

**Galileo**  
**Theory Choice**  
**and Theory Change**

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'the scientific method'

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# 'the scientific method'

- What is it?
- What ought it to be?

- Karl Popper, *Logic of Scientific Discovery*
- Conjecture and Refutation
- Very logical
- ...but rather little to do with science

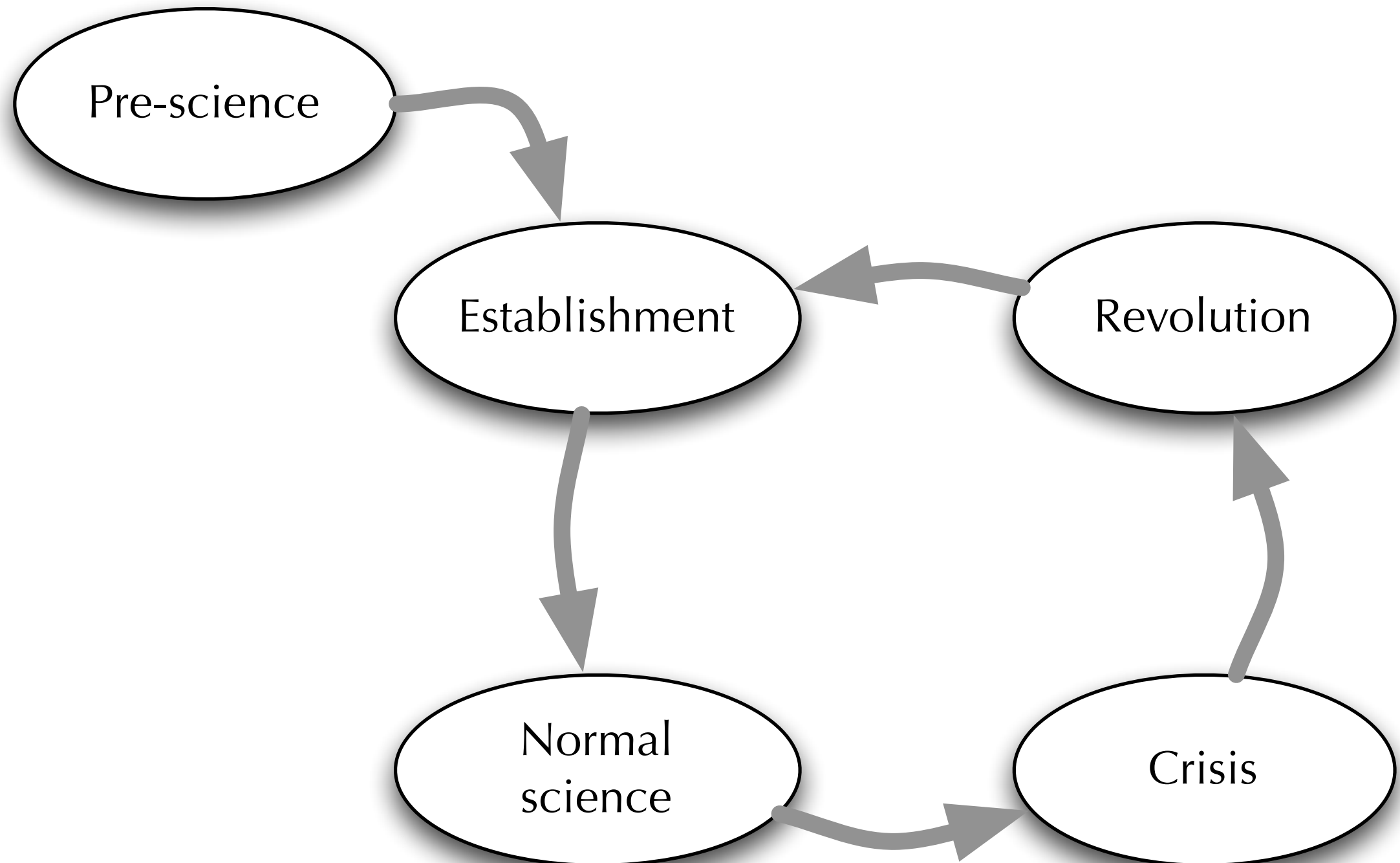
■ Thomas S Kuhn, *The Structure of Scientific Revolutions*

■ A historical approach to science

■ In *The Copernican Revolution*, his big questions are 'why did it take so long?' and 'why did it happen so quickly?'

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# kuhn's science



copernicus, tycho brahe,  
and kepler

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## mediaeval normal science

- The mediaeval analysis of hellenistic science had created a culture of criticism, and examined the cracks in Aristotelian/Ptolemaic science
- Ptolemy's model held up very well
- Tycho's data is good, but the slightly better agreement of Kepler's results wouldn't have won any arguments by itself
- But Tycho's non-observation of the parallax of comets had become a problem



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# mediaeval normal science

- Further, this wasn't just a cosmological problem: by this time Aristotelian physics was thoroughly coupled to the overall cosmological model
- So changing the cosmos was not just a matter of recalculating ephemerides, or 'just' a matter of changing the theology

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# mediaeval crisis science

- Aristotle's and Ptolemy's science *wasn't* really in crisis
- ...except for the messiness of Ptolemy's model
- ...and Tycho's data, maybe

feyerabend

The consistency condition which demands that new hypotheses agree with accepted theories is unreasonable because it preserves the older theory, and not the better theory.

