Science Popularization

Popularize What?


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# 科 普

## 普什么？

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# ALL ABOUT SCIENCE

PHILOSOPHY, HISTORY, SOCIOLOGY & COMMUNICATION


MARIA BURGUETE AND LUI LAM

EDITORS

There is a lot of confusion and misconception concerning Science.
The nature and contents of science is an unsettled problem.
For example, Thales of 2,600 years ago was recognized as the father of science but the word science was introduced only in the 14th century; the definition of science is universally avoided in books about philosophy of science.

This book aims to clear up all these confusions and present new developments on the philosophy, history, sociology and communication of science.
It also aims to showcase the achievement of China's top scholars in these areas.

The 18 chapters, divided into five parts, are written by prominent scholars including the Nobel laureate Robin Warren, sociologist Harry Collins, and physicist-turned-historian Dietrich Stauffer.

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# **Science Communication** (SciComm)

**Jiang Zemin** (2000):

- promote the scientific spirit
- popularize scientific knowledge
- communicate scientific thought and scientific method

**Lam** (2013):

- awaken citizens' inert curiosity about the world/universe

**What for?**

- promote citizens' ability to deal with practical problems
- promote citizens' ability to participate in public-affair management
- stimulate children's interest to be future humanists/scientists

# Science Communication
(or Science Popularization, PopSci)

## A brief history (from Peter Broks)

**Early 19th century**: Republic of Science—no separation of science from public; all could join.

**Late 19th century**: Rise of the expert; separation of scientific experts and lay public; SciComm is to bridge the gap. (1833, William Whewell coined the term “scientist”.)

**20th century**:

- 1950s: Sputnik triggers fear about scientific literacy.
- 1980s: **PUS** (Public Understanding of Science); SciComm as new duty for scientists.
- 2000: **PEST** (Public Engagement with Science and Technology); a whole new set of questions:

- What counts as being a scientist?
- Where do we draw the boundaries between science and non-science, between scientists and non scientists?
- What counts as expertise? Who are the experts? What about lay experts?
- Why listen?
- Engagement presupposes particular social and political relationships which in turn raises questions about authority and democracy.

# Knowledge

# Human knowledge has two parts:

1. A **human-independent** part (e.g., law of gravity; could be discovered by aliens, too).

2. A **human-dependent** part (e.g., human related—humanities and social science, including application of "science").

N.B.: The existence of human-independent part of knowledge is denied by the **Relativists**.

# Why the Humanities are Important

Importance of humanities could be seen:

