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DEVELOPMENT OF KNOWLEDGE IN PRE-COLONIAL INDIA: A PEEP THROUGH THE LENS OF HISTORICAL EPISTEMOLOGY

Rajan Gurukkal

Knowledge is a term semantically so entrenched that nobody feels like asking what it means. Let us define it as awareness of what, when, where, who, how and why with or without confirmation. Possession of the skill or craft to perform an act or produce an artefact is also a kind of knowledge.[1] It is impossible to delineate the sequential development of knowledge in time, even out of its orally or literally articulated and codified type. Tracing the skill/craft component of knowledge, never articulated or codified, is all the more eluding. What was knowledge in early India, who decided that and how: these are the questions engaging us in the essay at the outset. They lead to a consideration of forms of knowledge; their social historical context, epistemic structure, composition, function and reliability. All this comes under what one calls historical epistemology. Leaving the inexorably hidden beginnings of knowledge, we start with Vedic eschatology, Upanishadic metaphysics, aphoristic *Vedānga*-s and perceptions of truth. An attempt to discern traces of epistemology in *Anvikṣiki* follows. This is followed by a discussion of grammatical aphorism, epistemic properties of speculative thoughts, healthcare knowledge, mathematical astronomy and theorisation. Finally, the practice of producing proof in the language of mathematical formalism as manifested in astronomy is shown as the watermark of methodological height ensuring knowledge of its maximum reliability.

Vedic Knowledge

In Indian knowledge tradition, the *trayi* (the three Veda-s: *Ṛk*, *Yajur* and *Sāma*) is the feasible starting point, which renders eschatology, as exemplified by the *nāsatīya sūkta* of the tenth *maṇḍala* (relatively

late) of the *Ṛg Veda*, seeking the meaning of self against the metaphysical cosmology. This is elaborated in the *Upaniṣad*-s, the pedagogic texts generated and maintained by *upādhyāya*-s or *ācārya*-s (teachers) over a long period, presumably between c.800 and c.200 BCE, for their pupils (*brahmacāri*-s). Vedic knowledge is self-evident, unquestionable and foundational defying epistemological scrutiny.

The *Upaniṣad*-s represent, perhaps, the earliest mode of abstract knowledge production in northern India. It pertains to the eschatology of the self (*ātma*) and the metaphysics of the universe as the supreme consciousness (*brahma*), known as *Vedānta* (the terminal of the Veda-s) and *Brahmajñāna* (knowledge about *brahma*) disclosed as *sūtra*-s (threads) of thoughts. They formulate knowledge about the self through a series of eschatological interrogations and reach out the metaphysical knowledge about the ultimate or the absolute consciousness. Its metaphysics maintains that while the whole universe is subject to the objective categories such as space, time, and causation, *brahma* transcends all this and remain spaceless, timeless and beyond causality. *Brahma* is the inaudible that exists in audibility, the unseen that exists in seeing, and the inexplicable that enables explanation. Eternal, infinite and unconditioned,[2] *Brahma* is everything (*sarvam khalvidam brahma*), the cause and the result – the absolute combine that precludes the need for a creator.[3] What most *Upaniṣad*-s underscore as the ultimate knowledge (*brahmajñāna*) is the ontological unity between the individual self (*ātma*) and the universal consciousness (*brahma*). This knowledge is meant to empower every individual with the deepest self-awareness: "I am *brahma* (*aham brahmāsmi*),"[4] that is the supreme consciousness or the universe (*prajñānam brahma*).[5] With the acquisition of ultimate knowledge an individual is emancipated out of ignorance, desire, selfishness and misery. The most profoundly metaphysical aspect about this knowledge is the realisation that the multiplicity of external manifestations in the material universe is only the apparent.

Beginnings of Specialization

Systematized production of specialized knowledge in India goes back to the *Vedāṅga*-s (c.600–c.200 BCE), literally limbs of the Veda, which consist of six fields of knowledge viz., *śikṣa* (phonetics), *kalpa* (ritual), *nirukta* (etymology), *chandas* (metrics), *jyōtiṣa* (astronomy) and *vyākaraṇa* (grammar) enunciated on the basis of the detailed analysis of the Vedic hymns. This specialized knowledge had its beginnings in the *Brāhamaṇa* and *Āraṇyaka* portions of the *Rg Veda* long before its being structured into aphorisms (*stūra*-s) and classified

into six branches. It is reasonable to presume that these specialised studies owe their origins to normative pressure for ensuring perfect pronunciation of sounds, metrical chanting of hymns, meaningful use of terms, and flawless articulation of expressions as well as faultless observance of rituals with necessary knowledge in astronomy exactly as construed in the Veda-s. Naturally they must have been developed and transmitted as part of the content of contemporary instructional tradition.

What makes this knowledge methodologically distinct is its aphoristic structure of stating truth in the most condensed and memorable form. It is the method of articulating knowledge as terse announcements of universal validity. Astute observations formulated as principles of self-validation, they preclude the need for logical procedures. Their validity is what they provide to themselves. This is like mathematical equations or formulas that present descriptive relationships precisely by using symbols for making a self-evident truth. In both the cases, the purpose of brevity, its logic and the outcome are the same. Nevertheless, the marked difference between the two is that aphorisms attain their goal through the brevity achieved in the real language while equations or formulas reach their goal through the brevity secured in a language of symbols. One thing that makes the mode of knowledge production in India unique is this dependence on natural language for the exposition of even the most abstract concepts in eschatology and metaphysics.

It may be noted that heterodox perceptions of truth represented by the Jain, Buddhist, Ājīvika, Bāṛhaspatya and Cārvāka schools denied the infallibility of Vedic kbowledge. Of the various ascetic groups (*parivṛājaka*-s) like the Jain and Ājīvika, the Buddhists were best admirers of new knowledge. Buddha located new knowledge not in existence but in transcendence, and related knowledge to suffering and not to the sufferer. He argued that suffering ceased in people overcoming ignorance about existence and attaining deeper knowledge about transcendence, for it relieved them from the fetters of worldliness.

Heterodox worldviews brought about an alternative epistemic stream called the *sṛamaṇa* as opposed to the *brāhmaṇa*. Historical epistemology of both the sramaṇic and brahmaṇical forms of knowledge would show that they were socio-economically and culturally determined. For instance, the changing material milieu and the entailing social power relations in time and space had their impositions on the Vedic, Itihāsic, Śāstric, Purāṇic categories of the brahmaṇical knowledge as well as the *Piṭaka*, *Nikāya* and *Mahāvagga*

categories of the Buddhist knowledge.[6] The knowledge produced and preserved by the *śṛamaṇa*-s was primarily of a didactic kind with a pragmatic dimension due to the obvious factors related to their worldview of differing degrees of austerity. Healthcare, a prominent field wherein they generated knowledge was driven by the purpose of *dhamma* according to which treatment (*cikica*) of illness (*vāti*) was an important means to resolve the sorrow (*āti*) of the devoted people (*upāsaka*-s). It was more ontological in nature. However, that there was politico-ritual imposition on scholars would not mean that it precluded adherence to epistemological principles such as rationality, objectivity, verifiability, proof and notion of truth in their enterprise of knowledge production.[7]

Epistemological Traces

Though an exact counterpart of epistemology may not be identifiable among the knowledge fields of early India, there is plenty of evidence of certain logical procedures evolved and applied to ensure the reliability of knowledge. Traces of treating knowledge as object of knowledge and constituting knowledge about the nature and proof of knowledge are seen in the *Āraṇyaka* and *Brāhamaṇa* parts of the *Veda*-s and increasingly in the *Upaniṣad*-s. Being traces of knowledge about methods to be used for establishing the reliability of knowledge, they are indications of philosophy of knowledge or epistemology, and therefore of vital significance to the context. This embedded subject matter gradually becomes a specialized and codified branch of learning called *Anvikṣiki* that deals with logical procedures and exegesis.[8] It is considered as one of the four fields of knowledge (*vidyā*) along with the rest viz., *ṭrayī* (the three *Veda*-s), *daṇḍanīti* (knowledge of governance), *vāṛtta* (practical arts). According to tradition, Medhātithi Gautama of sixth century BCE was the scholar who codified this field of knowledge.

