sapiens* appeared 195,000 years ago in Africa, moved out from there 60,000 years ago for the second time and spread all over the world (see Table 2.1). That is, all living human beings are relatives from the same family tree. We share the same genes, more or less.

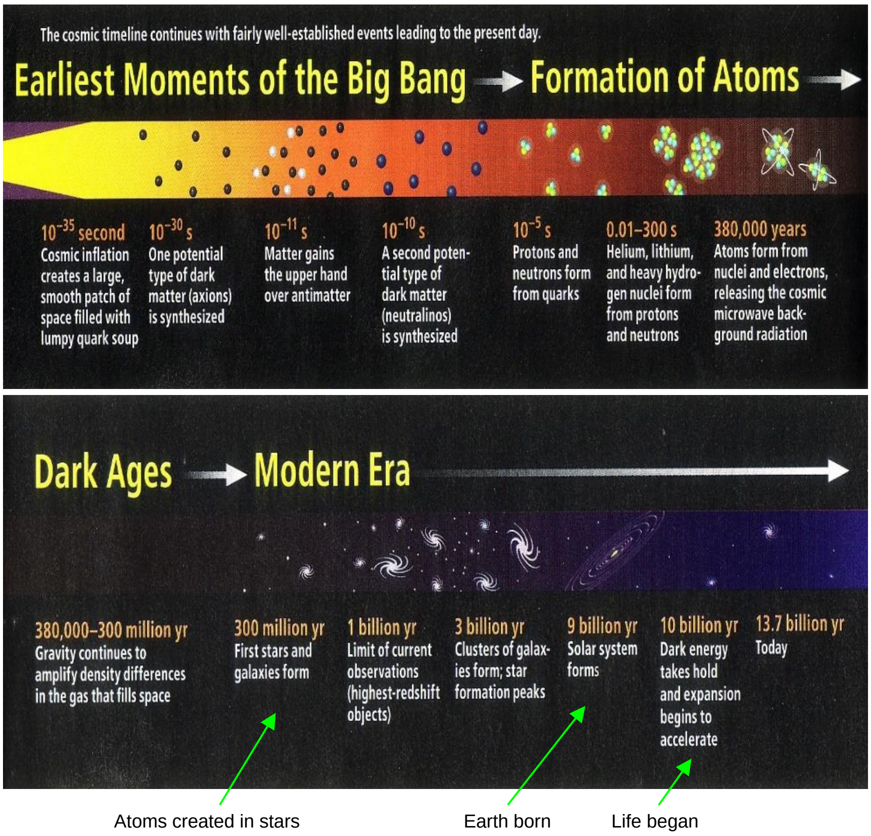


Fig. 2.1. A brief history of the universe. (Adapted from Turner, M. S. [2009] "The universe", *Scientific American*, Sept., 36-43.)

A turning point appeared 50,000 years ago: *Homo sapiens sapiens*, our immediate ancestors, suddenly became innovative. Without change of the brain size, somehow, innovations exploded (e.g., ritualistic burials, clothes making, complex hunting techniques were invented) and continued on ever since. Then another turning point appeared 10,000 years ago while humans settled down with villages created and agriculture began. Written history is known for only 8,000 years or so. Long before that, with plenty of free time available, our ancestors began wondering what happened around them—everything, down on earth and up in the sky, including, very likely, the crucial question of why we are here. By this time, the two pillars of civilization, ethics and arts (see Chapter 6), were already in place while science, the third pillar in a modern civilization, appeared much later about 2,600 years ago.

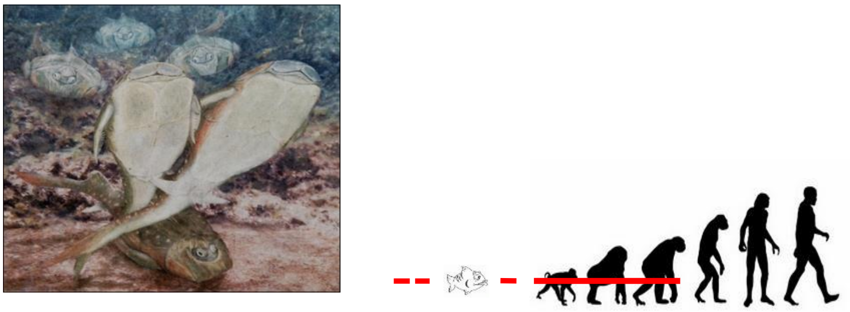


Fig. 2.2. *Left*: Microbrachius, the earliest fish that is known to have sexual organs. It is 8 cm long, lived 0.4 billion years ago. They are our common, earliest ancestors known to us so far. Shown in the front is a female (*left*) and a male (*right*) paring in copulation while swimming in the same direction; that is the way they mate. The rest are observers. *Right*: The usual pictorial depiction of human evolutionary history is partially wrong. We did not evolve from the monkey or chimpanzee (we split six million years ago, Table 2.1) but *did* evolve from the fish. So did the chimps.

