

The History of Science in Ancient India

5 sessions, one per week (Aug-Sept 2014)

Main questions of concern:

How and why did science arise in ancient India? (with reference mainly to the period from the 6th century BCE until the formation of the early historical cities)

How and why was science prevented from developing in the periods before and after this period?

What were the connections between science and philosophy in ancient India?

A comparison of the development of science in ancient India and ancient Greece?

JD Bernal's 4 volume work on Science in History.

Debiprasad Chattopadhyaya, Science and Philosophy in Ancient India

additional references to works by: Meera Nanda, Aristotle, Plato, Kancha Ilaiah,

Romila Thapar, AG Noorani, Howard Zinn, K. Damodaran

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SUMMARY

What we did in the class

Pre-session (12 August 2014)

Before discussing science in ancient India, we need to think about why - or whether - we should do so. When we discussed the question, "Why investigate the history of science?" it became clear that we had two different definitions of history: (1) the events that happened in the past; and (2) the study of past events and their interconnection with the present and the future. History, according to the first definition occurs with or without historians studying it.

We categorised a list of stated beliefs as to whether they are more or less materialist, dualist, or idealist. This was done so that we could later use our understanding of these terms to understand science in ancient India. We interpreted this exercise in different ways: (1) some of us categorised the statements based on our understandings of materialism, dualism, and idealism; (2) some of us realised: "I am idealist, and a statement is likely to be idealist if I agree with it, materialist if I disagree with it," etc; (3) some of us based our categorisation on our understanding of certain people we consider to be materialist, dualist, or idealist, and our judgement of whether such people would have the belief. I tried to insist that we categorise the beliefs rather than the people who might hold such beliefs, since one person may hold some beliefs which are materialist and other beliefs which are idealist, (although it is also true that we might further generalise a set of beliefs of a person). We had a number of confusions and disagreements as to the categorisation of several of the statements, and we realised that it was not a straight-forward task. In the process, I think we did make some progress in clarifying the definitions of these three terms.

Session 1 (19 August 2014)

We raised the question, “Can an account of the history of science be objective?” Most of us agreed that no account of history is fully objective, but some of us seemed to think that historians should try to be objective, while others (including me) felt that it is the responsibility of historians to side with the oppressed.

The question, “Why didn’t science develop further in India?” led to the sub-questions: What is science? Did science develop or not? Could it have developed further? When did it or did it not develop? What is India? etc. We then discussed a stereotypical western view that science did not develop in India due to “the Hindu predilection for sanctifying the secular, in contrast to the Greek tendency to secularise the sacred”. Perhaps the fact that science in ancient India is not normally in the HBCSE syllabus (until the present course) indicates a tacit belief that science of any value did not exist in ancient India.

This led to a discussion of the historical definition of ‘secular’ in different parts of the world. Although in practice it does not necessarily happen, governments may aim for a secularism defined as: (a) the state discouraging all religions; (b) a separation between the state and religion; or (c) the state supporting all religions. Western governments commonly state that they aim for (b), while Indian governments may state that they aim for (c).

This led to the question of what is the effect of secularism or non-secularism on the development of science. Defining ‘religion’ as beliefs based on faith, and ‘science’ as beliefs based on the scientific method (which includes questioning and observation of physical reality), I listed four possible relationships:

- The use of religion to validate science
- The use of religion to invalidate science
- The use of science to validate religion
- The use of science to invalidate religion

Meera Nanda argues that postmodernist religious fundamentalists use science to validate religion. I agreed, but argued that also, fundamentalist politicians may use religion to validate science, but do not use science to invalidate religion or religion to invalidate science, which perhaps is in line with their view of the secular as (c) rather than (a). If so, this may be of importance in investigating the question of how and why science may have been prevented from developing in certain periods of history in India. Perhaps it is also related to the claim of Debiprasad Chattopadhyaya that philosophers in India tended to verify and strengthen old philosophies rather than develop new ones - as compared to Greek philosophers who tended to criticise and reject their predecessors (i.e. validation in India compared to invalidation in Greece).

This led to our consideration of a Greek, Thales, who some claim is the first scientist because he attempted to explain observed phenomena without recourse to supernatural or mystical intervention.

Debiprasad Chattopadhyaya claimed that actually the ancient Indian, Uddaalaka could be considered as one of the first scientists. We analysed some quotes concerning Uddaalaka in the Upanishads in order to see if his

beliefs were scientific and/or materialist (as argued by Chattopadhyaya in the chapter we read). We contrasted this with an interpretation of the same text from the point of view expressed on a Spiritual website:

(<http://www.psychologytoday.com/blog/spiritual-wisdom-secular-times/201112/what-is-spirituality-2-updating-ancient-wisdom>).

