

## PREFACE

“Some time in the course of writing research papers as a clinical psychologist, I began to wonder what child care practices existed in ancient India and I suddenly realised that I knew nothing about child care in India, how children were brought up and so on. I had no notion of the tradition of child care in my own area of specialisation, in my own country! It was then that I began to find out more about this. First, I needed the help of Sanskrit scholars since I did not have expertise in the language. Then, I found that I needed the help of botanists and Ayurvedic physicians as well, as so many medicines had to do with plants and herbs.....” This is how Dr Malavika Kapur began her talk at the seminar, *“Into the Future with Knowledge from Our Past.”*

Dr Kapur’s predicament is not unusual. Most of us have gone through an education system that alienates us from our roots. While we retain vestiges of tradition in terms of customs and practices, rites and rituals, these are performed more by rote than with any inkling of their actual purpose. In due course, unable to continue with an exercise that to us is meaningless for all purposes, we give up. One more tradition is lost to posterity.

As Prof. B Mahadevan said in his talk at the seminar, mindless glorification and translation of our ancient texts by culturally illiterate persons, belonging as they do to alien cultures (predominantly western), has often resulted in making claims about ancient Indian wisdom seem ridiculous. As Prof. Dwarakadas said in his keynote address, what is required is a common platform for Sanskritists, Scientists and Researchers to come together so that each may learn from the other and their findings may be presented to the world in a logical, meaningful, methodical manner that will stand the scrutiny of sceptics.

Just as the Taj Mahal is a symbol of India and not merely a Muslim monument, so too the scientific heritage of India is a national treasure. We must not allow ourselves to be misled into believing that it belongs to any one community. Sanskrit belongs to all of us and we must reclaim it together.

**December 2006.**

**Sri Tirunarayana Trust.**

## A BRIEF SKETCH OF THE SPEAKERS <sup>1</sup>

### 1. **Sri Anand K**

Project Manager, *Advaita Sharada* Project, Dakshinamnaya Sri Sharada Peetham, Sringeri.

- MS in Computer Science from Washington University, St. Louis, USA.
- Pursuing Sanskrit studies in the traditional manner at Sringeri, Karnataka.
- Involved in the Peetham's Advaita Sharada project, an effort to build a knowledge base of ancient Indian Literature.

### 2. **Dr. B. Mahadevan**

Professor, Indian Institute of Management, Bangalore

- M.Tech, Ph.D. from the Industrial Engineering and Management Division of the IIT Madras.
- More than 15 years wide ranging professional experience in teaching, research, consulting and academic administration.
- Member of the Central Sanskrit Board, an advisory committee to the Government of India.
- Chief Editor of *IIMB Management Review* and on the editorial board of leading Indian and international professional journals.
- Received the "ICFAI Best Teacher" award from the Association of Indian Management Schools.
- Current research interests: Design of software for manufacturing system design, supply chain management issues in E-Markets and inventory policy framework in product remanufacturing, role of Sanskrit and ancient Indian wisdom in addressing contemporary issues in management.

### 3. **Prof. Malavika Kapur**

Hon. Professor, National Institute of Advanced Studies (NIAS), Bangalore

- Till recently, professor and head of the Department of Clinical Psychology at NIMHANS.
- Over three decades clinical, teaching and research experience.
- On the editorial committees of several professional journals.
- Awarded Scholar in Residency by the Rockefeller Foundation, recipient of Vidya Varenia Award.
- Author of two books, including '*Child Care in Ancient India*'. Also writes fiction for children.
- Areas of interest: developmental psychopathology and school mental health.

### 4. **Dr. R. Raghavendra**

Swami Vivekananda Yoga Anusandhana Samsthana (SVYASA), Bangalore

- Degree in Naturopathy and Yogic Sciences, Mangalore University.
- Working in the Department of Clinical and Psycho-neuro Immunological Research.
- Published papers in national and international journals and presented invited lectures in national and international conferences in naturopathy and yogic sciences.
- Recipient of prize for best paper in the field of yoga and naturopathy given by the Association of Physiologists and Pharmacologists of India in 2002.
- Research projects: influence of yoga therapy in immune modulation in rheumatoid arthritis,

integrated approach of yoga therapy in the treatment of breast cancer, yoga, meditation and health.

**5. Dr. K. Ramasubramanian**

Asst. Professor, Department of Humanities and Social Sciences, Indian Institute of Technology, Mumbai

- PhD in Theoretical Physics.
- Vidwat Pravara - Sringeri.
- Books authored / co-authored: *An Introduction to Ancient Indian Mathematics: 500 years of Tantrasangraha - a Landmark in the History of Astronomy.*
- Research Interests: Indian Science and Mathematics, Sanskrit, Physics.

**6. Dr. Sangeetha Menon**

Fellow, School of Humanities, National Institute of Advanced Studies (NIAS), Bangalore

- Received the international GPSS award (Global Perspectives on Science & Spirituality) for 2005-06.
- Recipient of “Young Philosopher Award” for 2001-02 from the Indian Council of Philosophical Research.
- Broad areas of research interest: Indian psychology, Indian philosophy, Indian dramaturgy and spiritual experiences in the context of current discussions on consciousness, new methods in the digital archiving of ancient manuscripts.

**7. Vidwan Sheshachala Sharma**

Eminent scholar in Sanskrit and Philosophy

- M.A. and Vidwat
- More than three decades teaching experience
- Acknowledged expert in various branches of Sanskrit such as Alankara, Vyakarana, Pracheena Nyaya and Vedanta
- Author of several books, notably the Kannada rendering of *Adi Parva of Mahabharata* and *Shankara Darshana*.
- Awarded the honorary degree, ‘Vachaspati’. by the Rashtriya Sanskrit Vidya Peetha, Tirupati.
- Recipient of President of India award for Sanskrit studies (2006).

**8. Dr. P.M. Unnikrishnan**

Foundation for Revitalization of Local Health Traditions (FRLHT), Bangalore

- Ayurvedic physician, with masters in medical anthropology from the University of Amsterdam.
- Currently coordinating a programme on endogenous development and local health traditions.
- Professional interests: inter-cultural medical research, role of traditional medicine in public health.

**Wisdom of the Ages**

All ‘Wisdom of the Ages’ quotes are from Sri. J. Gaurav Magar’s paper, ‘*Ancient Indian Cosmology*’. The research paper is mandatory for VTT Scholars. **Sri Gaurav Magar was the VTT Scholar for the year 2005-06.**

**Note :**

<sup>1</sup>The names are listed alphabetically.

## A NOTE TO STUDENTS

Some of you may have attended the lectures at the seminar *‘Into the Future with Knowledge from Our Past* held at the VVS First Grade College for Women, in October 2006. In this booklet, we have tried to capture the essence and spirit of those lectures, given by eminent professionals from diverse fields (A brief sketch of the speakers is given elsewhere in this booklet). As you know, there will be a quiz competition based on the contents of this Sourcebook. The details of the quiz are given below.

**Preliminary Written Round:** (OPEN BOOK FORMAT. YOU CAN FREELY REFER TO THE SOURCEBOOK DURING THE WRITTEN QUIZ)

Date: February 2nd Week\*

**Final Oral Round:**

Date: February 3rd Week\*

Venue for both rounds: VVS First Grade College for Women.

Prize: Winner gets a scholarship of Rs.300/- per month for one year and a medal in sterling silver. Runner up gets a medal in sterling silver. All finalists get certificates of merit.

In the scholarship year, the VTT Scholar is expected to do some research on the relevance of ancient Indian knowledge to the present day. The findings need not necessarily eulogize; a critical, scientific appraisal will be appreciated. Besides the scholarship, the VTT Scholar will also be given an opportunity to present a paper at the subsequent year’s seminar, based on the student’s research into the topic of the series, *‘Into the Future with Knowledge from Our Past.’* The research should exhibit some original thinking and spirit of inquiry. It cannot be merely reproduced from existing literature.

As far as this booklet is concerned, an attempt has been made to give the translation and transliteration of most Sanskrit terms. The proper pronunciation has been indicated by capitalising the extended vowels in the Sanskrit terms, where such terms occur for the first time. For example, Mitakshara is written as MitAkshara the first time it occurs. This indicates that the ‘a’ in the first syllable is extended and the word must be read as Mitaakshara wherever it occurs.

The purpose of the seminar and the quiz is to reach the message to the younger generation that India has a rich heritage of knowledge of which we need to feel justifiably proud, and also that there may be much to learn from our past for application in the present times as there is a yearning all over the world for simpler, more natural and sustainable alternatives to solutions which, though technically advanced, are often effective in the short term and create an adverse impact in the long term. So, read the Sourcebook from this perspective and think of newer avenues for research on the topics presented.

You can send your ideas and suggestions to [tirunarayana@gmail.com](mailto:tirunarayana@gmail.com).

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\*Exact dates will be announced after colleges re-open.

## GLIMPSES OF SOCIAL LAW FROM VIJNANESWARA'S MITAKSHARA

Sheshachala Sharma<sup>1</sup>

The present Indian law is mainly based on British jurisprudence. However, many parallels may be drawn between the present law of our land and the laws codified by our sages thousands of years ago. Many have heard of Manu, who is widely believed to have authored the first ever set of systematic rules and regulations, or codified law, for the smooth conduct of social life.

Like the *Manu Smriti*, Yajnavalkya, another wise sage of ancient India, also authored a set of laws that have come down to us as the *Yajnavalkya Smriti*. Yajnavalkya is also believed to have been the *Acharya* (principal teacher) of the *Shukla Yajur Veda*.

