A Brief History of Scientific Thoughts
Lecture 5

Palash Sarkar

Applied Statistics Unit
Indian Statistical Institute, Kolkata
India
palash@isical.ac.in



Thomas Samuel Kuhn (1922–1996)

(From the Stanford Encyclopedia on Philosophy)

- Developed a theory about the history of scientific development.
- This theory led to new ideas about the philosophy of science.
  - Conflict with the positivist view of science.
  - Conflict with Popperian view of science.
- In 1962, Kuhn authored a highly influential book entitled "The Structure of Scientific Revolutions".



History of Science: Pre-Kuhnian View

- There was a conception of how science *ought* to develop.
  - Based on the prevailing positivist-influenced philosophy of science.
  - Based on the popular, heroic view of scientific progress.
- Science develops by
  - the addition of new truths to the stock of old truths,
  - the increasing approximation of theories to the truth,
  - the correction of past errors.
- Progress accelerates in the hands of a great scientist (heroic view).
- There had been no earlier attempt to build a theory about how science had *actually* developed.



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History of Science: Kuhn's View

- The development of a science is not uniform.
- There are alternating *normal* and *revolutionary* (or *extraordinary*) phases.
- The revolutionary phases are not merely periods of accelerated progress, but differ qualitatively from normal science.
- Normal phases are periods of consolidation.



Disciplinary Matrix and Paradigm

Disciplinary Matrix.

- Strong commitment by the relevant scientific community to their shared theoretical beliefs, values, instruments and techniques, and even metaphysics.
- Elsewhere this is also called paradigm.
- Scientific training consists of the inculcation of the disciplinary matrix in mind-set formation.
- There is a tension between the desire for innovation and the necessary conservativeness of most scientists.



Paradigm (Narrow Sense)

- Consensus on exemplary instances of scientific research.
  - Examples: Ptolemy's computations of plantery positions and Maxwell's mathematization of the electromagnetic field as paradigms.
- Kuhn also describes great texts as paradigms.
  - Such texts contain the key theories and laws.
  - The applications of those theories in the solution of important problems, along with the new experimental or mathematical techniques.
  - This is what makes them paradigms.
  - Examples: Ptolemy's Almagest and Newton's Principia Mathematica.



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Normal Science

- Normal science resembles the positivist-based cumulative picture of scientific progress.
- Normal science is like ‘puzzle solving’.
  - The puzzle-solver will have a reasonable chance of solving the puzzle (depending on his/her ability and the puzzle).
  - The method of solution will have a high degree of familiarity.
  - There will be growing stock of puzzle solutions.
- In normal science, scientists neither test nor seek to confirm the guiding theories of their disciplinary matrix. Nor do they regard anomalous results as falsifying those theories.



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Revolutionary Science

- Crisis: a widespread failure in confidence.
  - Accumulation of particularly troublesome anomalies that poses a serious problem for the existing disciplinary matrix.
  - Undermines the practice of normal science.
  - Difficult to continue with confidence until the anomaly is addressed.
- Response: scientific revolution.
  - Search for a revised disciplinary matrix.
  - Lead to the elimination of at least the most pressing anomalies.
  - May optimally lead to the solution of many outstanding and unsolved puzzles.



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Revolutionary Science (contd.)

- The decision to opt for a revision of a disciplinary matrix is not one that is rationally compelled.
- Nor is the particular choice of revision rationally compelled.
- The revolutionary phase is particularly open to competition among differing ideas and rational disagreement about their relative merits.
- Kuhn-loss:
  - Revolutionary science is not cumulative.
  - Not all the achievements of the preceding period of normal science are preserved in a revolution.
  - A later period of science may find itself without an explanation for a phenomenon that in an earlier period was held to be successfully explained.



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Revolutionary Science (contd.)

- Even if there is some Kuhn-loss, a worthy replacement must also retain much of the problem-solving power of its predecessor.
  - The newer theory must retain all its predecessor's power to solve quantitative problems.
  - It may however lose some qualitative, explanatory power.
- Revolutions do bring with them an overall increase in puzzle-solving power.
  - The number and significance of the puzzles and anomalies solved by the revised paradigm exceeding the number and significance of the puzzles-solutions that are no longer available as a result of Kuhn-loss.



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Revolutionary Science (contd.)

- Increase in puzzle-solving power should not be taken to infer improved nearness to the truth.
- Suggests an evolutionary view of scientific progress.
  - Evolutionary development of an organism: response to a challenge set by its environment.
  - Does not imply that the organism is evolving towards some ideal form.
- Scientific theories: evolve in response to puzzles.
  - Progress is measured by its success in solving those puzzles.
  - Progress is not measured by closeness to an ideal true theory.



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Kuhn and Popper

- Alternating phase view of science rejects both the positivist and the Popperian views.
  - In the normal phase, a scientist does not question the disciplinary matrix.
- Emphasis on the conservative view during normal science.
  - Unlike Popperian view that a scientist is constantly trying to falsify.
- Revolutionary science.
  - Popper: logically required by an anomaly.
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"Philosophy of science is about as useful to scientists as ornithology is to birds."

