SCIENCE

Lecture 3: Evolutions, Revolutions and Paradigms

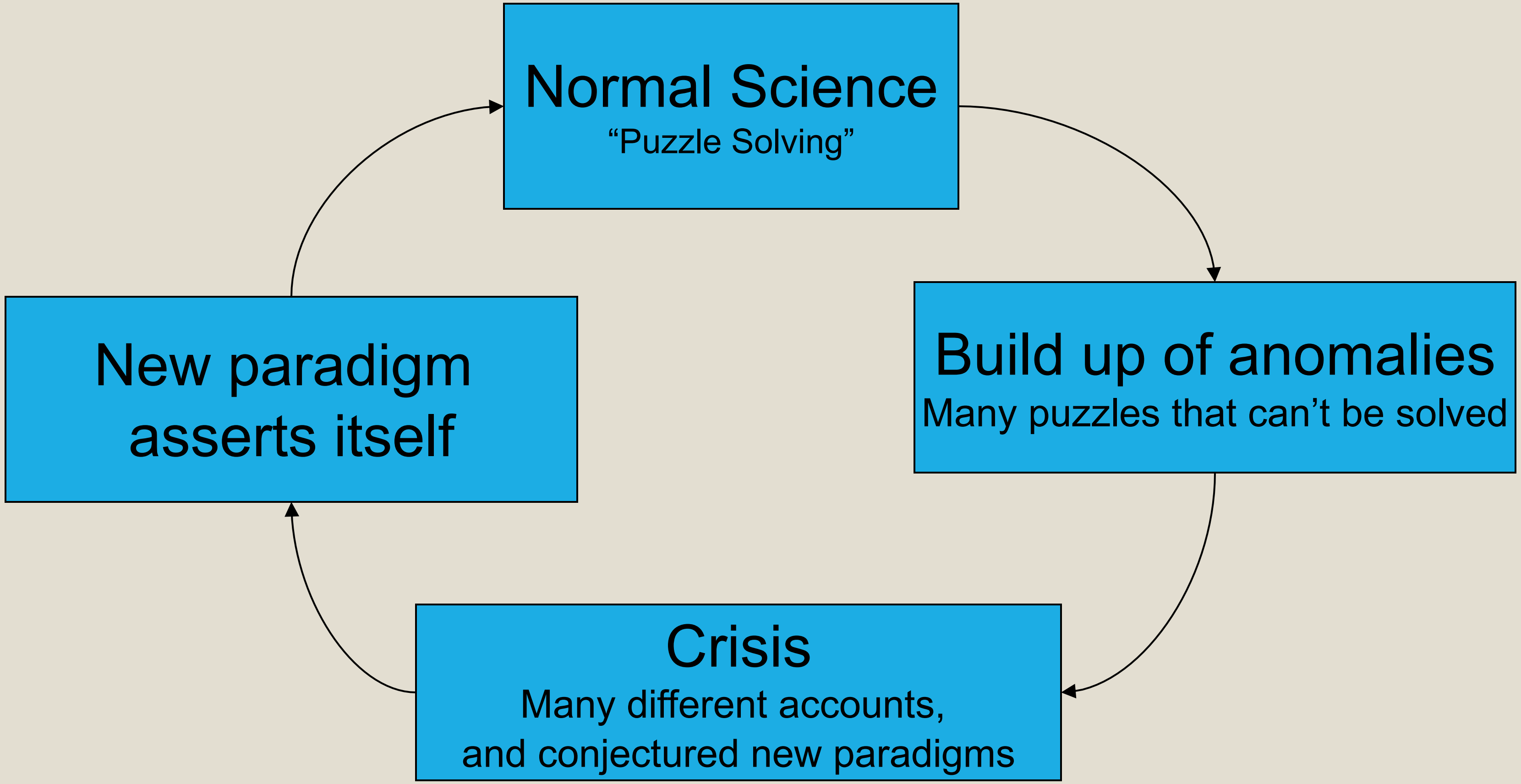
Overview

- Kuhnian Paradigmmatism

Recall

- Failure of Verificationism and Falsificationism in resolving the Problem of Demarcation (what is/should be Science?)
- Verificationism: 1) Problem of Induction, 2) Verification criterion is itself unverifiable, 3) Experimentation not always possible, 4) Underdetermination and Theory-ladenness show that Science isn't objective
- Falsificationism: 1) Doesn't fit the history of science, 2) Holist Underdetermination, 3) Falsificationism doesn't succeed in dissolving the P.O.I.