Much of India's ancient literature is in the form of *sUtras* (concise verses/ aphorisms) which only the best of scholars can understand and interpret without the help of *bhAshyas* (explanatory texts/ commentaries). Many commentaries were written for the original Sanskrit texts by various eminent scholars after in-depth reading of the original works. *PramitAkshara*, or *MitAksharA* for short, is a celebrated commentary on Yajnavalkya's well organised, structured *sutras* which laid down the tenets of social law<sup>2</sup>. In fact, the text continues to be referred to even to this day for the interpretation of Hindu Law in our courts, whenever doubts arise.

An incident that occurred in our pre-Independence days actually illustrates the importance that was accorded to *Mitakshara* even under the British Raj! Once, a case came up for hearing before the British judge of the High Court in Madras. As he felt doubtful about a particular point pertaining to the Hindu Law, he wished to refer to the *Mitakshara* in the original. Even in those days, about a century ago, the number of scholars who knew Sanskrit and could talk authoritatively about texts in that language was dwindling. One of the few persons at that time who had studied the *Mitakshara* in-depth and could interpret it reliably was a scholar who lived in Chamarajanagar, near Mysore. The judge of the Madras High Court ordered this scholar to be brought from Chamarajanagar to Madras. With the help of a *dubashi* (translator) fluent in Sanskrit and English, the judge then had the scholar interpret the *Mitakshara*. The British judge not only had his doubt cleared, but is also believed to have been highly appreciative of the wisdom of ancient Indians after learning of the contents of *Mitakshara*.

### MITAKSHARA AND IT'S AUTHOR

Vijnaneswara, the author of *Mitakshara*, was the son of Padmanabha Bhatta and belonged to the *BhAradwAja gOtra* (lineage of Bharadwaja) - this is the way people introduced themselves in the ancient days. He calls himself a *vijnAna yOgi* (a staunch follower of scientific methods). His commentary on *Yajnavalkya Smriti* is so significant that it is considered as important for the study of *Dharma ShAstra* (the law governing social conduct) as Maharshi Patanjali's *MahA BhAshya* is, for the study of *VyAkarana ShAstra* (the rules governing the grammar of the Sanskrit language).

*Mitakshara* can be considered a compendium (synopsis or thumbnail sketch) of the *Smriti Shastras*, as it contains detailed quotations from many *Smriti Granthas*<sup>3</sup>. Topics in *Mitakshara* are arranged in a scientific manner, in keeping with the author's claim to being a *vijnana yogi*. The author has also quoted extensively from the *PURVA MIMANSA*, signifying his deep study and understanding of this system of philosophy<sup>4</sup>. It is said that the *Mitakshara* was composed during 1070-1100 A.D.

## **A BRIEF INTRODUCTION TO YAJNAVALKYA SMRITI**

*Mitakshara* is only a commentary and its salience is due to the fact that it explains the *Yajnavalkya Smriti*. To appreciate the essence of *Mitakshara*, therefore, we need to understand what the original text, or *Yajnavalkya Smriti*, contains.

*Yajnavalkya Smriti* consists of three *kAndas* (sections), namely:

- the *AchAra kAnda* section detailing the laws that govern the general conduct of people who constitute the society.
- **the *vyavahAra kAnda* - section governing behaviour in the course of social interaction with family, at work, in profession, trade, commerce, etc.**
- the *prAyashchitta kAnda* - section containing provisions relating to atonement for offences committed.

As the subject matter of our speech pertains to Social Law, we are mainly concerned with the *Vyavahara kanda*. So, we will briefly touch upon the other two *kandas* and then discuss the *Vyavahara kanda* in more detail.

In the *AchAra kanda*, fourteen knowledge streams, or sciences, are mentioned. This section is mainly concerned with *varnAshrama dharma*, that is laws pertaining to people in different occupations.

In the *Prayashchitta kanda*, questions relating to the need for atonement, the form of atonement and practices allowable in times of distress (*Apaddharma*) are discussed.

The laws discussed in the second section, *Vyavahara kanda*, with which we are concerned in this paper, are relevant today and for all times to come for achieving unity and cohesiveness in society. As such, aspects discussed in this section require careful and considered reflection. Presented here is but a very brief introduction.

## **VYAVAHARA KANDA**

The term '*vyavahara*' consists of two *upasargas* (prefixes) namely, '*vi*' and '*ava*'. *Vyavahara* means to resolve (*hAra*) diverse (*vi*) problems (*ava*). *Yajnavalkya* describes *vyavahara* thus:

स्मृत्याचारव्यपेतेन मार्गेणाधषितः परैः ।

आवेदयति चेत् राज्ञे व्यवहारपदं हि तत् ॥

The *Vyavahara kanda* of *Yajnavalkya Smriti* consists of twenty five *prakaranas* (chapters). It is interesting to note that after detailing laws for twenty four different instances where problems may arise in the conduct of every day social life, the last chapter calls itself *PrakIrna Prakarana*, that is, "Chapter on those (transactions) not covered above"!

The first two chapters of *Vyavahara kanda* pertain to transactions, both ordinary and exceptional. It is amazing to see how intricately various aspects pertaining to different kinds of transactions (including stealing!!!) have been thought about. For instance, laws for stealing by stealth (that is, furtively or by secret means) are distinguished from other kinds of robbery, and laws pertaining to them are detailed in separate sections called *SthEya* and *SAhasa*, respectively.

There are separate chapters on transactions involving diverse aspects of sale of goods; Chapters 10, 11 and 12 of *Yajnavalkya Smriti* deal, respectively, with:

- Sale by a person who is not the owner;
- Improper delivery of goods by the seller and improper returning of delivered goods by the buyer; and,
- Retracting from a sale or a purchase

In separate chapters, there are also laws dealing with disregarding a contract, non-delivery of goods sold and collective trade.

Individual chapters are devoted to laws pertaining to partitioning of inheritance, boundary disputes and even disputes between a master and his subordinate who tends to the former's cattle! Significantly, *Stree Dharma* a chapter on extra marital relationships, deals with the conduct of married men as well as women. There are also laws governing the number and qualities required of members of the Jury; qualifications and qualities required for a Judge; and qualities of a Witness.

The second chapter, *asAdhArana vyavahAra mAtrukAprakarana* (Conduct of Exceptional Transactions), may be cited as an example of the genius of our thinkers and law-makers of yore. The chapter, among a host of other things,

- Lays down that while a plaint is pending in one Court, a plaintiff cannot petition the Court with another plaint for the same cause.
- Describes the qualities of a bail (*pratibhUlakshana*)
- Prescribes punishment for false accusation (*mityAbhiyoga danda*)
- Deals with transactions entered into with insane and intoxicated persons.
- Interestingly, a law in this chapter mentions that transactions between the following are inappropriate and improper (*aniyukta, asambaddha*) - teacher and disciple; parent and children; husband and wife; and siblings. Why could this law have been made? Think about it and you'll realise how wise and far sighted our ancient law makers were!

On the subject of laws pertaining to routine transactions (*sAdhArana vyavahAra mAtrukAprakarana*), there are eighteen topics that are common to both *Manu Smriti* and

*Yajnavalkya Smriti*. In *Mitakshara*, Vijnaneswara draws our attention to this fact with apt quotes from the older law book.

About *sadharana prakarana*, the following stanza from the '*NArada Smriti*' says:

एषामेव प्रभेदोन्यः शतमोत्तरं भवेत् ।  
क्रियाभेदान्मनुष्याणां शतशाखोनिगद्यते ॥

## IN CONCLUSION

At the start of the previous section we said that *vyavahara* means solutions to diverse problems. However, depending on the context, the term *vyavahara* can also be used to mean:

- transaction (the act of giving and taking/ selling and buying, etc.)
- legal petition
- settling a dispute
- The system and administration of Justice.

The *Yajnavalkya Smriti* states that it is the responsibility and duty of the ruler (which we could equate to government in the present day) to administer justice, and in order to discharge this duty the guilty ought to be punished as per law. Just governance is considered as representing *dharma*, that is, the highest code of conduct. The Court of Law and Justice, therefore, is described as *DharmAsana* or *DharmasthAna* - the Seat of Dharma.

Many of the observations made in *Mitakshara* are relevant to this day. I feel that if certain modifications are made, in keeping with the changing times, *Mitakshara* can serve the society well even today. Judges and lawyers could, therefore, benefit from an in-depth study of Vijnaneswara's commentary of the *Yajnavalkya Smriti*.

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### Notes :

- <sup>1.</sup> Based on Vidwan Sheshachala Sharma's presentation at the seminar, *Into the Future with Knowledge from Our Past*, held in Bangalore on October 13 and 14, 2006 and his paper on the subject.
- <sup>2.</sup> VishwarUpa and AparArka have also written commentaries on the *Yajnavalkya Smriti*
- <sup>3.</sup> *Smriti* = Spoken. *Grantha* = ? Guess. Surely, you've been to a *grantha bhandara* or a *granthalaya*?
- <sup>4.</sup> *PURva MImAmsa* is one of the six schools of traditional Indian Philosophy. Find out what the others are.

### Wisdom of the Ages

Yajnavalkya (c.9th-8th century BC) recognized that the Earth was round and believed that the Sun was "the centre of the spheres" as described in the Vedas. His astronomical text, *Shathapata Brahmana*, states: "The sun strings these worlds - the earth, the planets, and the atmosphere - to himself on a thread. "He recognized that the sun was much larger than the Earth, which would have influenced this early heliocentric concept. He also accurately measured the relative distances of the Sun and the Moon from the Earth as 108 times the diameters of these heavenly bodies, almost close to the modern measurements of 107.6 for the Sun and 110.6 for the Moon.