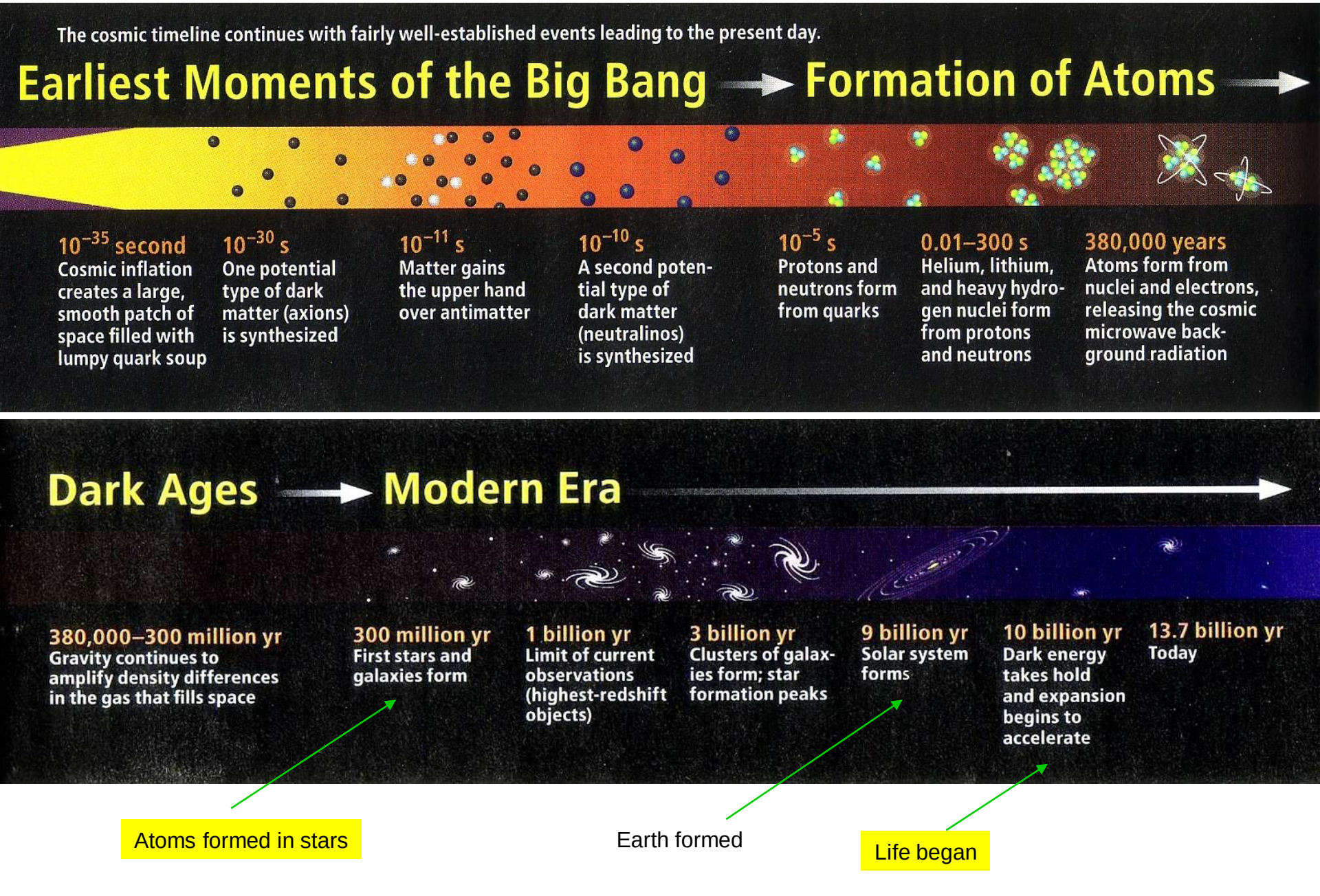
1. If all present “science” research is stopped or eliminated, the world is still the same—chaos and tragedies will continue—because it is the humanities (underdeveloped in the last 2600 years since Plato) that matters in human affairs.

2. Another way of seeing this is through the lesson of Apple company.


Putting a good humanist among the “scientists”/engineers could create great companies—good for the economy.

