

C.K. Raju, *Cultural Foundations of Mathematics: The Nature of Mathematical Proof and the Transmission of the Calculus From India to Europe in the 16th c., CE*. New Delhi: Centre for Studies in Civilizations and Pearson Education in South Asia, 2007, pp. xlv+477, Rs. 1,600

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This book brings new facts on the history of mathematics and science that if carried to its logical conclusions should transform our Eurocentric perceptions. The author C.K. Raju comes to this task with an impeccable hands-down knowledge of science and technology. He was a leading figure in the first supercomputer put together in India at a time when the US banned supercomputer exports to India, the ideology of computing in mathematics being identical to the Indian ideology of mathematics which he posits.

Science, Raju notes is (still) widely considered an internal domestic Western affair. Most conference organizers, teachers and researchers assume that the history and philosophy of science begins and ends within a Western trajectory. What he attempts is to bring new material from other cultures to fill in the gaps as well as highlight some of the contextual factors within Europe to highlight the particular wrong views he critiques.

He notes that the suppression of ideas has a long history in Europe. With the emergence of Christianity a lethal death penalty was declared on heretics and all schools of philosophy were closed

down in the Roman Empire eventually leading to the [Christian] Dark Ages. Christian mobs led by violent priests burnt down the great library at Alexandria and attacked their ideological opponents like the neo Platonists. The suppressed European classical tradition was partly kept among the Arabs, the latter adding knowledge from the East including from India. However, when Europe began moving out of the Dark Age partly utilizing Arab knowledge, the entire knowledge found in Arabic books up to the 11th century including those with Indic inputs was subject to a strategy of Hellenization attributing them solely to Greek sources. There was now a revisionist history being marketed with the early Greeks becoming the fountain head of all knowledge at Toledo (the Arabic intellectual centre in Spain) and elsewhere where the Arab contribution was considered only as transmitters of Greek knowledge. But if one examines the facts objectively one arrives at a different picture.

Not even a single historical source of Greeks books is available from Alexandria, Raju points out. Raju claims that monumental theories of Greek source of science has been built from stray casual remarks in texts from the 12th century. I am not a Greek historian but the implications of this are truly revolutionary.

Raju throws a harsh historical light on some of the legendary figures in the Greek tradition and comes out with a huge question mark. For example, the key historical source of information of the presumed Euclid of the *Elements* is a single remark in a manuscript by no means written before the 10th century AD. The archaeological evidence indicates that there was no definitive text of the *Elements* before the fourth century. If this were the actual historical evidence about one of the better known figures such as Euclid the situation with others such as Archimedes, Aristotle, Ptolemy was also problematic although the existence of Aristotle is not in doubt.

Another such possible Greek origin myth was "Ptolemaic" astronomy. Raju asks the question that if Ptolemaic astronomy was such a well-developed system why did the diaspora from Ptolemaic Alexandria look towards Indian astronomy in the sixth century Persian city of Jundishapur where an Alexandrian academy had been established and again later in ninth century AD Baghdad.

Tracing the origin of the calculus Raju notes that differences and series expansion were used in India at least from the fifth century. Calculus started with the use of the infinite series. Knowledge of aspects of the calculus was known also from very early times, integration being done by Bhaskara II and differentiation since Brahmagupta. Series expansions led over a thousand year period to what was later called in Europe the Taylor expansion. That infinite series were known in India has been acknowledged by Europeans for 200 years but the connection between them and the calculus as it developed in Europe was not acknowledged.

Calculus was a key input to Newtonian physics. Infinite series expansions are to calculus what decimal fractions are to arithmetic. The infinite series "Taylor series" named after the pupil of Newton dates from 1715. The Taylor infinite series allowed Newton to use Kepler's description of planetary motion as ellipses to arrive at his inverse square law of gravitation. Before Newton used the infinite series expansions Indian astronomer Nilakantha could develop a planetary model similar to the one Tyche Brahe arrived at later.

