SITUATING THE HISTORY OF INDIAN ARITHMETICAL KNOWLEDGE IN GEORGE PEACOCK'S *ARITHMETIC*

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The end of the eighteenth century was a watershed in the institutional and disciplinary differentiation of the sciences. This differentiation was legitimated through a number of moves, among which must be counted the new disciplinary histories of astronomy and mathematics crafted in the last decades of the eighteenth century. The history of Chinese and Indian astronomy and mathematics were integrated into the encyclopaedic histories produced in France, England and Germany during these very decades. This paper attempts to situate a significant nineteenth century history of *Arithmetic* authored by the mathematician George Peacock, and in particular to examine the sources on which his reading of the history of Indian arithmetic is anchored. Peacock's history comprises a detailed elaboration of the history of the concept of number in a comparative civilizational perspective. This comparative historiography serves as a frame for him to subsequently elaborate the history of number systems, notation and other central ideas in the history of arithmetic. This paper, as mentioned, seeks specifically to investigate Peacock's sources and reading that he inherits from the British Indologists who were researching Indian mathematical texts and the French mathematicians who preceded them.

Key words: *Brāhma-sphuṭa-siddhānta*, Classification of numbers, Colebrooke's translation, George Peacock, Historiography of mathematics, History of arithmetic, Numerals of different peoples

Towards the last decades of the eighteenth century as science was undergoing rapid disciplinary and institutional differentiation, the history of science began to reflect these transformations in disciplinary histories[1]. These disciplinary

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histories, be they of astronomy or mathematics, may also be envisaged as legitimizing the boundaries of disciplines; since these were written by the very actors namely scientists or mathematicians who were moulded by and moulding these institutional transformations[2]. Amongst the variety of sources that were assembled together in the production of these disciplinary/sub-disciplinary histories were also the histories of the sciences and mathematics of the Orient. These histories were produced by Occidental scholars based upon the accounts of European travellers, explorers and missionaries[3]. The present paper attempts to contextualise a chapter on the history of arithmetic contributed by the British mathematician, George Peacock to the *Encyclopedia Metropolitana*[4]. It has been pointed out that a school of algebraists formed in the early decades of the nineteenth century around the mathematicians Charles Babbage, George Peacock, Augustus de Morgan and Duncan F.Gregory and were joined by other mathematicians such as George Boole, and J.J.Sylvester. "The analytics" as members of the school were referred to, published specialist articles in journals and encyclopaedias devoted to the popularisation of education and a scientific culture. The *Encyclopedia Metropolitana* (1817-45) was one such publication where their articles appeared[5].

This paper explores Peacock's sources and reading that he inherits from the British Indologists who were researching Indian mathematical texts, and the French mathematicians who preceded them. In addition Peacock's history draws on other histories of mathematics and astronomy canonised at the time; e.g. that of Delambre, considered one of the first professional histories of science[6]. In drawing upon these other sources Peacock engages with them both as a resource as well as challenges some of the claims of the canon. I shall not venture here to set in context Peacock's entire text on the history of arithmetic that appears in the *Encyclopedia Metropolitana*[7]. The chapter titled "Arithmetic" comprises a historical review of the discipline of arithmetic. The section is called history of science and conforms to a genre of disciplinary history, mentioned above, produced towards the end of the eighteenth century. This chapter on the history of science commences on page 369 and terminates on page 482; composed in two columns and in very small print, densely packed. In other words this very chapter could stand apart as an independent treatise on the history of arithmetic. Further, it could well be argued that this conceptualisation of the history of arithmetic seeks to justify the programmatic effort to visualise arithmetic as a symbolic system. Durand-Richard has chronicled in detail the history of the school of British analytics, tracing the genesis of this philosophy of mathematics[8]. The objective of this paper is to

contextualise the history of arithmetic in India as it is positioned in Peacock's larger civilizational perspective on the evolution of arithmetic as a discipline. Its narrow focus is then the history of arithmetic in India as it appears in Peacock's work[9]. This may be seen as part of an attempt to construct the Indian mathematical tradition in Occidental scholarship between the eighteenth and nineteenth centuries[10].