# Human

# In the Beginning



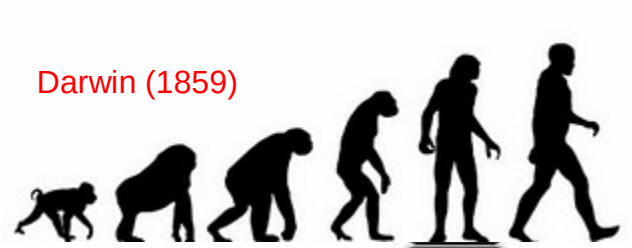

Atoms formed in stars

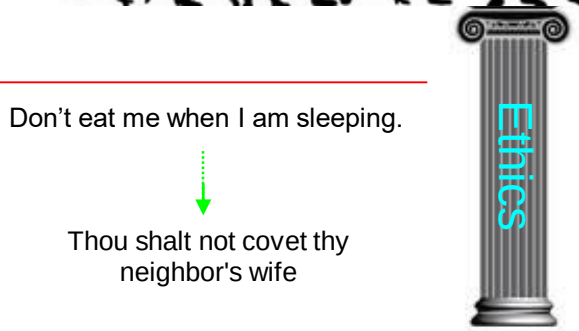
Earth formed

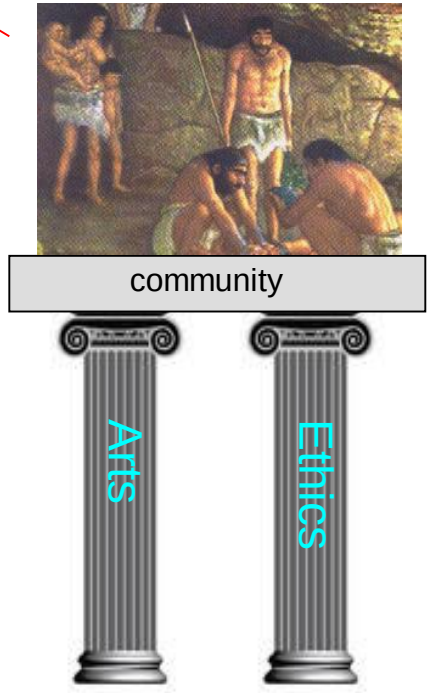
Life began

# Life Emerged and Evolves

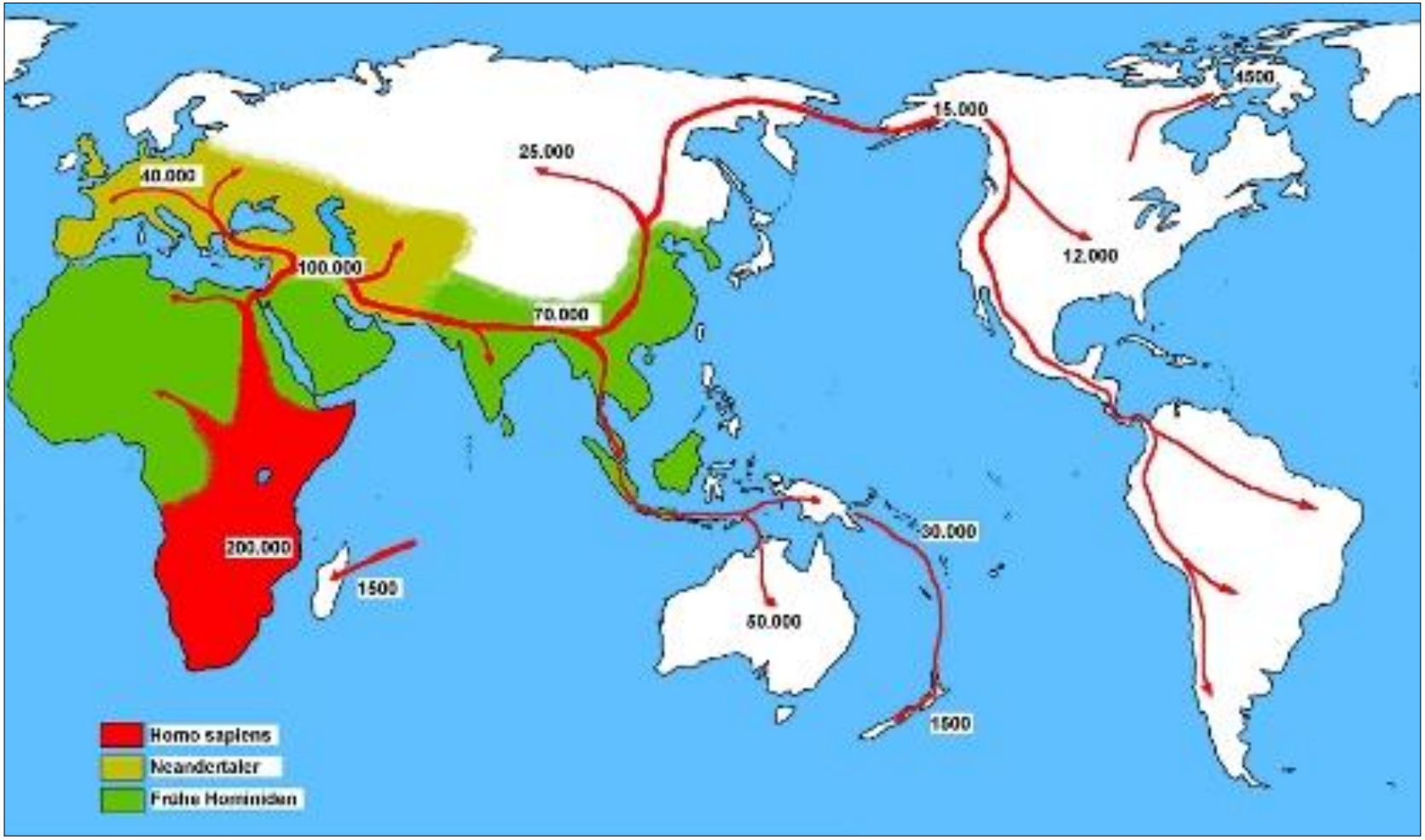
| Years ago | Evolut-ion | Migration | Life style | Art related |
|---|---|---|---|---|
| 6 million | Chimp and human lineages split. | | | |
| 2 million | *Homo erectus* appears. | | | |
| 1.8 million | | First wave of migration out of Africa begins. | | |
| 1.6 million | | | First use of fire; more complex stone tools created; arts could begin | |
| 400,000 | | | Earliest evidence of cooking. | |
| 195,000 | *Homo sapiens* (early modern humans) appears. | | | |
| 60,000 | | Second wave of migration out of Africa | | |
| 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 |