## YOGA FOR STRESS MANAGEMENT AND PERSONALITY DEVELOPMENT

Raghavendra Rao M<sup>1</sup>

Is stress good or bad? Actually, it is both good and bad. Stress is an internal drive that motivates us to work and face challenges. There is no problem if we are able to cope with the stress and use it to push ourselves out of lethargy and make our lives better or more worthwhile. But, when the stress causes an imbalance between our mental and physical levels, it results in mental, emotional and physical ill health.

Common stressors are: "not enough time", "not enough money", family demands, conflict within family or conflict with co-workers, feeling of not having any control over one's life or work situations, work pressure, lack of motivation/ satisfaction. For students such as you, stress could be caused by examination, competition, peer or parental pressure to excel, perception of skewed relationship between work demands and benefits, general feeling of dissatisfaction, declining motivation, burn out, interpersonal relationships and ego clashes.

Stress is not just an inconvenience it can affect your overall health. Our body copes with intermittent bouts of anger, fear and tension by constricting the blood vessels that carry blood to the heart. Prolonged stress, therefore, leads to increased blood pressure and forceful contraction of the heart. If left untreated, this stress percolates to the endocrine system, causing imbalances that result in diabetes, hypothyroidism, menstrual irregularities, infertility, etc. Ultimately, stress affects the immune system, causing infections, allergies and other diseases such as cancer. Over a long period of time, stress can seriously affect your overall health and result in conditions such as heart disease.

The World Health Organisation defines Health as not merely the absence of disease or infirmity, but as a feeling of well being at the PHYSICAL, MENTAL, SOCIAL and SPIRITUAL levels. **Yoga helps you gain mastery over your mind and achieve holistic health.**

Yoga is often associated with *Asanas*, levitation and acrobatic exercises. But yoga is not merely about flexing the body; it is about achieving flexibility of the mind. By equipping you with the skill to calm down your mind, yoga helps you to combat the imbalance at the physical and mental levels that is caused by various stressors. Our ancient texts have all defined yoga as the means of getting mastery over the mind.

- *Manah prashamana upAyah (Meaning: It is a means to keep the mind tranquil) says Yoga VAsishta*
- *Samatvam yoga ucyate (Meaning: Yoga is equanimity, it is said), says the Bhagavad Gita.*

### THE PRACTICE OF YOGA

*Yama, Niyama, Asana* and *PrAnAyAma* are the four 'limbs' of yoga. That is, the practice of yoga involves the observation of moral commandments (*yama*) such as non violence and truthfulness;

adherence to basic disciplines (*niyama*) such as cleanliness and devotion to God; practice of physical and breathing exercises (*Asana and pranayama*).

The practice of yoga in the prescribed manner helps channelise dormant energies, draw away the mind from sense objects, concentrate or focus the mind on the desired goal and achieve a blissful state of mind. Calmness, efficiency, attention, memory and learning are achieved through yoga.

## **YOGA FOR PERSONALITY DEVELOPMENT**

While the left brain controls imagination and creativity, the right brain controls scientific and analytical thinking. In most people, one side dominates. Unfortunately, "Our education system, as well as science in general, tends to neglect the non-verbal form of intellect. What it comes down to is that modern society discriminates against the right hemisphere" (Psychobiologist Roger Sperry). However, the brain can be trained to change its ability; what Nature has given (genetically) can be nurtured through nutrition, environmental stimulation, learning and social contact, or simply through yoga. Yoga stimulates the holistic functioning of the brain and helps to balance the left and right brain functions so that a person can excel both in academics and creativity.

I would like to mention here that an experiment was conducted to understand the comparative effects of yoga and dance on the right brain functions of children between 11 and 14 years. The right memory scores of the children who had undergone the 10-day yoga training increased by 43%, whereas there was only negligible change in the right brain functions of the children who underwent the 10-day training in dance. Various assessments have also found that yoga increases perceptual skills, motor skills and higher brain functions. These have applications in all areas from piloting planes and driving railway engines to using computers and strategic planning.

Yoga also has a significant effect on the neural networks in our brain. With yoga, we can both increase their spurt in the initial years and retain their capacity to perform till the end of our lives. As you all know, neural networks in a new born infant are minimal. They increase rapidly up to 3 years of age. The brain's function in most people reduces when they are in their eighties, as the neural networks begin to resemble a new born infant's. But this does not have to be, with yoga.

*Yogah chitta vritti nirodhah* (Meaning: Yoga keeps in check the mental state), says Patanjali's *Yoga Sutra*. True, for it helps attain equanimity of mind, use our brain optimally and retain its elasticity till well into our old age.

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### **Note :**

- <sup>1</sup> Based on Dr M Raghavendra Rao's presentation at the seminar, *Into the Future with Knowledge from Our Past*, held in Bangalore on October 13 and 14, 2006.

## BHASKARACHARYA'S 'LILAVATI'

K Anand<sup>1</sup>

**B**haskaracharya, or Bhaskara II<sup>2</sup> lived between 1114 and 1185 CE<sup>3</sup>. *Lilavati* is the evocative name of a portion of Bhaskaracharya's treatise<sup>4</sup> on Mathematics, called *Siddanta ShirOmani*. While *Lilavati* deals with Arithmetic, the other sections of *Siddanta Shiromani* and the topics they deal with are: *BIjaGanita (Algebra)*, *GolAdhyAya (Astronomy)* and *Griha Ganitam (Planetary motions)*.

Interestingly, *Lilavati* is written entirely in verse, and even those who do not understand mathematics may enjoy the poetic aspects of the book. For instance, offering his salutations to the gods, Bhaskaracharya says:

अमलकमलराशेश्च्यंपंचांशषष्टयैः  
त्रिनयनहरिसूर्यायेन तुर्येण चार्या ।  
गुरुपदमथ षड्भिः पूजितं शेषपद्मैः  
सकलकमल संख्यां त्तिप्रमाख्याहि तस्य ॥

Meaning: From a bouquet of white lotuses, one third were offered to Siva, one fifth to Vishnu, one sixth to Surya and one fourth to Arya<sup>5</sup>. The feet of the teacher were worshipped with the remaining six (flowers). How many lotuses were there in all, tell quickly.

*Lilavati* gives techniques to solve problems in a simple and easy manner; besides, the problems also provide a lot of interesting information from which one may draw conclusions about the kind of social life prevailing then. *Lilavati* has been translated into many of the world's languages and continues to be taught as a compulsory subject in *JyOtishya* (astrology); some foreign universities also teach parts of *Lilavati*, though few Indian universities have thought it fit to do so.

### SOME GENERAL OBSERVATIONS ABOUT BHASKARACHARYA & LILAVATI

- The author seems to have been a skilled poet as is evident from his ability to compress complex mathematical ideas into wonderfully cryptic verses.
- His approach appears to have been both intuitive and algorithmic. For instance, there is a paucity of notations, figures, proofs and derivations. At the same time, he has correctly calculated the length of the Earth's revolution around the Sun to 9 decimal places. There are also verses outlining the method to calculate squares, indeterminate equations, differential sine fractions and so on.
- Astronomy, the importance of observing Vedic rituals and practical needs and applications of Mathematics during his day appear to have been the driving forces behind Bhaskaracharya's genius.
- The notion of attracting a student to the subject appears to have been given a lot of thought (unlike in the present day?). Bhaskaracharya has used various imaginative ways to keep the students engaged in the arduous task of appreciating arithmetic. For instance, when

introducing or concluding a problem, Bhaskaracharya often uses an interesting turn of phrase to cajole, appeal to or challenge the student. Sample these:

- "O auspicious girl with lovable eyes like a young deer's.....!" begins a problem in multiplication.
- "O friend, if your intellect is as sharp as the sharp point of a blade of *kusa* grass, then give me the answer to ....." begins a problem in division of fractions.

Humour, satire and humility too are used, besides anecdotes and generous re-interpretation of mythological stories to keep the student engaged in the arduous task of learning mathematics! We will look at some examples later.

### **MATHEMATICAL CONCEPTS IN *LILAVATI***

*Lilavati* was written in the twelfth century. Today, Arithmetic has progressed a lot and we know many techniques that Bhaskaracharya did not. Yet, the extraordinary mathematical prowess of Bhaskaracharya is something we all need to feel proud of. Consider the spectrum of concepts he deals with in *Lilavati*:

- Squares, square roots, cubes, cube roots
- Fractions
- Direct and Inverse Proportion; Rule of Three
- Compound Proportions; Rule of five, seven etc.
- Business transactions such as:
  - Simple Interest, Shared Investments
  - Finding prices of different types of jewels given a condition
  - Finding weight and fineness of resulting gold when 2 or more kinds of gold are used
  - Rules for Barter (using proportions and rule of 3 etc.)
  - Groceries - Amount needed so as to buy in different suitable proportions various grains costing differently
  - Carpentry cost = Factor of area of a work, number and skill of carpenters and the quality of wood!
- Time to fill up reservoirs using pools (canals)
- Calculating unknowns
- *Viloma Kriya* - Reverse Process
- Indeterminate (Diophantine) equations - important to Astronomy
- Factorial, Permutations and Combinations
  - Total numbers that can be formed given 'r' digits

- Formula to find sum of the possible numbers
- Partitions of Integers: Given the sum of possible numbers with 'r' digits, find total number of permutations
- Believed to have inspired Srinivasa Ramanujan to discoveries in Partition Theory
- Permutations with repeating digits
- Combinations had application in *Chandas-Sastra* (Prosody); Architecture; Medical Sciences; Chemical Compositions.
- *Khandameru* (Pascal's triangle)<sup>6</sup>
- General solutions to find two sides given hypotenuse and to find all possible integer solutions for 3 sides of a right-triangle.
- Spheres, Cones, Pyramids
- Area for cutting wood, Volume of heaps of grain
- Calculus
- Recognition of a positive number having two square roots
- Trigonometric functions:  $\sin(a+b)$  and  $\sin(a-b)$ , differential of sine function
- Eight rules concerning zero.

