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Science and Religion in Ancient India

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The contrastive way of thinking, in which science and religion are put as if they were at the opposite extremeties, might have been strange to the ancient Indian people. For that matter we might even be allowed to ask whether either of the two words, science and religion, really has an Indian counterpart which may cover more or less the same semantic field. In the following essay I shall try to describe the ancient Indian activities which can be categorized as 'scientific' and to consider their relation with 'religious' activities.

(1) Language and Scientific Activities in Ancient India

Anthropologists or ethnologists may conduct field works in order to investigate the so-called 'ethno-science' which to some extent reflects activities of the ancient people and which has no or few written traditions. In the case of Indian subcontinent, however, we have a huge number of written records in almost all the fields of intellectual activities including what we may call scientific. Accordiing to Pingree's estimation (1978b, p.364) there still exist today some 100,000 Sanskrit manuscripts in the single field of jyotiḥśāstra (astronomy, astrology, and mathematics). It is mainly through these materials that philologists can approach to the scientific activities in ancient India. There also exist some remains of ancient products which tell high technological skills. The most famous among them is the Iron Pillar in Delhi which has puzzled modern scientists because of its huge size and incredible purity of iron (Ray p.99). Unfortunately we have no record how it was manufactured. The scarcity of records on technological products and on those who engaged in craftsmanship is one of the features which characterize scientific activities in ancient India.

The language, in which intellectual activities were recorded in India form the Vedic period (about 15-10 centuries B.C.) down to the 19th century, was almost exclusively Sanskrit. It was only about 150 years ago that Sanskrit yielded the leading status of scientific language to English. There are abundant Persian and Arabic documents in Indian archive but they were written by the people whom Indians regarded as foreigners. The use of Sanskrit as the language of intellectual activities is another significant characteristics of the history of Indian science. We cannot but admit the crutial role of language played by Sanskrit in deter-

mining the conceptual as well as social framework of Indian intellectuals. I must confess here that my view of the ancient India should naturally be affected by the same framework because my approach has been mainly through Sanskrit sources.

Sanskrit, which belongs to the Indo-Iranian branch of the Indo-European family, was brought to India by the Aryans who migrated in the north-western India and gradually expanded to the east during the Vedic period subjugating the native non-Aryan peoples in the subcontinent. When the Aryans established themselves as 'nobles'(ārya), Sanskrit ('refined language') was used as the most powerful tool to maintain their intellectual predominance. Their holy scriptures, called śruti ('that which was heard by holy sages'), were eternal, and the performance of sacrificial rites following the ordinance of the śruti was the way to the eternal heaven. The Aryans called themselves dvi-ja('twice-born') because, as they claimed, they were re-born by the initiation rite to the study of the holy scriptures, while non-Aryans, who were not allowed to the study, were called eka-ja('once-born'). Even in the *Carakasaṃhitā*, known for its moralistic attitude of teaching medicine, śūdras (lowest of the four varṇas) were excluded from those who were expected to learn the medical texts (CS I, 30,29). All the intellectual activities in ancient India were in the hand of Aryans, especially Brāhmaṇas who monopolized the performance of sacrificial rites.

The earliest branching of the religious study into specialized fields of learning took place about the 6th century B.C. when the manuals of the six 'auxiliary limbs of Veda' (Vedāṅga) were compiled in the sūtra or aphoristic style. The six branches were (1)śikṣā (phonetics), (2)chandas (metre), (3)vyākaraṇa (grammar), (4)nirkuta (etymology), (5)jyotiṣa (astronomy), and (6)kalpa (performance of rituals). It is worth noting that the first four branches are concerned with the study of verbal aspects of the scriptures. As the śruti was divine, so the word (śabda) comprising it was eternal. Voice (or speech) was personified as the Goddes Vāc in the Ṛgveda, and Bṛhaspati (or Brahmanaspati), divine priest of holy prayer, was later called Vācaspati (God of speech). Thus language was one of the primary concerns of Vedic ritualists. Above all vyākaraṇa (grammar) developed into the most advanced field of Indian learning, especially since Pāṇini canonized his exquisite system by the rigid logic and condensed symbolic expressions. Since all the scientific taxts, if they expected intelligent readers, had to be composed in standard Sanskrit, the first step of all the Indian scientists was to master the Pāṇinian grammar. Therefore the study of grammar set the model of all the learning. Pāṇini's grammar itself is one of the greatest monuments of the scientific genius of man (Staal, p.v), and his position in In-

dian science is very similar to that of Euclid in Greek science.