# Out of Africa

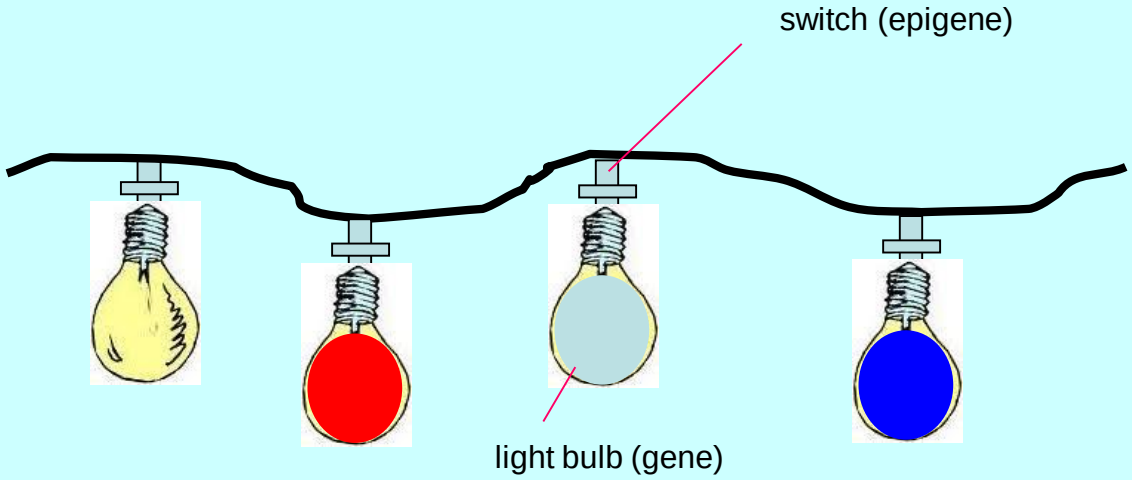



- All human beings have same origin and share the same genes, with similar intelligence.
- Science developed differently in different regions (e.g., ancient Greek and China) due to different choice of research topics.

# Nature and Nurture are both Important

New Understanding of Evolution (last 10 years):

A combination of Darwin and Lamarck




Learned behavior could be passed on to next generation, too, by epigenes

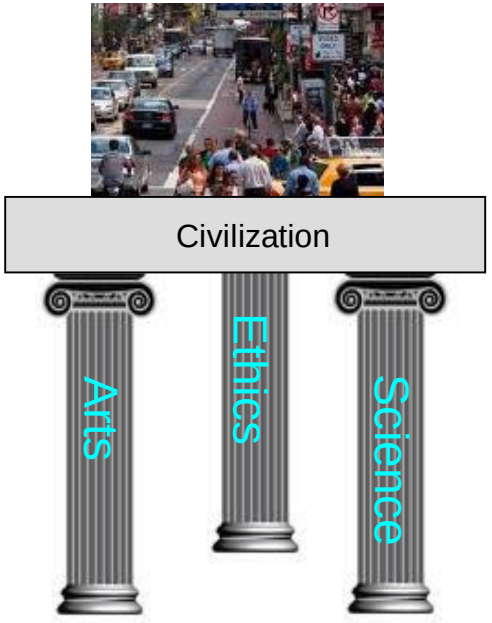
# Science

# Science

- Science is the study of Nature
- Nature includes all material system (which are all made up of atoms).
- Humans is a material system (made up of atoms, evolved from simple living systems).

→ Everything in Nature is part of science!