How did Peacock conceive the discipline of arithmetic? This question begs a reply if we wish to enter into the universe of historical concerns that guides Peacock's intellectual journey. Peacock proposes, in the first instance that the discipline of arithmetic includes the science of numbers, notation and the different operations performed on numbers. His own historical review precludes the theory of numbers[11], since that would require "an extensive knowledge of Algebra"[12]. In other words, the historical review charts out an autonomous domain of pure arithmetic. Furthermore, the historical review sections off the history of arithmetic to the study of common arithmetic operations and the rules employed in performing these mathematical operations. Peacock clarified that his "historical notice" seeks to comprehend how the manner of acquisition of number may serve as an introduction to the different modes of numeration[13]. And finally, this notice did not proceed to educe an a priori terrain where pure number or arithmetic exists, but related the origin of numbers in different societies and cultures to the variety of material practices. In Peacock's scheme of the evolution of mathematics he never offered an axiomatic presentation of symbolic arithmetic, but merely stated the reciprocity of arithmetical operations such as addition-subtraction, and multiplication — division[14].

This leads us to the next question concerning the historical method that guides Peacock's historical project, since this will open a window into Peacock's sources on India and the method adopted for exploring and interpreting the Indian arithmetical tradition. The method for the first half of the chapter is more or less determined by the central question he seeks to answer: namely the relation between systems of numeration and numerical words. And in this short paper I shall restrict my discussion to this question, postponing discussion on the other dimensions to a more comprehensive article. In order to unveil this relationship he is informed by the burgeoning discipline of philology. He turns for instruction to the "language of the people", for it is there that the connection between the "practical methods of numeration and numerical words" are clearly revealed. Further in languages far divorced from "civilized life", the primitive meaning and applications of words is

not governed by the sort of elaboration and accretion of culturally loaded layers of new meanings. The natural course of trading in ideas and goods between nations produces a fluctuation in languages, which makes it difficult to fix the meanings of words in languages. However, justifying the philological procedure, numerical words were considered primitive and would be unaltered by frequent transformations and changes that languages undergo[15].

The philological collections of the "numerals of different peoples" are discussed in some detail in order to ascertain the affinities between the languages. This would enable the determination of the movement of peoples and with them notations and numerical words. This task is complicated by the philological caution that the affinity of words cannot be considered proof of the affinity of languages. The numerals of more or less all languages of Europe and Asia were similar, and when they did differ they did so only slightly. But this circumstance cannot support the hypothesis of a common language[16].

He turns to Schlegel's classification of languages into three great language groups. The first comprised of Indo-Pelasgic, Sanskrit, Greek and Latin, Persian, German and their derivatives. The second composed of the Slavonic languages comprising: Armenian, Russian, and Polish; and finally the Celtic languages including Welsh, Erse, Gaelic, Armorican, Basque of Biscay[17]. Evidently, this classification was inadequate and Peacock himself found this classification deficient. One of these deficiencies according to him arose from a working hypothesis among philologists "to trace up all existing languages to a small number of others, which they considered primitive". Historically, however the number of languages have diminished around large empires rather than increased, so the order of evolution as envisaged by the philologists runs contrary to that of events[18]. An important point worth noting here is that several of these new classifications of languages had hardly been in circulation for more than fifty years; and this may easily be one of the early histories of mathematics authored by a mathematician and not an Orientalist or Indologist that draws upon them in such a detailed discussion. Peiffer points out that three intellectual genealogies come together in Paul Tannery's project towards the end of the nineteenth century: Orientalism, the history of sciences proper, and positivism[19]. It could well be suggested that the conjuncture of Orientalism with the history of sciences and the history of mathematics and astronomy more specifically occurred much earlier due to the remarkable researches of a network of British Indologists working in India.

In order to approach the issue of the rise of numerals to ascertain the affinity of languages, questions that naturally arise: [1] do these numerals presently exist in "their original and unaltered form"; [2] have these numerals been mixed up with others without being coherently assimilated into the system; [3] "have they become dialects of a more predominant language"[20]. The languages of "barbarous and primitive peoples' still hold the promise, as they did for the Orientalists, of providing the answers to these questions.

This philological elaboration leads him to move the discussion from numerals to the consideration that these be considered as "records of systems of numeration". Of the different systems of numeration, Peacock considers the quinary, denary and vicenary as natural. Underlying his approach are two propositions; the first is that the widely adopted scales of numeration have generally been picked out of these natural scales. Secondly, and related to this is the idea "that amongst all nations practical methods of numeration have preceded the formation of numerical language"[21]. This further reiterates his break with any kind of a priorism as suggested earlier.

