Presented at The 9th International Conference on Public Communication of Science and Technology (PCST), Seoul, South Korea, 17-19 May 2006; published in *The Pantaneto Forum*, Issue 24 (2006).

THE TWO CULTURES AND THE REAL WORLD

Lui Lam

Department of Physics, San Jose State University, San Jose, CA 95192-0106, USA; Institute of Physics, Chinese Academy of Sciences, and China Research Institute for Science Popularization, China Association for Science and Technology, Beijing, China (lui2002lam@yahoo.com)

The “two cultures” refer to the scientific culture and the literary culture, pointed out by C. P. Snow in the 1950s. The former derives from the study of material systems from the natural sciences, while the latter comes from the understanding of humans. However, humans are *Homo sapiens*—a (biological) material system, and are thus a part of the natural sciences since the latter is the study of *all* material systems. Consequently, science and the humanities are unified at the fundamental level—they are all “science matters”. The apparent “gap” comes from the different levels of scientific development, the deficiency in the school curricula, and the unfortunate misconception reinforced by current science communications. To help close this gap, a general-education course—The Real World—was introduced and taught by the author at SJSU. In the beginning, the students divided themselves into three groups; each group has a focused topic. Each group tried to find out the current status and the frontier in the scientific study of the chosen topic—through books, the Web and interviewing of experts. Concurrently, the instructor gave lectures on complex systems—on fractals, chaos, power-law phenomena, and active walks. These topics can link up science and the humanities. By pointing out the common themes and unifying principles, the merging of humanities with science could be achieved.

Keywords: The two cultures, science and humanities, general education course, active walk, complex system

1 THE TWO CULTURES—SNOW’S LECTURE

Forty-seven years ago, on May 7, 1959, Charles Percy Snow gave the lecture “The Two Cultures and the Scientific Revolution” at Cambridge University [1]. The lecture essentially contains three themes: the distinction and non-communication between the scientific culture and the literary/humanistic culture in the West, the importance of the science revolution (defined by Snow to mean the application of the “atomic particles,” presumably nuclear physics and quantum mechanics), and the urgency for the rich countries to help the poor countries. Very interesting, big themes—but nothing original, as admitted by Snow himself (see “The Two Cultures: A Second Look (1963)” in [1]).

The lecture generated tremendous interest and discussion round the world, which helped to earn Snow twenty honorary degrees (mostly from universities outside of England) and carve his name in history. While the other two themes are definitely worth talking about, it is the “two cultures” theme that causes the most controversy and debates. This is not at all surprising. Many in the literary circle felt slighted by Snow in his lecture and had to defend themselves or their profession (see Stefan Collini’s “Introduction” in [1]). And, by definition, literary people are those who can write.

The purpose of this article is not to discuss Snow’s lecture but to present the deep reasons behind the apparent gap between the two cultures, which are hardly touched upon by Snow himself. (After all, the existence and importance of the "gap" is not in doubt.) Furthermore, our effort in helping to close this gap is described.

But before we do that, for historical sake, Snow's errors concerning scientific matter in his lecture should be pointed out. Apparently, despite the worldwide fame of this lecture, no one has done this before.

Snow is wrong when he writes, "No, I mean the discovery at Columbia by Yang and Lee"[1] (p. 15 in [1]). While T. D. Lee indeed worked at Columbia University, C. N. Yang's "permanent" address at that time was the Institute for Advanced Study at Princeton, New Jersey (see the address bylines in [2]). In fact, Yang has never been associated with Columbia University. A few sentences later, still referring to the work of Yang and Lee, Snow makes another mistake in his sentence, "If there were any serious communication between the two cultures, this experiment would have been talked about at every High Table in Cambridge." The work of Lee and Yang is purely *theoretical*, which is to point out that there were no experimental evidence supporting or refuting parity conservation in weak interactions at that time. They went on to propose several experiments to settle this issue without predicting the outcome of these experiments. Parity nonconservation was indeed discovered in an *experiment* by C. S. Wu [7], a colleague of Lee at Columbia.

These two errors are minor by themselves and do not affect the rest of the lecture. Yet, they are factual errors that should be easily avoided. Lee and Yang received their Nobel Prize in December 1957, a mere 17 months before Snow delivered his lecture. With all the reporting of the parity-nonconservation story in the newspapers and magazines, not to mention the more formal academic publications, only a careless writer like Snow could miss the basic facts. And this is not an isolated incident. In 1932, Snow had to recant publicly his "discovery" of how to produce Vitamin A artificially after his calculation was found faulty. Snow, a trained chemist, decided to leave scientific research completely after this incident and became a novelist (p. xx in [1]). He indeed made the correct career move, judging by later developments.

