HSS 102
Lecture 7

Revision

What does A HoS Course Intend to Achieve?

- A course in the HoS invites a science student to ask fundamental questions about their approach and the achievements in sciences. It asks her to *study* science instead of *doing* it.
- It asks you to question the self-evidence of the scientific community: A Historian of Science develops a strategic suspension of the taken for granted perceptions in the scientific community and offers a "stranger's view" of science as opposed to the pre-existing "member's view of science" (Shapin and Schaffer, 1985).
- It advocates a set of "how" and "why" questions as opposed "what" and "who" questions.

The Approach to be Taken

- Play the role of the informed stranger among members and question the scientific community’s sacred self-evidence [Next slide---].
- We hold, science is collectively practiced and historically embedded. Therefore, we are more interested in structures and processes than remarkable individuals.
- We consider the sociological aspects of science to be internal and not just external to science.

Self-evidence and Its Problems

- Self-evident statement: ‘any statement which, by putting synonyms for synonyms, is convertible into an instance of a logical form all of whose instances are true’ (Quine 1943, 120, cf. Douglas 1999, 253).
- Example: ‘all bachelors are unmarried men’.
- ‘A self-evident statement is one which carries its evidence within itself’ (Douglas 1999, 253)>If a biology student at IISER Mohali is asked why she thinks that ostrich is a bird, her answer is likely to be that a) ostriches are just birds; b) Linnaean system of classification classifies ostriches as birds (Shapin and Schaffer 1985).
- Member’s account of science runs the risk of self-evident method. I take the presuppositions of my own culture’s routine practices for granted without explanation and examination. Such presuppositions appear to me to be natural and normal ways of doing things (Shapin and Schaffer 1985).
- They are guarded by powerful forces of convention and common-sense.

The Hessen Thesis

- A causal command-execution relation between social developments and scientific developments.
- ‘The technical problems the newly developing economy raised for solution’: navigation and the problem of longitude…> The Newtonian synthesis of terrestrial gravity and celestial motion. The third section of the Principia:

‘is devoted to the problems of the movement of planets, the movement of the moon and the anomalies of that movement, the acceleration of the force of gravity and its variations, in connection with the problem of the inequality of the movement of chronometers in sea-voyages and the problem of tides’ (p. 26).

The Zilsel Thesis

- ‘The Sociological roots of science’ (1939): Modern science was born in the intense conversation between university knowledge of natural philosophy and the craft knowledge of the ‘superior craftsmen in guilds’.
- The superior craftsmen wrote treatises in vernacular. ‘Real science is born when, with the progress of technology, the experimental method of the craftsmen overcomes the prejudice against manual work and is adopted by rationally trained university-scholars’ (Zilsel 1939).
- From 13th c onward, humanist scholars began to carry out reforms in pedagogy, one of which was to visit artisanal workshops
- They believed, familiarity with matter and natural materials, central to the craft of the artisan, could be put in conversation with the existing frameworks of natural philosophy.
- Legitimation of bodily labour in a specially designed space>laboratory as a means to produce scientific knowledge (Renaissance).
- New emphasis on a direct understanding of nature as a way to acquire knowledge>experience became the crucial link in obtaining knowledge.

Galileo's mathematical propositions were a direct outcome of his interaction with the manual workers of that era.

- ‘Dialogues Concerning Two New Sciences’ (Galileo):

‘The constant activity at Venice’s weapons factory suggests to the studious mind a large field for investigation, especially that part of the work which involves mechanics; for in this department all types of instruments and machines are constantly being constructed by many artisans, among whom there must be some who, partly by inherited experience and partly by their own observations, have become highly expert and clever in explanation’(Conner 2005, 285)

- A correspondent writes back to Galileo:

‘You are quite right…Conference with them has often helped me in the investigation of certain effects including not only those which are striking, but also those which are recondite and almost incredible’ (Conner 2005, 285).

- Artisan’s workshop appeared to be novel and generative of new knowledge about nature and objects to this new generation of natural philosophers such as Galileo.
- Central to the artisanal epistemology was the ability to recognize that nature constituted the primary source of knowledge and that knowledge of nature could be obtained by ‘bodily encounters’ with matter—that is, in the act of making. Knowledge is not to be gained from books but by manual labor (Pamela Smith 2004). This understanding was the harbinger of the modern experimental culture in science.