### **A MATHEMATICIAN-POET CREATES HIS OWN UNIVERSE**

I'd like to share with you some problems and passages from *Lilavati*. You can see how Bhaskaracharya makes the subject attractive for the student. Going through the problems will also give you a bird's eye view of some of the concepts dealt with in *Lilavati*. Remember, the original is in verse form; this is but a loose translation<sup>7</sup>.

- 1) "A peacock sitting on top of a pole 9 cubits high, sees a snake at a distance of 27 cubits, slithering towards the pole. The peacock pounces on the snake, jumping at the same speed as the snake's crawl. At this instant, how far is the snake from the pole?" (Application of what we now call Pythagoras theorem)
- 2) "To capture enemy elephants, a king covers 2 *yojanas* on the first day and then covers a fixed extra distance on subsequent days. If he travels 80 *yojanas* in 7 days, O intelligent one, find out the extra distance covered each day." (Arithmetic Progression and Warfare!)
- 3) "A gentleman gave 2 cowries in charity the first day and thereafter, every day, gave twice of what he gave the previous day. How many *nishkas* did he give away in one month?" (Geometric Progression and Charity!)
- 4) "How many kinds of chutneys can be made by using 1,2,3,4,5, or 6 types of substances from one each of sweet, bitter, astringent, sour, salty and hot substances?" (A jump to cuisine!)

- 5) "When 'a' is not equal to zero,  $a/0=khahara$ . There is no change in the infinite (*khahara*) if something is added to or subtracted from it, just as there is no change in infinite Vishnu due to the dissolution or creation of living beings."
- 6) "In the course of the war, Arjuna became furious, and in order to kill Karna, picked up a few arrows. With half the arrows, he broke all of Karna's arrows. He killed Karna's horses with four times the square root of the arrows. He destroyed Karna's spear with 6 arrows. He used one arrow each to destroy the top of the chariot, the flag, and the bow of Karna. Finally, he cut off Karna's head with another arrow. How many arrows did Arjuna discharge altogether? (An interesting problem in quadratic equations, despite the poetic licence used in re-interpreting the epic version of the incident)"
- 7) "If having given the four sides of a quadrilateral, a perpendicular or a diagonal of a quadrilateral is not given, its area is indeterminate. So one who asks such a question is a devil and one who can answer it must be a greater one." (Humour.....)
- 8) "To enable mediocre persons like us to master the Rule of Three, knowledgeable persons have given us many examples." (...and humility)

### SHORTCUTS FROM *LILAVATI*

#### Multiplication

$$24 * p = 20 * p + 4 * p$$

$$24 * p = (6 * p) * 4$$

$$48 * p = 50 * p - 2 * p$$

#### Squares - Alternate method 1

To find  $x^2$ , write x as some (a+b) and find

$$a^2 + b^2 + 2ab$$

$$112^2 = (100 + 12)^2 = 100^2 + 12^2 + 2(100)(12)$$

#### Squares - Alternate method 2

$$297^2 = (297 + 3)(297 - 3) + 3^2$$

$$\text{i.e } x^2 = (x+a)(x-a) + a^2$$

Pythagoras Theorem, Pell's Equation, Rolle's theorem, Diophantine equations, Euclid's algorithm for calculating GCD ..... students of modern mathematics will find these and many such familiar concepts in *Lilavati*. Mathematicians around the world have been fascinated by the works of Bhaskaracharya and other great Indian mathematicians.

*"In Indian mathematics, we find the use of a number of approximations which performed very well over specific ranges of a problem domain. It seems to be quite sufficient to use*

*successive approximations to perform a complex computation rather than 'spend time' in computing the exact value.*” said Prof. Furio Honsell, Professor of Computer Sciences, University of Udine, Italy.

“*Diophantus, the father of Greek algebra, got the first algebraic knowledge from India.*”, said Florian Cajori, 20th century historian of Mathematics.

Isn't it time Indians also recognise the contributions of ancient Indian mathematicians and take pride in them?

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**Notes :**

1. Based on Sri K Anand's presentation at the seminar, *Into the Future with Knowledge from Our Past*, held in Bangalore on October 13 and 14, 2006.
  2. Bhaskara I lived about 400 years before Bhaskaracharya.
  3. Nowadays, it is becoming the norm to use BCE (Before the Christian Era) and CE instead of BC and AD, respectively.
  4. Simply put, a treatise is a book. But it is a book that deals in detail with a particular subject.
  5. Arya is another name for Parvati.
  6. Chinese call this “*Yang-Hui*” triangle after their 13<sup>th</sup> century Chinese mathematician. Iran calls this “*Khayyam*” triangle after their 11<sup>th</sup> century mathematician. Italy calls this “*Tartaglia*” triangle after their 16<sup>th</sup> century mathematician. But in India we call it ‘Pascal's triangle’ though Indian mathematicians who preceded Bhaskaracharya gave it the name ‘*khandameru*’ or ‘*meruprastara*’!
- Meruprastara* was first formulated 18 centuries before Pascal by PingalAcharya. The concept was explained by HalAyudha, a 10th century commentator of Pingalacharya's work...And this was still 700 years before Pascal.
7. The primary source of reference was: *Lilavati of Bhaskaracharya - A Treatise of Mathematics of Vedic Tradition*, K.S. Patwardhan et al, Motilal Banarasidas Publishers.

**Wisdom of the Ages**

Aryabhata's magnum opus, the *Aryabhatiyam*, was translated into Latin in the 13th century. Through this translation, European mathematicians got to know methods for calculating the areas of triangles, volumes of spheres as well as square and cube roots.

## CONTEMPORARY RELEVANCE OF LOCAL HEALTH TRADITIONS

Unnikrishnan PM <sup>1</sup>

### INDIAN HEALTH CARE TRADITION

The diverse health care heritage of India may be classified under two main streams - the codified, classical stream and the oral, folk stream. Codified traditions of healing such as Ayurveda, Siddha, Tibetan and Unani have written philosophies, and instructions and practices based on the philosophies. Local Health Traditions (LHTs) are non-codified forms of health care, knowledge and practice. No institution teaches LHTs. They constitute the accumulated wisdom of centuries that has been passed down through generations by word of mouth. Many LHTs have become a part of our lives (Who does not know the medicinal properties of tulsi, turmeric, neem?)

There are more than 4,400 ethnic communities in India and between them, they use more than 8,000 plants and more than 200 resources of animal and mineral origin for treating various health conditions. Not surprisingly, LHTs are often locality or community specific and very diverse. There are specialised branches of folk healing too, the practitioners of which are known as *vaidyas*, *nAttuvaidyas*, *vaidu*, *amchis*, *hakims* etc. Traditional folk healers are major contributors to the maintenance of the health of rural communities.

Local health cultures take the form of local or regional food habits, specific customs followed, home remedies and special folk healing traditions. The spectrum of such practices includes day-to-day diet habits to cure or prevent simple as well as chronic disorders. For example, the practice of drinking medicated hot water is part of the daily food regimen in many households in Kerala; more than 20 different types of boiled drinking water practices are seen.

### NUMBER OF PLANTS USED ACROSS VARIOUS MEDICAL SYSTEMS

	Ayurveda	Folk	Homeopathy	Modern	Siddha	Tibetan	Unani
Ayurveda	1769	731	164	55	743	271	653
Folk	731	4671	147	56	635	201	486
Homeopathy	164	147	482	60	142	70	155
Modern	55	56	60	105	41	17	50
Siddha	743	635	142	41	1121	227	486
Tibetan	271	201	70	17	227	279	224
Unani	653	486	155	50	486	224	751

## KNOWLEDGE BASE OF LHTs

Indigenous knowledge systems have their own way of understanding nature and various natural phenomena. Their theories explain the what and the why related to health, diseases and their cures just as scientific theories do.

In the Indian context, two parallel streams are keeping alive the tradition of local health practices. At the household level, this knowledge is in the safe hands of grandmothers (as *pAttivaidyam*, *Patti manai oushadi* or *griha vaidyam*). Household-level traditions cover various aspects of curative and preventive health care at the primary level and 'medicines' include food practices, recipes and health related customs. At the community level, the knowledge is propagated through the informal clinical practices carried out by various categories of local folk healers:

- General practitioners attend to many general health problems as well as specific organ related conditions. Healers coming under this category have special skills in traditional ophthalmology, *marma*<sup>2</sup>, curing jaundice etc.
- Bone setters use different techniques of fracture reduction, bandaging and also use vital points (*marma*) in treatment.
- Traditional birth attendants attend to deliveries, and prescribe pregnancy and post delivery care.
- Poison healers, or *Visha vaidyas*, treat poisonous bites, stings and related health problems. Their medicinal resources mainly consist of locally available plants.
- *Mriga vaidyas* possess the knowledge of animal related health problems and their management. In the rural scenario, their service is still the first choice for attending to problems pertaining to animal health.