Other scholars known as experts in *Anvikṣiki* are Ajita-Keśakambali, Bṛhaspati, Cāṛvāka, Kapila, Dattātreya, Punarvasu Atreya, Sulabha Maitreyi, and Aṣṭāvakṛa, presumably of c. sixth –fifth centuries, who figure as sages of *Upaniṣadic* wisdom, and hence largely critical insiders of the Vedic tradition. Ajita-Keśakambali, the first known materialistic thinker, is believed to have founded an explanatory framework for understanding natural phenomena without resorting to super-natural powers. Bṛhaspati codifies it in a set of aphorisms (*Bāṛhaspatya-sūtra*) that Cāṛvāka expands through interpretation. Epistemological questions acquire remarkable significance in the

Bāṛhaspatya – Cāṛvāka materialistic thoughts, popularly known as *Lōkāyata* according to which perception (*pratyakṣa*) is the only primary and reliable source of knowledge. They maintain that inference having no means to establish its reliability is uncertain and hence invalid as a means of knowledge. For instance, smoke need not be universally and always the reliable source of inference for the presence of fire. According to them inference is not suitable to be used to ascertain metaphysical truth. Truth is merely an accident of inference rather than its unfailing character. The epistemological position here is that as long as the observation remains not proved as unconditional, it is a matter of uncertainty. Truth is the complete and final knowledge that becomes explicit on the unconditional establishment of observations and premises. These epistemological traits continue to influence the ways and means of validating knowledge. A significant aspect of the Cāṛvāka-Bāṛhaspatya epistemology is theorization using the possible minimum of *pramāṇa*-s (evidences). The mode of exposition of final knowledge has been fundamentally in the aphoristic structure and confined entirely to the use of natural language. It is not accidental that the first instance of the deepest and complete type of knowledge production pertained to the language itself.

Aphoristic Perfection

Production of knowledge about the Sanskrit language marks the first ever accomplished state of Indian epistemology that is distinguishable for its aphoristic structure of theorization, algorithmic nature of computation and amazing perfection. Pāṇini's *Aṣṭādhyāyi* (c.500 BCE) is the finest example of this. It occupies the most prominent position in the world map of classical linguistic studies for analytical completeness, observational exactness and theoretical rigour.[9] Pāṇini's work makes an exhaustive and systematic characterization of the Sanskrit language in terms of its grammatical rules coming to about 4000, phonological segments, verbal roots of about 2000 words and many lexical items, together with the description of rules regarding deviational strings that mark the linguistic change since the Vedic Age down to his own times. In short, Pāṇini's aphorisms (*sūtra*-s) provide the grammatical principle behind each correct utterance possible in Sanskrit.

Pāṇini might have thought under normative pressure, primarily about the easiest method of ensuring correct expressions in Sanskrit and hence described the rules in the most condensed form. However, *Aṣṭādhāyi* is not just a rule-ordering based on the principle that the

more specific rule applies prior to the more general rule and the 'elsewhere condition', as some linguists think in the absence of explicit theorisation about how the rules apply.[10] The thoroughness of analytical comprehension that the text exhibits about the structure, composition and functional contexts of the language is astounding. It is natural that such a meticulous work embodies discoveries of fundamental linguistic factors, the pattern of their relationships and deeper correlations across them, tantamount to theorisation. Pāṇini discovers the logic of grammatical rules, which enables him to compress them. There are rules within rules, rules over-riding rules and rules that need to be read along with other rules. At the outset, Pāṇini theorizes on the basis of the basic assumption that the ultimate truth about rules rests in people's utterances. This is a clear indication of his philosophical perspective that the ultimate truth in its diversity and complexity resides in the real world. A striking feature of his theorization is that it involves only the smallest possible number of devices but generates the largest possible empirical data.

Pāṇini's *Aṣṭādhāyi* has to be seen as the first known work that lays down the foundation of Indian epistemology not only for linguistics but also for all profound fields of knowledge, viz., astronomy, mathematics, healthcare, logic and philosophy. The fundamental property of knowledge according to Pāṇini is the theoretical generalisation of the ideal, made inevitably at the instance of the empirically given reality, if possible after checking each specific instance. He holds that indeed the ideal is real, but some part of it always escapes theorization. Hence, the epistemological position is that the fundamental knowledge is not with the theory based on the ideal with which one explains reality relatively. This position shows a leavening influence across all profound fields of knowledge in India. The *sūtra* mode of exposition of knowledge in its perfect form as exemplified by Pāṇini seems to have set the epistemological stance for all the knowledge systems in India. This is comparable to how Euclidian axiomatic logic of mathematics set the epistemological foundation for the post-classical European knowledge.

The Jain and Buddhist knowledge tradition that goes back to the turn of the CE is largely in the same epistemic tradition. Although basically aphoristic in the mode of exposition, the logic of Nāgārjuna (between c.150-c.250 CE) namely, *tetralemma* or (*catuṣkoṭī*), the fourfold negation (viz., affirmation, negation, equivalence and neither) and *prajñāpāramitā-sūtra* (aphorism regarding the perfected way of understanding the nature of reality) relating to the reliable basis of knowledge (*pramāṇa*) is considered

to be a major epistemological landmark. With this logic Nagarjuna theorizes reality as emptiness and interprets the Buddha's middle path in his *Mūlamadhyamakakārikā*. In this work, he sets down certain new epistemic properties of knowledge and propounds a new hermeneutic model that has been a significant influence on the interpreters of the underlying meanings of the *Upaniṣdad*-s. Several pervasive fields of knowledge emerged following the same epistemological parameters. Astronomical mathematics, thoughts, theatre and healthcare are examples of analytically constituted and aphoristically articulated systems of knowledge.

As extending from the same epistemic tradition of rational investigation, several fields of knowledge such as mathematical astronomy, logic, healthcare (*Āyurveda*), phonology (*Pṛātisākhya*), agriculture (*Kṛṣiśāstra*), Law (*Dharma-śāstra*) and statecraft (*Arthaśāstra*) developed by c. fifth century CE. In *Āyurveda*, *Suśṛuta-Saṃhita* (Suśruta's collection) and *Caraka-saṃhitā* (*Caraka's collection*) were composed during this period.