2 THE TWO CULTURES—THE ESSENCE

2.1 The Emergence of the Two Cultures

About ten thousand years ago on earth, the early *Homo sapiens*, our ancestors, started to wonder about the things around them—things in their immediate surroundings and things in the sky. Curiosity serves not just human needs but for those who figure how things work from their observations, it is a survival skill via the evolutionary mechanism according to Darwin.

Among these activities, literature is the description of humans' reflection on and understanding of nature. Here, nature include all (human and non-human) material systems, such as falling leaves in autumn, the changing weather and seasons, effect of moonlights on lovers, the way humans treat each other in different spatial and temporal settings, and, quite often, thoughts in one's brain as a function of happenings inside or outside the person's body.

---

[1] In the famous paper that earned Lee and Yang the Nobel Prize in 1957, the authors' names appear as Lee and Yang [2]. The ordering of the two names in this and other joint papers apparently is not a small matter; it plays an important role in the two men's subsequent total breakup of collaboration and friendship [3-6].

When the authors write all these down, they are using their bodily sensors (sighting, touching, smell, hearing, etc.) as the main detectors and their brain as the major information processor. Apart from that, for latecomers, they do benefit from reading what previous writers wrote.

As time went by, the observation and understanding of certain kinds of phenomena progressed faster. For example, how things fall under the influence of gravity can be predicted and measured with high accuracy. This is achieved not because the falling object under study is simple, but because (i) we can approximate it by something simple, and (ii) we use detectors and information processors other than those from our own bodies. For example, a human body falling from a tall building is the same complicated human body described in a piece of literature, but in physics we pretend that it is a point particle (i.e., an idealized particle with zero size) in our calculations. This is an approximation; it works because the size of the earth, the source of the gravitational force, is much greater than the size of the human body. Furthermore, we can record the positions of the falling body by digital cameras and compare them with our calculations, with the help of calculators or computers. (For smaller falling objects, low-tech devices are used to record the positions at regular time intervals. This is routinely done in freshmen physics labs.)

This branch of study is now called natural science, which involves mostly nonliving systems even though living systems (such as humans in free fall and other simpler biological bodies) are not excluded. As we just pointed out, natural science presently succeeds because it chooses to deal only with a special subset of phenomena. And literature is stuck with the complicated aspects—such as pride and prejudice—of the complex system called humans.

As study deepened, specialization became essential and we were left with two distinctive groups of practitioners, the writers in the literature profession and what Snow called scientists for those working in natural science. Since writers use their own bodies as tools, only those with supreme bodily sensitivity and suitable hard wiring of neurons in their brains can become good writers, while scientists need other types of quality (such as supreme self-confidence) to succeed. There is no overlap between these two groups of professionals, as Snow painfully found out for himself.

2.2 Why the Gap

The fact that scientists can talk to each other is true only to a certain extent. There is not much to talk about between a particle theorist and a condensed matter physicist if the subject is the standard model of particles. But all scientists, be they physicists, biologists or chemists, do share some common knowledge such as the second law of thermodynamics, because this law is a required learning in the college education of these scientists.[2]

Professional activities require high concentration of attention and usually are time consuming, and, especially in the case of science, involve very keen competition. Time is short, for the professionals. Many first-rate scientists do not read books, particularly science books, because

[2] The second law of thermodynamics is the example used by Snow to test the scientific knowledge of the literary people in a gathering (p. 15 in [1]). This is in fact quite unfair, because the second law is less universal and useful than people think. It applies only to closed systems and only to their thermodynamic equilibrium states. It applies neither to humans—an open system and the interest of literary people—nor to the expanding "cosmos" as Snow wrongly claimed (p. 74 in [1]). The reason is that our universe is ever expanding and is never in an equilibrium state [9]. See [10] for a detailed discussion.

what contained in books is usually not fresh enough. Instead, they read research papers that they think might be helpful to their (present or future) work. That is what the scientist had in mind when he, asked by Snow what books he read, replied, "Books? I prefer to use my books as tools." (p. 3 in [1].) Tools, here, mean something that will help him to do his research. There is in fact a fair chance that literary books will be read by scientists, for relaxing purpose, e.g., when they are in a plane after attending a conference. But these books are not Shakespeare's. The same goes for the literary people. Why should they read any science book if they cannot find anything there that would help them to do their job?