Scientific Revolutions and Normal Science



Kuhnian Paradigmmatism

- Founder: Thomas Kuhn
- Against Popper: criticized Popper for characterizing "the entire scientific enterprise in terms that apply only to its occasional revolutionary parts" (Kuhn 1974, 802)
- Popper's focus on falsifications of theories led to a concentration on the **rather rare** instances when a whole theory is at stake
- Kuhn: the way in which science works on such occasions cannot be used to characterize the entire scientific enterprise
- Instead it is in **"normal science"**, the science that takes place between the unusual moments of scientific revolutions, that we find the characteristics by which science can be distinguished from other activities (Kuhn 1974, 801)

History of Science as key

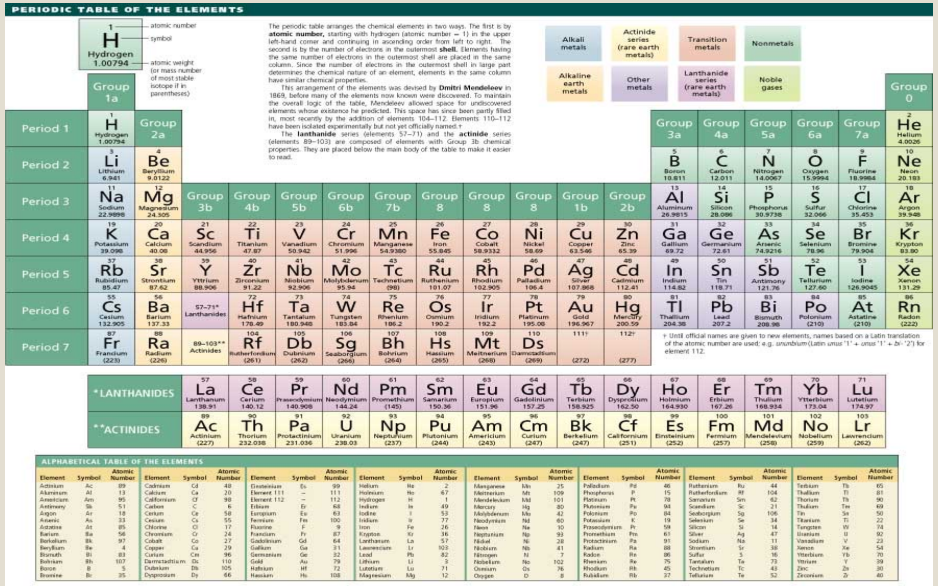
- Unlike most philosophers of science, including Popper, Kuhn **rejects** the distinction between the context of discovery and the context of justification
  - Discovery as the historical, psychological process and justification as the means by which the scientist justifies his theory once it is there (Article E, 1-2)
- For Kuhn, the history of science is important if we wish to arrive at an **accurate picture** of how science progresses
- The mistake of the logical positivists and Popper is to disregard this history, i.e. the context of discovery
- Rather, Kuhn argues that if the history of science is examined, it becomes clear that science does <u>not</u> progress via conjectures and refutations as Popper held, but by **paradigms and paradigm shifts**
- For Kuhn, the paradigm-exemplar functions as **both** discovery and justification – it tells scientists <u>how to generate</u> solutions for the puzzles as training with the exemplar helps them to see potential solutions to new puzzles; it also tells scientists <u>which solutions should be accepted</u> into the paradigm on the basis of how similar the new solution is to the paradigm-exemplar

Normal Science and Puzzle-Solving

- In these periods of normal science, the scientific community holds to a certain paradigm
- Paradigm: 1) a set of fundamental theoretical assumptions that are accepted by the scientific community at a given time AND 2) the accompanying exemplars (those problems that have been solved by the existing theories) AND 3) gaps but with clues as to where to find the answers
  - In short, a paradigm is **an entire scientific outlook** – a constellation of shared assumptions, beliefs, and values that unite a scientific community and allow normal science to take place (more later)
- What happens during normal science? Puzzle solving (as opposed to testing fundamental theories, i.e. the paradigm, which are **unquestioningly accepted**)
- The goal is to eliminate instances/puzzles where observations don't fit the paradigm while making as few changes as possible
  - E.g. the puzzle solving of Uranus' orbit to discover Neptune (as opposed to questioning Newtonian mechanics)
- If any results conflict with the paradigm, they normally assume that their technique is faulty or some experimental error has occurred, and not take it as a sign of falsification of the paradigm
- There is **cumulative growth** here as scientists generate more and more puzzle-solutions(this fits the traditional view of Science)
- Paradigms lasts for decades or even centuries

