INTERACTION OF SCIENTIFIC IDEAS IN THE ASIAN CULTURE AREA*

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Asian countries, over the centuries, interacted with each other socially, culturally and politically and exchanged ideas in different fields of science and technology. This interaction took place through traders and travellers, through scholars who travelled in search of knowledge and patronage or through the migration of people.

One of the contributors, the most commonly used channel, the catalyst among these interacting Asian countries was India--geographically at an advantage, intellectually aware, financially secure. India, the birth place of the single most revolutionising concept in the history of mathematics--the zero, transmitted and received ideas and thoughts from most of Asia, particularly Babylonia, China, west and central Asia. The seed of transmission was sowed by traders. Commercial contacts provided the springboard for the more fruitful cultural and, as a natural outcome, scientific contacts. India's commercial and scientific contacts with western Asia and Egypt extend to prehistoric times. In the Ninth Century B.C., intercourse existed between India and Assyria and the commercial merchants were ingenious enough to find an alternative to the hazardous mountain passes, by adopting the Persian Gulf route.[1] From 606 B.C. following the overthrow of the Assyrian empire, Babylon replaced Nineveh as the great trading centre in western Asia where Ionian traders, Jewish captives, Phoenician merchants and the Indian tradesmen from the Punjab regularly met and exchanged their merchandise.[2] A series of recent archaeological finds from Ur, Harappa and Mohenjo-daro have provided sufficient clues to establish the antiquity of India's relationship with western Asia to the Third Millenium B.C., when the ancient Indus cities were in regular and intimate contact with the Sumerian cities of Iraq. It is an established fact that Western scientific tradition was influenced by, even derived from, the Sumerians. Sumer has played a vital role in the development of western civilization. And Sumer in its turn, like other civilizations, was influenced by Indian ideas, travelled as they did, on the above mentioned commercial routes. So the fact emerges that India was one of the contributors to the formation of the modern western civilization--a fact discussed and established by Childe.[3] The interaction between China and India developed mainly due to

*Adapted form Irfan Habib, "Interaction of Scientific Ideas in the Asian Culture Area", in *Science and Technology in Indian Culture: A Historical Perspective*, edited by A. Rahman, National Institute of Science, Technology & Development Studies, (New Delhi: 1984), pp. 143-152 the opening of the overland silk routes. The spread of Buddhism into China further stimulated the process of transmission in the realm of ideas. With the birth of Islam towards the end of the seventh century and its consequent expansion, links between central and west Asia and the rest of the continent were strengthened. At the turn of the century, meaningful contacts were established with India which gradually led to fruitful interaction in various fields including astronomy and mathematics.

INTERACTION OF IDEAS BETWEEN THE INDUS VALLEY AND THE PEOPLE OF THE TIGRIS EUPHRATES BASIN

India's commercial and scientific contacts with the cultures of western Asia and Egypt extend to pre-historic times. Dulaurier, Wilkinson and others have referred to the Egyptian practice of wrapping their mummies with Indian muslin and of dying cloth with indigo. The word 'Sindhu' found in the old Babylonian tablets of the Seventh Century B.C. was interpreted by Lassen and Sayce as meaning cotton cloth the word being derived from Sanskrit.[4] Herodotus also refers to 'Sindhu', a cloth which was used in Egypt, Babylon and the Levant.

We find mention of Indo-Babylonian trade in one of the 'Jataka' stories as well. The 'Baberu Jataka'[5] writes that Indian merchants used to make periodic voyages to the land of Beberu or Babylon. In the course of these commercial contacts a significant interaction took place in the field of astronomy and mathematics. It has long been known that the seven day week and the division of the sky into 24 'naksatras' were derived from Babylonian sources. The idea of epicyclic astronomy developed by Aryabhata and subsequent Indian astronomers was most likely derived from Babylonian sources.[6] Pradyumna and Vijayanandin, who preceded Aryabhata, made a study of the superior and inferior planets and in the process were led to Babylonian sources and ideas. Indian knowledge of the method of separation of planetary inequalities produced by the gods of 'Manda' and 'Sighra' is also said to have been received from Babylonian astronomy. Neugebauer[7] has also given some specific instances of the influence of Babylonian astronomy on the Indian astronomy. The 'Panca Siddhantika' of Varahamihira, composed around 550 A.D. contains certain rules (in the Vasistha Siddhanta) for the computation of the lunar motion. The interpretation of these rules leads to the value of the anamolistic month as 27, 33, 16, 26, 11...which is in remarkable agreement with the Babylonian value of 27, 33, 16, 26, 54. Any further emphasis on the question of transmission of Babylonian ideas and methods into Indian astronomy seems unnecessary.