In short, the non-communication between these two groups is not due to the non-overlap of the people involved, but due to the absence of any common language or principle in their trades, at least in the 1950s when Snow delivered his lecture. This is no longer so. Since the 1980s, some general principles arise from the study of simple and complex systems, which are applicable to both the natural and social sciences, and to both living and nonliving objects. Here, we are referring to fractals, chaos and active walks [8]. (See Sec. 3 for more.)

2.3 Why Close the Gap

We want literary people to learn a little basic science and the scientists to read some good literature. The reason is not that we are afraid they have nothing to talk to each other about at a cocktail party. They can always talk about Ang Lee's *Brokeback Mountain* (2005) or his other movie, *Crouching Tiger, Hidden Dragon* (2000). The movie's storyline is as deep as Shakespeare's, and perhaps more entertaining.

And if the purpose is to make literary people appreciate the mental achievement of the humankind via the elegant theories established in science, then learning basic science is not the easiest way to do so and may not even be necessary.[3] In Snow's days, the television and telephone, and, if not enough, the two atomic bombs in 1945 and the Sputnik in 1957 should convince every sensible person on earth the high achievement of science, without the need to know the theories behind them. These days, a cell phone will do.

Yes, knowing some basic science supposedly will help you to cast sensible votes as a citizen on scientific matters, such as laws regarding global warming. But we actually rely on the experts on their professional opinions on these matters. Our rudimentary scientific knowledge is not sufficient for us to make the judgments ourselves, even though it may help us to pick which expert to trust. Unfortunately, this is easier said than done. Sometimes you can't even trust the Nobel laureates. (For example, there is one who believes in astrology, big foot, and that we never went to the moon.) The situation is like picking which financial advisor to help managing your money. You go to the big institutions and also look at their track record. It helps if you have some financial knowledge, but that is not enough.

A good reason for ordinary people to learn some science is to increase their personal safety. Some science knowledge could help people to eat and live healthy and avoid accidents. It could also help them to recognize the crooks when they see one. For example, if someone told you that the earth had exploded three times in the past and it was he who repaired it (which is

---

[3] Snow, a chemistry major, is mistaken when he writes that asking someone to define "acceleration" is "the scientific equivalent of saying, *Can you read?*" (p. 15 in [1].) The definition of acceleration ($\mathbf{a} \equiv d\mathbf{v}/dt$) involves calculus and the concept of vectors [11], and may be found to be difficult by some students in a freshmen physics course.

so against what we know in science), you could safely ignore what else he told you and should never gave him a dime, nor your other valuable possessions.

But why do we want scientists to read some good literature?[4] This is less clear, not even Snow has anything meaningful to say about this. What is sure is that it is not a bad thing to do, unless you happen to be a young scientist who needs undivided attention to your research. It could help scientists to meet more interesting people; many of them, at the time this article is written, know only literature but not science.

2.4 How to Close the Gap

The best time to get literary people and scientists to learn something from each other's trade is when they are still students in schools or colleges, when they are forced to attend classes. Apart from requiring the students to take some general education classes in both science and literature before they are allowed to graduate, as is the practice in most American universities, it would be wonderful to teach them something, if exist, that they could use for the rest of their life no matter what profession they end up with. Fortunately, these wonderful things do exist. They are the general principles governing many complex systems.

And the way to achieve this in the classroom is through educational reform; outside of the classroom, science communication [12]. But first, let us review the essentials of science.

3 SCIENCE—THE ESSENTIALS

3.1 What Science Is About

Science is about the systematic understanding of nature. And nature, of course, includes all material systems. On the other hand, human beings are biological and thus material bodies called *Homo sapiens*. Consequently, any study related to human beings, literature in particular, should be a part of science [13].

Since nature consists of everything in the universe, the two terms science and natural science are identical to each other.[5] In other words, in terms of the objects under study in science, we have

$$\begin{aligned}\text{Science} &= \text{Natural science} \\ &= \text{Science of nonliving systems} + \text{Science of living systems}\end{aligned} \tag{1}$$

whereas

$$\text{Living systems} = \text{Nonhuman biological systems} + \text{Human beings} \tag{2}$$

Since we human beings (and not, e.g., the ants) are the ones who do the study and control the research budgets, it is not surprising that a large part of the science activity is related to and is for the benefit of humans. In terms of the disciplines, these human-related studies fall into one

[4] In practice, as good literature is concerned, unlike the case in science, there is no unique choice suitable for everybody. Reading Shakespeare or Tang poems/Song proses will equally do.