Sanskrit, with its grammatical rigor, rich vocabulary, and morphological productivity, was better fitted to scientific expression than any living languages, but still it was not the 'mother tongue' to anyone (although there are some even today who claim it is). In this sense the role played by Sanskrit was similar to that of Latin in Medieval Europe. It is to be remembered that during the scientific revolution in Europe free thinkers got out of the 'mental straight jacket' (Leech, p.27) of Latin, even though they used it in order to coin new words.

Indian free thinkers like Gotama Buddha and Mahāvīra delivered sermons in the popular languages like Pāli and Ardhamāgadhī, and their words were orally transmitted and compiled in these languages in the earlier period. In the later period, however, when Buddhism and Jainism were systematized as philosophical doctrines, scholarly communications were made in Sanskrit. In all the fields of intellectual activities ideas of non-Aryan origin were conformed to the Aryan framework through the well-known process of Sankritization. Sciences of secular nature were sacralized by this process. The apparent supremacy of Brahmanical intelligence is a result of their shrewd control over the multi-layered cultures in the subcontinent. In fact, however, the structure of Indian culture can not be properly explained without the non-Aryan or non-Brahmanical contributions taken into consideration. In the next two sections I shall illustrate how the Sanskritization (or sacralization) proceeded in the fields which are now called natural sciences.

(2) Jyotiṣa (astronomy, astrology, and mathematics)

The reason astronomy was included in the Vedāṅga was simply because it served for the purpose of solving the problems concerning the determination of the proper time of ceremony. In the beginning the topic of jyotiṣa (from jyotis, 'luminary') was limitted to time keeping, calendar-making and the 27 nakṣatras (lunar mansions). No mention is found about planets, which were probably outside ritualists' concern. Judging from the calendric parameters used in the *Jyotiṣavedāṅga*, the level of astronomy is so primitive that I wonder whether the calendar was ever useful. In the Ṛgvedic recension of the *Jyotiṣavedāṅga*, which is probably dated in the 5th century B.C., a little evidence of Babylonian influence can be attested, but the Babylonian astronomy itself was not yet fully developed at that time, and it was rather omen taxts that were possibly transmitted to India during the Achaemenid occupation of nothern India (Pingree 1981, p.67). Only after the introduction of Hellenistic astronomy a drastic advance was made in Indian astronomy.

The oldest evidence of the Hellenistic influence on Indian astronomy is found in the *Yavanajātaka*, a Sanskrit adaptation of a Greek treatise on horoscopic astrology, which was brought to western India by Mediterranean merchants via sea route. (Yavana, a Sanskrit form of Ionia, means western barbarians in general.) The first prose translation (now lost) was made in AD 149/50 and the versified version appeared in 269/70. A long time before the Hellenistic influence, Indian people, like any other ancient people, had deep concern in omens (*nimitta* or *adbhuta*) including the astral ones, but what *Yavanajātaka* brought to India was quite novel: casting planetary horoscopes on the background of 12 zodiacal signs and 12 houses. The level of astronomy as is judged from the last chapter of the *Yavanajātaka* was not yet high enough to allow Indian astrologers to compute accurate planatary positions, but it stimulated their interest in the Western astral science and almost simultaneously some other texts on mathematical astronomy were transmitted to India.

It was Āryabhaṭa (born in AD.476) who first succeeded in presenting a well refined system of mathematical astronomy in Sanskrit verses. Some of his predecessors' names are known but only fragments of their works survive in quotations of the later period. Some bare the names which indicate their Western origin, like Romaka and Pauliśa. The interval of about 350 years between the first transmission of the *Yavanajātaka* and the appearance of Āryabhaṭa's *Āryabhaṭīya* (AD.499) was the interval necessary for Sanskritization and Indianization of the foreign astronomical system. Once Sanskritization finished, however, Indian astronomers lost interest in the 'babarian' astronomy, and progress was made only within the framework already formed. It is one of the most interesting facts in the history of astronomy that in spite of countless cases of evidence of Hellenistic elements in Indian astronomy, no trace is found of Ptolemy's (fl. AD.150) influence.

