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Reflections *on The Structure of Scientific Revolutions* and its Relevance to Contemporary Science and Technology



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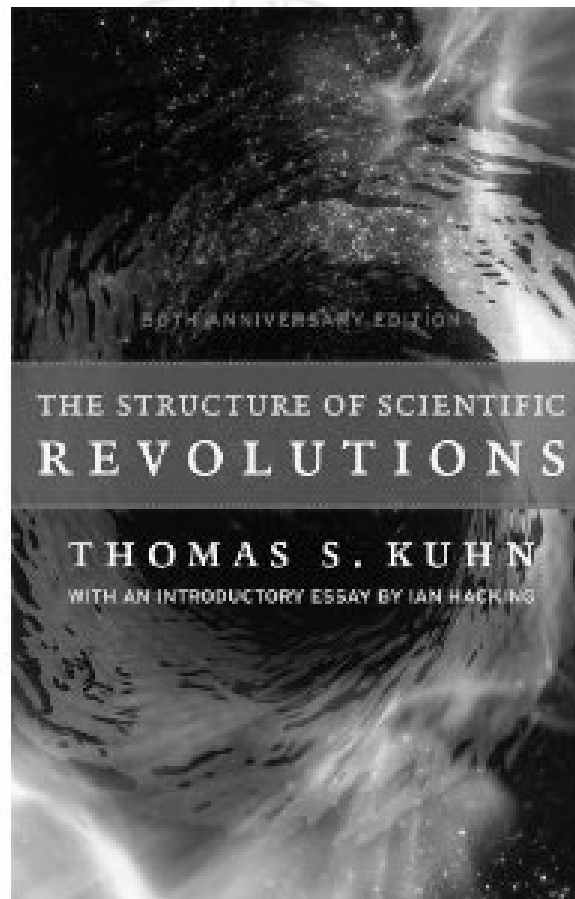
**CSSP, JNU, New Delhi
5 February 2013**

STSS@JNU?



The Plan

- (1) Discuss the significance of *The Structure of Scientific Revolutions*
- (2) The image of science we are now possessed since Kuhn
- (3) Kuhn and STS
- (4) A look at scientific method after Kuhn
- (5) Is Kuhn's account of understanding scientific change relevant to twenty-first century sciences?



Thomas Kuhn (1922-1996)



Physics – History of Science – Philosophy of Science

1949: PhD in Physics from Harvard University

1949-56: Assistant Professor of general education and history of science at Harvard University

1956-64: Professor, University of California, Berkeley

1964-79: Professor, Princeton University

1979-1996: Professor, MIT.

Thomas Kuhn

- “The man who changed the way the world looked at science” - John Naughton, *The Guardian*, 19 August 2012.
- How does science develop and change?
- According to Kuhn, the popular textbook notion of science is like an edifice that grows by one brick of scientific knowledge at a time (meta-narrative)
- Kuhn claims this way of understanding the historical evolution of the sciences is wrong
- Development-by-accumulation is the wrong way to write the history of any science...

Structure, the book

- “History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed.”
- A call for historicism
- Development of any scientific field has two phases:
- (1) Normal phase (standard)
- (2) Revolutionary phase (rare)
- Dialectics (contextual & hermeneutical)

History of Science

- Aristotelian dynamics, phlogistic chemistry or caloric thermodynamics, once current views of nature, as a whole, were neither less scientific nor more the product of human idiosyncrasy than those of today.
- According to Kuhn, historians rather than seeking the permanent contributions of an older science to our present vantage, must attempt to display the historical integrity of that science in its own time.
- Kuhn calls for a historiographic approach to the study of science.

The Structure of Scientific Change

- **Normal Science**
- Paradigm
- Puzzle solving
- Anomalies
- Crisis
- **Revolution**
- Paradigm Change (“Shift”)
- **Scientific Community**
- **Incommensurability**
- **Scientific Progress?**



The Structure of Science

- Normal science and puzzle-solving □ scientific development in relations to paradigms
- Science grows through puzzle solving based on a paradigm, but once in a while this normal affair goes awry □ crisis
- Paradigm change and revolution
- When a new paradigm is adopted, a new scientific regime evolves (new discipline)
- It looks different from the old scientific field from which the new evolved (speciation)

Normal Science

- Normal science means research firmly based upon one or more past scientific achievements
- Achievements that provides a **scientific community** the foundation for its further practice
- Normal science is basically solving puzzles (problems) that are left open in the field (discipline)
- Mopping up operations
- Determination of significant facts, matching facts with theory, and articulation of theory.
- Normal science does not aim for novelty, it discovers what it expects to discover, it often suppresses fundamental novelties as they can be subversive.