[5] With this understanding, every possible enquiry undertaken would be about nature. The term "science" in its German sense of *Wissenchaft*—any systematic body of enquiry—and its use in the English language will coincide with each other.

of two categories, viz., social sciences and humanities. Social science consists of anthropology, business and management, economics, education, environmental science, geography, government policy, law, psychology, social welfare, sociology, and women's studies [14]. Philosophy, religions, languages, literature, art and music make up the humanities. History, by its very nature, should be part of the social sciences, but it is listed in the humanities at some universities such as Stanford University.

The aim of literature, music and art in the humanities is to stimulate the human brain—through arrangement of words or colors, sound or speech, or shape of things—to achieve pleasure and beauty, or their opposites, via the neurons and their connecting patterns [15]. The brains, some sort of computer, of the creator and the receiver at the two ends of this process are heavily involved. The scientific development of these disciplines as complex systems is at a primitive level, and that is why they are separated from the social sciences, which are at an intermediate level. Linguistic is the study of the tools involved in written words and speeches, supporting the three disciplines mentioned above.

In terms of the disciplines, Eq. (1) could be rewritten as

$$\begin{aligned}\text{Science} &= \text{Natural science} \\ &= \text{Physical science} + \text{Social science} + \text{Humanities} \qquad (3)\end{aligned}$$

where physical science includes not just physics, but biology, chemistry, etc.

3.2 Three General Principles

There are three established principles that are able to unify many different phenomena found in nature, with examples taken from both the natural and social sciences, and even the humanities. They are [8]:

1. *Fractals*—the principle of self-similarity. Self-similar means that if you take a small part of an object and blow it up in proportion, it will look similar or identical to the original object. Self-similar objects are called fractals, which quite often have dimension not equal to an integer. A famous example is the Sierpinski gasket [16]. Fractals are everywhere, ranging from the morphology of tree leaves, rock formations, human blood vessels, to the stock market indices and the structure of galaxies. Fractals are even relevant in the corporate culture [17] and the arts [18].
2. *Chaos*—the common (but not universal) phenomenon that the behavior of many nonlinear systems depends sensitively on their initial conditions. Examples of chaos include leaking faucets, convective liquids, human heartbeats, and planetary motion in the solar system. The concept is found applicable in psychology, life sciences and literature [19, 20]. A general summary is available [21].
3. *Active walks*—a major principle that Mother Nature uses in self-organization. An active walk is a paradigm introduced by this author in 1992 to handle complex systems [22,23]. In an active walk, a particle (the walker) changes a deformable potential—the landscape—as it walks; its next step is influenced by the changed landscape. For example, ants are living active walkers. When an ant moves, it releases chemicals of a certain type and hence changes the spatial distribution of the chemical concentration. It next step is moving towards positions of higher chemical concentration. In this case, the chemical distribution is the deformable landscape.

> Active walk has been applied successfully to a number of complex systems coming from the natural and social sciences. Examples include pattern formation in physical, chemical and biological systems such as surface-reaction induced filaments and retinal neurons, the formation of fractal surfaces, anomalous ionic transport in glasses, granular matter, population dynamics, bacteria movements and pattern forming, food foraging of ants, spontaneous formation of human trails, oil recovery, river formation, city growth, economic systems, and, most recently, human history [9,13,23].

All three principles are an integral part of complexity science, which is becoming important in the understanding of business, governments and the media [24].

4 EDUCATIONAL REFORM—A PERSONAL JOURNEY

University educational reforms could involve three possible components: (1) the contents of the courses, (2) the way of teaching by the instructors, and (3) the learning method of the students. No matter how it is done, an unavoidable constraint that will crucially affect the success of the reform is usually not mentioned or ignored completely by the reformers, i.e., *the reform should not increase the teaching load of the instructors*. Also, the quality of the students taking a course—like the quality of a sample in a physical experiment or the raw material in a factory—is of primary importance; this factor is never emphasized enough. Obviously, with a defective sample, no good experimental result can be expected, no matter how skillful the experimentalist is. This last factor points to the need to start any educational reform from grade one on, or even better, from the kindergartens.

With the constraints understood and resources limited, I tried to do my best as a teacher. There is not much we can do about item (3). It is very hard for the students to change their learning habit after being wrongfully taught for 12 years before they show up in college, and this is not their fault. I therefore concentrated my effort in the first two items.

