HU3101: History and Philosophy of Science

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Question 1. In the light of the various theoretical models of 'Colonial Science', discuss the scientific career of Radhanath Sikdar.

Answer. India under British rule progressed very slowly in terms of science; the administration did very little to promote science, or at least science which does not directly benefit their economy, politics, or military. Basalla's diffusionist model of colonial science involves the movement of modern scientific material and tradition originating from Europe, practised in the colonies by Europeans, then transplanted into India by the efforts of Indian scientists. Deepak Kumar describes colonial science as one in which "result-oriented research in applied science heavily supersedes the curiosity-oriented research in pure science". As Sumit Sarkar notes, this means that scientific endeavours were focused on areas such as cartography, botany, geology, medicine, at the detriment of fields such as mathematics, physics, chemistry.

Radhanath Sikdar's name stands out as a great Indian scientist of the 19th century. Born in 1813 into a modest family in Calcutta, we was sent to Hindu college at the age of 11 years; his father planned for him to become a clerk. It quickly became apparent that Radhanath was a brilliant student, and thus he continued his studies for seven years. During this time, he became proficient in English, Greek, Latin, Sanskrit, as well as science and mathematics. Strangely enough, he also authored a prize-winning article, titled *The cultivation of science is not more favourable to individual happiness, nor more usesful and honourable to a nation than that of polite literature.*

Radhanath was a follower of Derozio, who promoted free-thinking among his students. In the context of science and philosophy, Radhanath was exposed to the ideas of Bacon and Hume. Under the guidance of John Tytler, he studied Newton's *Principia*, Euclid's *Elements*, Jephson's *Fluxions*, Windhouse's *Analytical Geometry* and *Astronomy*. Naturally, his greatest talents were in mathematics, and he soon joined the Great Trigonometrical Survey of India project as a computer. In 1832, he was sent to Dehradun.

The Great Trigonometrical Survey of India (GTS) was tasked with accurately mapping important points of India; this was both a scientific endeavour, as well as a means for the Government of India to acquire better maps and geographic information to rule (and exploit) India. George Everest was a prominent figure in this project, first as Chief Assistant-Surveyor, then Superintendent, Surveyor General of India, and a Fellow of the Royal Society. In order execute his plan of surveying, via 35 stations between Dehradun and Sironj, he was in search of talented natives well versed in trigonometry. Radhanath was recommended to him by Tytler, and his proficiency was not lost on Everest, who commented

> . . . there are few in India whether European or native that can at all compete with him. Even in Europe these mathematical attainments would rank very high.

He further describes Radhanath as a

> . . . hardy, energetic young man, ready to undergo any fatigue, and acquire a practical knowledge of all parts of his profession. ... There are a few of my instruments that he cannot manage; and none of my computations of which he is not thoroughly master. He can not only apply formulae but investigate them.

On one instance, he even prevented Radhanath from transferring to a different government department.

Radhanath was a great asset to the GTS; one of his jobs was to carry geodetic surveysthe study of the earths geometric shape orientation in space and gravitational field. He was capable of deriving his own, new working formulae from first principles and applying them to the task at hand. He published *A set of tables for facilitating the computation of trigonometrical survey and the projection of maps for India*, which proved to be immensely useful for years to come.

After Everest retired in 1843, he was succeeded by Andrew Waugh. On his orders, Radhanath was promoted to Chief Computer and transferred back to Calcutta. Here, he was set to work on measuring the heights of mountains, based on data collected by multiple teams of field observers. The process of gathering this data was complication by the fact that the snow peaks under consideration were practically on the India-Nepal border, and were thus observed from nearly a hundred miles away. On great advancement made by Radhanath in this regard is his understanding of the phenomenon of refraction, and the precise effect this has on the data. In 1852, Radhanath used a combination of six sets of observations to calculate the height of 'Peak XV' as 29,000 feet, superseding Kanchenjunga as the highest mountain in the world.