INTERACTION BETWEEN INDIA AND CHINA/SOUTHEAST ASIA

The Sino-Indian relations developed mainly due to the opening of the overland silk routes by the efforts of the Chinese diplomat Chang Chhien whom Needham has called a 'Seric

Livingstone'.[8] The links of the two culture areas were further cemented through Buddhism and gradually a multi-dimensional relationship was established. In 90 A.D., there were diplomatic and other contacts between the Chinese and Kushans who under the great Kanishka were about to conquer the whole of northern India.[9] Throughout this period, the Khotan region was a meeting place of Indian, Iranian, Greek and Chinese civilizations. The great period of Buddhist interchange, however, began from the time of Yuch-Chih Dharamaraksha (Third and Fourth Centuries A.D.). Renowned Buddhist scholars from all parts of India visited China by land and by sea, spent many years there, preaching the Buddhist doctrine and translating canonical texts. This was reciprocated by Chinese scholars and monks like Fa-hien, Huan-Chuang, I-tsing, and many others. In view of such prolonged religious and cultural contacts, it is natural to expect considerable interaction and cross-fertilization of scientific ideas between China and India. This topic has been studied and interpreted before, but only in the light of religion--from a theological perspective so to say. No one, except Joseph Needham, tackled it as possible material for the history of science, or as an invaluable insight into the interaction of Asian societies in the fields of science and technology.

There was a significant interaction of ideas between China and India in the spheres of astronomy and mathematics. In 636 A.D., Wei-Cheng completed a catalogue of the Sui dynasty in which a number of works began with 'Po-lo-men' meaning 'Brahamanical', dealing with Hindu mathematics and astronomy.[10] There is evidence enough to show that numerous Indian astronomers were working in China during the rule of the Thang emperors.[11] Chang-Nan, in the Seventh Century, had a small Astronomical Board where three Indian Siddhantas, the 'Gautam', the 'Kasyapa', and the 'Kumara' used to be taught. In the records of the Thang dynasty, there is a reference to four astronomers all being named Chutan, which is a Chinese translation of the Hindu name Gautam.[12] One of them, Chutan-Chuan composed a calendar for the first Thang emperor Kao-Isu. Another astronomer Chutan-lo was president of the aforementioned Astronomical Board. In the first half of the Eighth Century, another Hindu-Chinese astrologer named Chutan-Hsita, the Chinese version of the Sanskrit name Gautam Sidha, wrote an important treatise on Tantric divination and astrology, and translated a Sanskrit calendar under the Chinese title 'Chiu-Chi-li'. The translation is significant because it discusses Hindu decimal notation and arithmetical rules, and is probably responsible for the introduction in China of these Hindu notations and rules. Chutan-Hsita further remarked[13] that "with these numerals, calculation is easy to the eyes." According to Werner, the Chinese adopted the Indian decimal system and notations introduced by the Buddhists and replaced their custom of writing figures from top to bottom with the Indian method of proceeding from left to right.[14] In the same century, the Chinese Tantric-Buddhist, I-Hsing, was asked to investigate the chronological and arithmetical ideas brought to China from India by Chutan-Hsita. Sarton observes:

> The Chinese treatises of Chutan-Hsita and I-Hsing are of special value as witnesses of the penetration of Hindu mathematics into China. It is possible that the Hindu numerals were introduced into China at this time.[15]

When the Indian numerals were first introduced in China in the Eighth Century, a dot was used for zero. A small circle as the symbol for zero is first found in print in the Chinese work *Su Shu Chiu Chang* (Mathematical Treatise in Nine Sections) of Chhin Chiu-Shao of 1247 A.D.,[16] but many scholars believe[17] that it was in use already during the preceding century.

There are a number of examples of the transmission of ideas in the field of mathematics from China to India. *Chiu Chang Suan Shu* (Arithmetic in Nine Sections) is the greatest Chinese arithmetical classic compiled in the Second Century B.C. by Chang T'sang out of the fragments of earlier works which are believed, by the Chinese, to have been composed in 2700 B.C.[18] This book gives the area of a segment of a circle as 1/2(C+a)a, where C is the chord and a, the altitude of the segment. This rule is found in the work of Mahavira. The diameter of a sphere is given by 3 16/9 x volume, an erroneous rule found in Aryabhata. Another arithmetical classic, *Sun-Tzu Suan-China,* written by Sun-Tzu in the First Century A.D., discusses among other things solutions to indeterminate equations of the first degree. The examples given by Sun-Tzu in this case bear resemblance with those given by Brahmgupta. *Hai-tao Suan-Ching* (Sea-Island Arthmetical Classic), composed by Liu Hui in the Third Century A.D., discusses problems concerning the measurement of the distance of an island from the shore. These problems reappear in Aryabhata's 'Ganita'.[19]