- But this understanding could be reached only in the last 100 years of so, after Darwin's theory of evolution (1859) and Einstein's Brownian motion paper (1905) proving the existence of atoms.
- Early stage of science (starting with Thales) involves observations and speculations; systematic approach appears only in the later, mature stages (in the modern science period of the last 400 years since Galileo).



# Science Matters

**Science Matters** (SciMat, 人科), invented by Lui Lam in 2008, is a new discipline that treats all human-dependent matters as part of science.

Science = Natural science

= human-independent science + human-dependent science

Science Matters

Humanities + social science

SciMat Website: www.sjsu.edu/people/lui.lam/scimat

# Looking Back: A Brief History of Science

Simple systems
(plus medical science)

Complex systems
(including humans)

Thales (c. 624 BC-c. 546 BC)

Aristotle (384BC-322BC)

Islam

Dark Age

Renaissance

Galileo (1610)

Newton (1687)

Enlightenment (1688-1789)
Adam Smith (economics, 1776; *The Wealth of Nations*)

Condorset (*Progress of the Human Mind* ,1795)

Auguste Comte (sociology, 1844)

Charles Darwin (*On the Origin of Species* ,1859)

Einstein (1905)

Science Matters (2008)


1723-1790


1743-1794


1809-1882


1798-1857

Human system is a stochastic, complex system.

# History of Words

**Philosophy** (600 BC, “love of wisdom”, Pythagoras; 13c, English)

Philosophy (humans, metaphysics)

Natural Theology (God)

Natural Philosophy (14c, non-humans, non-God)

Science (14c, “pursuit of knowledge”, firm theories)

Scientist (1834)

Scientific Method (1854)

Philosophy

Theology

“**Science**” (since ~1800, Age of Revolutions)

present

William Whewell

Cambridge Don who invented the word “scientist” (1834)

# Some Misconceptions about Science

Wrong: Science is about the systematic study of repeatable and controlled experiments.

Correct: The backbone of science is the collection of (interrelated) theories and controlled experiments; historical sciences (like astronomy and paleontology) advance by comparing their findings with results from controlled experiments.

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Wrong: There is a set of well defined procedures making up the Science Method.

Correct: Science is about open-mindedness, honesty, earnest, admitting errors, and peer reviewing/checking. There is “scientific tradition” or “scientific experience” but no “scientific method”.

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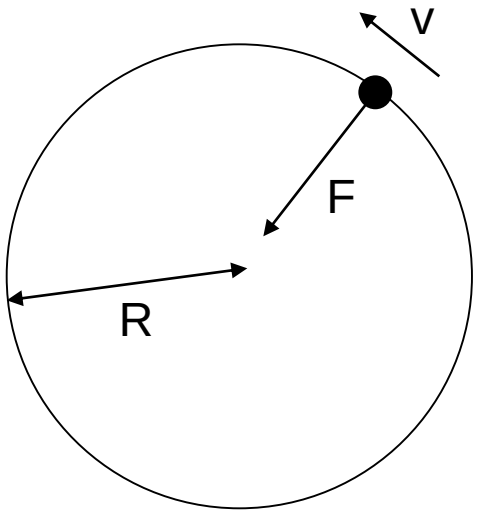
Wrong: Science is a social phenomenon (Hitler).

Correct: The science process is human dependent (and a social phenomenon) but the end result of nonhuman systems (like law of gravity) is human-independent.

# Surprise 1

- Science never proves anything, *rigorously speaking (in the mathematical sense)*, because confirming experiments are always done with finite resolutions.




Example

Uniform circular motion

$$F = mv^2/R$$

To check this equation we measure each quantity and show that the left-hand side equals to the right-hand side. Finite resolution of all the measurements means that we can only conclude the equation is valid within the uncertainty of the measurements.

# Surprise 2

- Science advances and lives with approximations.
  (It works because, like when lost in a forest, a rough map is all one needs to get out of the forest.)

Science is thus not the route to reach “truth” (if there is such a thing).

# Surprise 3

- Important scientific laws or theories are not always expressed in mathematical equations.

Two examples:

- The Third Law of Thermodynamics:

  It is impossible to reach to reach the absolute zero in a finite number of steps.

- Darwin's Evolutionary Theory:

  The fittest survives.