On item (2), I have tried something radically different. It is called "MultiTeaching MultiLearning" (MTML) [25]. We note that in a physics class, the teacher usually does not have enough time to cover everything. The attention span of a student is supposed to be about 15 minutes. Students in a class have different learning styles. Some students are more advanced than others. Active learning and group learning are good for students. To overcome these problems in the teaching of two freshmen classes in mechanics and thermodynamics, around 1999, I have tried a zero-budget and low-tech approach. In these classes, we cover about one chapter per week, using *Physics* by Resnick, Halliday and Krane as the textbook. In each course, there are three sessions per week, each 50 min. long. In the last session of every week, the class is broken up completely. Different "booths" like those in a country fair are set up in several rooms, manned by student volunteers from the class. The rest of the class is free to roam about, like in a real country fair, or like what the professional physicists will do in a large conference with multiple sessions. In this way, we are able to *simultaneously* offer homework problem solving, challenging tough problems for advanced students, computer exercises, Web site visits, peer instruction, and one-to-one tutoring to the students. The students seemed to enjoy themselves and benefited from it. However, this approach was soon discontinued. It did require a little bit of extra preparation time from the instructor, but more importantly, it did not seem to raise significantly the grades of the students. The "inferior raw material" factor might be at work here.

The next thing I tried, with better luck this time, was to integrate popular science books into my physics classes [26]. This is done by giving extra credits to the students who would buy a popular science (PS) book, read it and write up a report [27,28]. The instructor does not actually teach the books, and hence will not find the teaching load increased. It is like supplementary reading, a practice commonly used in the English classes but rarely adopted by science instructors. The aim of this practice is (1) to broaden the knowledge base of the students, (2) show them the availability and varieties of PS books in their local book stores, (3) encourage them to go on to buy and read at least one PS book per year for the rest of their life, and (4) become a science informed citizen—a voter and perhaps a legislator who is science friendly. It is about lifetime learning of science matters. This practice is quite successful and is still going on in my classes.

This PS book program is not trying to alter the course content per se. My first attempt in this direction, item (1) in educational reform, actually happened earlier. Soon after I started teaching at SJSU in 1987, I created two new graduate courses, Nonlinear Physics and Nonlinear Systems, respectively [8]. But these two were for physics majors. In Spring 1997, I established a general-education course called "The Real World," opened to upper-division (i.e., third and fourth year in college) students of any major. It results from my many years of research ranging from nonlinear physics to complex systems [8]. There were only nine students, majoring in physics, music, philosophy and so on, plus two physics professors sitting in. It was fun. The course stopped after one semester due to non-academic reasons, falling victim to the sociology of science.

Five years later in Fall 2002, the course was resurrected with the same name but modified to suit incoming freshmen students. It is this general-education freshman course that will be described in detail in the next session.

5 THE REAL WORLD—A GENERAL EDUCATION COURSE

In 2001 we have a new provost in campus. This very energetic and ambitious man, Marshall Goodman, wanted to make SJSU distinctive from the other twenty plus campuses of the California State University system. Introducing international programs with a global outlook was his way of doing that. But perhaps more important, with lightning speed as administrative things went, he was able to push through the university senate and actually had 100 brand new freshmen general-education courses set up and running in about half-a-year's time. Each of these courses is limited to no more than 15 incoming freshmen students. The program starting in Fall 2002 is called the MUSE program. "MUSE/Phys 10B (Sec. 3): The Real World" was one of the 100 offered.

5.1 The Course Description

Introduction to MUSE**:** University-level study is different from what you experienced in high school. The Metropolitan University Scholars' Experience (MUSE) is designed to help make your transition into college a success by helping you to develop the skills and attitude needed for the intellectual engagement and challenge of in-depth university-level study. Discovery, research, critical thinking, written work, attention to the rich cultural diversity of the campus, and active discussion will be key parts of this MUSE course. Enrollment in MUSE courses is limited to a small number of students because these courses are intended to be highly interactive and allow you to easily interact with your professor and fellow students. MUSE courses explore topics and issues from an interdisciplinary focus to show how interesting and important ideas can be viewed from different perspectives.

Course Description: To understand how the real world works from the scientific point of view. The course will consist of two parallel parts. (1) The instructor will introduce some general paradigms governing complex systems—fractals, chaos and active walks—with examples taken from the natural and social sciences, and the humanities. (2) The students will be asked to pick any topic from the newspapers or their daily lives, and investigate what had been done scientifically on that topic, with the help from the Web, library, and experts around the world. Outside speakers and field trips is part of this course.

Learning Objectives and Activities for this Course: This course qualifies as an Area B1 (Physical Sciences) course in your General Education requirements. It is designed to enable you to achieve the following GE and MUSE learning outcomes. By the end of this course, you should be able to

- Use methods of science and knowledge derived from current scientific inquiry in life or physical science to question existing explanations;
- Demonstrate ways in which science influences and is influenced by complex societies, including political and moral issue;
- Recognize methods of science, in which quantitative, analytical reasoning techniques are used;
- Understand the learning process and your responsibility and role in it; and
- Know what it means to be a member of a metropolitan university community.