A group of literature called *Śrautasūtra* are manuals of kalpa, one of the Vedāṅgas, which is concerned with the acstual performance of ceremonies. Staal (1982) argues that the earliest Indian sciences were ritual and grammar because they were provided with all the features of characteristics of science, namely, empirical adequacy, generalization, consistency, and methodology. The *Śulbasūtra*, usually a part of *Śrautasūtra*, is the most illustrative example in this respect. The goal of this manual is to construct the agnicayana altar, in the shape of a flying falcon, which consists of five layers, each made of 200 bricks of various geometrical figures. Here is found the earliest stage of Indian knowledge of geometry. 'Geometry' here is used in its etymological sense, i.e. 'measuring the earth'. In fact 'śulba' is the rope by which the earth was measured.

Some topics in the *Śulbasūtras* have attracted attention of historians of mathematics: for example, the problems of squaring the circle, the value of $\sqrt{2}$, and the 'Pythagorian Numbers'. One would naturally be inclined to propose the hypothesis of 'ritual origin of geometry'(Seidenberg 1962). No doubt ritual was the receptacle of geometrical knowledge, but we must be cautious when we speak of origin, because we cannot deny the possibility of transmission of some elements from the neighbouring civilizations, like *Śulbasūtra*'s value of $\sqrt{2}$ which is very close to that attested in the Cuneiform tablet (Neugebauer p.35). Putting aside the problem of origin, the geometry in the *Śulbasūtra* did not outgrow the framework of ritualism. Again it was after Hellenistic astronomy was transmitted to India that geometry made a considerable progress as a part of jyotiṣa, which in turn grew to be a larger receptacle than it had been in the Vedāṅga period.

Mathematics is the field of science where India's original contribution is most conspicuous. Among the best known are: decimal place-value notation, use of the symbol of zero as well as its mathematical denifition, quadratic equations and indeterminate equations of the first and second degree, permutation and combination, mathematical progressions, infinite power series, trigonometry, etc. It may sound strange then to hear that mathematics was not regarded as an independent branch of science in ancient India. Although we find sporadic mention to the art of counting in the old literature (e.g. *Chandogya-upaniṣad* 7.1.2, and *Millindapañha* II.3.7 etc), no independent work was written until quite later period. The art of counting, which is closely related with economical activities, may have originated outside the intellectual circle of Brahmanical tradition. The abundance of Jaina mathematicians can be explained by the occupation (trade and commerce) in which they tended to be engaged.

Again it was in the *Āryabhaṭīya* mentioned above that the first scholary description of mathematics is found in Sanskrit literature. The second chapter of the *Āryabhaṭīya* is entitled 'Gaṇita-pāda', a part (of the quadripartic book) on gaṇita. Gaṇita (originally 'what is counted') seems to have been already an established word for referring to mathematics in general in Āryabhaṭa's day, but it could not secure its status as an orthodox subject until it was successfully incorporated in the text of astronomy (jyotiṣa). Pingree (1981, p.56) says, 'There was never in India a jāti (caste) of mathematician, and rarely anything that could be called a school; most mathematicians were *jyotiṣīs* (astronomers and astrologers).'

As we have seen above jyotiṣa as the receptacle of knowledge was so enlarged that it could contain not only astrology of the western origin but also all kinds of divinations of popular origin as well as arithmetic and mensuration of the

non-Brahamanical origin. The enlargement of the receptacle named jyotiṣa culminated by the hand of Varāhamihira (6th century), who composed masterpieces in the three branches comprising jyotiṣa: *Bṛhatsaṃhitā* on omens, *Bṛhajjātaka* on horoscopic astrology, and *Pañcasiddhāntikā* on mathematical astronomy. The *Bṛhatsaṃhitā* ('Great Collection') is really one of the richest mines of Indian cultural heritages. Since all the natural phenomena are objects of divination, almost all the fields of science of his day are discussed in this text.

(3) Āyurveda (medicine)

Another branch of science whose origin is as old as Vedic rituals is medicine. If man's concern to his health and longevity is regarded as the origin of medicine, the origin of Indian medicine can be sought in the 'time immemorial', as Indian people often say. In the case of medicine the demarcation between science and non-science is harder than it appears. The earliest textual evidences of medical activities in India are found in the *Atharvaveda*, the last of the four Vedas. The major part of these text is devoted to incantations and spells (brahman/vāc/vacas) by which to dispel all kinds of enemies of human life, including diseases, in order to secure the means of leading a happy life. Some elements in the text go back to Indo-Iranian period as Filliozat (1949) investigated, and some others, especially those concerning herbs, diseases, amulets, and magic are of indigenous (non-Aryan) origin. The status of the Atharvan priests who commanded these knowledges and art of healing was not very high in the beginning, but it was gradually enhanced and finally their text acquired the status of the fourth Veda (Tsuji p.243). The collection of heterogeous knowledge and experience of medicine in the *Atharvaveda* was not yet systematically arranged.