2.2 Humans

To understand who we are we have to understand humans—the biological make up of a human body and humans' evolutionary history. Here are the basic facts about humans. A human body is composed of $5\text{x}10^{12}$ cells. Each cell is made up of molecules, a combination of atoms (coming from the stars). One of these molecules is the DNA molecule which is the same inside each cell. It is the DNA that passes biological information from generation to generation. However, a human being's thinking and behavior are controlled by the 10^{11} neurons in her brain. And the neurons could be influenced by external media (e.g., artwork, sunset) through the bodily sensors or substances (e.g., marijuana smoke) absorbed into the body.

There are several basic facts about human development that are relevant to our discussion, summarized in Table 2.1. Equally important is how humans pass on their genes and the question of "nature vs. nurture". According to the British naturalist, Charles Darwin (1809-1882), and putting it in modern language, human inheritance is stored in the genes and passed on from generation to generation. However, *random* mutation of the genes happens from time to time, resulting in the appearance of new species. Different species compete with each other for resources and "the fittest wins". This is called "natural selection" or the evolutionary pressure; the winner keeps the (new) genes that help it win—an adaptive trait in the evolutionary sense. Moreover, the evolutionary process is very slow and continuous; no learned skills can be passed on to the next generation.

Table 2.1. A brief history of human development. Data source: www.newscientist.com/movie/becoming-human (June 18, 2010).

Years ago	Evolution	Migration	Life style	Art related
6 million	Chimp and human lineages split.			
3.5-1.8 million			First hominids move from forest to savannah; meat eating begins.	
2.5 million	*Homo habilis* appears.			
2 million	*Homo erectus* appears.			
1.8 million		First wave of migration out of Africa begins.		
1.6 million			First use of fire; more complex stone tools created	
400,000			Earliest evidence of cooking.	
195,000	*Homo sapiens* (early modern humans) appears.			
120,000				Pigment use gives first evidence of symbolic culture.
72,000				Clothing invented and earliest evidence of jewelry
60,000		Second wave of migration out of Africa (Fig. 2.3)		
50,000				Cultural revolution: ritualistic burials, clothes-making, invention of complex hunting techniques
35,000				Oldest known cave art (in France, Spain,…)
10,000			Agriculture begins; first villages appear.	
5,500				Bronze Age begins.
5,000				Earliest known writing

The present understanding is that although we do inherit stable genes, we also inherit alterable epigenes. Epigenes are molecules external to the genes that can switch on and off particular genes (Fig. 2.4). More importantly, an epigene's switching state could be influenced by the environment and could be passed on to the next generation, for many generations. For example, this passing-on ability has been demonstrated in fruit flies. When exposed to a drug fruit flies show unusual outgrowths on their eyes that can last through at least 13 generations of offspring when no change in DNA has occurred. Similarly, experiments on roundworms fed with a kind of bacteria show changes that last at least 40 generations.

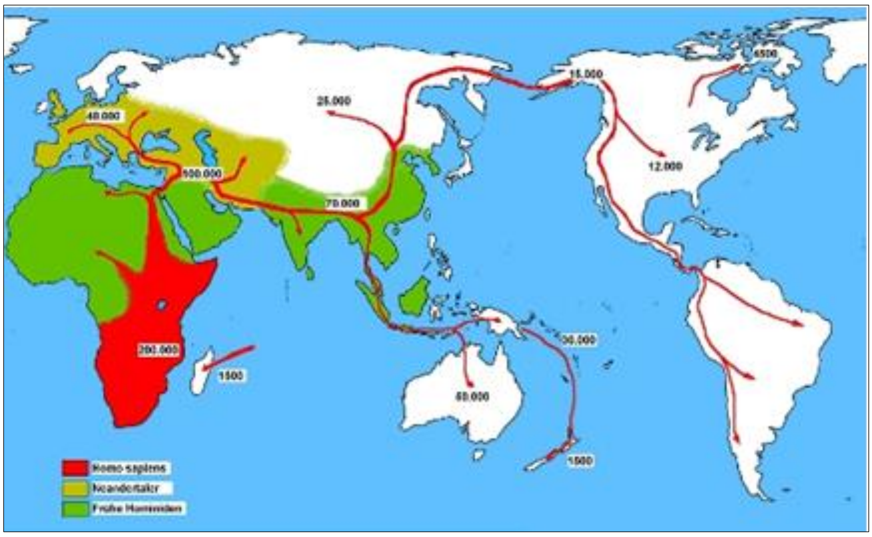


Fig. 2.3. Spreading of *Homo sapiens* out of Africa. (The numbers in this map differ slightly from those in text.) According to this map, everyone alive belongs to the same family tree; we are all relatives of each other, irrespective of race and skin color

