This article appeared in two parts in *The New Indian Express,* 13 & 14 October 2016, in answer to Meera Nanda's article "Hindutva's science envy" (*Frontline*, Vol. 33, no. 18, 16 September 2016). Because of formatting issues, the full text is given here in the original; it is otherwise identical to the online version, barring corrections of two typos. Both parts were published in the print edition on the same dates, but in abridged form.

Part 1

In Defence of Indian Science

Michel Danino

www.newindianexpress.com/opinions/2016/oct/13/in-defence-of-indian-science-1527495--1.html
(and subsequent pages)

Studies of India's ancient scientific accomplishments have seen two extremes: At one end of the spectrum, daydreamers fancy that the Vedas knew everything from electricity to interplanetary travel, that *vimānas* crisscrossed Indian skies millenniums ago, or that Aryabhata invented all mathematics. At the other end, gainsayers bristle at the thought that some science might not have emerged from the "Greek miracle": Indian scientific advances can only be borrowed or derivative, its imperfections and errors alone being original contributions, while its rational elements ultimately stem from contact with the Greeks; Indian savants knew no experimental science, followed no proper axiomatic method, and in any case ended up in stagnation, while Europe galloped forth triumphantly and gave us the boon of "modern science".

With minor variations and boring predictability, the two scenarios are repeated decade after decade, while serious scholars — both Indian and Western — quietly and patiently generate solid material which, in a normal (rational?) world, should suffice to dismiss dreamers and gainsayers alike to the obscurity they deserve. Indeed, ridiculing the former is easy, and occasionally needs to be done. Exposing the latter, however, is less commonly done, as they often conceal their biases or ignorance behind academic posts and imposing jargon.

A recent case in point is Meera Nanda, who has been for some years on a self-appointed mission to expose all claims to knowledge by (let us lump them together, as she does) Hindu enthusiasts, nationalists, right-wingers or Hindutva activists. Her latest contribution, "Hindutva's science envy" (*Frontline*, August 31), blames in a vast sweep "the current crop of Hindu nationalists and their intellectual enablers" for being the progeny of thinkers like "Bankimchandra Chattopadhyaya, Vivekananda, Dayananda Saraswati, Annie Besant (and fellow Theosophists), Sarvepalli Radhakrishanan, M.S. Golwalkar and countless other gurus, philosophers and propagandists" — doubtless a most despicable crowd!

I will not deal with Nanda's personal attacks on past and present figures, but will confine myself to discussing the considerable distortions in her two case studies of Indian mathematics: the case for early Indian knowledge of the Pythagoras theorem, and India's claim to be "the birthplace of the sunya, or zero."

The Pythagoras Theorem

Nanda attacks the view that Baudhāyana's *Shulbasūtras,* a text of geometry for the construction of fire altars, which she dates "anywhere between 800 and 200 BCE," knew the Pythagoras theorem (on right-angled triangles) before the Greek savant himself. Thus, Nanda informs us, Pythagoras "comes in for a lot of abuse in India." But this view is not that of hot-headed enthusiasts; it was stated as early as in 1822 by the British astronomer John Playfair ("On the Astronomy of the Brahmins"): "It is curious to find the theorem of Pythagoras in India, where, for aught we know, it may have been discovered." The eminent historian of Indian mathematics Bibhutibhushan Datta (in his *Ancient Hindu Geometry* of 1932) showed that knowledge of the "theorem" was actually traceable to the much earlier *Taittirīya Samhitā* (also known as *Krishna Yajurveda*) and *Shatapatha Brāhmana,* the first of which dates back to 1000 BCE at the least. In his landmark 1960 paper on "The Ritual Origin of Geometry", the U.S. mathematician and historian of mathematics A. Seidenberg independently reached similar conclusions: "The Pythagoras theorem ... was known and applied at the time of the *Taittiriya Samhita*." Playfair, Datta or Seidenberg were not members of the Sangh Parivar, to my knowledge; neither can they be blamed for "abusing" Pythagoras.

Nanda proceeds to ridicule the thesis that the Greek savant might have come to India to learn geometry "from Hindu gurus," unaware that the said thesis emerged not from one of her *bêtes noires*, but from a few minor neo-Platonic Greek texts picked up and amplified by Enlightenment philosophers such as Voltaire, the French astronomer Jean-Sylvain Bailly (in 1777) or the British Edward Strachey (1813).