The opening period of the systematization corresponds with that of the free thinkers and Upaniṣadic philosophers. Questioning the supremacy of ritualism as the sole way to heaven, they sought for the other ways. In the same period also flourished materialism, atomism, scepticism, antinomism etc. Medical truth was also explored outside the Atharvanic magic which had been skilfully assimilated to ritualism. We can glimpse the process of systematization in progress in the earliest Buddhist and Jaina canons where metaphors of medical remedy were employed in order to illustrate the way to liberation. As is often pointed out Buddha's teaching of the four truths (catuḥsatya) was formed by the analogy of medical care. In the classical medical texts we often encounter free discussions between the ancient sages in an atomosphere reminiscent of the Upaniṣadic one. The earliest strata of the Sāṃkhya and Nyāya-Vaiśeṣika systems

of philosophy also played very significant roles in the systematization of medical heritage, and conversely medical experiences and insights must have contributed much to the formation of the philosophical doctrines.

The textual and theoretical gap between the *Atharvaveda* (including the *Kauśikasūtra* which prescribes actual application of Atharvan mantras) and the classical medical txts is not easy to fill, although Buddhist and Jaina texts give us some hints as mentioned above. During this period of about 1000 years the huge amount of accumulated and still accumulating knowledge and experience must have been arranged and rearranged by those people who groped for systematic description.

It was in the second to the fouth centuries A.D. that, after a long process of compilation and revision, the two medical classics, *Carakasaṃhitā* and *Suśrutasaṃhitā*, assumed the present form which represents the well organized system of medicine. The era corresponds with the time when the sutras of the orthodox philosophical schools (darśana) were established in the present form. Caraka's enumeration of categories (CS I.1.44ff) is very close to that of the *Vaiśeṣikasūtra*. He shows a good knowledge of the Nyāya school of logic when he instructs how physicians should engage in discussions (CS III.1). Both in the *Carakasaṃhitā* and *Suśrutasaṃhitā* the first chapter of *Śārīrasthāna* (Section on Body) is devoted to the instruction of the twenty-five hierarchic factors (tattva) on the basis of Sāṃkhya philosophy. Sāṃkhya's three quality (triguṇa) theory might have contributed to the medical theory of three elements (doṣa/dhātu).

The medical system thus established came to be called Āyurveda, or the Veda of longevity. Sometimes it is called upāṅga, or the secondary part, of the *Atharvaveda*, and sometimes upaveda belonging to the *Ṛgveda*. Thus Āyurveda was authorised as a legitimate part of the Veda or sacred wisdom. Both Caraka and Suśruta expounded the divine origin of Āyurveda and the lineage of their texts. Ascription of śāstra (system of learning) to divinity was a common practice in ancient India: Āryabhaṭa says his work is a reproduction of the work of Svayambū (Brahma); in the *Yavanajātaka* the origin of jyotiṣa was ascribed to Prajāpati. Likewise the claim of divine origin of *Āyurveda* is an aspect of sacralization.

(4) Conservatism and pluralism

As we have seen above *Jyotiṣa* and *Āyurveda* were two major disciplines which absorbed various intellectual activities which may be classifies as natural sciences. According to a recent bibliography of science and technology in medieval India (Rahman & others), which covers the period from the eighth to nineteenth cen-

turies, 8390 items out of 10001 are classified in these major fields. The number would increase when 'botany', 'chemestry' and 'zoology' are included in Āyurveda as they were in the ancient period. In fact *Vṛkṣāyurveda* (Āyurveda of trees), which is a chapter of Varāhamihira's *Bṛhatsaṃhitā*, is a kind of 'botany', and the manuals like *Hastyāyurveda* (Āyurveda of Elephant) or *Aśvāyurveda* (Āyurveda of Horse) are known (Renou & Filliozat p.66), and chemistry (Rasāyana) is one of the eight branches of Āyurveda.