The following content and activities will be incorporated into the course as you engage in the subject matter of the course:

- Issues of diversity.
- Writing assignments consisting of a minimum of 1500 words
- Active learning through class participation and discussions.

At their conceptual center, all GE Science courses should demonstrate how scientists seek proof for causal relationships between microscopic phenomena and macroscopic observations. This course is no exception and will incorporate a number of demonstrations and experiments in which you will be actively involved in this process.

All Physical Science GE courses focus on laws of thermodynamics; structure of matter; interaction of matter and energy; behavior of physical systems through time; systems of classification; and physical processes of the natural environment.

Student Learning Objectives and Goals Specific to this Course**:** *After successfully completing this course, you will*

- Realize that there are general paradigms—fractals, chaos and active walks—governing the functioning of complex systems in the real world, physical and social systems alike.

- What nonlinearity is.
- How "dimension" is defined mathematically.
- The meaning of self-similarity and fractals.
- Recognize and able to evaluate data to show that any physical structure or pattern in the real world is a fractal or not.
- What a chaotic system is.
- Able to distinguish a chaotic behavior from a random behavior given the time series of a system.
- To realize that many complex systems in the real world can be described by Active Walks, and be familiar with a few examples.
- Recognize that there are multiple interpretations or points of view on some ongoing, forefront research topics, and that these interpretations can co-exist until the issue is settled when more accurate data and a good theory become available.
- Know the difference between science and pseudoscience, and the real meaning of the scientific method.
- How scientific research is actually done.
- Able to find out the latest scientific knowledge about any topic of interest in the future.
- Have improved your skills in communicating both orally and in writing.
- Have increased your familiarity with information resources at SJSU and elsewhere.

Course Materials: The following two books are required (both available at the Spartan Bookstore):

1. Lui Lam, *Nonlinear Physics for Beginners: Fractals, Chaos, Solitons, Pattern Formation, Cellular Automata, and Complex Systems* (World Scientific, River Edge, NJ, 1998), paperback (list price: $28). Reading assignments from this book will be announced in class. Additional materials will be provided by the instructor. Other information could be found from the Web, magazines, research journals and books from the library.
2. *A Spartan Scholar from the Start* (published by SJSU)

Grading: Assignments and quizzes are also listed on the class schedule and will be explained further in class.

Homework	20 %
Tests (3 total, including final; 10 points each)	30 %
Term project and presentation	20 %
MUSE activities	15 %
Field trip	5 %
Participation	10 %
(Extra credit for book report)	10 %
Total points (not counting extra credit)	100 %

Term Project: A term project is required. It is a group effort with three to four students in a group. The topic will be chosen by the group, with the help and consent of the instructor. Progress of project will be presented by group members orally in class throughout the semester. A written progress report is to be handed in about the middle of the semester, and a written final report is due at end of semester.

Extra Credit: Book Report (10%)—The student should decide to do the book report not later than **Sept. 16, 2002**, Mon. To do the book report,

- The student should pick a popular science book title from the list provided by the instructor.
- Buy the popular science book herself/himself.
- Show the **book and receipt** to the instructor not later than **Sept 30, 2002**, Mon. (The receipt will be marked by the instructor; each student should buy her/his own book; a paper-back book costs about $12-$17);
- Submit a written report (5-10 pages long, font size 12) on **Nov. 27, 2002,** Wed.

Teaching Philosophy and Expectations:

I expect that students be here at the University to learn to think critically about themselves, about their society, and about specific issues and problems. You can anticipate being asked many questions that involve problem solving, and is expected to participate in active discussion speaking out your mind. I will provide you with skills that will enable you to locate information and to generate your own relevant data.

The class will be run like a research group, with flexibility in content and timing according to the progress and need of the students, with the injections of other foreseeable and unforeseeable academic activities. The instructor will teach some basic knowledge about complex systems, while each term-project group will be treated like a research group. Each student will be trained to be a scholar, working individually and as a member of a team.

Attendance: Every class counts! Please keep track of the schedule and attend every class. If you do have to miss a day, please let me know in advance if possible, by leaving a message on my phone.