Nanda then points out that the Mesopotamians knew the theorem about 1800 BCE, which "blows holes through much of the case for Baudhayana's priority." Strictly speaking, all that the Mesopotamian tablets in question show is an acquaintance with certain sets of Pythagorean triplets; this may or may not imply knowledge of the theorem in its *general* form (as given in the *Shulbasūtras*). Even conceding that the Mesopotamians did know that general form, as is likely, does this badly puncture the Indian text's "priority"? Not necessarily, since the *Shulbasūtras* enshrine a geometrical tradition much older than the texts themselves, as Datta and Seidenberg demonstrated. How much older is a matter of speculation in the absence of clinching evidence.

But why should "priority" matter so much, after all? Nanda does not cite a single serious scholar, not even a "nationalist" one, who worries about it. Historians of mathematics rightly prefer to concentrate on understanding how each geometrical tradition — Mesopotamian, Greek, Indian or Chinese — approached and applied the theorem, or whether (as Seidenberg concluded) the first three traditions had a common origin.

Pythagoras in China

Nanda then informs us — and this is supposed to be very damaging — that the first "proof" of the Pythagoras theorem is found not in the *Shulbasūtras* but in a Chinese text of unknown authorship, *Chou Pei Suan Ching*, "dated anywhere from 1100 to 600 BCE." In current spelling, this is the *Zhou Bi Suan Jing* ("Mathematical Classic of the Zhou Gnomon"), which was "most probably compiled no later than the first century BCE," according to Joseph W. Dauben, a distinguished historian of science and expert on Chinese mathematics (I borrow his translation of the work's title). Christopher Cullen, another respected expert, agrees that the text "was probably assembled under the Western Han dynasty during the first century BC." In fact, Joseph Needham, the noted pioneer of history of Chinese science, one of Nanda's only two references in this whole issue, mocks those who "would cheerfully put the *Chou Pei* 1000 years too early" and accepts a date in the Han dynasty, that is, between 206 BCE and 220 CE.

This brings in an interesting aside: Nanda, as we saw, was willing to stretch Baudhāyana's date to 200 BCE, while most scholars have him earlier than 500 BCE (even to "800–600 BCE," to quote the U.S. historian of Indian mathematics Kim Plofker); in contrast, Nanda curiously ages the Chinese text by at least five centuries, taking it before 600 BCE — a neat somersault to suggest Chinese "priority" over the Indian text! (Of course, as pointed out by Needham and others, the *Zhou Bi Suan Jing* integrates older material and practices, but so do the *Shulbasūtras*.)

Such double standards apply to her statement that the first Indian proof, by Bhāskarāchārya in the 12th century CE, is "an 'exact reproduction' of the Chinese" one. This, she claims, was stated by Needham "and many others" (whom we shall not know). Actually, Bhāskara in his *Bījaganita* mentions two proofs which he attributes to tradition (and therefore of uncertain but older dates). One is *rāshigata* (arithmetical); the second, *kshetragata* (based on geometric algebra), does bear some likeness to the Chinese proof — but equally to the *Shulbasūtra*-type of constructions.

The evidence, again, is not clinching: Nanda fails to realize that likeness alone is no proof of borrowing — neither from India to China (as she blames unnamed "Indocentric historians" for always assuming) nor from China to India, as she herself favours. The methodology serious scholars follow is to note similarities and chronologies, whenever unambiguous, but to refrain from conclusions until an actual chain of transmission can be objectively established.

Finally, why should Nanda ridicule the "longstanding demand of Hinducentric historians that the theorem should be renamed 'Baudhayana theorem' "? Note, once again, that she does not cite a single such historian or source to that effect; even assuming such a demand has been made, it is by no means without justification, since Baudhāyana is undeniably one of the early mathematicians to formulate the theorem (which in Greece was not formulated, let us recall, until 300 BCE by Euclid). However, let us recall that mathematicians have renamed series discovered in Europe by Newton, Leibniz or Gregory as "Mādhava–Newton," "Mādhava–Leibniz" and "Mādhava–Leibniz–Gregory" series — after Mādhava, the fourteenth-century founder of the famous Kerala School of mathematics and astronomy, who discovered the said series long before European mathematicians. Similarly, a better term for the Pythagoras theorem would have to be "Baudhāyana–*Zhou Bi*–Pythagoras theorem" (in whatever order). It is far too unwieldy ever to be adopted, yet would be accurate, historically justified, and certainly no insult to Pythagoras, who made a profound impact on Greek and later Western thought without leaving behind a single written work.