Indian contacts with Southeast Asia began in the First Century B.C. and were firmly established by the Fifth Century A.D. Inscriptions show that there were close links between many Southeast Asian regions and the Tamil kingdoms, particularly during the period of the Chola Dynasty (Ninth to Thirteenth Century A.D.). There were Tamil trading settlements at this time at Baros in Western Sumatra and Takuapa on the Kra Isthmus.[20] This exchange began with trade and commerce but later a great amount of interaction took place in the field of science and culture, particularly in mathematics. Whereas the first epigraphic evidence for zero occurs in India in the Bhojadeva inscriptions at Gwalior, around 870 A.D., much earlier records illustrating the use of place value come from Cambodia (604 A.D.), Champa (609 A.D.), and Java (732 A.D.).[21] A Cambodian inscription of 683 A.D. uses the dot or 'bindu' to represent zero. These are no doubt the result of the Hindu influence in Southeast Asia. This mutual process of give and take went far in enriching these ancient Eastern cultures, so much so that the influence can be easily comprehended even today.

INTERACTION BETWEEN INDIA AND WEST/CENTRAL ASIA

The transmission of ideas from India to West Asia began with the establishment of trade centres on the Malabar coast of South India in the Seventh Century A.D. During the Eighth and Ninth Centuries, the Arabs were prompted by their intellectual curiosity, rationalist speculation and spirit of scientific inquiry to go to far off countries to find out what others were doing and thinking, to study and understand their philosophies and sciences and then to develop their own thought. This spirit brought several Arab travellers to India. The greatest of them all was Al-Beruni, who not only studied Indian sciences but also presented a comparative account of the Indian, Greek and West Asian knowledge of science and technology. His 'Tarikh-al-Hind' was certainly a great attempt in the direction of Indo-Arab interaction in the various fields of S&T. This interaction was stimulated during the reign of the Abbasid Caliphs in Baghdad through 'Baitul-Hikma' (House of Wisdom). During this period, Indian scientific texts on astronomy, mathematics and medicine were translated into Arabic and became the foundation of Arabic Renaissance. The level and degree of impact of the scientific and technological interaction can be judged by something mentioned by Ibn-Sina. Referring to Ismaili propagandists, he says:

> Presently they began to invite me to join the movement, rolling in their tongues talk about philosophy, geometry, Indian arithmetic, and my father sent me to a certain vegetable seller who used Indian arithmetic, so that I might learn from him.[22]

The interest in scientific astronomy was aroused, among the Arabs, by the knowledge that the Hindus of India, and the Persians of the Sassanian period, had cultivated among themselves a better and more scientific system of astronomy which was indispensable for making accurate and reliable calendars. This interest was stimulated after the translation of a Persian book on astronomy titled *Zij-al Shahriyar* into Arabic by Ali-ibn-Ziyad Altamimi. We have it from Al-Beruni that 'Shatro-ayar', 'Zij-al-Shaharyar' in Arabic, was itself based on Hindu astronomical methods of computation and parameters.[23] In the preface of his astronomical tables *Nazm-al-iqd* Ibn-al-Adami reports that an Indian astronomer, well versed in the science, visited Al-Mansur's court with the equations of planets according to the mean notions with observations relative to both solar and lunar eclipses and the ascension of signs.[24] Abu-Mashar of Balkh, an astrologer in the court of Al-Mansur, mentions an Indian astronomer from whom he derived the knowledge of the Hindu great cycle of the 'Kalpa'. The Caliph Al-Mansur ordered the translation of Brahmgupta's *Brahmanphutasiddhanta* and *Khandakadhyaka* into Arabic by Muhamanad ibn Ibrahim al-Fazari and Yaqub ibn Tariq with the assistance of Hindu pandits.[25] In the Arabic version, these treatises were called *Sindhind* and *Arkand.* These treatises exercised great influence among the Arab scholars, introduced to them a new scientific astronomy and initiated them in the higher branches of mathematics, particularly algebra and trigonometry. It is believed that it was at this time that the Hindu numerals were introduced among the Arabs.[26]