## HOUSEHOLD TRADITIONS

- In many communities, specific customs and food regimes are followed in relation to specific seasons, occasions or conditions. For example, in Kerala, *Marunthu kanji*, a medicinal porridge, is made in the monsoon season. This helps prevent rheumatism and associated problems.
- Customs that are related to the occasions of birth, puberty, seasons, pregnancy also have their roots in health care. For example, consumption of ghee, sesame oil and egg is a custom related to puberty practised in the rural areas of different parts of south India to give additional nutrition during this period. The sound of bangles tinkling during the customary *Valaikappu* festival performed for pregnant girls during the last trimester is believed to have a significant effect on the neural development of the child in the womb.
- Special food recipes / regimes are also followed in the pre- and post- natal periods. These ensure good health during this special condition.

- Every household has its own traditional medicinal recipes and practices that are used as first aid, that is, before seeking or deciding to seek expert medical help.

In certain areas it is also reported that the knowledge related to home remedies constitute more than 100 plant species and covers the major species of that locality. *Punica granatum* (pomegranate), for instance, is used to cure acidity, diarrhoea, worms, anaemia and morning sickness. *Piper nigrum* (pepper) is an appetiser, and cures cough, gastric disturbances, fever and cold. *Hibiscus rosa sinensis* (white hibiscus) cures fever, menstrual disorders, diabetes, premature greying of hair.

### **WHY DOCUMENT HEALTH TRADITIONS?**

As in any other folk knowledge stream, local health traditions are handed down to the next generation by word of mouth. The learning process includes being taught orally, field experience, sharing of skills and learning through observation. The *guru-shishya parampara* is maintained and this has helped to keep alive the traditional knowledge and skills. A discontinuity in the chain of this tradition can result in the disappearance of large bodies of knowledge and skill sets, as most of them are not recorded adequately and systematically. Documentation of traditional knowledge will also help challenge incomplete or misleading patent claims. Local health cultures are highly dependant on the local ecosystems for their resources such as plants, animal products and minerals. In recent times, many studies have been undertaken to document India's ethnobotanical, botanical and anthropological wealth. So far, very few serious attempts have been made to document health traditions so as to utilise them for the benefit of the community.

### **RELEVANCE OF FOLK HEALERS**

They are one of the largest private, community-supported health care providers. While pharmaceutical and drug companies are commercialising Ayurvedic preparations, local health providers take care of the needs of the community at a fraction of the cost. Among folk healers, there are more than 3 lakh general physicians, 7 lakh traditional birth attendants, 5,000 ethnic veterinary practitioners, more than 60,000 each of bone setters and poisonous bite healers, and 1,000 ophthalmologists. Many of them have alternative professions and provide health care as a service. Most of the folk healers have acquired the knowledge from their forefathers. In Villupuram, Pondicherry, for instance, Vaidya Nagaraja Mudaliar is a thirteenth generation practitioner!

Government expenditure forms only one third of the country's total expenditure on health. High travelling cost due to the distance of the hospital from the community, lack of supply of drugs and facilities, long waits and delinquency of staff are some of the reasons identified for dissatisfaction with existing government health care delivery systems. Viewed from this perspective, the services of the local health providers acquires special importance.

Even in a traditional, codified system of medicine such as Ayurveda, only 33% of the total known medicinal plants of India are used. There is, therefore, a lot of potential for additions from the knowledge base of LHTs to the pharmacopoeia of Indian codified medical systems.

## NEED OF THE HOUR

Organisations and individuals engaged in the re-vitalisation and practice of local health traditions have to overcome several hurdles. Some of the issues that dog them are:

- Lack of political support
- Lack of social support and esteem
- Marginalization
- Issues related to IPR and benefit sharing
- Lack of serious effort to undertake fundamental research for advancement of knowledge
- Paucity of resources to undertake such research
- Lack of collaborative research efforts to mainstream the local health traditions

### Rapid Assessment of Local Health Traditions (RALHTs)

This is a method of participatory research in which Community Members, Folk Healers, Practitioners of Indian Systems of Medicine, Western Medicine Practitioners, Field Botanists, NGOs and the Foundation for Revitalization of Local Health Traditions (FRLHT) have come together to assess and highlight relevant traditions through rapid research methods and mainstream the effective traditions through sustained social effort and political mobilisation.

The steps involved in RALHT are:

1. Prioritization of health conditions through periodic research regarding number of cases.
2. Documentation of local health practices for these Prioritized Conditions.
3. Searching for clinical and literary references related to Prioritized LHTs.
4. Participatory Rapid Assessment Workshops to assess LHTs, in the light of the empirical experiences of the community and clinical experiences of other systems of medicine.

I invite you to come to FRLHT to get an idea about the work we are doing.

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#### Note :

- <sup>1.</sup> Based on Dr. P M Unnikrishnan's presentation at the seminar, *Into the Future with Knowledge from Our Past*, held in Bangalore on October 13 and 14, 2006.
- <sup>2.</sup> There are 108 vital points (*marma*) on the human body. Any injury to these points, it is believed, causes disturbance or disintegration in the body.

#### Wisdom of the Ages

A 9th century Hindu scripture, Mahapurana by Jinasena, claims something as modern as the following: "Some foolish men declare that a Creator made the world. The doctrine that the world was created is ill-advised, and should be rejected. If God created the world, where was He before creation?... How could God have made the world without any raw material? If you say He made this first, and then the world, you are faced with an endless regression... Know that the world is uncreated, as time itself is, without beginning and end. And it is based on principles."

## CHILD CARE IN ANCIENT INDIA

Malavika Kapur <sup>1</sup>

Most major *samhitas* (compilations) of *Ayurveda* by Charaka, Sushruta, VAggbata the elder and Vaghbata the younger - have just one or two chapters on child care. However, *KAshyapa Samhita* is devoted entirely to child care, or *KaumArabhratyā*. The original, or earliest written version of the *Kashyapa Samhita*, is believed to be in the custody of the Royal Court of Nepal. Kannada translations of the same are available and an English translation was published in 2002.

### The Story of Jivaka

*Kashyapa Samhita* is also called *Vridhdha Jivaka Tantra* (The doctrine of old Jivaka). There is a story about how the *Kashyapa Samhita* acquired the latter name. Jivaka was a student of Kashyapa, to whom the author sage passed on the knowledge of his treatise on child care. By the time he was five years old, Jivaka, a child prodigy, had mastered the Samhita and could recite all its chapters (200 to 300 of them) by heart. Though Kashyapa felt that his student had acquired sufficient scholarship in the discipline of child care, other scholars and wise men were sceptical. Many of them, from all over India, gathered at Haridwar to test Jivaka. As was the practice those days, they asked him to immerse himself in the Ganges and come out before facing their test. Jivaka did as he was told. But, whereas he entered the river as a child of five, when he emerged from the ritual bath, he was old and wrinkled all over! The scholars realised their folly. As they had associated wisdom only with age, Jivaka's physical form aged suddenly, to match his mental maturity.

This symbolic story could also be considered to mean that to treat a child, one has to be a child himself/ herself, just as Jivaka was, but to treat a child is no child's play! As Kashyapa himself tells Jivaka, "If you don't have scholarship, don't treat a child as you may be conscience-ridden for life."

### KAUMARABHRATYA OR CHILD CARE IN KASHYAPA SAMHITA

#### Mother and child are a single unit

Western science, be it philosophy, psychology or medicine, treats body and mind as separate entities. Growth, intelligence, emotion, socialisation, etc. are all segmented into separate sections. But Indian systems of Science, such as the *Ayurveda*, consider the body and mind as one unit which interacts with Nature. The *pancha mahA bhUtAs* [*prithvi* (earth), *ap* (water), *tEjas* (fire), *vAyu* (air) and *AkAsha* (space)] for instance, are to be found inside us as well as in the universe. Similarly, the mother and infant before and after birth, are seen as a single unit. A pregnant woman is advised to perform soothing rituals, listen to good music and so on. A nursing mother is advised to consume various medicines so that their goodness reaches the infant through her breast milk.

## **Stages of development in distinct phases, starting from conception**

According to modern developmental psychology, at each stage in a person's life, there are tasks that follow each other. For instance, a child would cry, babble, speak words, string sentences together and then speak coherently. Similarly, in *Kashyapa Samhita*, various activities are prescribed for the various stages of conception and development. Thus, the baby is taken out to see the moon in the third month and the sun in the fourth month; *chUdAkarana* (tonsuring of the front portion of the head) is done around the sixth month - this would help to see if the soft front portion of the head, called fontanel, is closed as it should be and also see if the head shape is normal; *karnavEdhana*, or ear piercing, which is done around the first year of the child, is obviously a medical procedure. (Significantly, Ayurveda, which is a medical treatise, deals with the various steps that ought to be followed for performing *karnavedhana* - how the child should be held, where the source of light should come from, how to judge the flow of blood to the ear lobe and where to pierce the ear).

*Upanayanam*, or thread ceremony, which is supposed to signify the formal induction into study, is to be performed between the ages of six and eight. This is amazingly in tune with the modern studies in cognitive development by Piaget and others, who have clearly found that only around six years of age do children reach the cognitive level necessary for academic studies.

The rituals prescribed as part of child care and child rearing could be considered as developmental guidelines. At each stage when the baby is ready, there is an activity for it to do. This gave a certain uniformity to the norms of upbringing, without which there might have been extreme subjectivity as parents may have been at a loss, some, for instance, weaning away the child from a milk diet too early, and others not giving the child solids for even years!