There have been, Raju observes, two standards of evidence in Western history for the transmission of knowledge. One of a very lax standard of evidence for transmission from presumed Greeks and another, ultra-strict standard for transmission to the West from other sources such as the Indian ones.

Raju also notes that the history of science without its philosophy is blind, and that the philosophy of science without its history is lame. The present day philosophy of mathematics traces its roots to an assumed Greek tradition ignoring other traditions. There are strong epistemological contrasts between Greek and Indian approaches.

The Western tradition of mathematical proofs is through deduction based on logic given a set of axioms. But he points out that there could be different axioms and different types of logic as in Buddhist and Jain logic. In the Indian tradition proof is through practice—there was no separation of abstract conceptualizations from everyday reality. In the eastern tradition proof was empirical. Mathematics was calculation as opposed to mathematical proofs from a set of apriori axioms.

The epistemological discontinuities between the two traditions were also seen in the difficulty Europe had in absorbing the numeral zero, *sunya* which went to the West from at least the 10th century but took several centuries to be accepted. So great was the conceptual chasm to be bridged that although the practical application of Indian mathematics were valued in the West it took nearly 500 years for the system to be fully absorbed.

In the 16th century there was the transfer of mathematical and astronomical manuscripts from Cochin through Portuguese Jesuit priests. Part of this transfer included ideas of infinitesimals and the calculus. Again an epistemological struggle of the two approaches ensued in Europe which was resolved only towards the end of the 19th century.

Raju details the transmission of aspects of the calculus from India into Europe. This was in connection with the European navigational problem related to the determination of latitude, longitude and loxodromes. Finding that navigation was very important to the formation of European interest in mathematics during the 16th century and afterwards Raju traces key contributions from India which the Europeans of the 16th century took back to Europe. But like in mathematics there were difficulties in adopting Indian knowledge because European knowledge of the size of the earth was different from the Indians which latter was much nearer to modern figures. Unfortunately unlike Arab historians European historians have not acknowledged the contribution of this Indian knowledge.

In a chapter on the contemporary relevance of the revised history he presents, Raju shows that the epistemic divide in approaches to maths takes centre stage. The two streams of inherited mathematical traditions are one from Greece and Egypt and the other from the Indian subcontinent through Arab intermediaries. The result has been centuries long "maths wars" which recalls the cultural wars in the last couple of decades in the US. These maths wars have now been reconciled somewhat with the use of computers in mathematics which undermines traditional Western notions of mathematics.

The author is well read in comparative philosophy and history and shows much familiarity with both the Western tradition and those of other civilizations primarily the Indic one.

The author had wanted the book to be a joint project together with other scholars but due to exigencies has been made to do it as his own. The book brings together various papers made over a 10-year period by the author to an interconnected stream. Some of the material however does not hang together as a flow, the book reading sometimes as sections brought together and pasted from earlier work. Sometimes there is repetition. Good copyediting would have improved the flow of the book making it easier to digest.

The parallel to this book that I can point out are the three volumes of Martin Bernal on *Black Athena* which first demonstrated the falseness of the premise that Greece was the fountain head of knowledge. Bernal showed convincingly that the enthronement of Greece in the early 19th century was for the ideological purposes of Western expansion into other countries which required downsizing the contribution of non-European civilizations. Bernal's book struck at the very heart and ideology of Western classical studies. He consequently wondered how it would be received. But surprisingly the opposition was limited and most of what he has said has now been taken in by the Western academic establishment. But Bernal was working in an American academic milieu and he was the son of the well-known social historian of science H.D. Bernal. J

The material presented in this volume by Raju would require a re-examination of much Western historiography of mathematics and science. Its acceptance into the "mainstream" history of science and mathematics (read as legitimized in the West) requires that this information of Raju reaches those who study the history of science in the West. Unfortunately the history of science in the West is still extremely Eurocentric paralleling the history of philosophy which is considered as only European philosophy. A few years ago I attended the history of science conference in Minnesota and found that I was the only person presenting a paper on Asian history of science. The acceptance of the facts presented by Raju would be hampered by the contours of the present rigged geopolitics of knowledge.