Mathematical Astronomy

Another important field of knowledge that expressed itself in aphoristic form is astronomical mathematics that had its beginnings in the *Sulbasūtra*-s of the Vedic times. What is called Vedic mathematics comprised the geometrical techniques to facilitate how different types of altars of Vedic sacrifices are built. The *Sulbasūtra*-s containing geometrical prescriptions and rules of triangle, rectangle, rhombus, and circle, lay down the foundation of the knowledge in Indian astronomy. Out of it developed the *Jyōtiṣa-sūtra*-s, astronomical aphorisms constituting one of the six branches of the Vedic knowledge. Knowledge in astronomy has been advancing over the centuries along the epistemological track of Pāṇinian linguistic exegesis by accommodating mathematical procedures within the Sanskrit language. It is in *Āryabhaṭīyam*, the first landmark classic text by Āryabhaṭa (476-550 CE), we see astronomical knowledge presented with the Pāṇinian classificatory rigour and aphoristic brevity. In 121 *sūtra*-s it provides the basic astronomical concepts, arithmetic procedures, geometrical techniques, algebraic calculation and uses of trigonometric functions in determining the positions of the planets at a particular time, describing their motions and computing eclipses.

Several scholars had sustained engagements with this master text by way of interpretation (*vyākhyā*), commentary (*bhāṣyā*), compilation

(*saṃhitā*) and analytical comprehension (*saṅgrahā*). Although every *vyākhyā* or *bhāṣyā* was apparently an interpretative commentary of a previous text, in reality it was addition of fresh knowledge, sometimes even strikingly original. Although often stated as part of the original proposition, most of the elaborations and expansions made in the *vyākhyā*-s, *bhāṣyā*-s, *saṃhitā*-s and *saṅgrahā*-s were fresh. Each of them proved to be a corrective exercise, of course in varying degrees from text to text, and each analytical comprehension an integrative function upon the extant corpus of knowledge. Any of the taxa like *vyākhyā* or *bhāṣyā* or *saṃhitā* or *saṅgrahā* of disparate ages and regions in traditional India would vouch for this fundamental feature of knowledge production and transmission. Mathematical astronomy in India shows a systematic exponential growth through the formulation of new theorems for higher trigonometric functions and through the enunciation of new theories of numbers, efficient enough to resolve complicated problems. It is purely a necessity-driven advancement of mathematical knowledge rather than the result of mathematicians' pursuance to the ultimate axiomatic truth. Hence, the explicit epistemic distinction of Indian mathematical knowledge is its dependence on algorithmic and computational methods of solving issues specific to contingent astronomic needs. Mathematicians first attempted to solve the practical problem through algorithmic approximation and eventually perfected it by evolving theories of error and recursive procedures.[11]

Systems of Thoughts

Early Indian systems of thought (*daṛśana*-s), six in number, well-known as *ṣad-daṛśana*, are *Sānkhya*, *Yoga*, *Nyāya*, *Vaiśeṣika*, *Mīmāṃsa* and *Vedānta*, often divided into the *āstikā* (theistic) and *nāstika* (atheistic) categories.[12] Although the exact chronology is not known, it is generally accepted that most of them had their beginnings between c.600 BCE and c.100 CE, and as evolved thoughts with scholarly following they belonged to disparate periods. Vedic knowledge constitutes the undeniable foundational knowledge for all these systems of thought. All of them owe their metaphysical fundamentals and cosmology largely to the *Upaniṣad*-s, and the aphoristic mode of exposition to the *sūtra*-s, of course with degrees of difference in the overall worldview. Some of them are more or less like twins with the same metaphysics and cosmology. What matters to the context is the *Anvikṣiki,* or epistemology of these thoughts rather than their content. What these systems of thought accepted as their means of

knowing and the methods of making the known reliable constitute the subject matter of discussion. Initially their epistemology seems to have insisted upon *pratyakṣa* (percption), *anumāna* (inference) and *śabda* (verbal testimony), as the only reliable means of knowledge (*pramāṇa*-s). As the thoughts develop through the works of *ācārya*-s (teachers), new means of knowledge and methods of establishing the reliability are identified and differently prioritized. Though the exponential growth of these systems of thought is of a relatively brief period, they persisted through generations, obviously as part of the corpus of knowledge transmitted through the institutions of learning.

The *Sānkhya* thought is based on the *sūtra*-s of Kapila (c. sixth century BCE) and its commentary, the *Sānkhya-kārikā* of Āśvarakrishna (c.350 BCE). *Sānkhya* epistemology insists upon *pratyakṣa* and *anumāna* as the two reliable sources of knowledge. *Yōga* is linked to this system of thought as the frequent allusion of *Sānkhya-yōga* suggests. *Nyāya* is the system of thought that had a longer period of exponential growth and better epistemological advancement.[13] A system of thought exclusively pertaining to logic, rules of reasoning and epistemology far more than to metaphysics, the crucial importance of *Nyāya* in the discussion of knowledge production is explicit. Its foundational text is the *Nyāya-sūtra* by Akṣapāda Gautama, probably of the period between c.200 BCE and 2nd-century CE. The text, consisting of five chapters and 528 aphorisms (*sūtra*-s), is believed to have been expanded over a few centuries by several authors. *Nyāya* defines knowledge (*jñāna*) as consciousness (*anubhava*) rendered plausible as apprehension (*upalabdhi*) subsequently turned into a logically confirmed formal output through the process of cognition (*buddhi*). Syllogistic deductive reasoning, in which the inference gets established as conclusion on the basis of two or more empirically given or intellectually assumed premises, is central to the *Nyāya*.[14] Similarly *Vaiśeṣika*, another independent thought with its own metaphysics, ethics, soteriology and logic, bases itself on the *sūtra*-s (*Vaiśeṣika-sūtra*) of Kaṇāda Kaśyapa (c.200 BCE). Like Buddhism, it accepts perception and inference as the only two reliable means of knowledge. Over time, the *Vaiśeṣika* system became similar in its philosophical procedures, ethics and soteriology to the *Nyāya*. Its cosmology is based on the deeper realization that all material objects in the physical universe are reducible to the particle or *paramāṇu*, the irreducible.

Mīmāṃsā is, perhaps, the earliest among the six systems of thoughts, for it relates to the rituals. *Mīmāṃsā* deals with the faculty

of close perusal and analytical reflection of the literary text in Sanskrit. It is the early Indian counterpart of hermeneutics. Its first detailed exposition in the form of *sūtra*-s seems to have been made by Jaimini (c. 300-200 BCE). Relegating the hermeneutics of the Vedic ritual (*Karma-Mīmāṃsā*) as the initial form (*Pūrva-Mīmāṃsā*), a more intellectually challenging version namely, *Jñāna-Mīmāṃsā* acquired prominence during the later period. It is this version of *Mīmāṃsā*, which subsequently becomes *Vedāntā* as an independent system of thought with a longer duration of exponential growth in metaphysics and logic. This is not to mean that *Pūrva-Mīmāṃsā* phased out or dissolved itself into *Uttaramīmāṃsa*. In fact, through the later interpretations of *Jaiminīya-sūtra*, by Prabhākara and Kumārila Bhaṭṭa (c. seventh century CE), *Pūrva-Mīmāṃsā* did make significant epistemological advancement through the logical assertion of *pratyakṣa*, *anumāna*, *upamāna*, *arthāpatti*, *śabda* and *anupalabdhi* (non-perception or negative proof).

