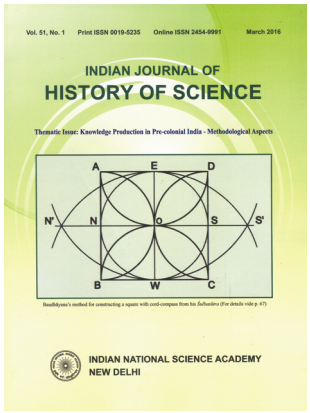

***Indian Journal of History of Science*. Thematic Issue: Knowledge Production in Pre-colonial India – Methodological Aspects.** A. K. Bag (ed.). Indian National Science Academy, Bahadur Shah Zafar Marg, New Delhi 110 002, 2016. vol. 51. No. 1. 166 pages.

Creation of knowledge is a cumulative process in which new ideas are assembled over time and across disciplines. Methods for knowledge development have been a subject of serious and continuous debate all through history. Discussions of methodologies are scarce in surviving records from early cultures. Historians of ideas and sociologists of science provide some material. They are nevertheless not comprehensive for exploring the 'patterns of knowledge production' and how new work builds upon old. Though science and technology in ancient and medieval India covered all the major branches of human knowledge and activities, written records of systematic methods of knowledge production in ancient India are not available.

This thematic issue of *Indian Journal of History of Science* (*IJHS*) edited by Rajan Gurukkal is a collection of 16 articles which deal with knowledge production in a wide range of disciplines. All of them, except one, discuss the question whether generation of knowledge in pre-colonial India was based on any universally valid methods. The essays are based on presentations during a national seminar organized by the Center for Contemporary Studies at Indian Institute of Science, Bengaluru. This compilation is significant as colonial scholars had tried to depict that rational or objective knowledge systems were lacking in pre-modern India.

In the first essay of the collection, Sharada Srinivasan emphasizes the need to connect archeometallurgical studies with ethnoarcheological studies to explore the direction of knowledge production in relation to metallurgy in ancient India. She argues that scientific methods such as experimentation and replication (as evident in the discovery of various alloys for making vessels, Aranmula mirrors, and water and sand clocks during the Iron Age of South India), cementation process and distillation were all known to early, Indian metallurgists. Extensive description of methods of extraction and purification of metals is codified in the Sanskrit texts *Rasaratnakara* of Nagarjuna and *Rasaratnasamuccaya* of Vaghbata.

Three articles deal with Ayurvedic knowledge. M. R. Raghava Varier discusses the origins and growth of indigenous knowledge of healing and health. M. S. Valiathan details Caraka's approach to knowledge. *Caraka Samhita* systematized and organized health-care knowledge. Caraka seems to have adapted philosophical traditions such as *Vaisesika*, *Nyaya* and *Sankhya* to suit health-care needs. He considered the entire universe as his teacher. His methods combine knowledge from non-empirical sources (a priori knowledge) with intuition and inspiration. Testimony of sages, perception, inference and reason were all used by Caraka to gain knowledge. He also emphasized that all biological events are based on cause and effect relationships. Three types of causes are listed, and cause and effect relationships are detailed in Ayurveda.

S. N. Venugopalan Nair and Darshan Shankar in their long essay highlight the holistic approach in the methods of generation of Ayurvedic knowledge. Ayurvedic approach stresses on the significance of human relationship with environment. They draw a parallel between *Sidhanta* theory as defined by Caraka and the hypothetico-deductive reasoning, central to modern scientific knowledge production. A guiding principle of investigations in Ayurveda is that knowledge of the whole cannot be acquired from the knowledge of its parts. Traditional Indian texts of knowledge mention four types of Sidhanta, and no Sidhanta is considered complete and sans change. Nair and Shankar list in a table, the procedures and focal points of debates used in intellectual discussions. This dialectical procedure – *Vada marga* – is based on *Nyaya Sidhanta*, used for improving and establishing knowledge in traditional India. The procedures include debate with reference texts (*vada*), proposition – which is to be proved at the end of the argument (*pratijha*), proof (*sthapana*), and counter proof (*pratisthapana*), example (*drstanda*), cause (*hetu*), rejoinder (*uttara*), inference (*nigamana*), theoretical conclusion (*sidhanta*), inference (*anumana*), purpose (*prayojana*), question (*anuyoga*) and further question (*pratyanuyoga*), abandonment of proposition (*pratjnahani*), acceptance (*abhanunja*), fallacy of reason (*hetvantaram*), and defeat or discomfiture (*nigrahasthana*).

