Evaluating the claims of ancient Indian achievements in science

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Orthodox, value-neutral dispassionate study of the workings of nature that we broadly call sciences is under a threat as never before. The pattern of scientific research in India that the greats of Indian science set up after independence is being systematically questioned in today's India. One of the axioms of the post-independence formulation was that modern science and technology (with a forward outlook to its utilization) was the way to the future. For this, both research in science and technology (S&T) was crucial and was well supported, but its path was left to the judgement of scientists with guidance from international scholarship. This has served the nation well. Today, there is hardly a field of international research where India does not have some expertise of value. However, having spread ourselves thin, it also means that most research requires international exposure to nourish itself. This too was reasonably well served. Today, scientists working in contemporary science have deep connections with the world scientific community. This is good for Indian and international science, but to people with blinkered vision this also makes Indian scientists stooges of Western science who are not Indian enough in their patriotism and commitment.

Paradigm of shift in Indian science

Today, the entire paradigm of Indian science is under review. As India begins to grow and the generation that fought for independence gives way to the post-independence generation, various questions are being asked about the fundamental assumptions of S&T and its future. As research in pure science becomes more and more complex, its direct applicability is reduced, except in terms of the technological needs of science itself. With a few weak bridges and tenuous links between scientific research and industrial technology, questions are being raised about the country affording financially intensive research programme with international collaboration.

Another major paradigm of Indian science was that we took the model for growth from Max Planck Institutes in Germany. This meant basing fundamental research in specialized institutes, while universities focused on teaching. This is also being increasingly questioned, as universities become more self-confident and assertive, and their talented staff demand research infrastructure. Teaching institutes with core research strength are being increasingly created. This augers well for the nation.

However, more severe is the intellectual challenge to the attitude of science and scientists. Fringe groups that harp on unrealistically fantastic achievements of the past constitute the most aggressive challenge to contemporary science. Men and women, trained in sceptical rationalist approach to studying nature in all its aspects, are unwilling to accept any claims of past glory without critically evaluated evidence and are proving to be the strongest challenge to these groups who wish to glorify our past beyond logic and reason.

In recent months, these groups that considered scientists trained in classical objective and axiomatic thinking as decadent representatives of the West and worse, are beginning to find voice. To them these men of critical studies are dangerous propagandists of counter culture that will not glorify our past for its own sake. In a markedly regressive step, they are reinventing (often literally) new 'evidence' of past glories of Indian S&T. They demand that our past achievements, significant in their own right, should be exaggerated way beyond their natural boundaries. In this, the scientists trained in modern axiomatic methods are considered more a nuisance or impediments than collaborators. They are being increasingly looked at as enemy combatants. These scientists, aware of significant success paths that have led to those discoveries, know that these claims of past successes were not achievable in the earlier periods.

Modern scientists and ancient sciences

Many of the scientists who are willing to read the past literature appreciate both its glory and its limitations. But as the fringe nationalistic groups who wish to go beyond these logical explanations, try to forcefully occupy the main stream dialogue on India's past, they are not willing to accept limitations imposed by logic. The great seers of the past were supposed to be all-seeing and all-knowing, period. There may be no evidence that they knew electromagnetism or thermodynamics, which are crucial steps that lead to quantum mechanics, but the fringe groups would want us to believe that they knew of quantum mechanics and even aerodynamics. Similarly, all rational studies of ancient literature and modern sciences firmly put a timescale of human evolution, but the fringe groups, with limited patience for logic and rationality would like to completely redefine the timescales, simply out of a false sense of pride.

One of their many arguments is that, not being present at these times gone by, scientists of today cannot fathom the capabilities of these ancient people. This shows a lack of understanding of the nature of evolution of science. So, it is worth reviewing how scientists judge historical science.

Evaluating the past and judging what our ancestors achieved is easier than most people would imagine. The most common approach to getting a timeline is that of direct dating of the archaeological remains with residues of human activity. Today's technology is so advanced that a few milligrams of such residues is sufficient to produce reasonably accurate results. This kind of study will tell you that the anatomically modern human arose about a million years ago and then, about one lakh years ago, the humans spread to different parts of the world, gradually dominating all landscapes. It is also universally accepted that modern humans arose in Africa and spread to the rest of the world from there, even as they mated with other local Humanoids. The accuracy of the numbers depends on how far back you are going, but broadly the sequence seems clear.

Human evolution and growth of our understanding of nature

The best evidence for human entry into the Indian subcontinent is around 70,000 years ago. We continue to come across sites where humans made various tools and left

behind other residues, and they show a gradual increase in sophistication with time. By about 7000–10,000 years ago, they began to take up farming in a serious way and settled down. At this stage they began to build large stone structures in different parts of the Indian subcontinent, including the Harappan Civilization. This story is fairly incontrovertible, except for a few fine points here and there. Note that the timelines of the migration of human beings from Africa, and the evolution of human settlements and technologies does not allow the claims being made for the antiquity of ancient Indian civilization.