Against this backdrop, Peacock takes up the case of numerical words and searches for a system of naming numbers. Speaking of Tibetan he points out that the system of numerical words in that language has a simple structure and offers a close approach to a numerical notation. If this structure was constant or prevailed throughout the language then the Western system of numeration was deeply indebted to Tibet. The difficulties surrounding this claim had to do with the questions of "local value" and 'zero'[22]. In the subsequent section of the paper we encounter the first reference to the "Hindu method of numeration" that the latter consider has a divine origin. The source for this is Colebrooke's *Algebra with Arithmetic and Mensuration from the Sanscrit of Brahmagupta and Bhāscara*. This is easily the most important work on Indian Algebra and Arithmetic in the nineteenth century and a study of its reception would reveal how certain key notions concerning Indian mathematics stabilised within the writings of historians of mathematics[23]. Key ideas from his dissertation which appeared in the preface of *Algebra with Arithmetic* reappear in the writings of Peacock, De Morgan[24] and Boole.

Thus Peacock quotes a passage from Colebrooke's translation of Bhāskarācārya: "the invention of nine figures with device of place being ascribed to the beneficent creator of the Universe"[25]. The passage suggests to Peacock the

antiquity of a system "whose origin is lost in the remoteness of antiquity". Colebrooke's translation is itself textually linked up with the work of an earlier generation of Indologists, and their philological concerns and theories. These theories developed around the analogy between grammatical structure and the many roots of the classical languages of Europe and Sanskrit, suggesting that the East was the origin of tribes "whose progress to the West was attended by civilisation and empire…" Premised on this inference, Peacock proceeds to lay his procedure; namely to infer the state of development of the arithmetical system based on the common numerical words which those languages possessed before these tribes parted[26].

Setting down the Sanskrit names for the first ten numerals, Peacock proceeds to illustrate the law of formation of the higher number names[27]. He draws upon Nathaniel Brassey Halhed's *A Grammar of the Bengali Language*[28]. Halhed (1751-1830) was an Orientalist and grammarian, whose book is the earliest Bengali grammar in English, basing himself upon Bengali texts and letters. Having studied at Harrow and Oxford, he was acquainted with the father of British Indology, William Jones. It has been suggested that he approached his subject matter in the spirit of the Enlightenment and Bengali characters were first seen in print in his work on Bengali grammar[29]. Secondly, for Peacock the variety of digital arithmetic arises from the diversity of material practices. Drawing again upon Halhed's observations of the Bengali methods of counting by touching the joints of the fingers, Peacock feels these are related to the practices of commerce and business[30].

He sets out to explain the law of formation of number names in Sanskrit and returns to Colebrooke for he is surprised to encounter the "luxury of names for numbers" so large that they were of little use even in astronomical or business calculations. These number names ranging from 1 to 10^{17} in increasing powers of 10, had no parallel in any of the modern and ancient languages; which implies "a familiarity with the classification of numbers according to the decimal scale and the power of indefinite extension that it possesses, which would only arise from some very perfect system of numeration"[31] (emphasis mine). Thus while Colebrooke's translation is the source of the number names, Peacock's reading of the system goes beyond Colebrooke's arithmetical horizon. The familiarity with dealing with such large numbers is reflected in the enormous astronomical periods and the "extravagant cosmology"; and this familiarity with large numbers existed at a time

when other traditions "were incapable by any refinement of arithmetical notation, of expressing numbers beyond one hundred millions"[32].

This brings up differences in the understanding of Peacock and that offered in the history of Delambre[33], though Peacock does not underline this difference too stridently; for he is in agreement with other aspects of Delambre's *Histoire*. Delambre's reading of the translation of Bhāskara by Colebrooke led him to conclude that if the Indians had an algebraic notation he was unaware of it. According to the British Orientalists, the Hindus possessed first and second degree algebra and knew how to solve indeterminate equations. Though they created a universally received arithmetic, the conception of geometry was limited[34]. But the truly important question was to determine when the Indians reached this stage in the development of arithmetic. This would indicate the direction of transmission of the system of numeration. Delambre feels that this was possibly after the 11th century AD, for Bhāskara's treatise ignores earlier work that was composed in the previous century[35]. It is evident that Peacock, reposed far greater faith in the translations of his compatriot Orientalists. But having said that Delambre's *Arithmetique des Grecs* and *Histoire de l'astronomie* were canonised by the time Peacock's chapter was composed for the *Encyclopedia Metropolitana*; and served as a backdrop for conversation on the subject of the history of mathematics and the history of arithmetic in this particular case.