At the most evolved state, the epistemology of the *darśana* holds *pramāṇa* (proof) as the most established property of knowledge that is about itself as well as about others. It validates itself and illumines other objects in *pratyakṣa*. The *darśana* epistemology recognizes two types of *pramāṇa*-s: *pratyakṣa* and *parōkṣa*. It does a meticulous detailing of the properties of *pratyakṣa* in contra-distinction with the *parōkṣa* that consists of varieties *smṛti* (memory), *pratyabhijñā* (direct knowledge), *tarka* (a test of knowledge's universal concomitance), *anumāna* (inference) and *āgama* (textual testimony). *Pratyabhijñā* is direct knowledge deductively drawn following the means and methods of *darśana*. In its standardised form the *darśana* epistemology insists on resorting to six reliable means of knowledge, viz., *pratyakṣa* (perception), *anumāna* (inference), *upamāna* (comparison), *arthāpatti* (postulation) *anupalabdhi* (apprehension), and *śabda* (verbal testimony). *Anumāna* is defined as *sādhya* (possible knowledge) out of *sādhana* or *hetu* (causality), the fixed-in concomitance with *sādhya*. It considers memory (*smṛti*), doubt (*saṃśaya*), error (*viparyaya*) and hypothetical reasoning (*tarka*) as invalid means of knowledge.

At its final stage of exponential growth the epistemology of *darśana* is what the *Nyāya* system of thought has debated and established over the years. Perfecting it as a rigorously self-reflexive and critical method of ascertaining the status of the knowledge first based on each of the four means of knowledge individually, and then collectively, to arrive at the relatively final form, the *Nyāya* sets the standard for testing the reliability of the means and methods

of knowledge for every system of thought and field of knowledge. This rigorous epistemology apart, Vedic knowledge was regarded as indisputable, every epistemological strategy for establishing reliability of knowledge is rendered infructous, for it is the ultimate *pramāṇa* that needs no extraneous confirmation.[15] This is true of the Jains and the Buddhists too for whom the ultimate *pramāṇa* being their canons. Scholars in different fields like materialistic metaphysics, astronomy, healthcare, *Vedānta* etc., had special interest in the nature, logic and authenticity of the knowledge of their respective fields.

Methodological Development

Knowledge production in early India, which was an individualistic meditative enterprise (*tapas*), improved upon through dialectics (*tarkā*), and hermeneutics (*mīmāṃsā*) advanced through textualization of interpretation (*vyākhyā*), commentary (*bhāṣyā*), compilation (*saṃhitā*) and analytical comprehension (*saṅgrahā*). Although every *vyākhya* or *bhāṣya* was apparently an interpretative commentary of a previous text, in reality it was addition of fresh knowledge, sometimes even strikingly original. Although often stated as part of the original proposition, most of the elaborations and expansions made in the *vyākhyā*-s, *bhāṣyā*-s, *saṃhitā*-s and *saṅgrahā*-s were fresh. Each of them proved to be a corrective exercise, of course in varying degrees from text to text, and each analytical comprehension an integrative function upon the extant corpus of knowledge. Any of the taxa like *vyākhyā* or *bhāṣyā* or *saṃhitā* or *saṅgrahā* of disparate ages and regions in traditional India would vouch for this fundamental feature of knowledge production and transmission. The textualization of knowledge, primarily in Sanskrit, was part of the pedagogic purpose of storing knowledge for learners (*brahmacārī*-s and *śṛamaṇā* monks) as well as practitioners (*ācāryā*-s and *parivṛājaka*-s). There is no such tradition of specialized subject-sepcific textualization of knowledge in the *śṛamaṇa* tradition, and hence in Pāli no similar taxa are seen. Further, due to the scriptural sanctity of the *Piṭaka*, *Nikāya* and *Mahāvagga* texts, hermeneutic exegesis on their knowledge components, could not take on. Subsequently, when under the *Mahāyāna* order monks began textualization of specialised knowledge, they did it in Sanskrit.

Most knowledge areas reached a plateau stage due to the profound depth already attained at the early phase itself as *Vyākaraṇa* and *Āyurveda* exemplify, leaving little scope for further epistemic advances. One area wherein knowledge production consistently advanced over centuries is Astronomy. It was the beliefs around the

Vedic sacrificial ritual that necessitated advancement of knowledge in astronomy, the seeds of which are present in the *Ṛgveda* itself.

An inquiry into the aspects of historical epistemology such as premises, inferential logic, proof, concept of truth, and method of confirmation of knowledge is feasible here for visualising the development of methodological pre-occupation in terms of the concept of objectivity, rationality, and methodology at distinct stages of the formulation of knowledge.[16] An important epistemic property of the traditional Indian astronomical knowledge is its theoretical situation beyond the empirically given and articulation of the premises and conclusions in the language of mathematics. The integrated nature of production of knowledge, essentially addressed to the extant corpus, necessitating every scholar to be thorough with the master texts, was another significant epistemic feature that ensured linearity about the intellectual progress through fresh contributions. Long-term direct observation as guided by the extant knowledge, and regular and systematic recording and reckoning by means of mathematical tools had been the features of heuristics related to contemporary knowledge production. Mathematics was the object of understanding, tool of analysis, field of hermeneutics, subject of discovery and medium of articulation. However, insistence on production of proofs as an epistemic property began only at a later stage.

Āyurvedic Knowledge

Knowledge of healthcare as part of survival needs is one of the very ancient fields of knowledge, the earliest form of which exists in the *Veda*-s with indications of classification of illnesses (*jwara*) and medicines (*ouṣadha*). For instance, the *Atharvaveda* mentions a kind of classification of medicines depending on wherefrom it is sourced into *prākṛtika* (*pancabhūta* or the five natural elements), *khanija* (excavated minerals), *samudraja* (marine objects), *prāṇija* (creatures) and *udbhija* (herbs) with some references to their properties.[17] An expanded form of the knowledge is there in the Jain and Buddhist (*sṛamaṇa*-s) canonical texts in Pāli and its codified and systematized form called *Āyurveda* in the *saṃhita* texts in Sanskrit. As accumulated, inherited and preserved through oral transmission over centuries, the knowledge base of *Āyurveda* becomes profoundly enunciated in the *saṃhita*-s of Suśruta (c. sixth century BCE) and Caraka (c. 200 BCE - 200 CE).

Buddhist monks who had set in the tradition of systematic recording of knowledge and treatment practices seem to have made

a lot of fresh additions to the corpus of knowledge about healthcare practices by way of rules pertaining to drugs and treatments for specific ailments as provided for in the *nikāya*s and the *piṭaka*s. The contribution of the Buddhist monasteries to the development of medicine by way of regularization of rules regarding the treatment of specific illnesses is remarkable. According to traditions, a rational causation of illness was offered by the Buddha against the brahmanical belief of *karma-phalā*, that is, the consequence of deeds in the previous life. It sought to explain illness as the consequence of imbalance in the combination (*sannipāta*) of *pitta* (bile), *sehma* (phlegm) and *vāta* (wind). This theory of *tridōṣa* or humoral imbalance is central to the *Āyurveda*.