We did not have a consensus of opinion concerning whether Uddaalaka thought or acted materialistically and/or scientifically. The following points were made by different people. This discussion was incomplete, and I have not remembered everything (the camera had stopped!), so please add to this list, and site evidence and examples.

1. He may not be materialist, dualist, or idealist, and even his beliefs may not be materialist, dualist, or idealist (we need more discussion is needed to understand why).
2. This categorisation may not be useful, because....
3. We may have insufficient data to categorise his beliefs.
4. He may have materialistic beliefs embedded within idealistic beliefs. For example....
5. He considered questions which were raised through observation of physical reality, which indicates materialism.
6. He realised and admitted not knowing answers, which indicates use of the scientific method.
7. He listened to and asked to be taught by someone from a 'backward' area (upon hearing the person asking interesting questions), which signifies use of a scientific method, rather than relying on faith in authority (he listened to a person not thought to be the authority).
8. He uses the word 'aatman', and he does not say that it does not exist, which may indicate a more idealist or dualist outlook.
9. He says that aatman is 'the earth', which may indicate a materialist outlook.
10. He implies that spiritual mysticism cannot answer basic questions, which indicates materialism.
11. He says that the essence of a thing is the matter itself, which he said is something that scriptural lore did not teach, which indicates materialism.
12. He demonstrates the essence of a thing by dividing matter (a fruit) into smaller and smaller parts, which indicates materialism and scientific method.
13. By tasting salt in water, he empirically demonstrates that a physical thing can exist even though it may not be visible, which indicates materialism and scientific method.
14. He (perhaps) anticipated atomic/molecular theory, which indicates materialism and scientific method.

Session 2 (26 August 2014)

We had some discussion on the use of the materialist / dualist / idealist categorisation in order to investigate the origins of science in history. We seemed to agree that there is some difference between the way religious beliefs are formed and the way science operates, but some of us are less clear about exactly what the differences are. The question arose as to how we could distinguish science from non-science without considering materialism, but this question remained unanswered.

We discussed a recent example of the use of science to validate religious beliefs (beliefs which are based on faith), which is the use of satellite photographs of the land and underwater geology of the region between India and Sri Lanka, to prove that Rama Setu exists and is not a natural formation, and also that Rama, Hanuman, etc existed. However, the Archaeological Survey of India stated that the photographs do not prove any of this. The historian, Romila Thapar stated that "Blasphemy does not lie in doubting historicity." and that religious sentiment is and should be separate from science, and science should not be used to validate religion. However, this Ram Setu controversy was an example of a conflict between religion and science, and it is not clear how such conflicts can be completely avoided.

Chattopadhyaya tries to show that since ancient times there have been conflicts between idealist and materialist ways of thinking, and materialist beliefs have been suppressed by the powerful minority. Thus, there were efforts to declare that the Upanishads express just one philosophy, and does not contain materialist beliefs. Although none of the original texts from before the Common Era survive, evidence that the materialist beliefs were important is found in later idealist texts that go to great efforts to refute materialist beliefs, indicating that they presented a serious conflict. Archaeological artefacts provide further evidence of the development of materialist beliefs and practices related to science and mathematics - e.g. studies of Harappan bricks and buildings.

This led to a discussion of the relation between work and science and technology. The question is whether an examination of history shows that there is a correlation between technological development and the development of science and the spread of materialist beliefs. This is something to keep asking throughout the History of Science course.

We then considered how beliefs about the nature of causality affected or were affected by the development of materialist beliefs and the development of science. There was a difference of opinion as to whether the existence (sat / being / truth) which is mentioned by Uddalaka is physical existence, or some sort of spiritual existence. There is the claim that everything that happens in physical reality has a physical cause, and that something cannot be created from nothing. This was used as an argument in favour of infinite existence (with no beginning or end). Regarding this, we also analysed the well known quote from the Rig Veda on creation. We discussed whether it indicates a materialist or idealist outlook, and found some possible indications of both, although it appeared to be mainly idealist. It also showed signs of being teleological. It was pointed out that parts of it could be interpreted as doubting a spiritual

creation (which may be scientific?), or alternatively, as claiming that raising the question of creation is a pointless waste of time. We considered whether the latter is anti-science, if it is anti-questioning, and if we believe that science means asking questions. The counter-argument was raised that science does not mean asking questions - asking questions which can be experimentally verified is science. (Is social science not science - because it is not possible to do experiments in social science, especially in a social science such as history? - or is it possible? - or do social scientists raise hypotheses and try to verify them?) This led to a discussion of whether or not scientists ask questions concerning what is the beginning. It was pointed out that nowadays scientists do ask questions about human origins, the origin of the earth, the solar system and even the entire universe. The question of how we are to know whether or not a question can be answered through experimental verification beforehand was also raised, in relation to the history of science in which the sphere of science seems to be expanding over the years to include more and more domains.