Six schools of thought seem to have influenced systematization of Ayurvedic knowledge into Samhitas, which advocate an evidence-based approach for the creation of theoretical knowledge and clinical practice. Four proofs of knowledge accepted by Ayurveda acharyas include direct sensory perception (*pratyaksa*), inference (*anumana*), experimental reasoning (*yukti*) and testimony of the vedas (*aptopadesa*). There are others as well, such as comparison (*upamana*), implied knowledge (*arthapatti*), incidence (*sambhava*) and presentations (*chesta*). Cowherds, goat herds and other foresters were sources of knowledge regarding medicinal plants. *Astanga Hrdayam* recommends testing of toxicity by administering substances to animals.

Mathematics in India has a long and continuous history. An early example of mathematical creativity is the invention of decimal enumeration (counting with 10 as the base). P. P. Divakaran makes a detailed enquiry into the features that unite practice of mathematics in different cultures across India. He illustrates how the challenges in doing mathematics because of an oral and formal form of enunciating and passing on knowledge were overcome. The Indian approach to geometry and its variance from the Hellenic, idea of proof in ancient India and its evolution, and original contributions from Kerala mathematicians of 15th and 16th centuries are also surveyed.

Divakaran also comments on the motivations and methods for mathematical discourses, the value attached to mathematical activity, and how mathematics was thought of and made use of in three different civilizations – Indian, Greek and European. Contacts with the Hellenic world around 3rd century AD seem

to have changed the nature of mathematical activity in India. Natural phenomena were subjected to mathematical analysis. Quantitative study of astronomical observations and making geometrical models of planetary motion were initiated during this period.

Aryabhata (AD 499) defined the direction of mathematical astronomy and mathematics in India. Interestingly, the origins of discoveries of Aryabhata, Brahmagupta and Madhava can be traced to the Vedic geometric work books known as *Sulbasutra* (ca 800 BC). Divakaran attributes the uniformity of thoughts and methods over a long span of time and geographical distance, to information that was passed on by traders, pilgrims, soldiers and artisans.

Mathematical texts of ancient India are all words without symbols and equations. This is attributed to the legacy of oral and verbal Vedic culture. The dependence on an oral culture had its effect on the genesis and evolution of a system for counting and production of a mathematical language and grammar.

Indian geometry differs from that of Euclid in the sense that geometrical truths are conveyed through diagrams, and thus is more visual. Number-free 'cut and fit' geometry of areas is characteristic of many constructions in *Sulbasutra*; but they do not contain proofs.

Indian masters of mathematics never clearly defined terminologies or bothered to indicate how the results were obtained. This tendency led to the view that they did not have proofs for their discoveries. Now it is recognized that the aim of canonical texts was to only leave a record of new knowledge and not provide explanation, because learning was through oral explanation, clarification and response to questions. Very few results obtained by Indian masters are wrong and it is unlikely that they were the result of guess work. Nilakantha, an interpreter of Aryabhata, has expressed that even in mathematics the primary instrument of acquiring and validating knowledge is our senses, followed by analysis and drawing inferences by means of mental faculties and exposure to criticism by the knowledgeable. The significant emphasis on the organization of proofs is evident in the title *Yuktibhasa* written by Jyesthadeva, a disciple of Nilakantha. Yukti is 'reasoned justification' or proof. The hallmark of *Yuktibhasa* is that proofs are definite and complete with precise and organized features.

A recursive process of reasoning and absence of the device of *reductio ad absurdum* are also features of ancient Indian mathematics. Recursive logic under the name '*Samskaram*' was powerful in the Nila school. The starting point in all *Samskaram* computations is an educated, approximate first guess at the answer. Mathematics of the Nila school was spurred by its own internal logic rather than by possible applications. Divakaran states that Nila calculus is conceptually and technically more sound than that of Newton and Leibniz.