Paradigm

- Paradigms are shared examples (exemplars) of a scientific community
- Major scientific achievement(s) that are sufficiently unprecedented to attract an enduring group of adherents away from the prevailing state of affairs
- They are open-ended with plenty of problems for the new group (scientific community) of practitioners
- In “Second Thoughts on Paradigms” Kuhn admitted two ways of looking at paradigms:
 - (1) Local sense as various types of exemplars
 - (2) Global sense that focuses on what defines a scientific community.

Anomalies & Crises

- Anomalies occur when discovery shows something is not right, a novelty that runs counter to what was expected (of normal science)
- Discoveries that cannot be explained away with the existing theory (paradigm) – leads to crisis
- Crisis involves a period of extraordinary research with a proliferation of competing articulations, willingness to try anything
- Expression of discontent, recourse to philosophy(izing) and to debate fundamentals
- Out of the ferment arises new ideas, methods, theories
- Theory choice necessitates a scientific revolution

Revolutions & Change of World View

- Extraordinary episodes that shift professional commitments, new basis for the practice of science
- Tradition-shattering complements to the tradition-bound practice of normal science
- Instead of claiming that after a revolution one's view of the world changes, Kuhn claims that scientists work in a different world
- After Copernicus (astronomers), Lavoisier & Dalton (chemists), Brown & Einstein (physicists), Darwin (biologists) lived in a different world.
- Theory choice is not a rational process – transfer of allegiance is often a conversion than a choice.

Theory choice as conversion?



Progress through Revolutions?

- Science grows and accumulates knowledge during its normal science phase
- That is the only way to look at scientific progress
- But revolutions destroy continuity and hence what happens to scientific progress?
- Revolutions cause progress away from previous conceptions of nature - world change
- Science does not aim at *the truth* about the universe, there is no full, objective and final account of nature.

Resolution of Revolutions

- Kuhn equates scientific progress similar to the process of evolution and speciation (similar to Darwin's theory of evolution);
- Progress not towards any set goal (non-teleological)
- What could 'evolution', and 'progress' mean in the absence of a specified goal?
- The resolution of revolutions is the selection by conflict within the scientific community of the fittest way to practice science;
- The net sequence of such revolutionary selections, separated by periods of normal science, is what we call modern scientific knowledge.

Kuhn and his critics

- Science is more than a problem-solving activity.
- Kuhn stripped away the critical and skeptical elements of scientific process and inquiry.
- Scientists do challenge their central theories, adherence to the *status quo* is not always the norm.
- Kuhn used paradigm inconsistently....21 different ways (Masterman).
- Do revolutions destroy scientific progress? Kuhn-loss (revolutions destroy relevant previous achievements)
- Does scientific change and progress have no rational basis? Theory choice based on mob psychology?
- Allowed rampant relativism (epistemic relativism)

Kuhn and his critics

- It was Immanuel Kant who first invoked the idea of scientific revolutions
- Mathematical (Babylonia & Arabian) techniques of proofs from postulates reaching Greece and on to Europe & Galileo's experimental techniques.
- Ian Hacking says that Kuhn was influenced by Wittgenstein (through Cavell) when he hit upon the problematic of paradigm (family resemblance).
- Kuhn's notion of scientific community was prefigured in Ludwig Fleck (thought collective)
- Kuhn did acknowledge Fleck's influence, but said Fleck was wrong on his focus on the individual rather than the community.

Kuhn's Influence on STS

- The central protagonists of a scientific enterprise are the members of a scientific community
- Kuhn's picture of science allowed a more liberal conception of science than what philosophers taught
- Kuhn's rejection of rules determining theory choice and hence scientific outcomes permitted appeals to extra-scientific factors
- Social, economic, cultural and psychological factors influence the outcome of scientific debates
- SSK: The very content of scientific knowledge is determined by social factors and values
- Social construction of science and rest is history!