We examined a timeline showing a few ancient Greek and Indian philosophers, and it was pointed out that almost none of their original texts have survived - we know them only through second-hand accounts. The dates of many of them, particularly the Indians are a matter of speculation. There was a period between about 600-200 BCE in which Greek philosophy and science developed and then died out. The Indian philosophies also developed during this period, but persisted much longer - for some of them their development can be traced all the way up to the present. One similarity between both Indian and Greek ancient philosophies is that both were confronted with conflicts between idealism and materialism.

As a prime example of Greek idealism, we then briefly discussed Plato's idealism, as shown in the allegory of the cave which he discussed at length. It is an example of an extreme idealism in which the physical reality that we perceive is declared to be merely a shadow of a puppet show which is nothing like the real reality which Plato conceives as geometric perfection.

This was contrasted with Aristotle's teleology, and discussed in relation to the differences between correlation, cause, and purpose. An example of Aristotle's Zoology in which he describes and compares different animals was shown in order to show why some consider him to have done science. It was pointed out that it reads like an 19th century Indian school book, which is more concerned with description than with asking 'why' questions., although its concerns are of course materialist. Another difference between Aristotle's science and modern science is that Aristotle was living in a slave society and his writings upheld the slave society rather than being used in conjunction with the development of new technologies.

Session 3 (2 September 2014)

The discussion in the last session was continued, as we discussed how Aristotle's teleology was an idealist belief - because he tried to show that things happen not just due to physical reasons, but because of a 'final cause' or ultimate purpose. (i.e. human happiness). The idealism can also

be seen in his claim the world always was as it is now because that is the reasonable way for it to be - ideas are basic (harking back to his teacher, Plato).

According to more materialist beliefs, such as those expressed by Uddaalaka and the Lokayata, events in physical reality are caused only by past events in physical reality, and things are the way they are because of the things they are made from. Natural scientists differentiate between 'cause' and 'purpose', and this may be one way that we can distinguish between science and non-science, in order to study the origin of science in history. Although human beings have some ability to act purposely (which is one of the main things that distinguishes us from other animals, who have less ability to plan and do things on purpose), in nature (for the most part) things do not happen intentionally.

We mentioned that around the same time as Aristotle there were also other Greeks who had more materialist beliefs - such as Democritus, who, like Uddaalaka and the Lokayata believed in some sort of atomism. Democritus is known for saying that "Everything existing in the universe is the result of chance and necessity". By this he meant (in opposition to Aristotle's final causes) that things happen in the absence of a purpose. Aristotle believed that it is impossible for order (e.g. all humans having the same arrangement of teeth) to appear by chance - it must be the result of intention. (However, even as applied to biology, this belief was disproved by Darwin's mechanism of evolution by natural selection.) We discussed different meanings of 'cause', 'chance', 'random' and 'necessity'. * Two things or events can be causally related, or they can be relatively unrelated to each other, neither of which directly causes the other. Being random is different from having no cause. Something might appear to be random or irrational or mystical or unpredictable just because we do not understand its cause, but it still may have a cause. Some of the ancient philosophers believed that causes exist, and they tried to find causes in physical reality, whereas other philosophers relied on myths or non-material reasons for explanations. Interestingly, in the Lokayata, we found the belief that the world came into being as the result of the **unplanned** combinations of the four elements (earth, air, water, and fire).

Some people (myself included) claim that Aristotelian beliefs in (1) teleology, (2) the separate, fixed individuality of things, and (3) a basic constancy in the universe, actually hindered the development of science in the west. This can be contrasted to another way of thinking about the world in which one believes that change is inherent and basic. The Lokayata, for example, professed a belief that everything changes.

I am claiming that this realisation of change is another factor that supports the development of science. It is in opposition to the more idealist belief in constancy, which supports the maintenance of the status quo.

Although it is not possible to identify very clear-cut boundaries between scientific and religious beliefs, I proposed that generally religion is based on speculation, authority, faith, and mysticism, while science is based on observation of physical reality, questioning, testing, and finding evidence in physical reality. We see many examples of idealists who see this

difference - for example from the Upanishads: "The gods are fond of the obscure and they detest direct observation."