- Cargo-cult science: distinguishing science from non-science.
- "The Meaning of it All" is a collection of three lectures delivered in April, 1963.
  - The Uncertainty of Science.
  - The Uncertainty of Values.
  - This Unscientific Age.

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Feynman on ‘What is Science?’

One or more of the following.

- A special method of finding things out.
- The body of knowledge arising from the things found out.
- The actual doing of new things.
  - This is called technology.
  - The popular view of science is partly technology too.

Technology.

- Manifestation of science in the form of giving power to do new things.
- No instruction on how to use the power.
- The power to do something is of some value.



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Content of Science

- Content: the things that have been found out.
- Work is not done for the sake of an application.
- It is done for the excitement of what is found out.
- Imagination, ‘subtle trickery, beautiful tightropes of logic’.

> *“The scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it, and he takes pleasure in it because it is beautiful. If nature were not beautiful it would not be worth knowing, and life would not be worth living.”*

– Henri Poincaré



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Method of Science

- Observation is the ultimate and final judge of the truth of an idea.
- Principle of science: “The exception proves that the rule is wrong.”
- Observing an exception spurs attempts at understanding and trying to find other exceptions and new rules.
- Progress and excitement in trying to show that the current rules are wrong.



Discipline of Observation

- Thoroughness: check and recheck to be sure of the conditions and to avoid misinterpretations.
  - Sometimes this itself is misunderstood as science.
- Interpretation. *Scientific reasoning requires a certain discipline.*
  - Mysterious observation: white horses on a farm eat more than black horses.
  - De-mystification: There are more white horses.
- Objectivity.
  - Due to irregularities, the result of experiments may vary.
  - Serious error: you want the results to confirm a hypothesis (theory-laden observations) and so ignore (and do not report) results which do not suit your hypothesis.



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Formation of Rules

- Purpose of rules: prediction.
  - This is the most exciting thing about rules.
- The more specific a rule is,
  - the more powerful it is (in the sense of prediction),
  - the more liable it is to exceptions,
  - the more interesting and valuable it is to check.
- Wording of rules.
  - Should be careful about the meaning of words.
  - But,

"I think that extreme precision of definition is often not worthwhile, and sometimes it is not possible – in fact mostly it is not possible."



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Source of Ideas

- Rejects the Baconian view that observations suggest a hypothesis.
- Since ideas are tested against observations, the source of idea is not important.
- There is no authority to decide what is a good idea.
- Imagination in science.
  - Interesting in itself and different from that of an artist.
  - The challenge:

"The great difficulty is in trying to imagine something that you have never seen, that is consistent in every detail with what has already been seen, and that is different from what has been thought of; furthermore, it must be definite and not a vague proposition."



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Nature of Scientific Laws

- Laws are not observations.
- Experiments are always inaccurate.
- Laws are guessed laws, extrapolations, not something that the observations insist upon.
- Every scientific law is some kind of a summary which leaves out details.

All scientific knowledge is uncertain!



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Doubt, Uncertainty and Ignorance

- Doubt is of great value and extends beyond science.
  - You have to leave open the possibility that you do not have it exactly right.
  - Otherwise progress will be stifled.
- Scientific knowledge.
  - Body of statements of varying degrees of certainty.
  - Some are most unsure; some are nearly sure; but none is absolutely certain.
  - Does not clearly address the issue of ‘absolute truth’.
- Calls for a satisfactory ‘philosophy of ignorance’.
  - Doubt is not to be feared; it is to be welcomed.
  - Demands the freedom to doubt for future generations.



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Cargo-Cult

- During World War-II, planes used to land on some islands with lots of good materials.
- After the war, the people of the islands wanted the trips to continue.
  - They arranged for things like runways.
  - Put fires along the sides of the runways.
  - Make a wooden hut for a man to sit in.
  - Wooden pieces to look like headphones and bamboo sticking out like antennas.
- These had the *appearances* of a runway and an air traffic controller.
- But, the planes did not arrive.



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Cargo-Cult Science/Pseudo-Science

- People and things which follow all the apparent forms and percepts of scientific investigations.
- But, they miss something very essential.

Examples given by Feynman.

- Astrology.
- ESP.
- PSI: mind reading and bending things.
- Good parenting.
- Educational methods.

"Ordinary people with commonsense ideas are intimidated by this pseudoscience."



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Demarcation Between Science and Pseudo-Science

- A missing feature in pseudo-science: *scientific integrity*.
  - A principle of scientific thought that corresponds to utter honesty.
  - This is never explicitly mentioned in science education.
- You should report both the positive and the negative results.
  - Details which could cast doubt on your interpretation should be given, if you know them.
- *All* information should be given and not just those which lead the judgement in one direction.
  - Advertisement: XYZ oil does not soak through food.
  - Correct: at certain temperature no oil does.
  - But: at certain other temperatures all oil do.
- Wish from Feynman: the good luck to be somewhere where you are free to maintain the above kind of integrity.



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