The introductory portion of the section on symbolic arithmetic commences with a discussion of Greek arithmetic and Peacock relies upon Delambre's *Arithmétique des Grecs*. As mentioned above, Peacock makes it quite clear that he is putting his eggs in Colebrooke's basket and considers Delambre's views on Indian numeration and notation to be a product of hubris[36]. Thus Peacock writes: "Delambre considers it *a fact humiliating of the pride of human genius that the discovery of the notation by nine digits and zero, should have escaped the sagacity of these illustrious men* (meaning the Greeks) especially when engaged in researches connected with the improvement of arithmetical language and notation" [37] (emphasis mine). Peacock on the other hand eschews presentism in pointing out that retrospectively the invention may appear simple but the ideas contained therein ran counter to the mental associations, in other words there was an epistemological obstacle that prevented the realization of these inventions. What was the nature of this obstacle? According to Peacock the Greeks had been "accustomed to the use of twenty seven independent symbols" all of which

may have appeared equally necessary for arithmetical notation. To show that only nine of them were necessary for arithmetical operations was a non-trivial task. Having arrived at this conclusion the next step was to employ these operations to express numbers that in turn necessitated the invention of the zero and the device of place, "both of them refinements of a nature not easily discovered. The Greeks also were ignorant of the advantages of notation as distinct from language"[38]. There were thus three steps in the process to the completion of this system of numeration; and Peacock charts out the process diachronically for the Indian case and in a comparative way proffers an explanation of why the Greeks did not develop such a system of numeration.

We would then have to ask as to the reason why the Indian system of symbolical arithmetic superseded "other species of numeral symbols, both in Asia and Europe"[39], or on what grounds did Peacock accept the Indological argument concerning the antiquity of the Hindu system of arithmetic. The first explanation evoked is the internal evidence of the numerical language. However, one of the founders of French Indology, and more or less a contemporary of William Jones, Abraham Hyacinthe Anquetil Duperron (1731-1805) had pointed out that like in the ancient Greek three classes of numerical letters were distributed through ancient Sanskrit. Peacock, finally accorded priority to a notation "with nine figures and a zero" on the pragmatic grounds that an inconvenient notation could not have been adopted when an efficient one was already available. However, Duperron, Peacock reckons, is no push over as an Indologist, and has to take on his views carefully. Thus he points out that the views of "this very fanciful and learned author" were not corroborated by the researches of the British Indologists who according to him "were incomparably better acquainted with the antiquities of the Sanscrit language than himself"[40]. One of the criticisms about Duperron had been that his access to the Sanskrit world had been through the Persian translations of the Upanishads by the Mughal prince Dara Shikoh; while the British Indologists were discovering and translating original Sanskrit texts into English. In any case, the only of Duperron's works referred to by Peacock is the former's translation of the Zendavesta [41].

The problem thus reduces to establishing the antiquity of the invention of this numerical system based on the testimony of "Sanskrit sources"[42] ; and this was available to Peacock in Taylor's translation of the *Līlāvatī*, Strachey's translation of the *Bījagaṇita* and Colebrooke's translation of both texts. In

Peacock's chapter there is hardly any discussion around the translations of Taylor and Strachey, on the contrary Colebrooke is "an author equally remarkable for his profound knowledge of oriental literature, and for his great scientific acquirements"[43]. In Peacock's eyes, Colebrooke's translation had incontrovertibly established: [1] That the author of the text *Siddhānta Śiromaṇi*, Bhāskara, had lived in the middle of the XIIth century of the Christian era, [2] Brahmagupta, author of extant treatises on arithmetic and mensuration, lived in the early part of the seventh century AD, and Bhāskara refers to his work, [3] Āryabhaṭa, author of a treatise on algebra and arithmetic, flourished in the 5th century AD, and was "the oldest of their uninspired and merely human writers", who is referred to by Brahmagupta[44].

From the above Peacock is satisfied that there is substantial evidence to conclude that:

[1] Hindu algebra and arithmetic were as ancient as the work of Diophantus. [2] This tradition preceded the introduction of the above sciences among the Arabs by four centuries. [3] Āryabhaṭa, Brahmagupta and Bhāskara do not mention the invention of the notation by nine digits and zero, but as "the benefactions of Deity". This was proof of an "antiquity antecedent to all existing records" of the system of numeration[45].