Finally, we discussed the question, "What are the requirements for the development of science?" According to Chattopadhyaya, they are:

(1) People need to be aware of the need for a materialist framework, and interested in looking for the material basis for events and processes. If society is dominated by an idealist way of looking at the world, people will instead assume that things are the way they are due to non-material causes, which cannot be empirically verified.

(2) People need to be able to free themselves from the grips of mythological-supernatural mystification. Rather, people need to look for "the simple conception of nature just as it is without alien addition".

(3) The political situation needs to be such that it does not inhibit the development or spread of a scientific method. Throughout much of history, the scientific method of enquiry has been actively discouraged in order to maintain the division of society into a toiling majority controlled by a leisured minority. Science has been dangerous to the maintenance of the status-quo, and political and legal systems have prevented its spread, by encouraging "myth-making or beneficial falsehood", and by censoring direct observation and the collection of empirical evidence.

(4) Philosophers should do scientific explorations of the physical world in order to solve practical problems, rather than concern themselves with "the mystery of the indwelling soul" or pure speculation - or with controlling the toiling people.

The 3rd point in particular drew a lot of discussion. It may be difficult to understand this point without a consideration of a wider range of history, including the 'scientific revolution' which accompanied the advent of capitalism in Europe.

Session 4 (9 September 2014)

We have been trying to figure out how, why, and whether science arose in ancient India. One (rather idealist) way to understand how science arose is to think that it arose because one or two people (almost always men) were born who were very intelligent and they started thinking and reasoning and new ideas came to them and they started doing science. If we believe this, we might study the history of science by concentrating on a few individuals. But this approach does not make much sense to me - and it begs the question of why those individuals arose in those places at those times - there must be some material reasons. What was there about the society that gave rise to scientists? There were actually some changes in society which facilitated the development of science, and the science must have also facilitated changes in society. In other words, interdependencies between science and society affected the development of science. If we ignore the difference between materialism and idealism, how else can we understand the difference between science and non-science? I claim that this is the most crucial difference. Try to find evidence that I am wrong.

We started this session with the question: "What do materialism and idealism have to do with research in science education?" I presented an argument that a more materialist and less idealist approach to choosing a research topic will be to place more emphasis on direct experience and observation of physical reality: teaching. We cannot form relevant research questions without teaching and observing what actually happens in schools.

We then formed groups to discuss "What is science?", based on examples from the texts we read of what doing science involves. In answering, we mentioned the following:

- Trying to come up with explanations for observations which are not supernatural and do not require mystical or spiritual intervention

- Looking for causes in nature

- Assuming that all of what we observe has strictly natural explanations - even if we can directly observe the causes

- Making solid, direct observations of physical reality.

- Collecting empirical data

- Making hypotheses - based on both observation and analysis (including making analogies)

- Relying on natural principals for explanations and first causes

- Maybe making probabilistic statements

- Requiring verification - questioning what has been said and written - allowing questioning

- Categorising

- Defining, and identifying what we are talking about

- Jumping to conclusions without adequate evidence or reason may be a sign of being less scientific

- Living in a place and time which is not too deeply teeming with superstition and mysticism, or in which its rejection is possible

- Living in a culture in which manual work (technical, crafts - work in which nature is manipulated) is not socially degraded (no caste contempt) - so that the work of the hands and the mind can be explored in an integrated manner

We then discussed some of the ideas mentioned in the Lokayatas.

In this regard, we had an interesting discussion on the definition of physical reality and whether it can be defined on the basis of being observable - either directly or indirectly observable. Also hinted at, are questions of whether things like forces and atoms exist or are observable or are part of physical reality, and the difference between physical reality and models (which are representations of physical reality). Certainly the Lokayatas had atomist beliefs - very similar to those found in ancient Greece.

It was also pointed out that there was some indication of probabilistic thinking in the Lokayata - e.g. in the quote: "If the rarely perceived be

taken for the unperceived, how can they call it the unperceived? How can the ever unperceived, like things such as the horns of a hare, be existent?"

A discussion about the following quote led us to discuss the meaning of karma and how scientific this belief is:

"Others should not here postulate (the existence of) merit and demerit from happiness and misery. A person is happy or miserable through (the laws of) nature; there is no other cause."

We had different opinions on this. Some of us thought that karma it is quite scientific - if it is defined as 'doing good acts in order to have good effects'. Others thought that karma is usually taken as 'doing something which is intended to be good (from the point of view of some authority) in order to have a better after-life' (and in this sense it might even be used by authorities for coercive purposes).

Session 5 (15 September 2014)

Student presentations