# Reality Check: Uniqueness of Scientific Knowledge

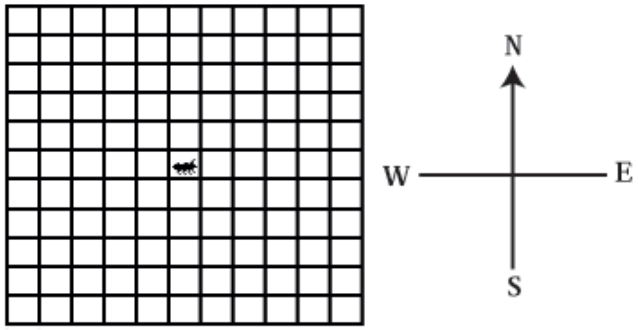
- And there is always the reality check.
- The "cell phone test"—any new theory, if it conflicts with that behind the building and working of a cell phone, has to explain why and why it is better. (The working of a cell phone depends on Maxwell Equations, quantum mechanics, semiconductors, general relativity,…)
- Science is valued because it works.

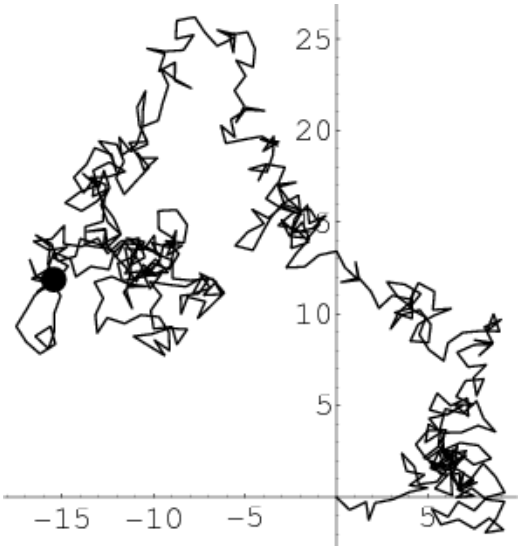
# What to Communicate

# 1: The Human World is Stochastic

The human world is stochastic, i.e., probability is involved.
Two simple examples: Random Walk and Active Walk

- **Random Walk**




**Louis Bachelier**

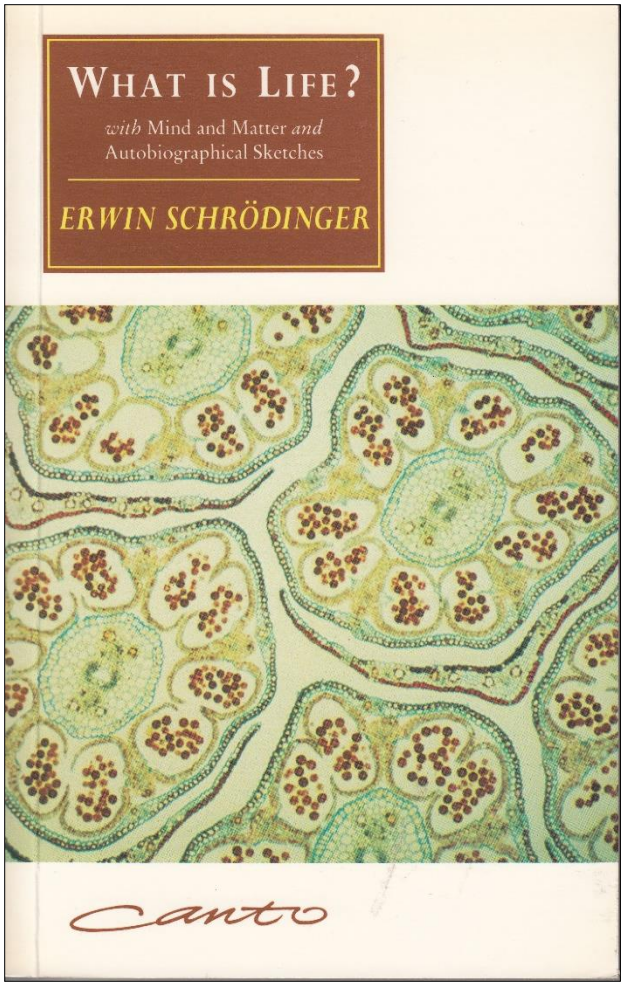
Ph.D. thesis in economics (1900)