However, the entire evidence for the early habitation by Sanskrit speakers in India is literary and there are few, if any, archaeological sites that can be directly associated with early Sanskrit speakers. In this case, therefore, there is a fair scope for error. However, two criteria are used to date them. One is that languages are not constant and consistent. After all, my own grandfather had a completely different vocabulary compared to mine – if you do not believe me, pay attention to the agonizing that *Oxford English Dictionary* goes through every year. Since language evolves, it is also possible to date ancient documents. For example, if I see an English essay that uses 'Thou' or 'Thine', it is certainly several decades and probably hundreds of years old. The other method is to look for records of astronomical clues, internal dating of family trees, etc. as well as description of animals, and flora and fauna to pin down the place where the writing occurred and the period during which it happened. One can then use the description of technology to create a logical timeline – in general, technologies become more advanced with time. This can be used as a consistency test.

In recent decades, genetics of humans, animals and plants has proved invaluable in understanding the movement and mixing of people and their migratory pattern. The genetics of languages can also provide other supporting evidence.

From the Ashokan period, we get monuments that can be dated by the above method and they provide direct evidence and written material of the human activity in the historic period.

The scaffolding of science

However, when extreme claims are made, there are other arguments that can be brought to bear upon the matter under discussion. Most importantly, no field of science today has arisen in isolation. To reach quantum mechanics, we had to learn about thermodynamics, atomic physics and electromagnetic theory in its full mathematical complexity to realize that the problem of stability of atom required a new kind of physical law.

Similarly, to get to the stage of aeroplane, we needed to understand the dynamics of air and wind, its movement, measure air pressure and its difference when it went over a curved surface compared to a flat surface. Bernoulli's principle did not arise in vacuum and Wright brothers could not have even imagined an aircraft without a 100 years of industrial revolution and deep understanding of metal, internal combustion engine and so on. Interplanetary travel required the understanding of distances between planets, a firmly established heliocentric idea of the organization of the solar system. Extremely powerful engines that could lift objects out of the gravity of the Earth (and hence a good understanding of gravity itself) and a basic mathematical foundation in calculus to get there. Experimental facilities, test facilities, manufacturing facilities all go hand in hand for this kind of a capability to arise.

Similarly, for genetic engineering, we need to understand life at the molecular level. For this, one needs to know that the smallest objects are molecules made of atoms. We need to know that there is only a small variety of atoms that provides the entire variety of the universe. We need to understand the centrality of carbon in life and so on, which in turn needs an understanding of the periodic table of elements. We need to understand atomic physics and chemistry for which we need X-ray, optical and infrared devices and photographic plates that can take spectra of lights from atoms and allow us to create a mathematical theory about how biology works. This needs to be further supported by microscopy and other devices to understand and create molecules of various complexities and manipulate them to understand how they interact. After a century or more of such studies, one begins to realize how heredity is based on the information provided to a foetus through the very process of conception. We then need to isolate these cells in extremely clean and low-temperature environment, and then study and manipulate them. Only several decades of such studies can give us the basic rules of genetics. Manipulating these genes to make composite life-forms is an order of magnitude more complex. We need to first understand how genetic information is actually read and executed. We need to understand the consequences of removing or replacing some genes from one life-form into the life cycle of another life-form. This again requires huge amount of resources and time, not to mention a rigorous educational system and sophisticated laboratories. It also needs a group of people devoted exclusively to the purpose of unravelling the mysteries of genetics. In fact, modern genetics has taken inputs from physicists, chemists and biologists to accomplish what it has. So far, there is no evidence, either archaeological or in the literature of the existence in the past of such a group of people or facilities needed for this.

Similarly, nuclear weapons arose after we had understood the uniqueness of atoms, interaction of atoms and the nature of energy coming from unstable nuclei. We needed technologies to isolate atoms of specific materials in sufficient quantities. Even then, pure uranium will not instantly give you an atom bomb, since the neutrons emitted by a uranium atom may or may not go and hit another uranium atom. To achieve sustained fission, the core of uranium has to be compressed in a specialized compression technology to make an atom bomb. This requires highly evolved metallurgy and other infrastructure, not to mention complex mathematics. And atom bombs are certainly not light enough to be put on an arrow head or be deployed by individual humans.

Also, implicit to all this is that electricity is crucial to the entire process. It provides the most convenient and versatile source of energy which can be converted into other forms. There is absolutely no evidence that our ancients knew how to generate and use electricity.