It is interesting that in tracing the linkages between Āryabhaṭa and Bhāskara, Peacock is gesturing towards not only a genealogy of the arithmetical tradition in India but also towards a continuity of the tradition spanning several centuries; in which case the ideas of Bhāskara from the XIIth century cannot be singled out as the first occurrence, as Delambre had hinted, of the system of numeration in the tradition.

As further evidence of the antiquity of this system of numeration among the Hindus, Peacock cites the engraving on a copper plate discovered by the British Indologist Charles Wilkins (1749-1836), who authored *A Grammar of Sanskrit*[46]. The copper plate engraving refers to a land grant and interests Peacock in as much as it reveals the existence of a notation, for the date on the plate is inscribed in figures, and corresponds to the 23rd century before the Christian era[47]. This clinches the issue as far as the antiquity of the system among the Hindus is concerned: "long before the Persian, Arab, or any other people"[48]. The logical step then is to fix the date of transmission of this notation from India to the Arab world. Again the historical authority cited by Peacock is the 'dissertation"

of Colebrooke[49]. The testimony of the Arab sources themselves was seen to be decisively indicative of "the source from which" they obtained the notation[50].

The issue of the source of the system of numeration was an important one at the time. There were however mathematicians and historians of mathematics in early nineteenth century France such as Michel Chasles who argued that the Christians possessed a number system that is the same as ours today but was inherited from the Greeks, and that they received nothing concerning numbers from the Arabs[51]. These numerals appear in the work of a Pseudo-Boethius who was influenced by Gerbert from Aurillac in Auvergne. Gerbert of Aurillac is otherwise is credited with introducing Arab numerals in to Europe in the latter part of the Xth century. Peacock is very sceptical about this claim of a Pseudo-Boethius and shares Colebrooke's assessment on this matter, arguing that even if the system was known to Gerbert, it "was barren in his hands", since there were no traces left in his works, that of his contemporaries, or his successors[52].

For the purpose of this paper, I shall not proceed with the resolution of this controversy and the dismissal of the last mentioned claims in the work of Delambre. But point out that Peacock's subsequent discussion on the progress of arithmetic, following the introduction of Arabic numerals proceeds through a thematic discussion and not a discussion of authors. This diachrony proceeds from a discussion on numeration "in a regular series through the common operations of Arithmetic"[53]. And here again he sets out his departure from the *Histoire* of Delambre. Thus while acknowledging the advantages of "a regular analysis of the works of the principal writers, a plan which has been adopted so successfully by Delambre in his *History of Astronomy*"[54], Peacock chooses another path for his own opus.

Subsequently, in the thematic discussion on mathematical operations in section 100, he commences with a mention of eight fundamental operations of arithmetic as given in the *Līlāvatī*[55], basing himself on Colebrooke's translation. In a footnote he cites an earlier work, the *Brāhma-sphuṭa siddhānta*, whose twelfth chapter deals with arithmetic. The passage cited has for Peacock a very contemporary ring to it. He informs his readership that this text commences by defining "the knowledge which constitutes a *gaṇaka* or calculator". Brahmagupta writes:

> "He who distinctly and severally knows addition and the rest of the twenty logistics and the eight determinations, including measurement by shadow, is a calculator"[56] (emphasis mine).

The logistics mentioned here include the 5 rules for reducing fractions, the rule of 3 terms, 5 terms, 7 terms, 9 terms, 11 terms and the eight fundamental operations of arithmetic.

This definition appeals to Peacock's own project that saw two parts to the science of algebra, namely arithmetical algebra and symbolical algebra. Arithmetical algebra was defined as follows: "In arithmetical algebra we consider symbols as representing numbers, and the operations to which they are submitted as included in the same definitions as in common arithmetic…"[57]. This concurs with his conception of arithmetic as set out in his introduction to the larger chapter on the history of arithmetic. Further, the discussion on the Hindu system of numeration and notation is central to his reconstruction of the arithmetical field. This is evident in the reciprocities noticed between the definition of "calculation" in the Indian tradition and arithmetical algebra as conceived by Peacock himself.