The Result of the Unification of Hand and Mind (Pamela Smith)

- Mathematical hypotheses about nature>derivation of their precise quantitative consequences>testing of them through experimental method.
- Invention of tools of measurement such as barometers, thermometers, compasses, telescopes, clocks>modern laboratory in which these instruments in controlled environment would produce a detailed understanding of nature.
- The growth of a mechanistic understanding of nature that sought to elucidate the operation of the natural world in terms of matters in motion.
- The experimental method that characterizes modern science was developed primarily by unknown artisans. Zilsel: ‘These quantitative rules of the artisans of early capitalism are, though they are never called so, the forerunners of modern physical laws’.

What are the Key Features of the New Scientific Knowledge?

- Units and Quantitative Analyses
- A mathematically driven understanding of the patterns in natural occurrences.
- In this context, what are the historical questions that a historian of science asks about the early-modern period?
- "How did the fundamental scientific concepts — such as number, force, heredity, and probability—and practices—such as experiment, proof, and classification — develop in specific historical contexts? How and why did everyday cultural experiences, such as counting, weighing, collecting, and describing, become specialized scientific techniques? And in what ways did originally local knowledge, devised to solve specific problems, become universalized?" (Smith, 2009).

Revolution

- Two sets of meaning:

A) Rebellion, Revolt, Insurrection, seizure of power…change in the mode of production, etc.>CHAGE. [more modern usage, became popular only after the “Glorious Revolution” of 1688].

B) An instance of revolving/a circular movement: ‘the movement of an object in a circular or elliptical course around another or about an axis or centre’ Turn, Rotation, Spin, etc. [more ancient usage]: “The earth makes one revolution around the sun in about 365 days”.

- Need to maintain both the meanings to understand Scientific Revolution in general and the Copernican Revolution in particular.

Revolutionary Historicism

- Revolutionary Historicism: Understanding revolution as a single process and reducing all past developments as somehow leading to a revolution>refers to a “linear, irreversible and a unidirectional conception of time” (Shapin 1996).
- The “traditional” notion of scientific revolution >a one time-one space phenomenon which first originated in Western Europe and then became global over time through diffusion and adaptation>denial of coevalness.>eclipse of the meaning II of revolution by meaning I: the political understanding of revolution which the West underwent between the end of 18th c and the beginning of the 20th c.

What's a "Paradigm" in the *Structure*

- Every major science discipline navigates two stages of metamorphosis: "Pre-paradigmatic" stage and "Paradigmatic stage".
- Pre-paradigmatic Stage: Coexistence of multiple modes of practicing science, availability of more than one school of thought (and hence, heterogenous), no consensus about methods. A contemporary example: Climate Science.
- Paradigmatic Stage: Emergence of consensus, disappearance of schools of thoughts, uniformity in inquiry, uniformity envelops plurality in doing science. This transition happened first in Astronomy [Ptolemy] and then in Physics [Newton], Chemistry [Lavoisier, Dalton] and Biology [Darwin]. The emergence of paradigm distinguishes science from art, literature and social sciences—where plurality in methods and practices defines merit.
- A paradigm specifies the exact ways in which inquiry in a certain field should/ought to proceed—what problems to handle and how to handle them. "Paradigms are universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (p. vii). Paradigm thus refers to the ground rules, the master-explanatory framework and a disciplinary matrix for a group of professional scientists in a given time.

“Normal Science”

- Once a science reaches the stage of a paradigm, it advances a “normal science tradition”. Normal science refers to the everyday conduct of problem-solving premised upon the conceptual apparatuses made available to the community by the paradigm. It is a cumulative and tradition-bound exercise. The practitioner of the normal science is a scientist who internalizes the paradigm of his/her time through university education.
- A shared commitment to a paradigm ensures that its exponents probe into the kinds of research questions to which their own theories can straightforwardly supply answers. This explains the ubiquity of textbook culture in the realm of science education.
- A scientific community cannot act science without commonly agreed-upon beliefs (p 4) in the sense that paradigmatic rules are to be taken for granted in order to conduct normal scientific activities. Hence, normal science resists radical thinking in the sense that its practitioners conform to the existing paradigm while adjusting “existing theory or existing observation in order to bring the two into closer and closer agreement”, and extending “existing theories to areas that it is expected to cover but in which it has never before been tried” (p. 233). It is normal science that makes science a highly successful socio-cultural enterprise.
- Normal science refers to a period of stable and coherent growth in science.
- So, what is the relation between a paradigm and a normal science?>This is where Kuhn appears to draw from structuralist philosophy in linguistics (Saussure), Psychoanalysis (Freud) and sociology (Durkheim)>follow the lecture.