## **MULTIPLE CAUSATION OF HEALTH & DISEASE**

Current medical science is all about how to cure diseases. But traditional Indian medical system is about leading a healthy life. Not just treatment of ailments, but a healthy way of life is the goal. Towards this end, diet, mental and physical exercises are all prescribed, not just medicines. And often, these take the form of rites and rituals, as we saw in the previous section on 'Stages of Development'.

However, *Kashyapa Samhita* also deals with 46 common disorders for which various herbal preparations and fomentation techniques are prescribed. Interestingly, there are 12 diseases that are described as *bAlarOga*. From their description, it is evident that these diseases correspond to similar syndromes discussed in modern science, such as cerebral palsy, meningitis and tuberculosis, which are caused by bacteria or viruses. Ayurveda prescribes various rites, probably taken from folk culture, to deal with the *grahas* (demons) that have 'caught hold' of the children! Only in dealing with these 12 diseases does *Ayurveda* speak of supernatural intervention to explain observed phenomena. Perhaps, their inability to know the cause of the diseases due to the absence of knowledge of bacteria and other microorganisms forced them to resort to these kinds of explanations.

## KASHYAPA'S 'FOUR PILLARS OF TREATMENT'

The four pillars of treatment according to Kashyapa are:

- Qualities of the physician
- Qualities of the drugs
- Qualities of the patient
- Qualities of the attendant

Modern medicine works within the very minimal sphere of cause and cure. The patient approaches a family doctor or a specialist, the affliction is identified and the patient is treated for it. The patient does not worry about the scholarship or uprightness of the doctor; the doctor does not look to see the qualities of the patient - he is concerned only with the ailment; the quality of drugs is taken for granted; and no thought is given to the persons who will be taking care of the patient. Are there any? Are they willing? How healthy are they? and so on.

Modern medicine attends only to a patient's apparent physical affliction. But the ancient Indian system of medicine did not see man in isolation of his biological, social and psychological framework. Body and mind, man and the universe were seen as inseparable entities. It was clearly understood that every individual had certain inborn, inherited characteristics of mind (*triguna - sAtvic, rAjasic, tAmasic*) and body (*tridOsha - vAta, pitta, kapha*). Further, it was understood that these characteristics interacted with the environment and hence were not to be seen in isolation.

## SCIENTIFIC METHODOLOGY OF SANKHYA & MODERN SCIENTIFIC METHODOLOGY

Ayurveda has diligently followed the principles of Sankhya philosophy by which it has been guided, namely *pratyaksha* (observation), *anumAna* (inference), *upamAna* (comparison), *shabda* (the established word). *Kashyapa Samhita*, for instance, talks of ten diseases that may be identified simply by observing how a baby cries, tosses, moves and eats. As for *shabda*, or the principle that the established word or the word given by a scholar must be accepted, this is the norm in modern science too. Do we not talk of the '*shabda*' or theories of Einstein or Sigmund Freud? Do we not go by the word of various scientists till they are disproved?<sup>2</sup>

The steps in modern scientific methodology are: observation, formulation of theories [word of scientists (*shabda*)] and hypotheses, experimentation and prediction.

Though very strong in observation, drawing inferences from observed phenomena, making comparisons and arriving at logical conclusions, our ancient Indian scientists were weak in experimentation and prediction. In fact, some of their predictions even appear frivolous such as those linking the shape of a child's finger with what the child will become in the future. It is human tendency to predict, but scientific prediction of complex phenomena is difficult. As the Chaos Theory states, cause and effect relationship, which is very linear and predictable, does not exist in Nature. Similarly, psyche or the human mind is difficult to measure and study. But, as we have seen thus far, modern science has a lot in common with Ayurveda. How can we validate this? Perhaps, by finding the answers to some questions, such as:

- Can the recommended child care practices in our ancient texts be empirically examined?
- Can the study of *Triguna* and *Tridosha* in children be validated?
- Can such constructs as *Tridosha* and *Triguna* in medical practice be scientifically examined?
- Is *Satvik* nature a protective factor? Can it be acquired?

The search for answers to these questions would be long. It would involve seeking the help of not only Ayurvedic physicians, but also botanists and Sanskrit scholars. But the results would be rewarding as few such studies have been done<sup>3</sup>.

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**Notes:**

- <sup>1</sup>. Based on Dr Malavika Kapur's presentation at the seminar *Into the Future with Knowledge from Our Past*, held in Bangalore in October 2006, and her book, *Child Care in Ancient India from the Perspectives of Developmental Psychology and Paediatrics*, which she wrote with Dr Hemalata Mukundan.
- <sup>2</sup>. Have not some of Newton's Laws been disproved? Were we not told till yesterday that there were nine planets?
- <sup>3</sup>. One of the few comprehensive studies on child care is Dr. Kamalabai Deshpande's thesis on *Child Care in Ancient India*, pertaining to the *sanskAras* (customs) contained in the *Griha Shastra* (Householder's Manual).

**Wisdom of the Ages**

I) The *Rig Veda* questions the origin of the cosmos thus: "Neither being nor non-being was as yet. What was concealed? And where? And in whose protection? Who really knows? Who can declare it? Whence was it born, and whence come this creation? None can know from where creation has arisen, and whether he has or has not produced it. He who surveys it in the highest heavens, he alone knows - or perhaps does not know."

II) The notion of time spans that are truly gigantic by modern standards are rarely found in ancient civilizations as the notion of large number is a rare commodity. Apart from the peoples of the Mayan civilization, the ancient Hindus appear to be the only people who even thought beyond a few thousand years. In the famed book *Cosmos*, physicist-astronomer-teacher Carl Sagan writes: "A millennium before Europeans were willing to divest themselves of the Biblical idea that the world was a few thousand years old, the Mayans were thinking of millions and the Hindus billions."

## ANCIENT INDIAN WISDOM – OUR SCIENTIFIC AND CULTURAL HERITAGE

B Mahadevan<sup>1</sup>

Lord Macaulay, in an address to the British Parliament on February 2, 1835 is believed to have said,

*“I have travelled across the length and breadth of India ... Such wealth have I seen in this country, such high moral values, people of such calibre, that I do not think we would ever conquer this country, unless we break the very backbone of this nation, which is her spiritual and cultural heritage, and, therefore, I propose that we replace her old and ancient education system, her culture, for if the Indians think that all that is foreign and English is good and greater than their own, they will lose their self-esteem, their native culture and they will become what we want them, a truly dominated nation.”*

Whether or not Macaulay actually said these words, the fact is that we have lost our pride in our past. Seven hundred years ago, S Ayan Acharya, a celebrated commentator on the *Vedas*, and a preceptor of the Vijayanagar kings Harihara and Bukka, was able to perceive, comment upon and declare hard core scientific ideas from Vedic literature. Today, these texts yield no meaning of any kind to us... The common refrain is:

- What is ancient Indian wisdom? Is it science, meta science or just religious prescriptions and matters of blind faith ...?
- Where is it? Extinct? Or, if it exists, isn't it too difficult to cull out? Isn't it incomprehensible and uninteresting?
- Why do we need it? It provides no material gains. Will it feed the masses? Will the society be any better?

The ground realities are:

- Our education system does not even take cognisance of our ancient wisdom.
- Traditional wisdom must pass through Western acceptance before it becomes valued knowledge.
- A person spending 12 years of his life learning the *Vedas* is “seen” as uneducated by the society, and sadly, also by himself.

The moot point is, do we need to dig into our past?

### ACTIVE AND PASSIVE INHERITANCE

A country's progress is irrevocably linked to the manner in which its past achievements, strengths and culture are transmitted down the generations. Active transmission results in enhancing the self esteem of the community, which translates into progress. Passive transmission results in

degeneration of the community values. The following table shows the difference between active and passive inheritance.

<b>Passive Inheritance</b>	<b>Active Inheritance</b>
Blind emulation	Rational approach
Eventually leads to means	Eventually leads to ends
Superficial, grossly physical involvement	Involvement through in-depth understanding
Distorted understanding	Experiential learning
Confused, weakened, mis-conceived value system	Reinforcement of enduring value systems
Degeneration of life	Enrichment of life

### **THE PRIDE OF INDIA PROJECT**

*Pride of India* is a 208-page book published by Samskruta Bharati after more than seven years of rigorous research; it was released in Bangalore in August 2006. Rather than a mindless glorification of our past, the book quotes from the original Sanskrit texts (with transliteration and translation as well) in an attempt to make us aware of the knowledge heritage of our nation and sow the seeds of alternative world views for global development based on the sustainable, ancient Indian model.

The book has 19 chapters spread across five sections. Science in our ancient texts is dealt with under various heads, including mathematics, medicine, astronomy, physics, chemistry, metallurgy, civil and mechanical engineering<sup>2</sup>. The book also makes an attempt to date the *Vedas*, the Indus Valley Civilisation and the *Mahabharata* in a scientific manner. Interesting comparisons are drawn between ancient Indian wisdom and Western thought and modern day practices.

So, where do we go from here? We have a rich heritage of Mathematics, Astronomy and Medicine; we have made accurate predictions of fairly complex phenomena (speed of light, value of pi, one sidereal rotation, distance of the sun and the moon from the earth, etc.); the wisdom and knowledge base of ancient Indians might have been ahead of Western thought by 400 to 4000 years. Should we simply be satisfied with a universal acceptance of these facts? Or, is there something more that we can learn from what the *Pride of India* teaches us?