Advances outside the domain of calculus include abstract algebraic approach, assured handling of infinite series, stress on formally presented proofs, and renouncing searches for geometric justifications of arithmetical and algebraic identities. Madhava modernized mathematical mindset, and Divakaran states that Madhava's original approach seems to anticipate the developmental stages, which mathematics passed through in Europe following the Cartesian revolution. He also assesses cross-cultural currents that could have influenced different mathematical cultures.

C. Rajendran in his article analyses the evolution of the concept of inference (*anumana*), which was used as a method for knowledge acquisition in all domains in India in ancient times. The nature and structure of the process of inference, however, differed considerably among different systems. Rajendran demonstrates how ancient Indian intellectuals excelled in the art of logical reasoning with forceful methods and how they helped strengthen the scientific climate. Science of reasoning was important in the curriculum of Kautilya. The key concept of the inferential process is invariable concomitance (*Vyapti*), and according to Naiyayikas and Budhists, inference is two-fold – one for one's own sake (*swarthanumana*) and another for the sake of others (*pararthanumana*). Interestingly, the Carvakas did not accept inference as a means of valid knowledge as no logical certainty can be attributed to it. Buddhist logicians spurned the Carvakas' skepticism. Naiyayikas proposed ways to avoid faulty reasoning and conceived the concept of faulty reason (*hetvabhasa*). This was used in the context of defective process of thinking and defective conclusion. Rajendran suggests that these methods followed by philosophers might have been followed in empirical sciences as well.

A. Raghuramaraju attempt to determine the principles of organization of knowledge. He argues with evidence that while during the Vedas and the Upanishads, the prominent approach in philosophy was based on maxims or aphorisms, post-Buddha, debates gained pre-eminence in enquiries. Ideas in a debate obtain vitality and transparency through difference, logic and argument which are part of philosophical debates and result in critical evaluation. Logic developed in ancient India from the tradition of *Vadavidya*. In the beginnings of the Christian era, several *vada* manuals which prescribed how to conduct debates successfully were available. In *Nyayasutra*, Aksapada describes three types of debates: honest (*vada*), tricky (*jalpa*) and destructive (*vitanda*). Raghuramaraju also discusses the fate of debating methods of knowledge production during the colonial period and the consequences. He concludes with an appeal to restore the debating method for knowledge production.

Sundar Sarukkai deliberates on the role of translation in the transmission and circulation of ideas and knowledge across different cultures. Ideas move from one culture to another primarily through translation. Translation is also a method to discover a wide range of meanings for concepts. Sarukkai considers the methodological issues such as theoretical assumptions in translational activities.

There are two articles which survey the beginnings and growth of early Tamil grammatical knowledge. R. Champakalakshmi probes early knowledge production in Tamil language, literature and culture. She surveys the historical Sangam literature and the influence of Jains and Buddhists on Tamil language and literature. *Tolkappiyam*, the earliest work in Tamil grammar aided the understanding of the phonology, morphology and meaning of the Sangam poems, thus creating a basis for a knowledge system and a method of interpreting grammar for early Tamil language. Y. Subbarayalu also reviews the context of genesis of *Tolkappiyam* and its salient features.

Mundoli Narayanan in his composition uses teaching methods in the traditional art form Kathakali to demonstrate how unique 'body–mind and body–memory'

are established through repetitive physical exercises focusing on specific parts of the body (stylized actions, movements, postures and rhythmic dance steps) that progressively develop in intensity and complexity. The aim is to inscribe aesthetic, emotive, thematic and other aspects of performance in the student and train the body to perform without the involvement of the conscious mind. There is seldom any attempt to pass on knowledge of a conceptual nature to the trainee. Rise in the mental awareness of the student enhances the quality of performance. Narayanan also examines the societal contexts in which the teaching practices of Kathakali developed, drawing a parallel with the training of the martial art *Kalalaripayattu*. He suggests that the culture of training during 17th and 18th centuries, the period when pedagogy evolved in *Kathakali and in Kalaris*, was to create an embedded knowledge that can be elicited at will and without resorting to 'conscious' intervention of the mind.