Radhanath also made significant contributions to meteorology; in 1852, he became the superintendent of an observatory in Calcutta, and soon began the process of correcting barometer readings to a standard temperature. This has to be done since temperature affects barometers in two ways: the brass scale as well as the mercury expand and contact in different ways. Without access to work done in Europe, he constructed his own reduction formulae and tables using his knowledge of physics from first principles. The practice of regular, hourly observations began under his supervision, and the result was the first proper climatological data set of a city in India. Again, his published work on this subject including surveying manuals and computational tables remained invaluable even in the 19th century.

In 1854, Radhanath and Peary Chand Mitra founded the *Masik Patrika* for women, where he wrote articles in simple, vernacular language. In this respect, he rebelled against the sanskritized form of Bengali favoured by Vidyasagar and Akshay Kumar Datta; "Of what worth is a piece of Bengali writing, if it cannot be grasped readily by every housewife?". On the other hand, he wrote nothing about science in Bengali, perhaps finding the language a bit too imprecise. Thus, he played practically no role in popularising science, or influencing scientific thought in general society; something which is essential for carrying out reformation.

Radhanath retired in 1862, and taught mathematics in the General Assembly's Insitution. In 1864, he was honoured as a Corresponding Member of the German Philosophical Society. He died in 1870.

It can be argued that Radhanath was the first modern Indian scientist: he was trained in mathematics and physics, participated and made a living from the GTS which was a great scientific endeavour, and he even made several original contributions in the field. We have observed that the European influence was critical to his training, and it seems fair to say that without Derozio or Tytler's influence, he would not have gone very far in this field. He learnt from European scientific literature, as this was the most advanced of the time. Once he established himself in the GTS however, he quickly began cultivating a wealth of knowledge by himself, making several key contributions. As remarked earlier, these were in areas of practical or applied science, and ultimately served to benefit the British Government's grip on the nation. Thus, Radhanath's career conforms well with both mentioned models of colonial science.

Radhanath's relationship with the British administration was rocky at best; it is evident that despite heaping him with praise, Radhanath was not treated with the respect that a scientist of his stature deserved. For instance, his salary was well below that of his colleagues, despite the quality of his work. There is also a well documented incident in which he protested the unlawful exploitation of his own departmental workers by Magistrate Vansittart; after many sketchy proceedings and a court trial, he was fined a sum of 200 rupees; Everest seems to have been complicit in this matter. Without going in to too much detail, perhaps the greatest injustice was the very naming of 'Peak XV' – Mount Everest – by Waugh, who did so in honour of his predecessor and mentor. This was inspire of Everest's own policy of deferring to the native name (which would have been *Deodhunga*), again on sketchy grounds of lack of information. In a meeting of the Geographical Society, Waugh was awarded the Victoria Gold Medal for his contributions, accepted by Everest on his behalf. Sikdar's role seems to have been either quietly understated or his name omitted entirely, despite being the first person to even suspect that Peak XV was the tallest mountain in the world. Another instance is that of the book *Manual of Surveying for India*, whose preface acknowledges Radhanath's name as essential, with many of its chapters being entirely his own. After Radhanath's death, the third edition was published without this acknowledgements, causing outrage even among a group of Englishmen: Colonel John Macdonald spoke out against this "robbery of the dead", and was subsequently suspended and demoted.

Question 2. Francis Bacon's and Rene Descartes' approach to science was quite dissimilar — yet both of them are hailed as the precursor to modern science. Discuss.

Answer. Bacon and Descartes are two figures who contributed to the scientific method, in an attempt to answer questions such as: what does it mean to *do* modern science? How does one proceed with a given problem or idea? When should one be satisfied with an answer?

We start with Francis Bacon, who was a fairly distinguished English subject. He declared "all knowledge as his province", and wrote several volumes on history, along with a science-fiction novel (*The New Atlantis*). We emphasize his key insight – *knowledge is power*. His formulation of science and learning is in service of gaining practical knowledge for the enrichment of mankind; while these ideas seem commonplace today, these were important steps in the seventeenth century.