Kuhn and Post-Modern Science

- Though Kuhn never instigated or endorsed, *Structure* set off various strands of post-modern sciences
- Influenced by post-structuralism
- No more grand narratives or meta-theories
- Epistemic relativism (science just another knowledge enterprise?)
- Just a craft of a scientific community who shares a paradigm? (shared values and world views)
- Community of practitioners and postmodern sciences
- Science wars (*Social Text* and the Sokal Hoax)

Science, values and methods

- Turning science into problem-solving normal science blunted the normative and critical nature of science
- Norms and ethos of science
- Robert Merton and the four norms of science
 - § Communism
 - § Universalism
 - § Disinterestedness
 - § Organized skepticism
 - § (Originality)

What constitutes a scientific field?

- Positivism: Emphasis on the empirical verification of knowledge claims – questions/claims that cannot be empirically verified are false or pseudo-science
- Karl Popper: in order to claim something is scientific (theory or hypothesis), it must be falsifiable – theories must be testable.. (Conjectures and Refutations)
- Thomas Kuhn: puzzle solving by a scientific community within a paradigm signifies the scientific status of a field – “no puzzles to solve, no science to practice.”

Scientific Method

- Induction: begin with observation and then deduce principles – theories
- Facts arranged in a logical manner would reveal the inner secrets of nature (Bacon)
- Hypothetico-deductive method; begin with hypothesis and deduce consequences through experimental data
- Kuhn: All observation (facts, data) is theory-laden (theory-dependence of observation or under-determination of theory by observation)
- Darwin as the quintessential scientist – one can only observe through the lens of a theory
- Theories are contingent entities.

Scientific Method

- Science provides the best naturalistic explanation to make sense of the world.
- Science is a human/social enterprise that helps us continually probe and understand the universe.
- Science is the best and most reliable knowledge we have. It is not just *another* knowledge.
- Richard Dawkins: “There is a real world, we live in it, true and false things can be said about it, science is how we find out about it.”
- Richard Feynman: “Science is the culture of doubt.”
- Carl Sagan: “Science is a candle in the dark.”

Kuhn and 21st Century Sciences

- Kuhn's model for his theory of scientific change was based on the physical sciences
- Kuhn did not look at the structure of biological sciences
- Used Darwin's work to make a philosophical claim
- 1962 was a watershed year in terms of the beginning of a new scientific revolution
- Watson & Crick received the Nobel Prize for their discovery of the structure of the DNA
- Physical sciences have less influence now than it did during Kuhn's time
- Biological, information and sustainability sciences dominate the world now.

Sustainability Science

- Sustainable development is concerned about the fundamental question of enhancing human well-being.
- Maintaining and improving the quality of life of all citizens of the globe, within a healthy earth system.
- Sustainability science is about enhancing well-being without compromising the very foundations of human-environment systems.

Sustainability Science

- It is about constructing reliable knowledge of our understanding of the integrated system of societal institutions, the natural world, and the changes humans bring to the earth system.
- It encompasses natural, social and human sciences.
- *Simultaneous* consideration of the dynamic interactions of environmental, ecological and socio-technological systems.
- Crutzen's Anthropocene – a new geologic epoch – as the basis of scientific inquiry (doing science)
- Understanding and managing resilient complex socio-technological systems.

Sustainability Science

- If we apply Kuhn's model, is "sustainability science" a mature science?
- What sort of puzzles and methods of solving puzzles?
- Did it originate as a result of a paradigm shift?
- Is sustainability science emerging as the resolution of a scientific crisis, a scientific revolution in the making?
- If so, what is/are the central paradigm(s) of sustainability science?
- What constitutes the scientific community of sustainability science?
- Or is it a coherent research field/program?

Concluding Thoughts

- Did Kuhn change the image of science by which we are now possessed?
- Did the Kuhnian deconstruction of science undermine the image of science?
- Kuhn's ideas had the most influence in shaping STS
- Has epistemic relativism gone rampant?
- Can the methodological debates of the scientific process that Kuhn unleashed explain the sciences of the 21st century?



Thank you!