Concluding with the Indian sources in Peacock's *Arithmetic*, it is evident that he relied on the works of the British Indologists, and in particular he reposed an unquestionable faith in Colebrooke's *Algebra and Arithmetic*. This view of Indian mathematics was the culmination of the school of British Indologists who held sway between 1780 and 1820 and included William Jones, N.B. Halhed, Charles Wilkins, Ruben Burrow, Samuel Davis and several others, who laid the foundations of Indology as a discipline. The point I would like to suggest here is the canonization of Colebrooke's magnum opus was rendered possible through the repeated allusions to this work in the writings of Peacock, August De Morgan and George Boole[58]. All three were members of the symbolical school of mathematics, subscribing to a modern abstract approach to algebra, and committed to securing for algebra a place in British liberal education[59]. On this count the engagement of the latter two mathematicians with the history and pedagogy of mathematics in India was significant. De Morgan himself was to write to a British official in India: "I have always regarded the old science of India with particular attention…"[60]. This also indicates that the circle of British algebrists was clued into the activities of the network of British Indologists, and indicates the historical juncture wherein the corpus of knowledge produced by the latter was incorporated in to histories of mathematics. This intersection of pedagogic orientation and historical interest must give us cause to think about the close relationship in the nineteenth century between these two activities. Boole, De Morgan and Peacock

would plunge into Colebrooke's translations of the Indian mathematical *siddhāntas*, to find a representation of the Indian mathematical tradition. Their standing in the world of algebraists would enable the canonization of Colebrooke's representation of the Indian mathematical tradition as an algebraic one, and this would materialize in standard histories of mathematics that began to appear by the turn of the nineteenth century. There remains the question of the spatio-cultural frame within which these histories were set. For the late eighteenth and most of the nineteenth centuries the history of sciences when engaging with the antiquity of the sciences internalised the concept of "civilization" within which these early histories were organized and then narrativised – the concept was itself possibly a mid eighteenth century French invention. And this legacy and partitioning of the world into civilizations with corresponding orderings of knowledge, number and form would be part of an unchallenged legacy of the history of science for another century.

Notes and References

1.   A.C. Crombie. *Styles of Scientific Thinking in the European Tradition : The History of Argument and Explanation especially in the Mathematical and Biomedical Sciences and Arts*, Volumes I and III, Duckworth, 1994; Rachel Laudan,. "Histories of the Sciences and their Uses: A Review to 1913", *History of Science*, (1993), xxxi, pp.1-34.

2.   Thomas F. Gieryn,. "Boundaries of Science", in Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch (Eds.), *Handbook of Science and Technology Studies*, Sage Publications, 1994, 393-443.

3.   François Charette, Orientalisme et historie des sciences: L'historiographie des sciences islamiques et hindoues, 1784-1900; M.A. Thesis, Department of History, University of Montreal, 1995 ; Laudan, op. cit. (1) ; Dhruv Raina. *Nationalism, Institutional Science and the Politics of Knowledge: Ancient Indian Astronomy and Mathematics in the Landscape of French Enlightenment Historiography*, Institutionen för vetenskapsteori, Göteborgs Universitet, Rapport Nr. 201, 1999.

4.   George Peacock. "Arithmetic" in *Encyclopedia Metropolitana: Or System of Universal Knowledge on a Methodical Plan Projected by Samuel Taylor Coleridge*, 2nd Edition, London, 1845.

5.   Marie-José Durand-Richard,."L'Impact des Travaux de l'Ecole Algébrique Anglaise dans les Journaux Scientifique Autour de 1830 », *Riv. Stor. Sci*, 1995 (S.II), 3 (2), 119-156, 127. For more details on Peacock see Agathe Keller. "Peacock in the Land of Peacock? Gregory Peacock's Arithmetic in the Historiography of Mathematics in India", *present volume*.

6.   I.Bernard Cohen. *Revolution in Science*, Belknap Press of Harvard University, 1985.

7.   Peacock, op. cit. (4).

8.   Marie-José Durand-Richard. « Genèse de l'algèbre en Angleterre : une influence possible de J.Locke », *Rev.Hist.Sci.* (1990), XLIII/2-3, pp. 129-180. ; Marie-José Durand-Richard. « L'École algébrique anglaise : les conditions conceptuelles et institutionnelles d'un calcul symbolique comme fondement de la connaissance », in Catherine Goldstein, Jeremy Gray and Jim Ritter (Eds.), *Mathematical Europe : Myths, History, Identity*, Éditions de la maison des sciences de l' homme, Paris (1996) pp. 447-477.