Example of Paradigm

- Mendelev's periodic table.
- He arranged the elements in groups according to weights and properties, **leaving gaps** where he expected an element and predicting its properties.
- When Gallium, Germanium and Strontium were discovered, they had the weights and the properties he predicted.
- **The periodic table told scientists where to look and how to recognize and classify what they found.**
- Here is a real-world example of a paradigm guiding research.



Scientific Revolutions & Paradigm Shifts

- Over time, more and more anomalies occur, eventually reaching a point of **crisis** when scientists begin to question the paradigm and offer alternative theories
- The **revolution** begins and typically lasts for a generation until a new paradigm is in place (wait for the older ones to die…)
- Though **not all** pre-existing puzzles from the previous paradigm are necessarily solved under the new paradigm – **Kuhn-loss**
  - E.g.: when taking on the Newtonian paradigm, lost the Cartesian explanation for why all planets revolve around the sun in the same direction; Newtonians didn't care as they considered it to be a question about the origin of the solar system.
  - E.g.: when moving towards the oxygen paradigm away from the phlogiston paradigm, lost the ability to ask and answer why metals were so much alike; Lavoisier's chemical theory inhibited chemists from asking this question
- Nonetheless, according to Kuhn, there is an **increase in puzzle-solving power**
- E.g. geocentric-heliocentric, Aristotelian-Newtonian-Einsteinian

Conversion Experience

- A new paradigm takes hold when a conversion experience between scientists occur.
- While there might be good reasons for scientists to switch allegiance from the old to the new paradigm, Kuhn argues that it nonetheless involves a **certain act of faith** which cannot be forced.
- Kuhn does briefly mention that extra-scientific factors <u>might</u> help decide the outcome of a scientific revolution—the nationalities and personalities of leading protagonists, for example (1962/1970a, 152–3)
- Implications: science is **not** a rational objective activity but an irrational one.

- Furthermore, the LP had thought that the COD was subjective and psychological while the COJ was objective and rational, a matter of logic and algorithm.
- Kuhn argued otherwise: if the paradigm-exemplar is that which both tells you how to generate a solution as well as whether to accept a new solution, then the COJ itself is already ‘contaminated’ by the paradigm
- This also explains why Kuhn thought that theory/paradigm-choice is never rational since each paradigm candidate would set out criteria to privilege itself over rival candidates (more on that later)

Other Accompanying Ideas

- Theory-ladenness of data collection during periods of normal science: observation not as objective as we think
- Incommensurability of ideas between paradigms: fully objective choice between paradigms not possible (like two people arguing with no common ground).

Theory-ladenness of Data

- 3 ways that data can be theory-laden, i.e. contaminated by the theory, such that data is not objective
- 1) Perception theory-ladenness: a scientist makes observations through the lens of an existing paradigm / set of theories; he is not really observing things objectively or neutrally.
- In other words, his data is already theory-laden as perception is heavily conditioned by background beliefs,
  - E.g. scientists seeing men with beards in sperm
- 2) Semantic theory-ladenness: reports are couched in highly theoretical language such that one's theory is already privileged
  - E.g. report: "an electric current is flowing through the copper rod" contains a lot of theory about electricity that would not be accepted by a scientist who does not hold standard beliefs about electricity.
- 3) Salience theory-ladenness: where one's theory determines which variables are relevant (i.e. salient)and should be observed and which aren't

◦ Hence, the logical positivists' view that there can be a sharp distinction between theory and observational statements is false

Incommensurability

- 2 paradigms may be so different that the viewpoints and knowledge in them do not ‘make contact’ with each other.
- In other words, they ‘talk past’ each other to the point that they no longer compete for the ‘same ground’
- This then means that we cannot truly compare two or more ‘competing’ theories and thus choose objectively between them
- 2 different ways that incommensurability happens: Standards and Language