Evidently the two authorized disciplines served as receptacles of varieties of Indian scientific activities. They grew larger and larger receiving foreign and heterogeneous elements. Somewhere in later period the diagnosis by taking pulse was assimilated into Āyurveda probably from Arabic medicine. Evidence of the introduction of Islamic astronomy began appearing in the tenth century (Pingree 1978, p.626) and the Islamic influence reached its apex in the court of Jayasiṃha in the 18th century.

Even today these receptacles are still receiving western science. I had a good experience when I attended a colloqium on history of oriental astronomy held in New Delhi in 1985. A professor of astrophysics, who belongs to the family of jyotiṣī, wanted to prove the validity of the Vedic astronomical tradition by his modern knowledge. Another reporter 'proved' Indian origin of the zodiacal sings by his knowledge of western astronomy. On the other hand, as I learned in south India, there are still several jyotiṣīs (astrologer-astronomers) who annually issue traditional almanacs (Pañcāṅga) of which the planetary positions are computed by purely traditional methods.

In the case of Āyurveda there has been a long conflict between 'purists' and 'integrists' (Roşu 1982) since Western medicine was introduced to India. From the historical point of view I am inclined to deem those 'integrists' more traditional. To them the receptacle of Āyurveda is large enough to contain Western medicine. This is an example revealing the nature of Indian conservatism, which is almost equivalent with pluralism, — acceptance of coexistence of differenct values in a large receptacle. Here no revolutionary change is possible. The pluralistic attitude is one of the most remarkable features which characterizes Indian science as well as Indian religion.

Buddhism was another large receptacle of Indian culture. Almost all the fields of Indian learnings were contained in the Tripiṭaka ('three containers'). As far as scientific activities are concerned, however, the level remained to be that of unprofessional encyclopedia.

Professionalization or specialization is another characteristics of Indian science which I will briefly mention in the next section.

(5) Specialization

The hierarchic social system which is ususlly called caste is also a factor which determined the characteristics of Indian science. After Āyurveda was systematized as is found in the two classical texts, the learning of medicine was limitted to those who are qualified. Both texts prescribe detailed qualifications for a medical student (CS III.8.8, SS I.2). We find heredity (tatkulaja, 'born in the family of Āyurveda') as one of the qualifications enumerated by Caraka. Already in his time (probably 2nd century AD) the physician was called *vaidya*, a word which had a higher connotation than *bhiṣaj* (Atharvaṇic medicine man) or *cikitsaka* (curer). There is an interesting reading in a recension of the *Carakasaṃhitā* (VI.1.4.53) where a physician is called *tri-ja* ('thrice-born'), because after the second birth through the initiation rite he is to attain the third birth by the study of Āyurveda. So one could not be physician merely by birth but special training was required for him to be called *vaidya* ('one who knows Āyurveda').

Also in the case of jyotiṣa the transmission of knowledge was mostly hereditary. Varāhamihira learned astrology from his father and he was succeeded by his son Pṛthuyaśas. Bhāskara's family produced numerous astronomers and mathematicians around the 12th century. There were cases where a son was sent to study with an external teacher, but family connection was an important factor (Pingree 1981, p.121). In Kerala where a pure, especially Brahmaṇic, tradition was maintained almost without foreign influence, the specialization led the astronomer-mathematicians to an extremely advanced level. In the lineage which can be traced back to Govindabhaṭṭa (1236-1314) infinite mathematical series were investigated and that which is essentially equivalent to Gregory's power series was discovered in the 16th century or even before.

Thus it is true that specialization also contributed to high mathematical achievement. But it is also true that the more specialized a discipline was the more separated it was from the other disciplines. The lack of communication between intellectual disciplines is evident in ancient India. This is why the high level of Indian mathematics did not find fields of its application. The same thing can be said about secular works of artisans. Most of the arts of craftsmanship were kept exclusively in a particular caste and transmission was made only through oral communication, thus escaping Sanskritization (Rau p.231). Far more scarce were communications between intellectuals and craftsmen.

I have tried to refrain from giving some definite evaluation of Indian science. First of all it is too early to do so because the study of the history of Indian

science is still a scarcely explored field, and I have not studied enough to draw some conclusions. Usually the criterion of the evaluation of science of a culture has been whether it contributed to modern science or how it was closer to western science. I do not take recourse to this measure, because modern science, which is a historical product and not older than 300 years, is still in the process of change, and no one can say it is a flawless system. Indian scientific activities have existed in its own right for nearly 3000 years. Probably we should wait another several centuries until we find how Indian scientists shall have integrated modern science without, most probably, abandoning their religious identity.

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