No theory ever agrees with all the facts in its domain, yet it is not always the theory that is to blame.

In addition to natural interpretations, Galileo also changes sensations that seem to endanger Copernicus ... he offers no *theoretical* reasons why the telescope should be expected to give a true picture of the sky.

The Church at the time of Galileo not only kept closer to reason as defined then and, in part, even now; it also considered the ethical and social consequences of Galileo's views.

galileo



The consistency condition which demands that new hypotheses agree with accepted theories is unreasonable because it preserves the older theory, and not the better theory. Hypotheses contradicting well-confirmed theories give us evidence that cannot be obtained in any other way. Proliferation of theories is beneficial for science, while uniformity impairs its critical power. Uniformity also endangers the free development of the individual.

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# galileo and the dialogue

- The *Dialogue* isn't particularly rational; it's rhetorical and highly propagandistic
- Galileo's new physics isn't consistent with the prior theory, and there are aspects where it's flatly contradicted by observation
- And indeed Galileo had used much the same thought experiments to argue *against* Copernicus in his earlier *Trattato della sfera*

No theory ever agrees with all the facts in its domain, yet it is not always the theory that is to blame. Facts are constituted by older ideologies, and a clash between facts and theories may be proof of progress. It is also a first step in our attempt to find the principles implicit in familiar observational notions.

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# galileo's disagreements

- Numerical disagreements: eg, Mercury's perihelion for Newton and for Eddington, and all through contemporary science
- Qualitative failures: Newton's optics can't explain reflection; his gravitational theory remained disappointing; ultraviolet catastrophe; Planck's counting
- This is *Theory Choice*: how do we make up our minds?

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# galileo's disagreements

- Galileo simply ignores refutations of heliocentrism
- Galileo 'defuses' the objections in the tower argument – he doesn't prove them wrong

In addition to natural interpretations, Galileo also changes sensations that seem to endanger Copernicus. He admits that there are such *sensations*, he praises Copernicus for having disregarded them, he claims to have removed them with the help of the *telescope*. However, he offers no *theoretical* reasons why the telescope should be expected to give a true picture of the sky.

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# natural interpretations

- Feyerabend's term: what we 'see' we presume to be non-illusory
- Anamnesis: Galileo corners his readers into a new way of thinking
- A new theory gives a new observation

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# galileo's paradigms

	<b>I: deer and hunter</b>	<b>II: motion of boats</b>
<i>Natural interpretation:</i>	All motion matters	Only relative motion matters
<i>Falling stone proves:</i>	Earth at rest	No relative motion w.r.t earth
<i>Motion of earth predicts:</i>	Oblique motion	No relative motion w.r.t earth



galileo and the telescope

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# the telescope

- What you see through a telescope is less impressive than you might think
- Tiny field of view, it shakes, it needs focus, illusions, dark-adaptation, no cues in the sky, different observers, need to *learn*
- Galileo wasn't familiar with contemporary optical theory, and didn't have time to become so

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# the view through a telescope



- Galileo demo-ed the telescope at a party in Bologna on 24–25 April 1610. He and his student had set everything up carefully
- 20 big guests, some of whom couldn't see anything; others of whom refused even to look
- (a bit like UFOs or ESP?)
- Other professional observers couldn't see anything
- Only Kepler supported Galileo in print

The Church at the time of Galileo not only kept closer to reason as defined then and, in part, even now; it also considered the ethical and social consequences of Galileo's views. Its indictment of Galileo was rational and only opportunism and a lack of perspective can demand a revision.

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# feyerabend and the church?

- Feyerabend isn't being an apologist for the Church, here

- (and there were other reasons for the Church's position)

- ...but stressing that the 'right' answer emerges here, for what Popper and co would regard as completely illegitimate reasons

- ...indeed *because* of them

normal science

- By the middle of the seventeenth century, it is difficult to find an important astronomer who is not Copernican; by the end of the century it is impossible
- ...and during the eighteenth century, lectures on Tycho and Ptolemy were gradually dropped
- (quoting Kuhn)
- That is, by 1633, the argument was effectively over



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## why this matters

- “Pluralism of theories and metaphysical views is not only important for methodology, it is also an essential part of a humanitarian outlook.”
- “There may, of course, come a time when it will be necessary to give reason a temporary advantage and when it will be wise to defend its rules to the exclusion of everything else.”
- “All methodologies... have their limits.”

This has drawn heavily from

- Thomas S Kuhn, *The Copernican Revolution*, Harvard University Press (1957)
- Thomas S Kuhn, *The Structure of Scientific Revolutions*, Chicago University Press (1969)
- Paul Feyerabend, *Against Method: Outline of an Anarchistic Theory of Knowledge*, 3rd edition, Verso (1993)

<http://www.astro.gla.ac.uk/users/norman/lectures/galileo/>