Incommensurability of Standards

- Proponents of different paradigms may disagree about the standards for evaluating paradigms, about which problems a good paradigm should solve, about what an acceptable solution to those problems would look like etc.
- This is because the standards for accepting solutions (and thus evaluating paradigms) are themselves paradigm-dependent
  - A ‘good’ paradigm is one that is similar to the paradigm-exemplar or a good paradigm solves particular puzzles which are different for different candidate paradigms
- For example, to many in the seventeenth century, Newton's account of gravitation, involving action at a distance with no underlying explanation, seemed a poor account, in that respect at least, when compared, for example, to Ptolemy's explanation of the motion of the planets in terms of contiguous crystalline spheres or to Descartes’ explanation in terms of vortices.
- However, later, once Newton's theory had become accepted and the paradigm by which later theories were judged, the lack of an underlying mechanism for a fundamental force was regarded as no objection, as, for example, in the case of Coulomb's law of electrostatic attraction. Indeed, in the latter case the very similarity of Coulomb's equation to Newton's was taken to be in its favour.

Incommensurability of Language

- No common language between paradigms as scientific concepts derive their meaning from the theory in which they play a role
- E.g. ‘Mass’ means very different things to Newtonian and Einsteinian physicists.
- Newtonian mass is conserved while Einsteinian is convertible with energy. Only at low relative velocities may the two be measured in the same way, and even then they must not be conceived to be the same
- This difference in meaning in terms complicates efforts to choose between their theories and renders communication between scientists of each paradigm very difficult (weak) or impossible (strong)

Paradigmmatism - Implications

- Makes Science look irrational!
  - Choosing between one paradigm and the next is **subjective** as a theory can never be conclusively verified or falsified.
  - Think Contrastive Underdetermination (for verification) and Holist Underdetermination (for falsification)
  - Further, Kuhn thought that paradigms were **incommensurable**, i.e. that the paradigms are so different that comparison between the two is very difficult (though not altogether impossible) due to the lack of common language between them
  - Kuhn also postulated that there could be **extra-scientific factors** behind paradigm choice – the nationalities and personalities of leading protagonists
  - Given that we can never escape from our paradigm to take up an external, 'God-like' view of the paradigms, then any choice is inevitably subjective
  - Kuhn likened this move from one paradigm to the next as a conversion experience as opposed to a rational choice.

- Science no longer objective
  - **Theory-ladenness** – science is done through the lens of an existing paradigm such that observation is not objective
    - Hence, even the act of observation, so crucial in science, is not objective
    - As opposed to the traditional view of Science which held that facts are directly given to careful, unprejudiced observers via the senses, are prior to and independent of theory, and constitute a firm and reliable foundation for scientific knowledge
  - Incommensurability, both of **Standards** and **Language** mean that paradigm choice becomes difficult, if not impossible, as proper comparison between them cannot be done

- No cumulative progress for Science
  - This is because paradigm choice is irrational and cannot be conclusively justified
  - Incommensurability means that we can't think of the old paradigm as "wrong" and the new as "right" as that would mean that we have a common framework to adjudicate between the two – which we don't have
  - Kuhn-loss also happens, thus 'off-setting' the increase in puzzle-solving power of the new paradigm
  - **Who's to say which is more important – the increase in puzzle-solving power or the loss in those puzzles that can no longer be solved?**
  - Not necessarily moving towards more correct theories given that the newer paradigm could well be more similar to a really old paradigm (e.g. Einsteinian relativity more similar to Aristotelian physics than Newtonian physics)
  - In fact, **the notion of Truth can be disputed** – given incommensurability of paradigms AND theory ladenness, truth now becomes relative to the paradigm rather than to something objective (after all, both the act of observing and the recording of observations are paradigm-dependent)

‘Progress’ in Science - Evolutions

- Nonetheless, it would be incorrect to say that for Kuhn, there is no notion of progress for science at all
- He argued that new paradigms are indeed better than the ones that they replaced in at least one particular way – they have better puzzle-solving ability
- So while there is Kuhn-loss, the new paradigms nonetheless retain at least the majority of puzzle-solving power of the old paradigm *as well as* the ability to solve the anomalies that gave rise to the revolution in the first place
- But this better puzzle-solving ability doesn’t mean that science is getting closer to the truth for Kuhn
- Rather, he favours an evolutionary view of scientific progress (1962/1970a, 170–3).
- The evolutionary development of an organism might be seen as its response to a challenge set by its environment. But that does not imply that there is some ideal form of the organism that it is evolving towards.
- Analogously, science improves by allowing its theories to evolve in response to puzzles and progress is measured by its success in solving those puzzles; it is not measured by its progress towards to an ideal true theory.