Tentative Topics Covered by the Instructor:

Part I

1. The World is Nonlinear

1.1 Nonlinearity
1.2 Exponential growth
1.3 Gaussian distribution (the bell curve)
1.4 Power laws
1.5 Complex systems are nonequilibrium systems

2. Fractals

2.1 Classification of patterns

2.2 Self-similarity
2.3 Definition of "dimension"
2.4 What is a fractal?
2.5 Fractal growth patterns

3. Chaos

3.1 Sensitive dependence on initial conditions
3.2 The logistic map
3.3 A dripping faucet
3.4 Chaotic vs. randomness

4. Active Walks

4.1 What is an active walk?
4.2 Examples of active walks

5. Conclusion

5.1 Simplicity can lead to complexity
5.2 Order can arise from chaos
5.3 The world can be understood scientifically

Part II

From time to time, these special topics will be inserted between the chapters:

1. How scientific is the scientific method?
2. Science vs pseudoscience
3. How are research topics born?
4. Diversity: the first woman president of the American Physical Society
5. Does the world have a meaning?

5.2 The Outcome

There were 12 students in the class. In the beginning, every student was asked to buy and read a newspaper, pick out the topics that interested her or him, which could be about international conflicts, movies or television programs, sports, or anything. After class discussion, three topics—Creativity, Predictions, and "What is Life?"—were chosen. Three groups with four students each were formed; each group focused on one of the three topics. Each group tried to find out the current status and the frontier in the scientific study of the chosen topic—through books, the Web and interviewing of experts. Each group gave regular progress report in class and, at the end of semester, handed in a written report after orally presenting it. Simultaneously, the instructor gave lectures on complex systems—on fractals, chaos, power-law phenomena, and active walks.

At the end, we were all exhausted. The students seemed to have a good time. Did they really get the message that the real world can be understood and is governed by some unifying principles? Only time can tell. My feeling is that this course is better offered to non-freshmen who are more mature and motivated. In fact, this course—with the content and approach intact but the depth of coverage modified—could be taught at any level, from undergraduate to graduate.

6 CONCLUSION—WHAT IS TO BE DONE?

The “two cultures” issues are clarified. What the literary people and the natural scientists do are similar to each other at the basic level. They both try to understand the world around them. What differentiates them is, roughly speaking, that literary people confine their investigation to using their body as the detector and their own brain as the information processor, while modern scientists use tools other than their own body to do their work (Sec. 2). All these activities could be viewed as parts of a big project—to understand nature (human and nonhuman systems) systematically, except that literature is still doing it empirically and is at a less developed level, scientifically speaking. But this is also the case with the study of many other complex systems, because the problem involved is much harder (Sec. 3).

The gap between the two cultures can never be completely closed, and there is no need to do so. What should be and could be done is to teach everybody the fact that our real world is governed by some unified principles, which are applicable to both the human and nonhuman systems and could be shared beneficially by people in the two cultures, and in fact, in any culture. And a course for this purpose has been designed and tried (Sec. 5), which should be taught at school of any level, the earlier the better. Furthermore, to reinforce the effect, lifelong learning through popular science books is strongly urged [28]. Beyond that, it would be good to make both natural science and literature writings an essential reading for college students. This can be easily done by incorporating a few popular science books—such as James Watson’s *The Double Helix*—into the list of required readings in the general education of every student in every university.

It does not help if in science communication of any kind, we keep conveying to the public the wrong impression that natural science, social science and the humanities are three very different things, without anything in common. A remedy to correct this in the science museums is to show the unifying themes of all natural and social phenomena before the museum exit [29].

Through appropriate effort, the merge of science and humanities is possible. Examples include the merging of biology and sociology to form Sociobiology [30]; economics and physics, Econophysics [31]; sociology and physics, Sociophysics [32], and, more recently, the creation of a new discipline called *Histophysics* through the link up of history with physics [9,13,23].

REFERENCES

1. C. P. Snow, *The Two Cultures* (Cambridge University Press, Cambridge, 1998).
2. T. D. Lee and C. N. Yang, “Question of parity conservation in weak interactions,” *Physical Review* **104**, 254-258 (1957).
3. C. N. Yang, *Selected Papers 1945-1980 with Commentary* (Freeman, New York, 1983).
4. T. D. Lee, *Selected Papers*, Vol. 3 (Birhauser Inc., Boston, 1986).
5. C. J. Jiang, *Biography of Chen Ning Yang: The Beauty of Gauge and Symmetry* (Bookzone, Taibei, 2002).
6. C. Zi, H. Z. Liu, and L. Teng (eds.), *Solving the Puzzle of Competing Claims Surrounding the Discovery of Parity Nonconservation: T. D. Lee Answering Questions from ScienceTimes Reporter Yang Xujie and Related Materials* (Gansu Science and Technology Press, Lanzhou, 2004).