Another important figure who stimulated this process of transmission was al-Khawarizmi. He learnt Sanskrit, prepared an abridged version of *Sindhind* and wrote on arithmetic, explaining the Hindu system of numeration.[27] This book is not available in original but we have its Latin version, titled *Liber Algorismi de Numero Indorum* (the Book of al-Khawarizmi on Indian Numerals) possibly by Adelard of Bath[28] or by Robert of Chester. According to Ibn al-Qifti's indication, the title of the Arabic original may have been like 'Kitab hisab al-added al-Hindi' (Treatise on Calculation with Hindu Numerals). J. Ruska[29] visualises its title as "Book of Addition and Subtraction by the Method of Calculation of the Hindus." The Syrian Ibn Wahshiya, in his work *Ancient Alphabets and Hieroglyphic Characters Explained Etc.* (855 A.D.), gives three forms of Hindu numerals as three species of Hindu alphabets which shows that the forms were well known in his time in Arabia.[30] Al-Jahiz also mentions Indian numerals as 'Figures of Hind'.[31] Abu Yusuf al-Kindi and al-Dinawari, each wrote a tract on Indian computation called *Hisabul Hindi*.[32] Al-Dinawari was a lawyer and attempted to introduce Hindu methods of business. Abul-Hasan al-Uqlidisi wrote his *Kitab al-Fusul fi al-Hisab al-Hindi* (Book on Principles of Hindu Computation) in Arabic at Damascus in 952/953 A.D.[33] It is said that this is the earliest available Arabic book that gives an account of the Indian system. Al-Uqlidisi has written in the introduction of the book that he travelled extensively and read almost all the books he could find on Indian arithmetic. He has dealt with Hindu numerals and placed valuable notation in the first chapter of his work and has also made several interesting suggestions like these:

1. Modifications of Indian schemes whereby the (dust) abacus can be dispensed with, and ink and paper used instead.

2. Greek letters might replace the nine Indian numerals.

3. The Indian numerals with super-imposed dots might form a new Arabic alphabet.[34]

Al-Beruni, as referred to earlier, played a unique role in transmitting the knowledge of Indian mathematics, astronomy, and other sciences to the West and Central Asia. During his stay in India in the Eleventh Century, he not only studied Indian science, but compared it with the sciences of the other culture areas. He has given a detailed account of the Indian numerals in his two books, namely *Kitab al-arqam* (Book of Ciphers), and *A Treatise on Arithmetic and the System of Counting with the Ciphers of Sindh and India*. In his *Athar al-Baqiyah* (Vestiges of the Past), written in 1000 A.D., Al-Beruni calls the then modern numerals 'al-arqam al-hind', i.e. 'the Indian ciphers', distinguishing them from other systems.[35] His knowledge of Indian numerals is expressed in the following words:

> As in different parts of India, the letters have different shape, the numeral signs too, which are called 'anka', differ. The numeral signs which we use are derived from the finest forms of Hindu signs.[36]

Severes Sebokht, a bishop of Qen-neshre in the middle of the Seventh Century, referred to the Hindu numerals in one of his fragments.[37] He paid tribute not only to Indian science, but to the science of the East, when he wrote:

> ...their (the Hindus) subtle discoveries in astronomy, discoveries that are more ingenious than those of the Greeks and the Babylonians; their valuable methods of calculation; and their computing, which surpasses description. I wish only to say that this computation is done by means of nine signs. If those who believe, because they speak Greek, that they have reached the limits of science, should know these things, they would be convinced that there are also others who know something[38]

A look at these historical developments brings out one fact very clearly, that the centres of science and technology have been shifting from one cultural area to another. This could not have taken place without the transmission of ideas. Those "wisemen of the East" knew the value of transmission and however arduous the means, they hardly ever failed to seek and imbibe the best from each other. Interaction of ideas was one of the reasons why these Asian cultures flourished. It was also responsible for supplying the basic tools for the present day western scientific tradition, particularly in the fields of astronomy and mathematics. India and China started learning from each other around the Third Century A.D. This interaction accelerated and reached a sort of peak in the Seventh Century A.D. About this time, Islam started to grow and finally established itself in Central Asia. This in a way came between China and India. Interaction between the two began to cease gradually and nearly petered off by the Eleventh Century A.D. The period between Eighth to Thirtieth Centuries A.D. was the high watermark of Indo-West Asian and Indo-Central Asian interaction.

I hope, in this paper, enough evidence has been gathered to dispel the biased notion that Asians as a people were unscientific. In the early centuries, they were ahead of the Europeans. It was only later when the Europeans, particularly the British, grew in power that the Asian societies succumbed to the West and started to interpret each other through the guidelines fed to them by the West. The tragedy, or should we say the irony of the situation is that they are lagging way behind the West now.

