Kuhn and scientific revolutions

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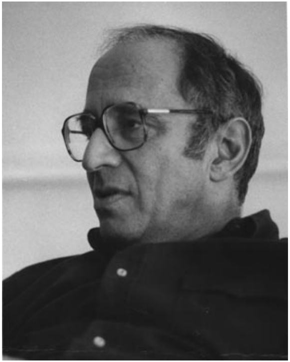
Thomas S Kuhn (1922-1996)



- born in Cincinnati OH, educated at Harvard (physics)
- 1949 PhD, taught at Harvard, Berkeley, Princeton, MIT
- 1962 *The Structure of Scientific Revolutions*
- 1977 *The Essential Tension: Selected Studies in Scientific Tradition and Change*

What is a paradigm?

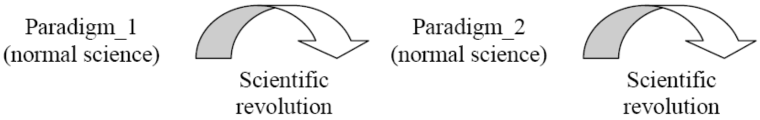
Characterisation (Broad sense)

A paradigm (in the broad sense) is a whole way of doing science in a particular field that includes an entire package of ideas and claims about the world, as well as of methods for gathering and analyzing data, of pursue the theoretical elaboration of the field.

Characterisation (Narrow sense)

A paradigm in the narrow sense is a key part of a paradigm in the broader sense, a specific achievement, typically in the form of a exemplary problem and an exemplary solution.

Scientific change: normal science and revolutions



Contrast with Popper

1. Normal science:
   - Popper: science permanently open to criticism and revision
   - Kuhn: no, periods where a lot of background is held constant
2. Scientific change:
   - Popper: smaller and bigger conjectures and less or more dramatic refutations, but essentially the same
   - Kuhn: change within normal science vs revolutionary change
   - normal science and revolutionary science (or 'crisis science') science must be described very differently
   - in normal science: conventions about standards for justification of arguments
   - in revolutions: no such thing
   - progress: obvious in normal science, problematic in revolutionary science
3. role of history of science: Popper: none; Kuhn: important

Peter Godfrey-Smith (2021, 106)

> *1. Kuhn's constant emphasis on the arbitrary, personal nature of factors often influencing scientific decisions, the rigidity of scientific indoctrination of students, the tenacity with which ideas are held by scientists and the 'conceptual boxes' that nature gets forced into..., and*
>
> *2. Kuhn's suggestion that these features are actually the key to science's success—without them, there is no way for scientific research to proceed as effectively as it does.*

Peter Godfrey-Smith ([2]2021). *Theory and Reality: An Introduction to the Philosophy of Science*. University of Chicago Press.

Question:

How can it be beneficial for science to involve decisions which are grounded in such personal and biased inclinations?... really: in anything other than data?

Normal science

- pre-normal science: before establishment of paradigm, not well ordered, not effective
- establishment of a paradigm
- examples of paradigms: Newton's, Einstein's, Skinner's behaviorism, modern molecular genetics, etc
- one paradigm per field at any given time (usually)
- characteristic of normal science: absence of debate over fundamental tenets ('consensus-forging' role of paradigms)

  Kuhn: Yea   Popper: Nay
- 'puzzle-solving' in normal science, extending and refining the paradigm

Anomaly and crisis

- "only a poor workman blames his tools"
- anomalies: data irreconcilable with paradigm or puzzle that has resisted resolution
- disposal of entire paradigm only if two necessary conditions are met
  1. critical mass of anomalies is reached
  2. a rival paradigm has emerged
- crisis science when first condition has been met, but not second
- For Popper, every little anomaly should count as a refutation.
- Kuhn: willingness to reject hypotheses can go too far

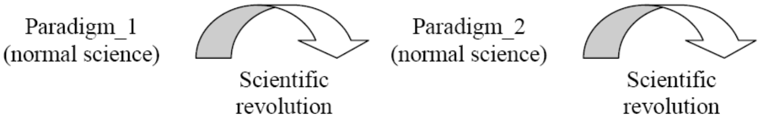
Criticism of theory so far

- Some have challenged Kuhn's insistence on there only being one paradigm in a given field at a given time.
- Kuhn seems to have exaggerated the degree of commitment of normal scientists to their paradigm.

Next: revolutions

«La Prise de la Bastille» le 14 Juillet 1789, par Jean-Pierre L L Hoüel (1735-1813)

Scientific revolutions



In scientific revolutions, rules and standards break down and are replaced, even the scientific language.

Two issues:

1. How do revolutions occur?
2. What's the relationship between pre-revolutionary and post-revolutionary science?

How do revolutions occur?

Recall the necessary conditions for large-scale scientific change:

1. critical mass of anomalies is reached
2. a rival paradigm has emerged

⇒ Crisis alone will not lead to a paradigm being 'falsified'.

⇒ The emergence of new paradigm alone does not suffice to persuade scientists to change camps.

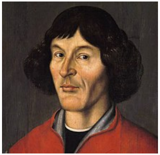
Challenge: are crises really necessary preludes to revolutions? E.g. in case of appearance of genetics around 1900?

⇒ Perhaps condition (1) is not strictly necessary.

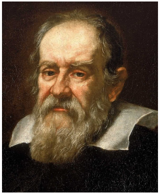
Example: Ptolemaic astronomy and the Copernican revolution

Ptolemaic astronomy was not replaced until the emergence of a credible rival (the Copernican system, including the contributions of Galileo, Kepler and Newton), even though it suffered from major anomalies for centuries.