7. C. S. Wu, E. Ambler, R. W. Hayward, D. D. Hoppes, and R. P. Hudson, "Experimental test of parity conservation in beta decay," *Physical Review* **105**, 1413-1415 (1957).
8. L. Lam, *Nonlinear Physics for Beginners: Fractals, Chaos, Solitons, Pattern Formation, Cellular Automata and Complex Systems* (World Scientific, Singapore, 1998).
9. L. Lam, *This Pale Blue Dot: Science, History, God* (Tamkang University Press, Tamsui, 2004).
10. K. H. Zhao, "The end of the heat death theory," in *Philosophical Debates in Modern Science*, edited by X. L. Sun (Peking University Press, Beijing, 2003).
11. D. Halliday and R. Resnick, *Fundamentals of Physics* (Wiley, New York, 1988).
12. L. Lam, "Science communication: What every scientist can do and a physicist's experience," *Science Popularization*, No. 2, pp. 36-41, 2006. See also L. Lam, in *Proceedings of Beijing PCST Working Symposium*, Beijing, June 22-24, 2005.
13. L. Lam, "Histophysics: A new discipline," *Modern Physics Letters B* **16**, 1163-1176 (2002).
14. http://www.sosig.ac.uk.
15. S. Pinker, *How the Mind Works* (Norton, New York, 1997).
16. L. Lam, "A science-and-art interstellar message: The self-Similar Sierpinski gasket," *Leonardo* **73**(1), 37-38 (2004).
17. H.-J. Warnecken, *The Fractal Company: A Revolution in Corporate Culture* (Springer, New York, 1993).
18. J. D. Barrow, *The Artful Universe: The Cosmic Source of Human Creativity* (Little, Brown and Co., New York, 1995).
19. R. Robertson and A. Combs (eds.), *Chaos Theory in Psychology and the Life Sciences* (Lawrence Erlbaum Associated, Mahwah, NJ, 1995).
20. N. K. Hayles, *Order and Chaos: Complex Dynamics in Literature and Science* (University of Chicago Press, Chicago, 1991).
21. J. A. Yorke and C. Grebogi (eds.), *The Impact of Chaos in Science and Society* (United Nation University Press, Tokyo, 1996).
22. L. Lam, "Active walks: The first twelve years (part I)," *International Journal of Bifurcation and Chaos* **15**, 2317-2348 (2005).
23. L. Lam, "Active walks: The first twelve years (part II)," *International Journal of Bifurcation and Chaos* **16**, 239-268 (2006).
24. See http://www.trafficforum.org/budapest for a description of an upcoming conference on "Potentials of complexity science for business, governments, and the media," Budapest, Aug. 3-5, 2006.
25. L. Lam, "MultiTeaching MultiLearning: A zero-budget low-tech reform in teaching freshmen physics*," Bulletin of the American Physical Society* **44**(1), 642 (1999).
26. L. Lam, "Integrating popular science books into college science teaching," *Bulletin of the American Physical Society* **45**(1), 117 (2000).
27. L. Lam, "Raising the Scientific Literacy of the Population: A Simple Tactic and a Global Strategy," in *Public Understanding of Science*, edited by Editorial Committee (University of Science and Technology of China Press., Hefei, 2001), pp 330-336.
28. L. Lam, "Integrating popular science books into college science teaching," *The Pantaneto Forum*, Issue 19, 2005 (http://www.pantaneto.co.uk).
29. L. Lam, "New concepts for science and technology museums," *The Pantaneto Forum*, Issue 21, 2006 (http://www.pantaneto.co.uk). See also L. Lam, in *Proceedings of International Forum on Scientific Literacy*, Beijing, July 29-30, 2004.
30. E. O. Wilson, *Sociobiology* (Harvard University Press, Cambridge, MA, 1975).
31. R. N. Mantegna and H. G. Stanley *An Introduction to Econophysics* (Cambridge University Press, New York, 2000).
32. S. Galam, "Sociophysics: A personal testimony," *Physica A* **336**, 49-55 (2004).

A version of this article was presented at The 9th International Conference on Public Communication of Science and Technology, Seoul, May 17-19, 2006.

Lui Lam obtained his BS (with First Class Honors) from the University of Hong Kong, MS from the University of British Columbia, and PhD from Columbia University. He is now a professor at San Jose State University, California; and a Guest Professor at both 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 150 scientific papers. He is the founder of the International Liquid Crystal Society (1990), the founder and editor-in-chief of the Springer book series *Partially Ordered Systems*, and the cofounder of the Chinese Liquid Crystal Society (1980).