Dīghanikāya shows how monks acquired knowledge of the human anatomy through the observation of animal body dissected by the butcher, exposing internal organs and structures.[18] Another method of acquiring knowledge about the human body was through direct observation of the decaying cadavers left on the charnel ground. Monks are advised to engage in continuous observation of the dead body until it is completely decomposed, all bones exposed, the skeleton become white and eventually begin to turn into dust. This is a clear indication of the conscious production of concrete knowledge on the basis of firsthand visual experience (*pratyakṣa*), experimentalist learning (*anumāna*) and reflective postulation (*arthāpatti*) of truth. It was not possible for those under the control of the brahmanical notion of impurity and pollution to generate anatomical knowledge through direct observation and reflection *in situ*. *Āyurveda* owes its knowledge in human anatomy, external structures and internal organs to the painstaking and patient observations made by the Buddhist monks. Monks' engagement in the production of healthcare knowledge presupposes the monastery's institutional involvement in the activity. It is natural that healthcare, the most vital field of service to the ailing, received significant attention in monastic establishments that were seats of learning, where monks engaged in the production and transmission of knowledge in different fields. Some of the monasteries like Takṣaśila were universities where legendary physician sages Atreya and Agniveśa taught and great physicians like Jīvaka studied healthcare. They not only collected, redacted and codified the available knowledge in healthcare, but also generated new knowledge in the field and treated the sick people by moving from place to place.[19] In short, what came to be called *Āyurveda* had its codification and systematization with a lot of addition done by the Buddhist monks in their monasteries.

Efforts of codification and classification continued at the level of

individual physicians and teachers among whom Suśṛuta and Caraka rank the foremost. They made comprehensive texts (*saṃhita*-s) that obviously helped as manuals for learners and practitioners in healthcare. *Suśruta-saṃhita* that deals with surgery (*śalya-kriya*) and *Caraka-saṃhita* that deals with the treatment (*kāya-cikitsa*) are the two major texts of this tradition. Their method of exposition follows the sequence of fundamental aphorisms, etiology, theoretical knowledge about the body, taxonomy of illnesses and treatment practice. Metaphysics of the humoral equilibrium is what prevails in *Āyurveda*, as its overarching framework of comprehension, explanation and practice.

Suśrutasaṃhita provides in detail, type of instruments, methods of handling them, types of surgery, consequences, remedial and preventive strategies. Its explanation of the eight different procedures of surgery, viz., excision (*chedyā*), incision (*bhedyā*), scrapping (*lekhyā*), puncturing (*vedhya*), probing (*eṣya*), extraction (*āhāryā*), draining (*viśrāvyā*) and suturing (*sīvyā*), exemplifies the meticulous nature of the *saṃhitā*. Quite similar is the approach of Caraka to the discussion of medical treatment in his *saṃhitā*.[20] According to the textual tradition, the *Caraka-saṃhita* seeks to redact the teachings of Atreya, the legendary author of the master text in *Āyurveda*. However, there are clear in-text indications to believe it to be strikingly original, especially in Caraka's declarations of his sources of knowledge other than the teachers of the past or the pieces of advice of the wise (*āptōpadeśā*) that constitutes the *a-priori* component. For s specific example, he acknowledges how he acquainted himself with the wisdom flowing from the remote past, by observing what the shepherds, cowherds and forest dwellers practised.[21] Both Suśṛuta and Caraka, great physicians themselves with amazing proficiency in theory and practice of medicine, show that *Āyurveda* had already become a well-expounded domain of healthcare wisdom enabling its practitioners to command enormous respect and ranking.[22]

Although the *Atharva-veda* mentions about the classification of medicines with some references to their properties, the level of knowledge at that stage must have been relatively elementary. Nevertheless, the knowledge level of the theory and practice of *Āyurveda* is fairly high by the time of the *saṃhitha*-s. They contain an elaborate list of herbs, medicinal properties of their roots, stem, flower and fruit; the procedures of preparing the medicine out of them; and the ways of administering them when to whom, how and against what illness. Among the *khanija* objects, they mention minerals, salts and metals as elements of medicinal preparation. Some of the medicinal preparations, namely *rasāyana,* using metals

even of toxicity, are mentioned in the *saṃhitha*-s along with detailed procedures of their preparation based on principles of *rasa-śāstra* (metallurgy). It is evident that the processing involved the ways and means to turn the metal into its nano-particles ensuring that the metallic medicines are free of side effects and toxicity. This is not to suggest that the texts vouch for the existence of knowledge about nano-particles. Indeed, through trial and error they had learnt about the side effects and found out the ways to overcome them. Further, they indicate the existence of the knowledge about medicinal properties of various other substances such as coral, seashells, and feathers, processed and administered to cure illnesses.

Tantra-Yukti

Saṃhitha-s are largely aphoristic in structuring their exposition and self-reflexively realist about their epistemological traits, indicative of the explicit influence of the *Nyāyasūtra*-s.[23] These texts consciously articulate the methodology of knowledge production, which makes clear that the *Āyurveda* is a profoundly enunciated system of knowledge, conscious and reflexive about the epistemic procedures of its theorization and validation. *Tantra-yukti* or the way of doing and its logical plan, established by the *Nyāya* thought, is what the *saṃhitha* texts state as their methodology. It lays down the method of constitution and authentication of knowledge. According to *tantra-yukti* the concept of truth (*darśana*), proof of knowledge (*pramāṇa*) and logical procedure (*yukti*) are the three fundamental elements of knowledge production.[24] These are of crucial importance even in the present-day epistemic principles.[25] The *Āyurveda* follows the critical reflexive method to reconfirm the *pramāṇa* by reviewing the causal basis of its constitution (*pramā-kāraṇa*), the logical procedures of its authentication (*yukti*) and the precepts of its argument (*vāda-vidhāna*), as enunciated in the *Nyāyasūtra*-s.[26] What it seeks to reassure is the indisputability of the logical sequential connection between *pramāṇa* and the explanation or theory (*sidhāntā*). *Tantra-yukti* insists upon transparency about the ontological unity of *pramāṇa* and theorization. At the same time, as in the case of *Nyāya,* the divinely ordained (*deva-vipāśŗaya*) is the ultimate truth rather than the logically sustained (*yukti-vipāśŗaya*).

Of the various steps in the logical procedures (*tantra-yukti*) of knowledge production articulated in the *saṃhitā*-s, the starting point is *anubhavā* (experience). It triggers *jijnāsa* or curiosity about *saṃbhava* (source) and leads to *anuyōgā* and *pratyanuyōga*, that is

questions and counter questions. This state engenders *anumāna* (inference) generating *saṃśaya* (doubt) and necessitating *vāda* (debate) that involves discrimination of a series of binaries such as, *pṛatyakṣā* >< *parōkṣā* (direct perception >< indirect perception), *hetu* >< *ahetu* (reason >< fallacy), and as *pramā* >< *apramā* (valid >< invalid) about the basis of *anumāna*. Consequently the process ends with *parihārā* (amendment) to the *anumāna* and formulation of the *sidhāntā* (theory), the acceptance of rejection of which depends on the logical success in establishing its ontological unity with *pramāṇā* (proof).

There was always curiosity to discover the analytically accessible rules or principles and an effort to theorise them explicitly, discretely and systematically with universal application along with a capability to be predict the effects. Knowledge of this kind was made up of context-free elements, transcending subjectivity and with amazing completeness that commands the whole domain.[27] *Spōṭavāda*, *Hetuvidya*, *Vyaktiviveka* and *Dhvanyālōka* are some of the well-known examples. *Spōṭa* ('bursting, opening, or spurt') is an important concept in the Indian linguistic and grammatical tradition called of *Vyākaraṇa*, relating to the problem of speech production, how the mind orders linguistic units into coherent discourse and meaning.