At the heart of the Baconian method is induction from hard evidence. In order to verify a hypothesis or understand a phenomenon, a scientist must collect data (vast amounts of data), look for patterns, and then seek to generalize, perhaps arriving at some principle of nature. Again, there is a great deal of emphasis on the collection of materials/data; naturally, Bacon was a great encyclopedist. His stance was to reject Aristotle's *anticipation of nature*, and instead focus on *interpretation of nature*. Bacon felt that the former was too rigid and restrictive for science: after all, if one makes observations merely to confirm what one already 'knows', has anything new been gained? In this manner, one cannot discover new things simply by building upon old knowledge with pure logic and syllogisms: one must introduce new data in order to make progress. Bacon thus advocates interpretation of nature, wherein the constant acquisition of data via experiment leads to new discoveries, ideas, and a broader perspective. Progress can be achieved because with more knowledge, one gains the ability to do even more experiments and repeat the process; along the way, the practical innovations lead to the betterment of society. Bacon thus calls for large scale collaboration – *organized science* – since the task of collecting data is long and arduous. We see this influence in the formation of the Royal Society, and other similar scientific bodies.

Bacon also identifies certain obstacles to scientific progress – false conceptions – and calls these *Idols of the human mind*.

1. *Idols of the Tribe:* These originate from human nature; the human mind and perceptions are fundamentally 'crooked', and it's possible that we are simply incapable of grasping the truths of nature on some basic level.

2. *Idols of the Cave:* These are present on the scale of the individual: preconceptions or ideas based on personal experience without the proper factual backing/evidence. This 'personal cave of the mind' prevents one from looking out into the real world.

3. *Idols of the Marketplace:* These originate from public communication, likened to rumours and gossip. We often hear words and phrases in passing and have these ideas enter our minds without actually understanding them (social media?!).

4. *Idols of the Theatre:* These originate from dogmatic, old, outdated theories and philosophies; such constructions describe a fictional world, which may well work internally and be reasoned about, but there is no reason to believe that they have any bearing on reality.

Rene Descartes was a Frenchman, often called the 'Father of Modern Philosophy'. He is famed to have said 'Cogito, ergo sum': I think, therefore I am. His most famous work is perhaps *Discourse on the Method*: in one chapter, he describes four rules used to arrive at knowledge.

1. Skepticism, i.e. never accept anything which one does not clearly know to be true.
2. Divide and conquer, i.e. divide a problem into as many parts as one can.
3. Prioritization, i.e. start with the simplest problems and work ones way upwards, building on what one knows.
4. Thoroughness, i.e. be as general and comprehensive as possible, in order to avoid omissions.

Descartes emphasizes deductive thought: one can produce ideas and theories from intuition, and draw conclusions from pure reason. Performing an experiment to verify these conclusions plays a smaller role, almost an auxiliary one.

One interesting aspect of Cartesianism is dualism, in this case the separation of religion and science. In other words, these fields should not impose oneself on the other. This proves to be an important step towards a modern science.

Of course, Descartes made several contributions to science and mathematics itself; Cartesian geometry, the x, y, z notation for unknowns and a, b, c for knowns, the superscripts indicating powers are a direct result. One interesting perspective was that all beings, humans and animals, were fundamentally machines; only humans possessed a certain spark – a soul – that enabled self-awareness and consciousness. While this leads to quite cruel interpretations (for instance, the idea that animals do not actually feel pain), this model of biological machines reacting to external stimuli is quite useful, say when talking about reflexes.

Through the works of Bacon and Descartes, we see the beginnings of modern science. Bacon's method of induction rightfully puts the spotlight on experiment (not just as a means of verification, but as a means of discovery) as the only real way of understanding nature. On the other hand, there is a creative aspect to science – the formulation of a hypothesis or a great idea – that cannot be denied, and we see that intuition and deduction certainly plays a role. Without this human touch, it becomes impractical to generate principles purely by processing immense amounts of data. There are also awkward questions which can be raised regarding induction, for instance: how much data should one be satisfied with? Establishing a principle using this scheme seems to be impossible. We have already seen that the study of this very problem of induction, among other things, lead Popper to his falsification principle.