(To be concluded)

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Part 2

Gainsaying Ancient Indian Science

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www.newindianexpress.com/opinions/2016/oct/14/gainsaying-ancient-indian-science-1527846--1.html
(and subsequent pages)

The Zero and the Decimal Place-Value System

Meera Nanda moves on to the notion that "Bharat gave zero to the world," which she calls "the sacred cow of Hindu sciences." Her all-too-predictable line is that China is the likeliest source for both the concept of zero and the positional decimal system of numeral notation. That system — the one the whole world uses today — is technically called "decimal place-value system of numeral notation," since the value of a numeral depends on its place: 261 is not the same as 621 (whereas the value of XXIII, 23 in Roman numbers, does not change if the two Xs are switched: it is not a positional system).

Nanda cites Needham (who wrote on Chinese mathematics in 1959) and a more recent scholar, Lam Lay Yong, to suggest the "possibility of the South-East Asian transmission of zero from China." She complains that Lam's "rigorously argued and evidence-backed thesis" has met with a "deafening silence" in India. What are the "rigorous arguments," then?

First, "the absence of place value in Indian numerals until around the sixth century of the Common Era, and secondly, [the fact] that the first physical evidence of zero comes not from India but from Cambodia [in 683 CE] and other South-East Asian countries that lie between India and China." Nanda combines the second point with Needham's and Lam's thesis to argue that the mathematical zero is traceable to China, not India.

There is nothing wrong in giving credit where credit is due, and ancient Chinese civilization did witness brilliant advances in mathematics and other sciences, not to speak of technologies, often far ahead of the rest of the world. As it happens, however, Nanda's two arguments can only be maintained by sweeping under the (Chinese silk) carpet a mountain of evidence. Needham could be excused for advancing them six decades ago (far more tentatively and detachedly than does Nanda), but fresh material has come to light since his pioneering research, all of which Nanda ignores. The work of epigraphists and historians of science, both

Indian and non-Indian, all of it equally “rigorously argued and evidence-backed,” now permits a definite answer.

As a complete survey of the evidence would easily fill a thick tome (the French historian of mathematics, George Ifrah, devotes over 200 pages of his monumental *Universal History of Numbers* to the Indian systems and the zero), I will restrict myself to a few instances (and can supply references on request). Let us begin with three inscriptions deciphered by D.C. Sircar, from all accounts the greatest post-Independence authority on Indian epigraphy:

- The Mankuwar Buddha image stone inscription of 428 CE includes a “small globular symbol” representing zero. This is not a positional context, however: zero here acts as a mere place-holder.
- The Dabok stone inscription (near Udaipur, Rajasthan) bears the date of “701” (in the Vikrama Samvat era, that is, 644 CE), again not in a true positional fashion, but with a symbol for 700 followed by a dot (zero as a place-holder) and 1.
- The Khandela stone inscription of Rajasthan gives its date as “201”, now in the proper positional system, and with a small circle for the zero. Sircar applied the date to the Harsha era, which yielded 807 CE.

The Mankuwar and Dabok inscriptions, both of which antedate the Cambodian inscription of 683 CE, are conclusive epigraphic evidence for an early use of the symbol for zero in India (initially in non-positional systems). Even the common notion, relayed by Nanda, that the zero in a positional context is first depicted in India in the Gwalior inscription of 876 CE is belied by the Khandela inscription. Besides, the famous Bakhshāli manuscript, a mathematical work dated to the 7th century CE by the Japanese scholar Takao Hayashi, author of the most thorough study on it (of course, others have proposed older as well as more recent dates), manipulates numbers in the decimal place-value system, with the zero represented as a dot.

In fact, many more inscriptions bearing a symbol for the zero (always a *bindu* or small circle) predate the Cambodian one. I have not listed them as they are on copper plates, and according to Nanda, “many of [the copper landgrant plates] have been later proven to be fake.” The trick of declaring “many” (how many?) copper-plate inscriptions “fake” has long been resorted to whenever their dates proved inconvenient to the prevailing theories — but the said “fakeness” is almost never “proven”; it is no more than a matter of opinion. That is what happened to the well-known copper-plate inscription of Sankheda (Bharuch), which records its date as “346” in a local era, equivalent to 596 CE. Its authenticity was questioned but, as

Bibhutibhushan Datta (with A.N. Singh) and Ifrah independently explained at length, without valid ground. In any case, stone inscriptions such as the above cannot be faked.

Ifrah's conclusion as regards the epigraphic evidence is categorical: "There exist very numerous records [other than the Sankheda inscription] of perfect authenticity which prove beyond dispute that the zero and the positional decimal numeral system are definitely — and solely — of Indian origin, and that its discovery goes back to a far more ancient period than the oldest known inscription on a copper plate."

Are Inscriptions the Only Evidence?