Most importantly, the language of science is not Sanskrit, it is mathematics. While most sciences begin with descriptive recording of their work, true and rapid progress comes only after these results are put in mathematical format, allowing generalization and cross-applications. We have no evidence of such a transition in the past. Most modern developments in science would not have arisen without several important mathematical tools that are now routinely applied to science. Even the best works in Indian mathematics stop at the limiting value theorem that came up

in the Kerala School between the 14th and 16th century AD. While *Rig Veda* deals with large numbers in powers of ten, the classical *beej ganita* is of much later origin and was not the language of ancient seers.

Even if one is willing to ignore all this, it is also worth asking what happened to all these wonderful technologies and capabilities? How is it that these technologies were lost? Why was there no precise documentation of the technologies? What were the cataclysmic events that destroyed all traces of these technologies? Why is there even no legend or myth of their destruction? If foreign invasion is the reason, then would not the invading forces be keen on using these abilities for furthering their ambitions of subjugating the entire world? Is it not inconceivable that anyone would destroy such potent weapons and technologies?

Reflections on education

The arguments of the fringe group also raise questions about the educational system and scientific temper being imparted to young minds. Clearly, the very fact that irrational ideas hold sway over such a large group is a major failure of our educational system. When a medical doctor specializing in sex change operations quotes the example of Shikhandi (a transgender in the *Mahabharata*) as an example of sex change operations in that period, it raises questions about the scientific temper of the Indian psyche. Clearly, we also do not seem to emphasize timeline and logical sequencing in the study of history. History is not so much about dates as about the sequence of growth of human civilization.

So when one talks of whether a particular technology was known to our ancestors or not, one must sit back and pause. Consider the amount of other knowledge that led to a particular insight into the working of nature, and satisfy yourself and convince others that this entire scaffolding of knowledge existed at the period being discussed. The evidence can be in the form of reliable documents in appropriate language, evidence of experimental facilities, evidence of technological competence as well as mathematical competence. Without this evidence, all claims are simply fantasies of an untrained mind. It is worth bearing in mind that none of these claimants of the technology of the past has made a single prediction stating that a particular technology will be the next one to be found and that the ancient literature defines how to reach this unattained technology. While it can be suggested that the early scientists did not fully understand the potential of their capabilities, later commentaries should have been more predictive of the consequences of the technologies. At least the modern readers of these texts should be able to make predictions based on these ancient formulations.

The shrillness of debate

When evaluated in light of these powerful stable and sustainable arguments, attempts at making grandiose claims of past achievements are self-defeating. Further, they destroy the credibility of the entire system and serious scientific studies of India's past get discredited in light of these efforts. These attempts drag down more than just themselves. They bring down the morale of the contemporary scientists and divert attention and resources away from modern science and technologies. As the 102nd Indian Science Congress recently debated the true scientific capabilities of ancient Indian seers in a session 'Science in Sanskrit', on other forums claims have been made that ancient Indians could make interplanetary voyages. This is difficult to accept, when they had no detailed knowledge of geography beyond the Indian subcontinent. The idea that the earth was spherical was not even considered in India until AD 500, when Aryabhata proposed the idea of heliocentric solar system. As a result, fundamental issues like the deeply perceptive studies of these ancient scientists in mathematics and astronomy that changed the world are not receiving attention. Indeed a stage has come where even those pointing out demonstrably impressive achievement do not find a decent audience. Contemporary scientists see ghosts of ultranationalists in them and ultra-nationalists do not find them committed enough. In this hazing, our entire ancient heritage is being condemned by the heretics.

In turn, we all lose our national heritage and national pride. No one wins. The ultranationalists who seem to think that a lie repeated a thousand times becomes truth – do no good to their professed desire to have Indian scientific achievements appropriately recognized. It also does not help the contemporary scientists who feel hounded by these fringe elements. Even on forums for rational evaluation of past sciences, they feel intimidated out by these shrill voices.

The true Indian contribution to science

It is not that Indian achievements were not significant for their own period, as an editorial by Narasimha[1] pointed out that even the most casual visitor to Indian science will feel impressed by the works of Aryabhata and his collaborators, or of the zinc smelters of the past. They will also be impressed by the work of the Kerala School of Mathematics or of the secular approach of a large fraction of literature in Sanskrit with its intricate arguments on the working of the world. To that one must add the exacting architecture from the Harappan towns to the Taj Mahal and the rockets of Tipu Sultan. The list is both impressive and large.