### **THE LEARNING INFRASTRUCTURE**

As a management researcher and a teacher, I would be interested to look at the larger picture, a glimpse of which is provided by the *Pride of India* book. Long before invading armies came to India attracted by her material wealth, history records that travellers from all over the world came to India to partake of her wealth of knowledge. Indian Universities such as Nalanda and Taxila were world renowned. How was all this possible? Is there something for us to learn from this? Can we apply the same process once again so that we become a knowledge society that the world will respect?

## Think Big

From the lessons we can imbibe, based on ancient Indian literature, it appears that to think big is the first requirement for a strong learning infrastructure. The imagination of our ancient sages and seers appears to have been unbounded - they could visualise phenomena like the *Viswaroopa Darshanam*<sup>3</sup>, and talk in terms of huge numbers that boggle the mind<sup>4</sup>. Here, we are talking about the end goal as against the means to the end. Setting goals high, having a vision is the first step towards creating a strong knowledge society. In our own time, we have the examples of persons like Dr Govindappa Venkataswamy of Aravind Eye Hospital, Reliance founder Dhirubhai Ambani and Infosys' Narayanamurthy.

### ARAVIND EYE HOSPITAL

Aravind Eye Hospital started as a modest, 11-bed hospital in Madurai, Tamil Nadu in 1976. It is today recognized as one of the world's most productive eye hospitals, handling the largest patient volume. The thinking that resulted in this unique business model can be seen in Dr Venkataswamy's famous quote:

"If coca cola can sell billions of sodas and McDonalds can sell billions of burgers, why can't Aravind sell millions of sight restoring operations and, eventually, the belief in human perfection?"

The cataract cases treated by this hospital is 150% the number of cases treated in the rest of India. And, only one-third of the patients pay. Two thirds are treated free! Today, the Aravind Eye Care System encompasses five hospitals, a manufacturing centre for ophthalmic products, an international research foundation and a resource and training centre that is revolutionizing hundreds of eye care programmes across the developing world. The success of Dr. Venkataswamy's vision is evident from the fact that Tamil Nadu's rate of eye disease, reportedly, is now 20% less than that of India as a whole.

## Cultivate a Spirit of Inquiry

A society that does not question, does not encourage dissent, cannot create the kind of superior knowledge our ancients had. All you have to do is count the number of questions in our *Upanishads*, the *Gita* and the *Puranas* to understand how much our ancients believed in the importance of questioning for the expansion of knowledge.

## Be precise

Meticulous attention to detail is very important for a scientist or researcher. Results must be verifiable, for which experiments must be repeatable and produce the same result every time. Consider this definition of 'nAdhika', a unit of time, from Canto 3 of Srimad *Bhagavatam*, a religious text:

द्वादशार्धपलोन्मानम् चतुर्भिश्चतुरन्गुलैः ।

स्वर्णमाषैः कृतच्छिद्रम् यावत् प्रस्थजलप्लुतम् ॥

Bore a hole at the bottom of a pot (of copper) weighing six *pala* and having a capacity of one *prastha* of water. The hole should be bored with a gold needle four *angula* long and weighing four *masha*. The time that such a pot takes, when left on water, to be filled with and consequently submerged in water is the measure of a *nadhika*.

Whether it is Vuluka's Vaisesika school of philosophy or Gotama's<sup>5</sup> Nyaya school, their emphasis is on negation of false knowledge and arriving at conclusions based on logical reasoning. These values promote life long learning in an organisation/society

### **SOME YARDSTICKS TO MEASURE INDIA'S SCIENTIFIC HERITAGE**

Is there a systematic approach?

- Empirical observation
- Efficient classification and coding
- Generalisation of principles
- Stand the test of logical and face validity
- Confirmed by alternative approaches

Can it be verified by repeated experiment?

- Emphasis on specification of conditions
- Need for unambiguous measures

Will ancient Indian wisdom satisfy these parameters? I leave it to you to find out.

### **A short list of some of the topics dealt with in *Pride of India***

1. **Science in the Vedas**
2. **Mathematics**  
Algebra and Arithmetic  
Geometry  
Trigonometry
3. **Physics**  
Mechanics  
Matter  
Magnetism  
Optics
4. **Astronomy**  
Rotation of the earth  
Gravity of the earth  
The heliocentric theory  
The speed of light

Lunar eclipse  
Moon a satellite of the earth  
Planetary motion

5. **Civil Engineering**  
Building construction  
Temple architecture  
Town planning
- 

**Notes :**

1. Based on Prof. Mahadevan's presentation at the seminar *'Into the Future with Knowledge from Our Past'* held in Bangalore on October 13 and 14, 2006.
2. A short list of some of the topics dealt with in *Pride of India* given at the end of this chapter.
3. Dr. J. Robert Oppenheimer who directed the scientific team in charge of exploding the world's first atom bomb, is believed to have drunk deep of the philosophy of the *Bhagavad Gita* and applied the same to his life. Asked about his reaction to the first explosion, which caused a tremendous burst of light followed by a deep growling roar, Oppenheimer is reported to have quoted a *sloka* (Ch.11, Sl.12) from the *Gita* describing the Universal Form of the Lord: "If the radiance of a thousand suns were to burst into the sky, that would be like the splendour of the Mighty One" (*Source: Robert Jungk, Brighter than a Thousand Suns: A Personal History of the Atomic Scientists, trans. James Cleugh (NewYork: Harcourt, Brace, 1958), 201*).
4. 1 anguli parva = 7 yava, 1 yava = 7 sarshapa, 1 sarshapa = 7 liksha raja, 1 liksha raja = 7 go raja, 1 go raja = 7 edaka raja, 1 edaka raja = 7 shasha raja, 1 shasha raja = 7 vatyayana raja, vatyayana raja = 7 turti, 1 turti = 7 renu, 1 renu = 7 paramanu raja.  
*Therefore we have,*  
1 Paramanu raja =  $7^{-10}$  anguli parva  
*Furthermore,*  
1 paramanu =  $6.14 \times 10^{-7}$  gms and 1 paramanu raja =  $2.87 \times 10^{-7}$  mm!!!
5. Not to be confused with Gautama Buddha or the Hindu sage Gautama, one of the Saptarishis.

## HINDUISM AND SCIENCE - THE STUDY OF 'CONSCIOUSNESS' <sup>1</sup>

What do we mean by "Consciousness?". Consciousness, or *chEtana*, as it is called in Sanskrit, is a sophisticated word for "mind". Hindu philosophy recognizes three states of mind - the sub-conscious, the conscious and the superconscious. According to Patanjali (150 B.C.E), the sub-conscious mind is a storehouse of past thoughts and *samskAras*. Every thought and action of ours leaves an impression on the internal organ called mind stuff (*antahkarana in Sanskrit*). These stored impressions, or *samskaras*, affect our conscious tendencies and character. When the conscious mind is fully controlled and concentrated, it can reach a super-conscious level and acquire astounding powers.

The Hindu tenets of consciousness are derived from the Sankhya philosophy, which is thousands of years old. The western world, on the other hand, was only interested in the conscious state of mind till the beginning of the 20<sup>th</sup> century, when the well-known French psychologists Jean Martin Charcot and Pierre Janet recognized the existence of the subconscious state of mind. Charcot and Janet's Paris school of Thought also opined that "one cannot study the psychology of man without guiding ideas, without philosophical or even religious interests."

In Hindu philosophy, Divinity, or God, is believed to be all pervading. Cosmic energy is believed to be present behind everything and every being. Psychic energy is clearly considered a manifestation of this cosmic energy, which we call *prAna*. But, for neuroscientists engaged in frontier areas of research, the question still is whether mind created God or God created mind! However, Dr. Vilayanur Ramachandran - a neuro-physiologist who has been declared one of the 100 persons across the globe to watch out for in the next decade - feels that many of the findings of modern neurophysiology are re-interpreting the ancient Hindu lesson of "*mAya*," or illusion. Ramachandran's internationally acclaimed studies have shown that our individual sense of being a "self" that is in some way separate from the "creation" consisting of the world around us is an illusion. A century ago, Albert Einstein said something similar:

"A human being is a part of a whole, called by us universe, a part limited in time and space. He experiences himself, his thoughts and feelings as something separated from the rest... a kind of optical delusion of his consciousness. This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest to us. Our task must be to free ourselves from this prison by widening our circle of compassion to embrace all living creatures and the whole of nature in its beauty."

Until recently, most neuroscientists concerned themselves mainly with medical problems pertaining to the brain's health and attempts to fathom the brain's neural mechanisms. Emboldened by their growing understanding of how the brain works, however, scientists are now investigating the relationship between the brain, human consciousness and a range of intangible mental experiences. Brain Studies and Consciousness Studies have been major research areas in the last decade. But in our tradition, fundamental questions about consciousness have been asked since ages:

- What is Consciousness? How to understand it, define it?
- Where is Consciousness located in the brain?
- How is Consciousness produced? What is the causal mechanism behind the production of Consciousness?
- Who is Conscious?

As the *KatOpanishad* states, we are limited by what affects our senses. Unfortunately, we are created with sense organs that are directed outwards and not inwards. Can we overcome this limitation and acquire skills and attitudes that will help us to look beyond the transient world?

Hinduism, as espoused by our ancient sages, provides a foundation for us to become better individuals and reach a point of absolute satisfaction with the self. Then, nothing and no one can stop us.