Ptolemy
(100-160)

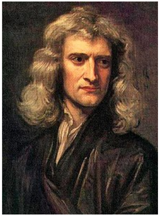


Copernicus
(1473-1543)



Galileo
(1564-1642)

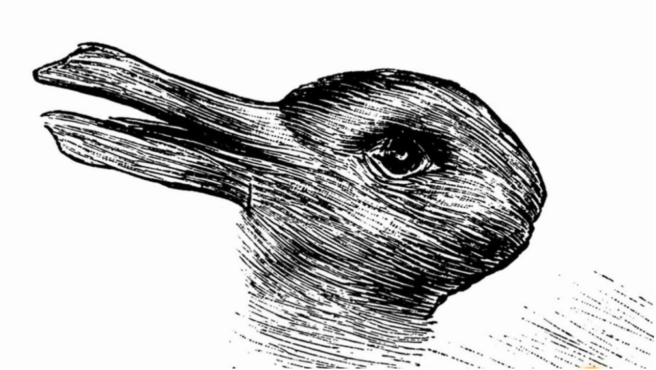
Kepler
(1571-1630)



Newton
(1643-1727)

The changing standards

- Standards, particularly their explication and specification, are part of paradigm.
- If a paradigm is replaced, so are some of the standards.
- The shift from a paradigm to another is like a conversion, a 'gestalt switch'.



The changing standards

- There are rock-bottom standards: theories must be predictively accurate, consistent with well-established theories in neighbouring fields, able to unify disparate phenomena, and fruitful for future research.
- Diversity and variation within and without a paradigm is a strength of science.

In short

Science is a social mechanism that combines capacity for sustained, cooperative work with capacity to break down and reconstitute itself.

Gains and 'Kuhn losses'

- revolutions are non-cumulative episodes in the history of science
- There are gains, particularly concerning problem-solving power.
- But there are also some losses ('Kuhn losses'): questions that the old paradigm answered may appear puzzling in the new paradigm, or disappear altogether.

Examples of Kuhn losses

(1) Descartes' vortex theory explained why all the planets revolve around the sun in the same direction, whereas Newton's gravitational theory did not (although it later succeeded in doing so);

(2) "Lavoisier's chemical theory inhibited chemists from asking why the metals were so much alike, a question that phlogistic chemistry had both asked and answered" (*SSR*, p. 148)

- Question: is there an unbiased way of comparing gains and losses resulting from a revolution?

Incommensurability

Definition (Incommensurability)

Two entities are incommensurable just in case they are "not comparable by use of a common standard or measure".

(Godfrey-Smith, p. 119)

1. Linguistic incommensurability: holistic view about meaning of scientific language implies that languages used in different camps are different

Examples (linguistic incommensurability)

- example: 'mass' in Newtonian mechanics and in special relativity
- example: 'planet' (intension and extension) in various astronomical theories (and recent redefinition)
- problems: hard to come up with real examples from history of science; scientists often 'bilingual'

2. Methodological incommensurability: lstandards of what qualifies as good evidence, good argument, etc depend on paradigm

Example (methodological incommensurability)

- example: role of causal explanation
- The Newtonian theory of gravitation involving instantaneous action at distance hard to supplement with mechanistic explanation.
- Does this mean Newtonian theory is to blame, or should demand for causal explanation be dropped?

Paul Hoyningen-Huene:
Two misunderstandings of incommensurability

Paul Hoyningen-Huene (1993). *Reconstructing Scientific Revolutions: Thomas S. Kuhn's Philosophy of Science*. Chicago: University of Chicago Press.

1. First misunderstanding: Incommensurability implies complete incomparability
    - Theories can be compared in their empirical potentials.

Hoyningen (1993, 220)

> *Though the incommensurable concepts may be central to both theories, many [...] predictions may be formulated entirely commensurably.*

Example

- position of celestial bodies predicted by Ptolemaic and Copernican astronomy

Paul Hoyningen-Huene:
Two misunderstandings of incommensurability

2. Second misunderstanding: Incommensurability implies full discontinuity
    - at least part of achievement of a paradigm is permanent

SSR, p. 130

> *[After a revolution] much of [the scientist's] language and most of his laboratory instruments are the same as they were before. As a result, postrevolutionary science invariably includes many of the same manipulations, performed with the same instruments and described in the same terms as its revolutionary predecessor.*

Scientific progress according to Kuhn

Main idea:

scientific progress as increased problem-solving capacity

- cumulative only in periods of normal science, non-cumulative through revolutionary phases
- appearance of progress from standpoint of victorious paradigm
- objective sense in which revolutions increase problem-solving power, i.e. number and precision of solutions to problems tend to grow over time
- This is guaranteed because the new theory is required to be able both to solve most problems the old theory solved, and to cope with the anomalies incurred by the old theory.
- This constitutes objective scientific progress for Kuhn, and allows him to reject charges of relativism (according to which successive theories don't differ in quality).

Hoyningen: three qualifications

1. First qualification: 'losses' in revolutions
2. Second qualification: devaluation of the loser's perspective
3. Third qualification: no 'drawing closer to the truth'
   - development of science isn't a process towards a fixed goal set in advance, but development in which articulation and specialization of knowledge increases
   - historical argument: no ontological convergence in lineages (Aristotelian physics $\Rightarrow$ Newtonian mechanics $\Rightarrow$ Einsteinian relativity)
   - epistemological argument: meaningless to talk of what there really is, beyond all theory

Scientific progress is not a progressive approximation to truth, but an instrumental improvement of scientific knowledge.