For example, it is known in learned circles that the Pythagorean triplets were also discovered by Indian mathematician and the earliest reference goes back to *Sulba Sutra* possibly pre-dating Pythagoras. In fact, the Greeks were probably the last of the Great Civilizations of the past (Egypt, Mesopotamia, India, China and Greece) to come up with the realization of Pythagorean triplets and all the other civilizations had realized this well before the Greeks. So there is no doubt that Indians knew of the Pythagoras theorem before the Greeks learnt it. But when such an assertion is also mixed with claims of invention of *vimanas* that could undertake interplanetary journey, both the earlier claims get discredited. Those who set out to restore the glory of India's past do more damage to it. So, for example, the session of the Indian Sciences Congress on 'Ancient Sciences through Sanskrit' could have looked like:

(1) Nyaya–Vaisheshika system: Scientific approach to understanding the working of nature in ancient India. They are two of the six core schools of logic which derive their roots from Vedic literature. These schools of thought were fairly advanced and complex in their explanation of nature and the working of the physical world. They divide the knowledge about a system into seven parts (*padartha*): dravya, guna, karma, samanya, vishesha, samayaaya and abhaava. This provides an interesting approach and several new insights into understanding the property of matter and material that did not invoke

God or religion in any way. These were studies in the best rationalist traditions.

(2) Yoga and Ayurveda: Ancient India's approach to health and illness. This combination of self-discipline, exercise and plant-based medicine with a holistic approach to life and health has resulted in novel thinking. Its approach to health and healthcare continues to attract students from all over the world. Combined with Yoga, this healthcare system was analytical, rational and practical. Evolution of the system led to an equivalent of modern-day plastic surgery as the system evolved.

(3) Indian philosophy of science: The philosophy behind Indian approach to nature has not been fully understood due to lack of any systematic study. Within these secular philosophies lie some truly insightful ideas about humans and their interaction with environment and the working of nature. These go beyond the arguments of the Nyaya–Vaisheshika system and discuss a whole set of issues related to logic, reason and doubt. Beyond that, they are far more inclusive in discussing human exploitation of and respect for nature.

(4) An overview of Indian mathematics from the *Vedas* to the Kerala School: Indian mathematics has been justly recognized as being far-reaching and complex with a variety of ideas from number theory to second-order algebraic equations and the concept of limiting value.

(5) Astronomical ideas in Indian texts: Indian astronomy was both accurate and pragmatic. Without the love for circles that bogged down some of the work in Greek astronomy, the Indian astronomers were free to derive equations which gave good fit to the movement of planets. This resulted in creating the first sine and cosine tables and early trigonometry. The method employed to calculate eclipses and records of transits of planets all make a rich tapestry of study of astronomy in India. From Aryabhata's encyclopaedic work on astronomical calculations to Varahamihira's defining of syllabus for astronomy and clarification of various concepts, the achievements of Indian astronomical texts are astounding.

(6) Eclipse and planetary conjunctions: Mahurats, tithis, calendar, eclipses, and planetary conjunctions were an important part of Indian astronomy and panchang-making. The manner in which vyatipada (a conjunction of Sun and Moon at Rahu) that would produce an eclipse was calculated makes a fascinating subject in its own right.

And if the topic was made wider with ancient Indian sciences, topics such as architecture and technologies of Harappan civilization and the technological marvel of the Taj Mahal or rockets of Tipu Sultan and more can be added. The science of temple architecture of India could also have been included as it is a sensitive and scientifically well designed architectural work.

A session with these contents would have left behind a healthy legacy of Indian science in the minds of all participants and the world as a whole. It is probably important to realize that the most competent speakers on these subjects are people trained in dispassionate evidence-based method in scientific studies and have critically evaluated and found the gems of Indian science that should make all of us proud.

Reflections on the consequences of the present debate

However, in the extreme claims of the fringe elements, Indians stand to lose the most. It means that a rational and realistic study of India's past is now a much maligned field, which no rationalist scientist or citizen will attempt.

Equally importantly, the rationalist scientists will find their own work space squeezed as they begin to deal with a government that is influenced by parochial consideration. Pure excellence will give way to committed excellence – an oxymoron idea. There is no such thing as committed excellence. You cannot see white colour while wearing blue sunglasses. Some may be able to deduct the possibility of white colour where they see uniform bright blue, but most will live under the impression that the world is blue. The result is that those who can see other shades will be outcast, forced to find companionship only amongst those who do not wear sunglasses, or go away to places where sunglasses are not a norm (or worse, start wearing sunglasses themselves). We will all be poorer for it and our reputation will take a plunge from which we will be hard pressed to come back.

So what should we do? For one, the fringe groups need to be exposed for what they are. This will require a concerted effort and scientists will have to shed their traditional shyness. We will have to educate people as to why the claims of the fringe groups are nonsense without appearing to be ignorant or condescending of the past. For this, scientists will have to arm themselves with a better understanding of the true achievements of the past, and then step forward and take on the fringe groups who are well-organized, well-funded, shrill and increasingly tolerated, if not encouraged by the powers that be. This will be a distraction, but the battle is for the soul of the nation, no more, no less. A battle is not far, and it will be brutal, hard and long. It will have to be fought on every forum and every place, from Indian Science Congresses to the newspapers and public forums. But those who care for the soul of India and desire a rational nation to emerge will have to join the battle.

1. Narasimha, R., *Curr. Sci.*, 2015, **108**, 471–472.

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