9.   The history of mathmatics has been conceived very diversely as a discipline: on the one hand it is seen to lie at the intersection of mathematics, Orientalism and positivism: see Jeanne Peiffer, "France", in J.Dauben and C.J.Scriba (Eds.), *Writing the History of Mathematics: its Historical Development*, Birkhäuser –Basel, 2000. On the other hand it is located in the territory between mathematics, natural science and the social sciences: see Hans Wußing.. "Historiography of Mathematics: Aims, Methods and Tasks", in W.R.Woodward and R.S.Cohen (Eds.), *World Views and Scientific Discipline Formation*, Kluwer Academic Publishers, (1991), pp. 63-73, 63.

10. Charrette, op. cit. (3) ; Raina, op. cit. (3).

11. To avoid presentism the term theory of numbers is employed rather than number theory which represents to a specific stage and theory in the development of mathematics as a discipline.

12. Peacock, op. cit. (4), p. 369.

13. Peacock, op. cit. (4), p. 369.

14. Durand-Richard, 1996, op. cit. (4), 467.The basic operations of arithmetic are addition, subtraction, multiplication and division from which more complicated operations can be developed. But even of these take addition as a basic operation that involves combining two numbers into a single one. In which case subtraction can be seen as the opposite or reciprocal of this operation involving the calculation of the difference between two numbers. With subtraction being the reciprocal of addition, multiplication becomes the second basic operation and division its opposite or reciprocal.

15. Peacock, op. cit. (4), p. 371.

16. Peacock, op. cit. (4), p. 372.

17. Peacock, op. cit. (4), p. 372.

18. Peacock, op. cit. (4), p. 372.

19. Peiffer, op. cit. (9).

20. Peacock, op. cit. (4), p. 372.

21. Peacock, op. cit. (4), p. 371.

22. Peacock, op. cit. (4), p. 374.

23. Dhruv Raina. "Science East and West", in Helaine Selin (Ed.), *Encyclopedia of the History of Science, Technology and Medicine in Non-western Cultures*, Springer-Verlag (2008) pp. 1934-1943.

24. Dhruv Raina and S.Irfan Habib. "Ramchandra's treatise through The Haze of the Golden sunset: An aborted pedagogy*",Social Studies of Science,* 20 (1990) 455-172; Dhruv Raina. "Mathematical Foundations of a Cultural Project or Ramchandra's Treatise Through the Unsentimentalized Light of Mathematics", *Historia Mathematica,* 1992XIX, pp. 371-384.

25. H.T. Colebrooke. *Algebra with Arithmetic and Mensuration from the Sanscrit of Brahmagupta and Bhāscara*. Translated by H.T.Colebrooke. London: John Murray, 1817, p. 4; quoted in Peacock, op. cit. (4), 374.

26. Peacock, op. cit. (4), p. 374.

27. Peacock, op. cit. (4), p. 374.

28. Nathaniel Brassey Halhed. *A Grammar of the Bengali Language*, printed in Hooghly, 1788.

29. Muhammad Abdul Qayyum.. *A Critical Study of Early Bengali Grammars*, Asiatic Society, Dhaka, 2004; Banglapedia: National Encyclopedia of Bangladesh, Asiatic Society of Bangladesh, Multimedia CD, 2004; (cf. also http://banglapedia.search.com.bd'/HT/H-0031.htm; and http://banglapedia.search.com.bd/HT/W_0063.htm).

30. Peacock, op. cit. (4), p. 394.

31. Peacock, op. cit. (4), p. 374.

32. Peacock, op. cit. (4), p. 375.

33. Jean-Baptiste Joseph Delambre. *Histoire d'astronomie ancienne*, Tome 1. Paris: Imprimeur Libraire pour les Sciences, 1817.

34. Delambre, op. cit. (32), p. 556.

35. Delambre, op. cit. (32), p. 556. For a detailed discussion see: Dhruv Raina. "Disciplinary Boundaries and Civilisational Encounter: the Mathematics and Astronomy of India in Delambre's Histoire (1800-1820)", *Studies in History*, 17 (2001) 2.

36. This seems to be a singular instance where Peacock differs with the canonized works of Delambre, on most other occasions cited he does so in agreement or cites him as an authority authenticating his own perspectives.