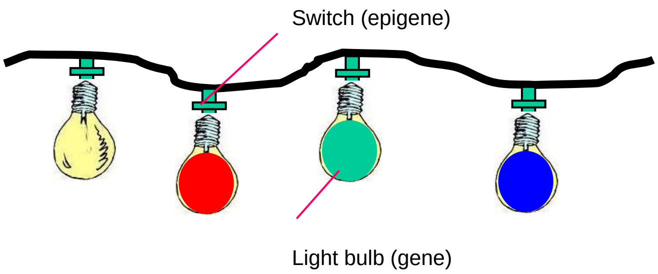


Fig. 2.4. Presently, a DNA chain can be visualized as a chain of light bulbs in different colors plus switches for the light bulbs. The light bulb represents a gene; the switch, an epigene.

What all these imply is that the debate of “nature vs nurture” is losing its importance since nature (genes) and nurture (environment acting through epigenes) are both inheritable.

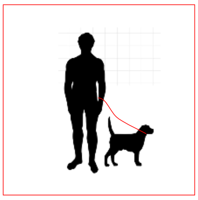
2.3 Summary

- Everything starts with the Big Bang.
- Everything on Earth including humans are made up of atoms created in the stars (except that hydrogen and helium appear soon after the Big Bang in the universe).
- We are one big family (with fish as our ancestor).
- Humans originated from Africa.
- Nature and nurture are both important.

2.4 Further Reading

- Jacob Berkowitz’s *The Stardust Revolution* (2012) gives a fascinating tale of how the elements on Earth were created, mostly in dying stars, and how they came to Earth, from which all living and nonliving matters are formed. It is also a collection of exciting innovation stories along the way.

Epilog



In the last 400 years or so since Galileo, the study of nonhuman systems under the name of "natural science" or modern science did enlighten deeply our understanding of Nature (e.g., Big Bang), make our lives easier (cell phone) and help to prolong our lives (for good or bad). But that is not enough as the future of humanity is concerned, as the so-called "revolt against science" tried very hard to remind everybody. *It is the humanities that determine our quality of life* (e.g., to pollute or not to pollute) *and bring us genuine happiness* (human relationships, arts). While the study in "natural science" should be continued, it is time for us to return to the Aristotelian tradition of treating the human system and nonhuman systems as equally important in our search for knowledge. This tradition was interrupted by the phenomenal success of modern science.

Deepening humanities' research and taking it to the next level do not require large increase of the research budget. No smashing machines needed to be built. *What is needed is a change of our concept of science and our perception of priority*. For example, for the four science-related humanities disciplines covered in Part II, shifting the focus from simple systems to complex systems, from nonhuman systems to the human system, can be started immediately. The humanities were the frontier for the early Greeks and ancient Chinese, which are again the new frontier for the rest of us.

For students majoring in "science" or engineering, it is imperative that you take a few humanities courses; for those in humanities, take some "science" courses and make sure you know how to use Excel, for example. Because the world out there is fast changing and not entirely predictable; we don't know where the new growth points are in the future. Except that we know for sure, the world is in desperate need of talents who are equally fluent in the humanities and "science".

Bibliography

Here is a subset of the full bibliography. It includes only the items recommended in Further Reading, and the author's selected writings from which the reader can find some pertinent references.

Berkowitz, J. [2012] *The Stardust Revolution: The New Story of Our Origin in the Stars* (Prometheus Books, Amherst, NY).

Budin, S. L. [2009] *The Ancient Greeks: An Introduction* (Oxford University Press, New York).

Churchland, P. S. [1989] *Neurophilosophy: Toward a Unified Science of the Mind-Brain* (MIT Press, Cambridge, MA).

Knobe, J. & Nichols, S. (eds.) [2008] *Experimental Philosophy* (Oxford University Press, Oxford).

Lam, L. [1998] *Nonlinear Physics for Beginners: Fractals, Chaos, Solitons, Pattern Formation, Cellular Automata and Complex Systems* (World Scientific, Singapore).

Lam, L. [2002] "Histophysics: A new discipline", Modern Physics Letters B **16**, 1163-1176.

Lam, L. [2004] *This Pale Blue Dot: Science, History, God* (Tamkang University Press, Tamsui).

Lam, L. [2005] "Active Walks: The first twelve years (Part I)", International Journal of Bifurcation and Chaos **15**, 2317-2700.