Example of Kuhn's Paradigms & Shifts

Example	What Kuhn calls this period	Describe the timing of the discovery	Describe the type of change in scientific knowledge	Describe what led to a general acceptance of the discovery
(A) Ptolemaic discovery	Normal Science	•Lasts for an extended time (Eg decade, or even a century)	•Incremental, cumulative •Progressive •Evolutionary	•Supposedly objective evidence (observation) •Checking against existing theories •This new discovery was a new piece that can help to solve the puzzle

Example	What Kuhn calls this period	Describe the timing of the discovery	Describe the type of change in scientific knowledge	Describe what led to a general acceptance of the discovery
(B) Coper-nican discovery	Revo-lution-ary Science	Infrequently punctuates long periods of normal science.	•Crisis arising from there being too many anomalies •Drastic, revolutionary change •Overthrowing of existing ideas with a whole different incommen-surate set of ideas.	•A "conversion experience", •Persuaded by peer pressure •Not a fully objective choice of the new paradigm because old and new paradigms are incommen-surate.

Example	What Kuhn calls this period	Describe the timing of the discovery	Describe the type of change in scientific knowledge	Describe what led to a general acceptance of the discovery
(C) Post-Copernican discovery	Normal Science	Same as yellow row (Example A) above		

KUHNIAN PARADIGMS

How scientific theories have changed through the ages…

What we are made of…

- We are made up of:
  - The Four Elements, to
  - Atoms of indivisible solid spheres, to
  - Atoms of neutrons and orbiting electrons, to
  - Sub-atomic particles, to
  - Multi-dimensional strings

Newtonian Physics to Einstein's Physics

- Time is absolute to
- Time is relative;
- Space is absolute to
- Space is curved;
- Mass is a force to
- Mass is a curvature of space

Heat

- From a substance that flows between objects, to
- Vibration of atoms

Electricity

- Positive charge that moves forward, to
- Negative charge that moves backwards.

Medicine through the ages

- 1000 BC: Here, take these roots and bark.
- 1500 CE: Roots and bark don’t work; here take these potions.
- 1900 CE: Potions don’t work; here, take these pills.
- 2005 CE: Pills don’t work; here, take these roots and bark.

Paradigmmatism - For

- Fits the history of Science and how scientists work
- Good reason to believe that in periods of normal science, scientists *typically* do not question the paradigm but work within it

Paradigmmatism - Against

- Some of the so-called paradigm shifts **aren't** as incommensurable as Kuhn suggested
  - Newtonian mechanics and Einsteinian relativity share much in common. It's just that if you look at a really big scale (i.e. planetary scale), then Einsteinian physics is correct. But at the normal, everyday scale, Newtonian mechanics is a good approximation that can be incorporated into general relativity
- Theory-ladenness isn't as bad as Kuhn made it out to be
  - Truly theory-neutral data is unattainable as Kuhn pointed out
  - But it doesn't mean that there can be no set of observational statements that two competing groups of scientists can't agree on. E.g. Copernican vs Ptolemaic scientists looking at astronomical data looking at planetary positions and speed, time and dates etc
- Kuhn's relativism is self-refuting
  - Any relativist will eventually be faced with the question – is your own claim about the relativity of truth itself objectively true or not?
  - Clearly, they mean it to be objectively true but that would be self-refuting

Problem of Demarcation

- Applied to the Problem of Demarcation, Kuhnian Paradigmmatism argues that Science is that which is involved in the business of puzzle-solving
- E.g. Astronomy vs Astrology
- Astronomy as puzzle-solving since if the prediction failed, the astronomer could solve the puzzle with more measurements or adjustments of the theory
- Not so for astrology since for that discipline, "particular failures did not give rise to research puzzles, for no man, however skilled, could make use of them in a constructive attempt to revise the astrological tradition" (Kuhn 1974, 804)
- Still, Popper thought that astrologers do indeed engage in puzzle-solving. So if he's right, then astrology would count as a science under Kuhn's criterion
- But don't forget that Popper's falsificationism means that theories are scientific if they are falsifiable even though they might be falsified
- Lakatos: A theory may be scientific even if there is not a shred of evidence in its favour, and it may be pseudoscientific even if all the available evidence is in its favour. That is, the scientific or non-scientific character of a theory can be determined independently of the facts" (Lakatos 1981, 117) -> unintuitive

Homework

- Article E
- Article F
- TOK 240-245