37. Peacock, op. cit. (4), p. 404.

38. Peacock, op. cit. (4), p. 404.

39. Peacock, op. cit. (4), p. 407.

40. Peacock, op. cit. (4), p. 412.

41. Abraham Hyacinthe Anquetil-Duperron. *Zend Avesta*, vol. 1, Paris, 1771, p. 172.

42. Peacock, op. cit. (4), 412. Keller rightly points out, debates on the priority of invention of the numerical system were often heated and acrimonious: see Keller, op. cit. (5). For a recent account of the transmission of the decimal system from India to the West via the Arabs, see Menso Folkerts.. "Early texts on Hindu-Arabic Calculations", *Science in Context* 14, 1 / 2 (2001) 13-38; and for an exhaustive summary of the different arguments proposed in favour off and in opposition to the priority of the Indian invention see the classic by Georges Ifrah. *The Universal History of Numbers II*, The Harwell Press, 2000.

43. Peacock, op. cit. (4), p. 412.

44. Peacock, op. cit. (4), p. 412.

45. Peacock, op. cit. (4), p. 412-3.

46. Charles Wilkins (1749-1836) may have been the first British Indologist to read Sanskrit inscriptions, and his readings of Sanskrit epigraphs laid the foundation of epigraphic and paleographic studies: see Charles Wilkins. *Sanskrit Grammar*. London; Printed for C.Nouse1785. Wilkins' was aided by Pundit Panchanan in the preparation of Bengali and Persian typefaces. Thus the trajectory of Wilkins' life closely intersects with that of Halhed, since the preparation of a Bengali typeface enabled the publication of the first typeset book in Bengali, namely Halhed's *A Grammar of the Bengali Language* mentioned earlier. Halhed was thus indebted to the polymath Wilkins whom he felt was a metallurgist, engraver, and printer. From 1788, Wilkins began publishing the research journal *Asiatick Researches* that was to become the official organ and research journal of the Asiatic Society: see *Banglapedia*, 2004.

47. Wilkins, p. 127, cited in Peacock, op. cit. (4), p. 413.

48. Peacock, op. cit. (4), p. 413.

49. Colebrooke, op. cit. (24), p. 69.

50. Peacock, op. cit. (4), p. 413.

51. Michel Chasles, *Histoire de l'arithmetique*, 1843, p. 28, Bibliotheque Nationale V.13349. For more discussion on the same see Dhruv Raina, *Nationalism, Institutional Science*

and the Politics of Knowledge: Ancient Indian Astronomy and Mathematics in the Landscape of French Enlightenment Historiography, Institutionen för vetenskapsteori, Göteborgs Universitet, Rapport Nr. 201, ISSN 0348-5560, 1999, pp. 248-250.

52. Peacock, op. cit. (4), p. 416.

53. Peacock, op. cit. (4), p. 425.

54. Peacock, op. cit. (4), p. 425.

55. Peacock, op. cit. (4), p. 427.

56. Brahmagupta cited in Peacock, op. cit. (4), p. 427.

57. Peacock quoted in Alexander Macfarlane. *Lectures on Ten British Mathematicians of the Nineteenth Century*, Mathematical Monographs (Eds.) Mansfield Merriman and Robert S.Woodward, No. 17, 1916, p. 6.

58. It would be interesting to ask where Colebrooke came from. It has been argued elsewhere that Colebrooke's work can be seen as the "mopping-up operation" of a research programme set out on paper by the Scottish mathematician John Playfair (1748-1819): see Raina, op. cit. (22). Playfair's genealogy clearly intsersects with that of the analytics for the terms "analysis" and "synthesis" are used in several senses; referring not just to the differing styles of mathematical practice in England and France, but equally to distinct approaches to mathematics education, not to mention his proximity to the Common Sense philosophers: see Amy Ackerberg-Hastings. "Analysis and Synthesis in John Playfair's Elements of Geometry", *British Journal of History of Science*, 35 (2002) 43-72. This is not to suggest that Colebrooke was one with the analytics, but that he was deeply influenced by Playfair.

59. Helena Pycior. "Augustus De Morgan's algebraic Work: The Three Stages", *Isis*, 74 (1983) 211-26; Raina and Habib, op.cit. (23); Raina (23). While the wider network of mathematicians included figures such as Babbage, Herschel, Gregory and others, their collective goal was not just the creation of abstract algebra but the whole scale reform of science and the organization of science. Durand-Richard offers a social epistemology of the emergence of this school in Britain in terms of one of the several outcomes of the Industrial Revolution Marie-José Durand-Richard. « Révolution Industrielle : Logique et Signification de l'Opératoire », *Revue de synthèse*, 4e sér, 2-3-4 (2001) 319-346, 341.

60. De Morgan, quoted in Raina and Habib, op. cit. (23).