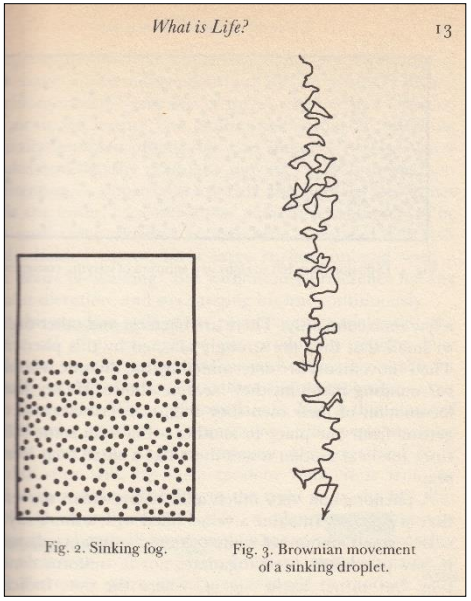
**Einstein**

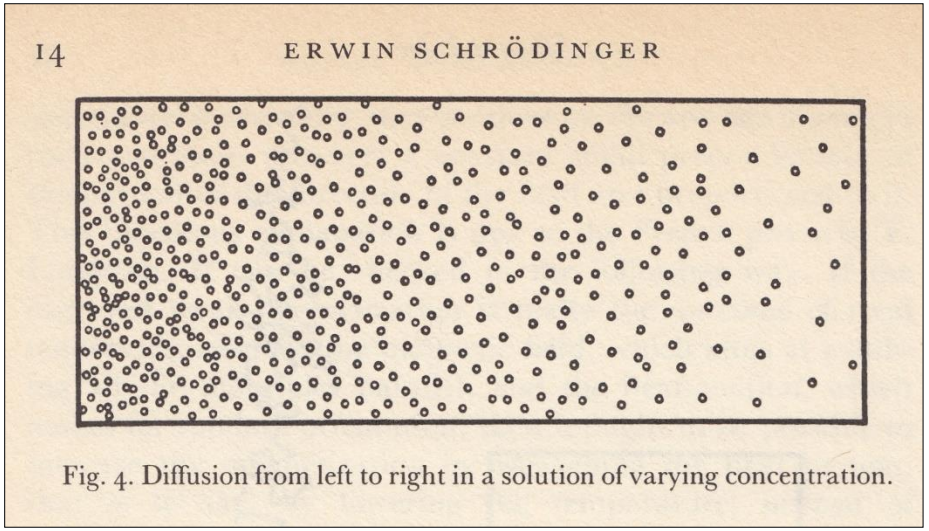
Brownian motion paper (1905)

# Erwin Schrödinger

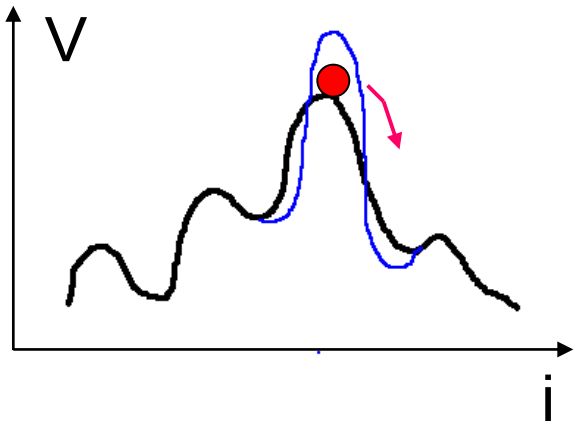
(1887-1961)



## Active Walk (invented by Lui Lam in 1992)




1. Landscaping rule: how the walker modifies the landscape as it walks.

2. Stepping rule: how the walker chooses its next step.

3. Landscape's self-evolving rule: change of landscape not due to walker (e.g. external factors).

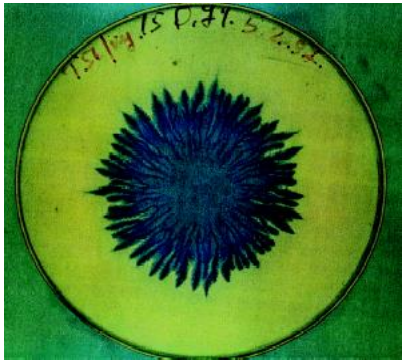
**Examples of stepping rule:**

- Deterministic (DAW): Walker goes to next-nearest site with lowest height.
- Probabilistic (PAW): $P_{ij} \propto \begin{cases} (V_i - V_j)^{\eta}, & V_i > V_j \\ 0, \text{ otherwise} \end{cases}$
- Boltzmann (BAW): $P_{ij} \propto [\exp(V_i - V_j)/T]$