It was Patañjali (c. second century BCE) who formulated the theory of *Spōṭa* (bursting out), which refers to the instant occurrence of meaning at the utterance of the word or the sentence. Bhartṛhari (c. fifth century CE) expanded the theory and elevated grammar to the level of a *darśaṇa*.[28] This theory is hailed as a holistic theory of grammar, semantics and philosophy.[29]

Hetuvidya is the Buddhist logic in its advanced form developed by the Mahāyāna monks in the seventh century CE imbibing the sceptical perception and rigour in ensuring the reliability of knowledge.[30] Diṅgnāga, who propounded the theory of exclusion (*apohasiddhānta*), represents the first major hermeneutic turn in the history of Buddhist logic. His theory established the validity of cognitive confirmation through a systematic logical negation of every possible alternative. Diṅgnāga shifted the emphasis from dialectical logic to epistemological exclusion through his theoretical propositions in the *Pramāṇasamuccaya*.[31] He maintained that a valid theoretical proposition is the one grounded in causality and that alone would best establish reliability of knowledge. Dharmakīrti, roughly of the same period, was the most prominent among the Buddhist epistemologists, who advanced the Buddhist logic further. Dharmakīrti argued that perception is causality-bound and is

concept-free knowing, distinguished from linguistic and conceptual cognition based on reasoning. It was Dharmakīrti's *Pramāṇavārttika* acted as a major transforming influence among contemporary scholars engaging in logic and the question of reliability of knowledge.[32] According to Dharmakīrti, scriptural knowledge is not reliable, for its source (*pramāṇa*) hardly has any epistemological claim to certainty. A major issue that his epistemology had to tackle was the contradictory position of the Buddhists towards the authority of scriptures. Buddhists had been accepting the infallibility of their own scriptural knowledge while they had been rejecting the infallibility of the Vedic knowledge. Dharmakīrti resolved this self-contradictory approach by establishing scriptural knowledge as reliable only in dealing with eschatological and metaphysical concepts like *ātma*, *karma* etc.[33] He maintained the *pratyakṣa* of a *yogī* as the *pramāṇa* for such soteriological ideas. A distinct feature of his epistemology which contrasts with the *Nyāya* is the acceptance of the transient particularity (*svalakṣaṇa*) as real and the rejection of the universal (*sāmānyalakṣaṇa*) as unreal. A significant position that the Buddhist epistemology sought to establish was the precedence of perception and inference over comparative reasoning and testimony.

Speculative theories were influenced more by the epistemological parameters of the *Nyāya*. For instance, the *Dhvanyāloka* of Ānandavardhana provided the most profound theory of literary criticism showing that the most successful poetry is the one that excites aesthetic pleasure sustained after all its linguistic tropes withdraw from the consciousness. This is rendered plausible by the rare semantic power of words transcending denotation and connotation by way of suggestion. *Vyaktiviveka* of Mahimabhaṭṭa, another instance, also deals with poetics developing an alternative theory of grammar and aesthetics as the anti-thesis of *Dhvanyāloka*.[34] Navya-Nyāya developed a sophisticated language and conceptual scheme that allowed it to raise, analyse, and solve problems in logic and epistemology. Theoretical exercises in their turn led to a rigorous systematisation of Nyāya concepts. However, the four fundamental epistemic categories of the old school, viz., *pratyakṣa*, *anumāna*, *upamāna* and *śabda* remained.[35]

Production of Proof

It was in mathematical astronomy that real attempts at production of proof were made. Initially strong traditions were resorted to for establishing statements of precursors. However, traditions were not to be accepted as *pratyakṣa*. No tradition was valid without *pramāṇā*

or a rule of thumb. A *pramāṇā* is an all-inclusive abstraction stated in verse (*ślokā*), almost like a formula or an equation, but with a prescriptive tone. It is a statement of observational results but often without disclosing the cognitive strategies followed to arrive at them. Sometimes, a precursor's statement was adopted and sustained as *pramāṇā* for the reason that he had stated it affirmatively. Initially in mathematical astronomy, theorems were stated explicitly but without proof. It began to be routine for a *vyākhyā* or *bhāṣyā* to delve seriously into an earlier claim, made as a *pramāṇā* by a precursor and to try and make explicit the basic premises of the claim and to develop on the inferences thereof.

Āryabhaṭīyam, the most widely-cited text of authority on time and space, had acquired empirical base and proof for its theoretical propositions only during the successive ages, through scholarly interpretations and elaborations.[36] However, something culturally significant about the tradition of reinterpretation in Indian astronomy is the retention of Āryabhaṭa's authority as the highest in spite of corrections, additions and improvements on his findings by others through independent perception. In the perspective of historical epistemology, when the previous claims are explained in the light of new perceptions, variations occur even at the level of the basic structure as a result of historical changes. In fact, this text was subjected to the greatest number of reinterpretations and additions, of which probably the first known case that improved Āryabhaṭa's results was by Haridattan who is said to have added graded tables of the sines of arcs of anomaly and of conjugation at intervals of 3° 45' to determine the correct planetary positions. Similarly Nārāyaṇa Paṇḍita's *Gaṇitakaumudi* and an algebraic treatise called *Bījagaṇitāvataṃsā* are said to have added a methodological discussion of mathematical operation to Āryabhaṭa's theory of planetary positions.

There is a perceptible epistemic shift in traditional Indian knowledge production in general, and astronomy in particular, since the time of Madhava of Sangamagrāma (c.1340-1425 CE) in Kerala. It has been shown that Madhava's discoveries include the Taylor series for the sine, cosine, tangent and arctangent functions, the second-order Taylor series approximations of the sine and cosine functions and the third-order Taylor series approximation of the sine function, the power series of p (usually attributed to Leibniz), the solution of transcendental equations by iteration, and the approximation of transcendental numbers by continued fractions.[37] Unfortunately, Madhava's texts have not survived except in the form of references to the main findings in them by scholars who followed him. Madhava

began extending certain results found in earlier works, including those of Bhaskara and Aryabhata.[38] He is said to have significantly improved Aryabhaṭa's model for Mercury and Venus. Working on all the inferential items of *Āryabhaṭīyam* to see whether they could be developed into reliable knowledge, Madhava had made several new discoveries such as a better approximation of the value of π, theory of certain transcendental equations, concept of infinity, the sine-cosine infinite series, their various trigonometric functions, and strange relations in geometry. He is said to have correctly computed the value of π to nine decimal places and thirteen decimal places, and produced sine and cosine tables to nine decimal places of accuracy. Of all the contributions what is most commendable is his estimate of an error term, which presupposes his deeper insights into the limit nature of the infinite series. It is clear today that Madhava had discovered the fundamental principle behind the infinite power series, their rational approximations and trigonometric functions. Who invented Calculus was a matter of controversy until recently – Gregory, Leibniz or Newton? It is a settled fact today that the concept of infinity and knowledge of power series goes back to Madhava of Sangamagrāma.[39]

Madhava's method was improved upon by Paramesvaran (c.1380-1460 CE), Puthumana Somayaji (c.1410-1490 CE) and Nilakantha Somayaji (c.1444-1544 CE). Inferences drawn from Madhava were subjected to scrutiny and correction by Parameśvaran, his pupil, in the light of the results of his long-sustained observations. He seems to have done direct astronomical observations for 55 years, systematically recorded the results, and wrote a treatise on *Dṛggaṇitā*, a mathematical model of astronomy, an example *par excellence* of the epistemic tradition. His mastery over the extant knowledge and sizeable contribution to it in the form of new theorems are embodied by the *bhāṣyā*-s he wrote on *Mahābhāskarīyā*, *Āryabhaṭīyā* and *Līlāvatī* of Bhaskara II. The mean value theorem propounded by him is considered to be quite crucial and essential subsequently in proving the fundamental theorem of calculus. Similarly, his mean value type formula for inverse interpolation of the sine function, a one-point iterative technique for calculating the sine of a given angle, and a more efficient approximation that works using a two-point iterative algorithm, is now understood as identical to the modern secant method.[40] He is said to be the first mathematician to provide the radius of a circle with an inscribed cyclic quadrilateral.