> Rediscovery of their scientific and technological tradition and its interaction of the centuries will not only help to free themselves from intellectual colonisation but also to rediscover their interacting cultural heritage and reinforce their cooperation and collaboration for future development.[39]

NOTES

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2. H. G. Rawlinson, *Intercourse between India and the Western World*, (Cambridge:, 1916).

3. Gordon, V. Childe, "India and the West before Darius," *Antiquity*, 13, 1939, pp. 5-15.

4. S. N. Sen, 'Transmission of Scientific Ideas between India and Foreign Countries in Ancient and Medieval Times," in *Bulletin of NISI*, No. 21, 1963.

5. Cowell and Rouse, *Berberu Jataka* (English translation), (Cambridge: 1907).

6. P. C. Sen Gupta, "Aryabhata, the Father of Indian Epicyclic Astronomy," J. Dep. Lett. Calcutta University, 1028, 18. p. 1 56.

7. O. Neugebauer, *The Exact Science in Antiquity*, (Princeton: 1952).

8. J. Needham, *Science and Civilization in China*, Cambridge, 1975, Vol. I, p. 176.

9. W. M. McGovern, *Early Empires of Central Asia*, (University of North Carolina Press: 1939), pp. 249-251.

10. George Sarton, *Introduction to the History of Science*, Vol. I, p. 450.
These works were as follows:

    (a) Po-lo-men tien-wen-ching - Brahmanical astronomy.
    (b) Po-lo-men Chieh-Ch'ieh hsien-jen tien-wen-shuo - Astronomical dissertations of the Brahmana Chieh-Chieh.
    (c) Po-lo-men--tien-wen-Brahmanical astronomy.
    (d) Po-lo-men Suan-fa-Brahmanical methods of calculation.
    (e) Po-lo-men Yin Yang Suan Ching - Brahmanical method of calculating time.

11. P. C. Bagchi, *India and China: A Thousand Years of Sino-Indian Cultural Relations*, (Bombay: 1944).

12. George Sarton, *op. cit.*

13. K. Yabuuti, "Researches on the Chiu Chihli (Indian Astronomy under the Thang Dynasty", 618-906; *Acta Asiatica*, Vo.. 36, p. 12, 1979.

14. B. K. Sarkar, *Hindu Achievements in Exact Sciences,* (London: 1918), p. 11.

15. George Sarton, *op. cit.*

16. J. Needham, *op. cit.*, Vol. III, p. 10.

17. Y. Mikami, *The Development of Mathematics in China and Japan*, 1913, p. 73.

18. G. R. Kaye, *Indian Mathematics*, (Calcutta: 1915), pp. 326-356.

19. S. N. Sen, *op. cit.*, p. 23.

20. Alastair Lamb, "Indian Influence in Ancient South-East Asia," in A. L. Basham, ed., *A Cultural History of India,* (Oxford: 1975), pp. 449-450.

21. H. J. J. Winter, "Science," in A. L. Basham, *op. cit.*, p. 157.

22. A. Rahman, "On Relevance of Ibn Sina Today." *Ibn Sina Millenary Celebration.* 2-5, (New Delhi: Nov. 1981)

23. S. N. Sen, "Transmission of Scientific Ideas between India and Foreign Countries in Ancient and Medieval Times," in *Bulletin of NISI*, No. 21, 1963, pp. 24-25.

24. *Ibid.*

25. B. Datta and A. N. Singh, *History of Hindu Mathematics*, (Bombay: 1962), Part I, p. 89.

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28. D. E. Smith, *History of Mathematics*, (New York: 1958) Vol. I, p. 170.

29. G. J. Rule, Article on al-Khawarizmi in *Dictionary of Scientific Biography*, Vol. 7, 1973, p. 360.

30. B. Datta and A. N. Singh, *op. cit.*, I, pp. 96-97.

31. *Ibid.* p. 97.

32. R. A. Jairazbhoy, *Foreign Influence in Ancient India*, (Bombay: 1963), p. 113.

33. R. C. Gupta, "Spread and Triumph of Indian Numerals," in *Indian Journal of History of Science*, 18 (1), (May: 1983), p. 26.

34. G. J. Rule, Article on al-Uqlidisi, in *Dictionary of Scientific Biography*, Vol. 13, 1976, p. 545.

35. B. Datta and A. N. Singh, *op. cit.*, I, p. 99.

36. E. C. Sachau, *Alberunit's India*, (New Delhi: 1964), Vol. I, p. 174.

37. J. Needham, *op. cit.*, Vol. I, p. 220.

38. *Ibid*

39. A. Rahman, "Science and Technology in Medieval India," in *Journal of Scientific and Industrial Research*, Vol. 40, Oct. 1981.