The strongest evidence is however not of epigraphic nature. Consider:

- The system of computation found in Pingala's *Chhandasūtra* (variously dated between 400 and 200 BCE), a set of rules on Sanskrit prosody, used a binary system to classify all possible metres (no numerals are involved, let us note, only Sanskrit letters and syllables). In the course of the calculations, which demand a place-value notation, Pingala refers to the symbol for *shūnya* or zero, which, as the historian of science S.R. Sarma demonstrated, had to be an integral part of the system. This does seem to be its conceptual origin, after which it took a whole millennium to be worked out with numerals and to spread across the subcontinent, and beyond.
- The Buddhist philosopher Vasumitra (1st century CE) wrote, "When [the same] clay counting-piece is in the place of units, it is denoted as one, when in hundreds, one hundred, when in thousands, a thousand," which is plainly a positional system of counting. A few Jain savants between 100 BCE and 100 CE have been credited with similar statements, but more research is required to bring out their contributions. Vyāsabhāshya, before 400 CE, made a statement similar to Vasumitra's: "The same stroke [i.e., numeral 1] denotes 100 in the hundreds place, 10 in tens place and 1 in units place."
- Sphujidhvaja's *Yavana Jātaka,* an adaptation of a Greek work on astrology, gives its own date in a system called *bhūta-samkhyā* which is strictly equivalent to the decimal positional system; the date is 191 of the Shaka era, that is, 269 CE. Concludes Kim Plofker, "Evidently, then, positional decimal numerals were a familiar concept at least by the middle of the third century, at least to the audience for astronomical and astrological texts."
- *Lokavibhāga,* a Jain text of 458 CE, explicitly uses (with words rather than numerals) the modern place-value system along with zero.

- Āryabhata, who wrote his celebrated *Āryabhatīya* about 500 CE, spelt out a number of rules for mathematical and astronomical applications. Although he created his own semi-positional system of numeral notation based on Sanskrit syllables, that system will not work for the algorithms he formulated for the extraction of square and cube roots instance, among other procedures: only the full-fledged place-value system with zero, as we know it today, will work with such algorithms. This was briefly noted two decades ago by the current Indian doyen of historians of science, R.C. Gupta, then was amplified by Ifrah, who offered a rigorous mathematical proof of this, which anyone familiar with school-level maths can follow. This is irrefutable evidence that the modern system was well known to the Indian scientific community in the 5th century CE.
- Subandhu, in his *Vāsavadattā* of the 6th or 7th century CE (but often dated two or three centuries earlier), compared stars to *shūnya bindu*s, that is, "zero dots".
- Finally, in 662 CE, the Syrian bishop Severus Sebokht wrote about "the science of the Indians ... their subtle discoveries in astronomy, discoveries that are more ingenious than those of the Greeks and the Babylonians, and their valuable methods of calculation which surpass description ... done by means of nine signs." This is a clear reference to the place-value system, which will not permit "valuable methods of calculation" without the integration of zero. Why should a Christian bishop go out of his way to acknowledge the scientific advances of "Pagans" if there was not good ground to do so? Let us note the date, 221 years before the Cambodia inscription.

I wonder why Nanda is "deafeningly silent" about such incontrovertible evidence, some of which was discussed as early as in 1929 by the U.S. Sanskritist W.E. Clark. Even the highly conservative historian of Indian astronomy David Pingree conceded that "there is evidence in Buddhist and Jaina texts of uncertain date, but near the beginning of the Common Era, that a decimal place-value system was in use, but there is no certain evidence that a symbol for zero was in place before the fifth century A.D." As we saw, the second part of his statement can arguably be pushed back by two or three centuries, but it is good enough for our present purpose.

From India to China?

Desperate to somehow connect the issue to Hindutva propaganda (apparently Sangh Parivar hotheads discuss the "sacred cow" of the numeral system everyday at breakfast), Meera Nanda makes it appear as a recent one. In reality, the debate of the origins of the place-value numeral system and the zero goes back well over a century and initially was conducted wholly among Western scholars. Leaving aside Alexander Wylie, who wrote in 1897, let me come to the British scholar G.R. Kaye, author of studies on Indian mathematics and astronomy and a strong proponent of the colonial prejudice that Indians could have created no science of their own: it had to be always derivative, borrowed the Greeks, the Persians or the Chinese. As a result he declared all early Indian inscriptions to be "fakes" and insisted that the place-value system originated in Southeast Asia under Chinese influence and travelled thence to India — a thesis he first formulated in 1907, and which is almost verbatim Nanda's. A couple of decades later, the French scholar George Cœdès, revered as the "unchallenged dean of Southeast Asian classical scholarship" and author of numerous volumes of inscriptions from all "Hinduized states of Southeast Asia," as he called them, gently rebuked Kaye for his "strange opinion" and plainly favoured an Indian origin.