Naresh Keerthi discusses the concept and implications of *Prabandha*, which as a category meant several things to musicologists from Matanga (8th century AD) to Venkatamakhin (16th century AD). Various examples of *Prabandha* songs are found in musicological sources from the late medieval period. Keerthi traces the history of *Prabandha* in musicology literature and examines the geneology, theory and practice of *Sriranga Prabandha*, a specific sub-type of the genre. He opines that 'reading musical composition and genres as historical–cultural artifacts makes them amenable to very different analyses'. He also debates on how the mix of textual and performative features in musical *Prabandhas* made them, in comparison to literature more understandable to a larger audience.

Architectural practices in India date back to the Indus valley civilization (c. 300 BC). Monuments at various locations affirm the astonishing level of perfections achieved by designers, masons, craftsmen and artisans of early India. R. V. Achari distinguishes *Vastuvidya* (architecture) from *Vastusastra* (sociocultural norms of building construction) and documents the textual tradition, principal features and transitions in *Vastusatra* and the modern reinventions. Achari portrays *Vastuvidya* as a modern incarnation of *Vastusastra*. He concludes that 'the historical monuments are enduring testimonies to the *Vastuvidya* knowledge of our past masters'.

In summary, the articles in this collection reveal that traditional Indian intellectual pursuits were not 'simply magical, romantic, speculative and dogmatic'. The reviews in various domains of knowledge systems suggest a genuine scientific approach in which both inductive and deductive approaches were abundantly followed. The interesting, informative and illuminating contents of this Special Issue of *IJHS* would benefit both students and scholars from a broad range of disciplines. I recommend the study of this collection to all those who are curious to know whether ancient Indian masters possessed logic and reason.

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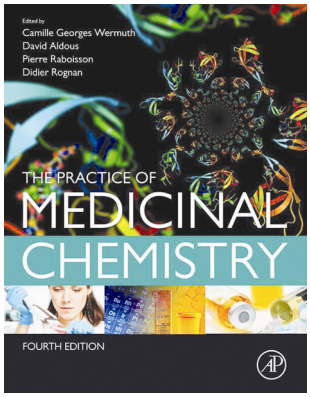

The Practice of Medicinal Chemistry. Camille Georges Wermuth, David Aldous, Pierre Raboisson and Didier Rognan (eds). Academic Press, An Imprint of Elsevier, 125, London Wall, EC2Y 5AS, UK. 2015. 4th edn. xxii + 880 pages. Price: US$ 150.00.

The book *The Practice of Medicinal Chemistry* is in the fourth edition which highlights the importance of the topic and its relevance. The book has been rightfully called as 'bible of medicinal chemistry'. It has been reviewed and recommended since the first edition in 1996.

The book has been divided in seven major areas which contain relevant subtopics. The main topics cover areas such as general aspects of medicinal chemistry, lead compound discovery strategies, structure–activity relationships, substitutions and functions, molecular modelling, pharmacokinetics and formulations. Each sub-chapter has detailed definitions and explanations of different concepts. The editors have given the responsibility of each area to experts in the field, for example the sub-chapter on natural products as pharmaceuticals and sources for lead structures is written by David J. Newman who publishes review on natural products and their role on pharmaceuticals regularly. This has helped in bringing in the required depth to the chapter.

The book describes in detail, various aspects of medicinal chemistry. Target identification, strategies for new lead compounds, in silico screening, fragment based drug discovery, structural changes to improve the inherent properties of the chosen molecule, pharmacophore identification, drug transport mechanism, formulations and nomenclature are the important topics covered. Ample illustrations help understand the concepts described in the book.

This book is recommended for the practitioners of medicinal chemistry, scientists involved in drug discovery, colleges and universities which teach medicinal chemistry in their curriculum.

The book has a minor limitation. As the chapters are written by different individuals, the drawings that are included are not uniform and the authors will hopefully overcome this in the next edition.

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Annual Review of Nutrition, 2016. Patrick J. Stover (ed.). Annual Reviews, 4139 El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, USA. Vol. 36. x + 693 pages. Price: US$ 96.

It is common knowledge that dietary practices across economies, geographies and ethnicities need to be considerably modified in order to stem the increasing crisis of malnutrition at both ends of the spectrum. While at one end the number