Likewise Nilakantha Somayaji in his *Tantṛasaṅgrahā* carried the process further producing more clarity in pre-existing theories,

particularly expansion of the sine cosine series of Madhava.[41] He is acclaimed for expanding the methods and theories of Madhava, particularly by elaborating his derivation, improving proofs for his series of the arctangent trigonometric function, and other infinite series. *Tantṛasaṅgrahā* is in 432 *slōkā*-s in Sanskrit and in eight chapters, generally on the epicyclical and eccentric models of planetary motion, but specifically dealing with the motions and longitudes of the planets, various problems related with the sun's position on the celestial sphere, including the relationships of its expressions in the three systems of coordinates, namely ecliptic, equatorial and horizontal coordinates, the lunar and the solar eclipses, the deviation of the longitudes of the sun and the moon, the rising and setting of the moon and planets, and a graphical representation of the size of the sun-shine part of the moon.

Nilakantha's study is a clear indication of how new knowledge is created lineally by developing on the results of the previous studies. He is an example worth citing in the context of epistemic universals about knowledge production in traditional Indian, such as rationality, analytical comprehension of the extant knowledge, new tools of observations, methodological modifications, systematic recording of observational results, mustering of inductive mathematical proofs for previous theorems, hermeneutic additions and scholarly integration. The *Tantṛasaṅgrahā* embodies these epistemic distinctions, which one of its contemporary *bhāṣya*-s, namely *Yuktidīpika*, is said to have highlighted.[42] His *Graha-parīkṣā-kramā* is a methodological manual of observations in astronomy and the use of observational tools. *Siddhāntadarpaṇā* is Nilakantha's another significant work, often noted for the interest he exhibited in methodological instructions. Nilakantha's *Āryabhaṭīya-bhāṣyā*, his masterpiece, provides a heliocentric model of the solar system and many results on calculus. Nilakantha attributes the series to Madhava, although it is not possible to ascertain whether Madhava discovered all the series. Nilakantha's equation of the centre for these planets remained the most accurate until the time of Johannes Kepler in the seventeenth century. It was C.M. Whish, a civil servant of East India Company, who brought to the attention of the western scholarship the existence of *Karaṇa-paddhatī* of Puthumana Sōmayāji, *Sadratnamālā* of Sankara Varman (1774-1839 CE) and *Yuktibhāṣā* of Jyēṣṭadēva (c.1500-1610 CE).[43]

Insistence of the production of proof as a primary epistemic requirement is best manifest perhaps for the first time in the work of Jyēṣṭadēva, namely *Yuktibhāṣā*, a Malayalam text.[44] It is interesting to note that proofs for Madhava's series expanded by

Nilakantha into sine, cosine and inverse tangent series were given only after a century by Jyēṣṭadēva in his *Yuktibhāṣā*, a Malayalam text.[45] Jyēṣṭadēva's *Yuktibhāshā*, which is in a way his *bhāṣyā* of *Tantṛasaṅgrahā*, embodies mathematical proofs of the theorems of Madhava and Nilakantha. Nilakantha's methodological rationality is best highlighted and pursued further by Jyēṣṭadēva who has given many rational approximations based on continued fractions, which scholars have not made out as yet. What has been shown totally new is a convergent infinite process capable of attributing the value of π to arbitrary accuracy. Jyēṣṭadēva shows that several such processes were known to the astronomers of Kerala. *Yuktibhāṣā* gives two methods for the calculation of the circumference: The first gives an algebraic recursion relation involving a square-root that converges to the exact value, and the second starts as a way to avoid square-roots in the calculation. What turns out as a matter of epistemic significance in *Yuktibhāṣa*, is the onset of the practice of providing proofs rather than just statements of results.[46] Another significance of the text is its use of the regional language (Malayalam) instead of Sanskrit and replacement of the poetic *genre* with prose. In short, it goes quite evident that the basic epistemic concept called objectivity was the cognitive motor in traditional Indian knowledge production and it progressively persisted as the central string of control across every *vyākhyā* or *bhāṣyā*.

Role of Social Matrix

As discussed above, with several centuries of persistent efforts and systematic progress in mathematical astronomy, the fundamental theorisation of calculus was achieved in Kerala during the fourteenth-sixteenth century CE. Nampūtiri-s had socio-economic as well as ritual reasons for acquiring knowledge in astronomy for predicting seasons and eclipses. Prediction of eclipse had greater importance because there was the strong belief that the conduct of Vedic sacrificial rituals would be futile with the incidence of lunar or solar eclipse during their performance. Being elaborate, long lasting, and expensive in terms of goods, services and rewards, the Vedic sacrificial rituals, once commenced, should proceed to their successful completion. Having to terminate a sacrifice on the incidence of an eclipse was ignominious to the priest who officiated and the king who patronized its performance. Therefore, ability to predict the eclipse was crucial for both the priest and the king. Mathematics began to grow as the most fundamental tool

of astronomy under the ritual pressure for generating predictive knowledge about planetary positions and movements. It cannot be altogether accidental that the great mathematicians of Kerala had written manual-like texts on the calculation of the planetary motion, obviously in order to enable prediction of lunar and solar eclipses. Interestingly, most of them were Nampūtiri-brāhmaṇa-s of the Vedic tradition as well. Their association with the Vedic tradition is evident from the honorific suffix *somayājī*, indicative of the priestly status of the Soma Sacrifice, appended to their names.

Further, Nampūtiri-brāhmaṇa-s had strong belief in the auspicious time (*muhūrttam*) for the various observances of the daily life as well. Naturally, these beliefs became contemporary social obsession and *brāhmaṇa*-s set the calendar, *pañcāngagaṇitam* based on *nakṣatra-tithi-vārayogakaraṇa*-s, for the whole society, not only for economic practices but also for rituals. This accounted for the growth of knowledge in astronomy and arithmetic functions. Arithmetical competency enabled the landlords to be precise about the measuring of the productive lands and their yields. Inscriptions of the temples that were the headquarters of the agrarian settlements of Nampūtiri-brāhamaṇa-s, and a few copper plate charters vouch for the precise measurements of dues in terms of decimals. There was a preponderance of the cult of devotion to Āgamic gods and the entailing irrational beliefs. Naturally, this brought about a marked shift from astronomy to astrology at the popular level knowledge practices, quite explicable in relation to contemporary social compulsions on the one side and the declining critical intelligence of the scholarly generation on the other. Viewing in the perspective of historical epistemology, the process was that of an uncritical return to the axiomatic and the traditionally given, from the threshold of proof construction shown by Jyeṣṭhadeva in calculus.