In fact, according to Needham himself, "The circular symbol for zero is first found in print in the *Su Shu Chiu Chang* of Chhin Chiu-Shao (+ 1247), but many have believed that it was in use already during the preceding century at least." Thus the Chinese depiction of the zero is not only centuries later than the Indian inscriptions we saw above; it is also some 500 years more recent than the Cambodia inscription Nanda makes so much of: if the latter is evidence of Chinese influence, as she argues, why do we not have much earlier depictions of the zero in China itself?

And while Nanda is so sensitive to unnamed "Hinducentric historians," she ought to know that Chinese scholars are far more nationalistic as a rule than their Indian counterparts. This is the case of Lam Lay Yong cited by Nanda; Lam's theory of the Chinese origin of the place-value system is neither "rigorous" nor "evidence-based," as she completely ignores the Indian evidence (as a glance at the bibliography of the revised 2004 edition of her *Fleeting Footsteps: Tracing the Conception of Arithmetic and Algebra in Ancient China*, co-authored with Ang Tian Se, will show). Lam is no doubt a sound scholar of early Chinese mathematics, but she is ill-qualified for crosscultural studies, which is why her thesis, first propounded over 30 years ago, has met with no growing acceptance, despite to Nanda's assertion to the contrary.

Indeed, in a review of their book, the noted Sinologist Jean-Claude Martzloff was critical of Lam's and Ang's approach as regards India: referring to the early Tang dynasty or 7th century CE as "a period of intense contacts between China and India (where the concept of zero in its written form was already developed)," Martzloff pointed out that "Chinese translations of Indian mathematical and astronomical texts were made at this time and one of these, dated 712 AD, mentions precisely an Indian written zero in the form of a small dot. This aspect of the question is well documented, and certain of these translations have even survived. Still more significantly, the representation of numbers in Chinese Buddhist literature is often borrowed from Indian culture, especially in the form of phonetical transliterations of Sanskrit words into Chinese. Conversely, as far as I know, Chinese mathematical terms have never been detected in Indian or Islamic technical literature. Unfortunately, these aspects of the problem are passed over in silence in *Fleeting Footsteps*."

That is the crux of the whole issue: while no positive evidence of Chinese transmission to India exists as far as the number system is concerned, there is plenty in the opposite direction, as many scholars have documented. But even a brief survey of India's contributions to Chinese mathematics would require another longish article, and it is now time to rest my case.

Concluding Thoughts

First, let me clarify that I have not attempted to prove that India "invented the zero," as is often and wrongly stated. The Mesopotamians, the Mayans and the Chinese all had some concept of a zero, mostly as a place-holder (just as it was used in India before the place-value system spread across the subcontinent). India's unique contribution, as explained by Ifrah with meticulous care, was to integrate the zero in a positional system, in a way that zero now became a mathematical operator. Again, let us give credit where credit is due.

Secondly, there is no need to be obsessed with "priority," unless clear evidence is available, much less with supposed "superiority". There is also nothing wrong in discussing the occasional errors of Indian savants (Āryabhata, for instance, gives wrong formulas for the volume of the pyramid and the sphere; his diameters for the planets and the sun are also far too small). Indian mathematics rests on many well-documented breakthroughs from the *Shulbasūtras* to the Kerala School, especially in geometry, algebra and calculus; that is more than sufficient. Indian students, if those breakthroughs were not inexplicably concealed from them, would have a better and more intelligent appreciation of their country's intellectual history.

Meera Nanda, clearly, wants none of this to happen. She is no doubt entitled to her opinions, neo-colonial prejudices and even pet hates, but disregarding or concealing all material that runs counter to one's choices is poor scholarship. Worse, misleading the lay public into believing that the genuine accomplishments of early and classical Indian mathematics and astronomy are no more than Hindutva-created fictions reflects a jaundiced view of the whole field which not even the most contemptuous colonial scholar would have dreamt of. The mind boggles, and I wonder what Nanda's next targets will be. I wish her well in her explorations, but hope she will first study basic research methodology, without which no scholarly work can endure.

(Concluded)

Note: Except for long vowels, I have made no attempt to use standard diacritics for Sanskrit words, opting instead for spellings closer to their actual pronunciation. "BCE" and "CE" stand for "Before Common Era" (or BC) and "Common Era" (AD). I am thankful to Dr. M.D. Srinivas for a few inputs on Bhāskarāchārya's treatment of the so-called Pythagoras theorem and on Lam Lay Yong's work.

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