- Active Walk has been applied successfully to many living and nonliving systems from humanities, social sciences and natural sciences. See reviews by Lam in *International Journal of Bifurcation and Chaos* (2005, 2006).

Example

Bacteria patterns formed under hostile conditions

- Active Walk as a metaphor in the advancement of human efforts.

# 2: Popularize Complex Systems

**Steven Hawking**:

“Complex systems is the most important science in the 21th century.”

~~All world/human problems are complex.~~

Only 15 years ago, complex systems science had to justify its existence. Today it is taking the world by storm. Networks, big data, cascading crises, extreme events, the word "systems," and many other ideas are widely accepted and the basis for new advances and increasing the scope of science.

**EPL, 91 (2010) 68004** www.epljournal.org
doi: 10.1209/0295-5075/91/68004

# Bilinear effect in complex systems

Lui Lam[1], David C. Bellavia[1], Xiao-Pu Han[2], Chih-Hui Alston Liu[1], Chang-Qing Shu[3], Zhengjin Wei[4], Tao Zhou[2,5] and Jichen Zhu[6]

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[5] Web Sciences Center, University of Electronic Science and Technology of China - Chengdu 610054, China
[6] School of Visual Arts and Design, University of Central Florida - Orlando, FL 32826, USA

# 3: Modernize Science Communication

- In science communication,

  the essence of the so-called “scientific method” (such as the scientific spirit and scientific tradition) and
  the knowledge of human-dependent parts of science (concept of probability, the humanities and social sciences)
  could be more important than those about non-living systems in the public understanding of science.

- Popularizing complex systems will help the public to understand complex issues (e.g., global climate change) better as citizens, and will make CRISP the leader in the field of science communications.


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# International Science Matters Committee

(ISMC, established May 30, 2007)

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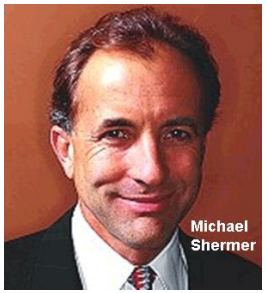
16. Robin **Warren** (Australia)

Author of *Cognitive Science, Literature and the Arts*

Father of Neuroarthistory

President of British Society for Philosophy of Science (1993-1995)




Columnist, *Scientific American*; editor, *Skeptic* magazine

**Nobel Laureate** (2005)

## Aim

To promote the SciMat idea and push the International SciMat Program.

# Science Popularization: Popularize What?

Lui Lam

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Science Communication (SciComm) is to communicate science to the public. There are two components: what to communicate, and how to communicate. This talk is mostly about the former, with brief comments on the latter. To understand what to communicate the utmost important thing is to understand what science is. It turns out that there is no easy answer. The reason is that Science evolves with time, from the early Greek time on; it is a moving target. We will trace the historical evolution of the concept of Science, and clarify some common or uncommon misunderstandings. We will argue that the contents of science could be classified into two parts: simple systems and complex systems. The latter is completely ignored in SciComm, with dire consequences as the public's interest is concerned.

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**Lui Lam**, physicist and humanist, obtained his BS from the University of Hong Kong; MS, University of British Columbia; PhD, Columbia University. Lam invented Bowlic liquid crystals (1982), Active Walks (1992), and two new disciplines: Histophysics (2002) and Science Matters (2008). He has published 14 books and over 170 scientific papers; the books include *Arts: A Science Matter* (2011) and *All About Science* (2014). 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). Lam is an editor of *Wuli* and *Science Popularization*. His current research is in Scimat (Science Matters), Histophysics, and Complex Systems; Scimat website: www.sjsu.edu/people/lui.lam/scimat. Email: lui2002lam@yahoo.com.