“Anomaly”, “Crisis”, “Revolution”

- The stable growth of normal science is, at times, punctuated by anomalies—moments when conceptual boxes provided by the paradigm fails to resolve certain newly observed anomalies in nature. Anomaly “subverts the existing scientific practice” (p 6). Anomaly leads to the recognition that nature has violated the paradigm-induced expectations that govern normal science
- A puzzle continues to remain a puzzle until it acquires enough critical mass (i.e., the manifestation of many major puzzles) calling for a certain rethinking of the conceptual matrix itself. This might take decades and might involve bitter fights within the community of scientists. The old-guard of the scientific community resists the changes in their belief-system.
- The deepening of the crisis eventually forces the community to re-evaluate and re-construct prior assumptions and facts. This is not an event but a time-consuming process. This is the moment of scientific revolution. It is only during this moment of transition from one paradigm to another that the scientific community take part in radical debates about the nature of their vocation and tests competing theories: Schools of thought resurface.
- Remember, temporally speaking, normal science has a much longer life than revolutionary science.
- However, when a shift takes place, "a scientist's world is qualitatively transformed [and] quantitatively enriched by fundamental novelties of either fact or theory" (p 7).

What then is the relation between the old paradigm and the new one?

- The new paradigm is not a logical development of the old, nor does it give you a better access to a higher realm of "truth". The two paradigms often have completely different set of apparatuses to conceive nature and hence they "cut the world differently". The two paradigms use different languages and even when they use the same language, meaning changes>Example> "atom". In ancient Greek natural philosophy, atom referred to the "uncuttable", uncreated and eternal. In his Law of Multiple Proportions, Dalton refers to atom to explain why "elements react in ratios of small whole numbers". Again, with the invention of sub-atomic particles, the idea of atom changed further.
- "Since new paradigms are born from old ones, they ordinarily incorporate much of the vocabulary and apparatus, both conceptual and manipulative, that the traditional paradigm had previously employed. But they seldom employ these borrowed elements in quite the traditional way. Within the new paradigm, old terms, concepts, and experiments fall into new relationships one with the other. The inevitable result is what we must call, though the term is not quite right, a misunderstanding between the two competing schools" (p, 163).
- The relationship between two successive paradigms is therefore not that of logical succession with a predestined goal for a progressively better approximation of truth but of complete incommensurability without having a common standard of measurement. Hence, truth is intra-paradigmatic and not inter-paradigmatic. Explanation in the next slide.
- Kuhn becomes extremely provocative and radical in his opinion when he says, "the world changes when paradigm changes". Therefore, doing science is not just about understanding the nature as it is out there. Rather, it is about changing the nature while performing science.

Where does Kuhn get the idea of incommensurability (meaning “to have no common measure”)?

- Ancient Greek Geometry: It referred to the non existence of a common measure between the lengths of the sides and the diagonal of a square.
- Incommensurable relations are represented by irrational numbers. Because there is no common measure in which to express both, irrational numbers are called incommensurable with rational numbers.
- “Two numbers are incommensurable with each other if and only if their ratio cannot be written as a rational number”.
- By incommensurability, Kuhn meant conceptual and logical incompatibility between two successive paradigms and not incomparability. Of course, we can use approximation ($\sqrt{2}$ is approximately 1.4142) to make a comparison possible.
- Kuhn’s example of mathematical incommensurability: “The hypotenuse of an isosceles right triangle is incommensurable with its side, but the two can be compared to any required degree of precision. What is lacking is not comparability, but a unit of length in terms of which both can be measured directly and exactly”.
- The idea of not having a common measure is important here.