Lam, L. [2006] "Active Walks: The first twelve years (Part II)", *International Journal of Bifurcation and Chaos* **16**, 239-268.

Lam, L. [2008a] "Science Matters: A unified perspective", in *Science Matters: Humanities as Complex Systems*, eds. Burguete, M. & Lam, L. (World Scientific, Singapore) pp. 1-38.

Lam, L. [2008b] "SciComm, PopSci and The Real World", in *Science Matters: Humanities as Complex Systems*, eds. Burguete, M. & Lam, L. (World Scientific, Singapore) pp. 89-118.

Lam, L. [2008c] "Human history: A Science Matter," in *Science Matters: Humanities as Complex Systems*, eds. Burguete, M. & Lam, L. (World Scientific, Singapore)pp. 234-254.

Lam, L. [2011] "Arts: A Science Matter," in *Arts: A Science Matter*, eds. Burguete, M. & Lam, L. (World Scientific, Singapore) pp. 1-32.

Lam, L. [2014a] "About science 1: Basics—knowledge, Nature, science and scimat", in *All About Science: Philosophy, History, Sociology & Communication*, eds. Burguete, M. & Lam, L. (World Scientific, Singapore) pp. 1-49.

Lam, L. [2014b] "About science 2: Philosophy, History, Sociology and Communication", in *All About Science: Philosophy, History, Sociology & Communication*, eds. Burguete, M. & Lam, L. (World Scientific, Singapore) pp. 50-100.

Lam, L. [2015] "Philosophy, Science and Scimat", in *Humanities as Science Matters: History, Philosophy and Arts*, eds. Burguete, M. & Riesch, H. (Pantaneto Press, London).

Lam, L. & Qiu Li-Meng [2011] "Su Dong-Po's bamboo and Paul Cezanne's apple", in *Arts: A Science Matter*, eds. Burguete, M. & Lam, L. (World Scientific, Singapore) pp. 348-370.

Miller, G. E. [1988] *The Meaning of General Education: The Emergence of a Curriculum Paradigm* (Teachers College, Columbia University, New York).

Russell, B. [1945] *The History of Western Philosophy* (Simon & Schuster, New York).

Tsui Hark & Lam, L. [2011] "Making movies and making physics," in *Arts: A Science Matter*, eds. Burguete, M. & Lam, L. (World Scientific, Singapore) pp. 204-221.

Wartenberg, T. E. [2012] *The Nature of Art: An Anthology* (Wadsworth, Boston).

About the Author

Lui Lam, humanist and physicist, obtained his BS (First Class Honors) from University of Hong Kong, MS from University of British Columbia, and PhD from Columbia University. He is a physics professor at San Jose State University, California, and adjunct professor at Chinese Academy of Sciences *and* the China Association for Science and Technology. 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 two new disciplines: Histophysics (2002) and Scimat (2007/2008). He has published 16 books and over 180 scientific papers. He is the founder of the International Liquid Crystal Society (1990); cofounder of the Chinese Liquid Crystal Society (1980); founder and editor of two book series: Science Matters (World Scientific) and Partially Ordered Systems (Springer). His current research is in scimat and complex systems. *Email: lui2002lam@ yahoo.com*

Science Matters Series | No.4

Since the ancient times humans are curious about the real world out there. We are curious about the trees, ants, sunset and the stars up in the sky, and the fate of us humans—past, present and future. And we keep on wondering whether there is a God out there. These questions were raised systematically about 2,600 years ago by the Greeks in the West and the Chinese in the East. The complete answer did not come, not even today. However, in the past 400 years since Galileo, modern science has prospered and we know much more. We even have the answer to some of the big questions raised by our ancestors.

In *Humanities, Science, Scimat*, some of these understandings are presented, from the scimat perspective that treats all human-depending matters as part of science. To understand where we came from, why we humans behave the way we do, and how we can make the world better tomorrow, we have to look back 13.7 billion years since the Big Bang. The book spans from science to human history, from arts to philosophy, and to the God question. It is a trans-disciplinary and cross-cultural introduction to some fundamental knowledge that everyone should possess today. The book is written as a textbook for a new, twenty-first-century general-education course for students of all majors, and for self-study by everybody else.

Lui Lam, humanist and physicist, is a professor at San Jose State University, California. He invented Bowlic Liquid Crystals (1982), Active Walks (1992), Histophysics (2002) and Scimat (2007/2008). He is the founder of the International Liquid Crystal Society; founder and editor of two book series, *Science Matters* and *Partially Ordered Systems*; editor of *Introduction to Nonlinear Physics* and *Nonlinear Physics for Beginners*; and author of *This Pale Blue Dot*.