Across Cultures

Circulation and progressive accretion of knowledge in Indian regions had always gone beyond the sub-continent to Persia and the Arab world in the west and to China and the larger Asia in the east, thanks to the long-distance itinerant traders. Long-distance trade hardly meant mere exchange of material goods. It inevitably involved exchange of cultures to which transaction of knowledge was integral. Production of new knowledge in a region was often catalysed by elements drawn from the knowledge of another region. Cultural transactions during the fifteenth and sixteenth centuries

that marked extensive and frequent overseas voyages by merchants and missionaries were of an unprecedented dimension. Often, regional sharing carried knowledge forward to higher phases, the accomplishment of which would normally be within a larger geographical entity with a knowledge-language of intra-regional use for sustained scholarly enterprises, unless socio-economic and politico-cultural changes become totally unsuitable.

A very significant factor was the unprecedented possibility of overseas transmission of the knowledge from the Kerala region to the Persian world and Europe through maritime traders and Jesuit missionaries.[47] Moreover, Europe after Renaissance was witnessing a phenomenal techno-economic, socio-cultural and politico-intellectual development, providing an ideal environment for the production of new knowledge, thanks to the primacy of reason, critical intelligence and curiosity of the age. Nilakantha's model of the planetary motion was identical to what Tycho Brahe (1546-1601 CE) presented subsequently. Jyeṣṭhadeva's formula showing a passage to infinity, which facilitates calculation of areas under parabolas, is an essential constituent of the theory of calculus.[48] It is the same formula that the seventeenth century CE European scholars like Pierre Fermat (1607-1665 CE), John Wallis (1616-173 CE), and Blaise Pascal (1623-1662 CE) had used. Similarly, what Wallis obtained as his results on continued fractions are identical to those obtained by Bhāskara II.[49]

There exists a running thread of the same epistemological control across the cognitive exercises involving empirical scrutiny, rational analysis and theorization in Jyēṣṭadēva's constitution of proofs for the power series and in Leibniz's or Newton's formulation of the fundamental theorem of calculus enabling higher trigonometric applications. Between the East and the West, there was no paradigm shift in terms of epistemic parameters regarding the production of astronomical knowledge in the seventeenth century. Actually what Europe developed subsequently was a linear advancement of the same epistemic tradition with additions enabling improvement of knowledge as well as cognitive means to go further. Their mathematical approach through the development of infinite series for understanding and reckoning planetary positions and movements were epistemologically the same. That there exists no linearity but instead an epistemic rupture about the progress of mathematics between India and Europe is a matter taken for granted under the influence of the long-sustained belief about the East as the opposite of the West, in all respects. The West had built up this

contrast through the historical process of representing the East on the basis of unfounded ideas, imaginary notions and prejudices, which subsequently gave rise to the myriad of discursive strategies of Eurocentrism for distinguishing the West from the East in every aspect of culture.[50]

Afterword

As in other cultures, in the Indian too, it is metaphysics first and then the systems of thought. This is not to mean that the latter were invariably in epistemic conflict with the former. Some of them were, while others either co-existed or synthesized. The theistic and the atheistic conflicted with each other, while the abstract and concrete among the rest synthesized. Nevertheless, they show the scene of conflicts witnessing the atheistic sometimes turning to theistic and theistic to meta-theistic. At some point of time knowledge becomes an object of analysis, discussing its nature, structure, composition, concept of truth, proof and techniques of validation. Scepticism was central to the process. Ways and means of strengthening the reliability of knowledge through critical methodology have been a major scholarly preoccupation in pre-modern India. It culminated in the practice of producing proof in the language of mathematical formalism, the highest watermark of methodological progress, as exemplified by the progress in astronomy during fourteenth-sixteenth centuries CE.

Scholars were engaged in addressing intellectual issues in the domain of knowledge of their choice, a process that inevitably transcended the region and Sanskrit, the language of specialized traditional scholarship, which facilitated their sub-continental convergence. It becomes clear that intellectual perception comes into being out of interaction with the community of scholars and their scholarship on the one side and under socio-cultural compulsions. The long-protracted and persistent *vyākhyā/bhāṣyā* tradition demonstrates a clear linearity about the progress of methodological pre-occupation in knowledge production of pre-colonial India from the axiomatic, through proof creation to the scientific, over centuries. What emerges is the universality of epistemic properties that make deeper knowledge distinct irrespective of its geography. Now we realize that there existed a single cognitive thread of epistemic control in the production of knowledge. There was no rupture in the process, although the next higher phases were manifested not in regions across India but in Europe.

Notes

1. For a detailed discussion of the meaning of knowledge, see D. Prichard, *What is This Thing Called Knowledge?* New York: Routledge Tylor & Francis Group, 2006, pp. 1-11. Also, see K. Lehrer, *Theory of Knowledge*, Boulder and San Francisco: University of Arizona, Westview Press, 2000, pp. 3-5.
2. *Kenōpaniṣad,* 1:5-8. For the text, English translation and commentaries, see Sri Aurobindo, *The Upanishads*, New York: Lotus Press, 2015.
3. *Chandōgyōpanishad* 3:14.1. For the text, translation and commentaries, see Sri Aurobindo, *The Upanishads*, Op. cit.
4. *Brihadāraṇyakōpaniṣad* 1:4.10. For the text, translation and commentaries, see Sri Aurobindo, *The Upanishads*, Op. cit.
5. *Aitareyōpaniṣad* 3:1.3. For the text, translation and commentaries, see Sri Aurobindo, *The Upanishads*, Op. cit.
6. See Kosambi, D.D. *Introduction to the Study of History*, Popular Prakashan, Bombay, 1958. Also his *Myth and Reality*: *Study in the Formation of Indian Culture*, Popular Prakashan, Bombay, 1962 and; *Culture and Civilisation in Ancient India in historical Outline*, New Delhi: Vikas Publishing House, 1964.
7. See B.K. Matilal, *Perception*: *An Essay on Classical Indian Theories of Knowledge*, Oxford: Oxford University Press, 1986.
8. See B.K. Matilal, *Epistemology*, *Logic*, and *Grammar in Indian Philosophical Analysis*, Mouton Publishers, The Hague, 1971. Also, see J.N. Mohanty, *Reason and Tradition in Indian Thought*, Oxford: Clarenden, 1992.
9. Paul Kiparsky calls it 'a complete, maximally concise, and theoretically consistent analysis of Sanskrit grammatical structure —'Pāṇini's grammar is a complete self-contained system of rules'— See his "P Pāṇinian Linguistics," in R.E. Asher ed. *Encyclopedia of Language and Linguistics*, Vol. 1 (6), Oxford: Pergamon Press, 1993, p. 2918 & 2920.
10. Ibid., p. 2920.
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21. The verse from *Caraka samhitha Sutrasthānam*, Chapter I, *Dīrghamjīvitiyam*, 121.
Oṣadhīr nāmarūpābhyām jānate hy'ajapā vane |
avipāścaiva gopāśca ye cānye vanavāsinah || 1.1.121 ||
Shepherds and other pastoral groups (*ajapa*-s and *gopa*-s) of the forest areas are well versed in the knowledge of herbs.
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