## THE FUNDAMENTAL PRINCIPLES OF HINDUISM

### 1) **Accepting Diversity:**

Hinduism is very accommodative. Even if something is not agreeable initially, it is retained and reflected upon. Ultimately, it may become part of the system. There is respect for diversity. Pluralistic thinking has given scope for understanding Reality in diverse ways.

### 2) **Ahimsa:**

Non-injury to mind, body and spirit is a fundamental tenet of Hinduism. Non-violent disagreement, and engaging in dialogue with mutual respect for ideas that one may find initially unacceptable results in the birth of many original, creative ideas. Accommodative space for another point of view is the basis of modern ecological practice, where we bargain in the international arena, every day, for fundamental living needs.

### 3) **Satya:**

Truth is explained in many ways. What is real truth? What is ultimate truth? What is metaphysical truth or, what lies beyond? In seeking answers to all these questions, what is stressed upon is that you should be true to yourself, not just when interacting with another outside yourself.

### 4) **Detachment:**

When faced with the consequences of your action, Hinduism asks you to stand aside and watch (*sAkshI bhAva*). Rather than respond with extreme excitement or deep depression, accept what comes to you, without your intervention, with a certain detachment. In victory and failure, reflect, understand, inquire. The way you think influences your way of life and helps you motivate yourself without external aids.

The fundamental structures on which Hinduism rests - the Vedas and the *Upanishads* - evolved through a rigorous discipline of inquiry. Science, the ultimate inquiry, too, begins further investigations from what is known or given.

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**Note :**

- <sup>1</sup> Based on Dr Sangeetha Menon's talk at the seminar *Into the Future with Knowledge From Our Past*, held in Bangalore in October 2006 and information available in the public domain

**Wisdom of the Ages**

I) Hinduism suggests that the universe undergoes an infinite number of deaths and rebirths. According to Carl Sagan (1934-1996), "Hinduism is the only religion in which the time scales correspond...to those of modern scientific cosmology. Its cycles run from our ordinary day and night to a day and night of the Brahma, 8.64 billion years long, longer than the age of the Earth or the Sun and about half the time since the Big Bang". Carl Sagan was also a distinguished Cornell University astronomer and Pulitzer Prize-winning author.

II) Professor Arthur Holmes (1895-1965) geologist, professor at the University of Durham, writes regarding the age of the earth in his great book, *The Age of Earth*: "Long before it became a scientific aspiration to estimate the age of the earth, many elaborate systems of the world chronology had been devised by the sages of antiquity. The most remarkable of these occult time-scales is that of the ancient Hindus, whose astonishing concept of the Earth's duration has been traced back to *Manu Smriti*, a sacred book."

III) Rev. Roger Bertschausen (Minister of the Fox Valley Unitarian Universalist Fellowship Appleton, Wisconsin): "In Hindu Cosmology, a universe endures for about 4,320,000,000 years (one day of Brahma, the creator) and is then destroyed by fire or water elements. At this point, Brahma rests for one night, just as long as the day. This process is called *pralaya* (cataclysm) and gets repeated again and again, for ever. This view of the universe contrasts sharply with other religious perspectives on the age of the universe. Early Judaism, Christianity and Islam had no inkling of the long age of the universe."

IV) Alan Watts, a Professor, graduate school dean and research fellow of Harvard University, drew heavily on Vedanta. He wrote: "To the philosophers of India, however, relativity is no new discovery, just as the concept of light years is no matter for astonishment to people used to thinking of time in millions of *Kalpas*. The fact that the wise men of India have not been concerned with technological applications of this knowledge arises from the circumstance that technology is but one of innumerable ways of applying it. It is, indeed, a remarkable circumstance that when Western Civilization discovers Relativity it applies it to the manufacture of atom-bombs, whereas Oriental Civilization applies it to the development of new states of consciousness."

## HISTORY: DOES IT REVEAL THE TRUTH?

K. Ramasubramanian<sup>1</sup>

“History is an elaborate attempt at myth making,” said Claude Alvares, author of *De-Colonizing History - Technology and Culture in India, China and the West*. This is particularly true of the history of ancient civilizations such as India's, because no one knows how old our philosophy is and there are no records. But, what is known is that we were:

- A pluralistic society, where a variety of gods were (and are) worshipped, and
- Major contributions to the foundations of calculus and mathematical analysis, came from the highly religious and orthodox sections of the society.

The civilizational genius of India, right from the Vedic times, seems to have maintained a clear demarcation between the practice of science and religion. However, it is unfortunate that the projected picture in the pages of history is often contrary to this reality. Even renowned scholars such as Prof. Amartya Sen, seem to have failed to recognize this fact. For instance, in his recent book, *'Argumentative Indian'*, Sen describes Brahmagupta as “. . . spinelessly kowtowing to orthodoxy through bad-mouthing Aryabhata” and says “Brahmagupta played up to the religious orthodoxy by criticizing Aryabhata for apostasy in rejecting the established theological astrology<sup>2</sup>, even though Brahmagupta himself continued to use Aryabhata's scientific methods and procedures” (p.29)

Whereas Brahmagupta deserves to be praised for his courage and uprightness in expressing his views soundly and clearly against the fairly well-established Aryabhatan school, he seems to have been abused by Sen!

I would also like to highlight the point that Brahmagupta challenged Aryabhata's views purely on the basis of his own experimental and observational results along with perfect logical reasoning, which he had imbibed as a great mathematician, and not based upon religious scriptures and orthodoxy.

One of the primary reasons for such incomplete understanding of our scientific heritage is clearly the dwindling scholarship (in Sanskrit) on the soil in which these studies emerged. Modern authors of history depend on translations of the original texts, mis-read the original texts which are written in technical Sanskrit language, and/ or fail to thoroughly analyse the texts along with the commentaries. This results in misconceptions about our past emerging from time to time.

Another premise that is prevalent is that Indian astronomers and mathematicians were only concerned with the results and never worried about the logical reasoning. This is the primary issue that will be discussed in this paper. **In offering scientific explanations for an observed phenomenon, were the Indian scientists concerned about logical reasoning or not?** We take-up the discussion by considering a concrete example, namely 'the diurnal<sup>3</sup> motion of celestial objects'.

## THE ARYABHATAN VIEW

As far as we know, Aryabhata was the first Indian astronomer to propose an altogether new hypothesis to explain the diurnal motion of celestial objects. In *AryabhatIya*, *GolapAda*, verse 9, he says,

Just as a person in a boat moving in the forward direction observes the stationary objects (trees etc., on the bank) to be moving in the opposite direction, so also the stationary stars seem to move directly westward for an observer in Lanka<sup>4</sup>.

Interestingly, however, in the very next verse<sup>5</sup> he says:

For the sake of rising and setting, being blown by the Pravaha wind, the stellar sphere along with the planets moves westwards at a uniform rate<sup>6</sup>.

Here, Aryabhata has clearly mentioned that the stellar sphere, along with the planets (each of which has its own movement) is set in motion by the Pravaha wind and that this causes the rising and setting of the celestial objects<sup>7</sup>.

Now, let us examine this critically. Aryabhata independently came up with the theory of a rotating earth for the first time in the history of 'Indian' astronomy. But, was he justified in presenting two alternate views without mentioning which was the correct one, or at least which view he supported? By merely presenting both the views is he not completely misleading and confusing the readers? Is it not against the ethical norms to be followed by a scientist?

In the scientific arena, questions regarding the 'correctness' of a model are generally decided based on the following considerations:

- (a) Which of comparative models leads to more reliable results/predictions? and
- (b) If the power of prediction is equivalent, then which of them is simpler or more consistent with existing bodies of knowledge?

As far as (a) is concerned, since the issue of relative motion and calculations pertaining to planets were kinematical in nature, there was no question of whether one model would score higher than the other with reference to 'reliable prediction'. Both the models would have been considered predictively equivalent.

As regards (b) it is evident that the Aryabhatan model of a rotating earth scores more in simplicity and elegance vis a vis the then existing model where all celestial bodies - sun, moon, planets, stars - were believed to be moving around a stationary earth!

The search for simplicity and elegance plays a central role in the advancement of science. Scientists long for theoretical entities that have exemplary beauty along with simplicity, of course, with a capacity to explain the observed phenomenon. Being a consummate scientist, Aryabhata might have sought a much simpler and elegant model for explaining planetary motion than the prevailing one. Convinced by the plausibility of the simpler model, he could have proposed the theory of rotation of Earth as an alternative hypothesis. However, in the absence of empirical

evidence to prove his theory, he might have considered it unjustifiable to give more weightage to what essentially was his insight or intuition.

If someone had approached Aryabhata and asked him to defend his hypothesis of rotating earth in a 'scientific' way, I believe, Aryabhata, as a scientist, would have simply said, "I do not attempt to, for it is simply not possible."

The point that is being made here is that Aryabhata was not only just, but perfectly correct in presenting both the hypothesis on equal footing. Given the tools available in those days, it would not have been possible for Aryabhata to give greater credence to one model than the other without making unwarranted and unjustifiable assumptions. That he did not do so is itself evidence of the fact that he adhered to the highest principles of ethics in the practice of science.

### **CRITICISM FOUNDED ON LOGICAL REASONING**

Aryabhata's theory of rotation of the Earth was not acceptable to many of the astronomers of a later period. Brilliant mathematicians and astronomers like Brahmagupta (b. 598 AD), Lalla (c. 768 AD) and Bhaskara II (b. 1114 AD), were quite sceptical about the theory and have strongly refuted it in their works. However, it is very important to note that such refutations were objective and solely based on sound logical reasoning<sup>8</sup> and not on religious belief, blind faith in some established order or due to a fear of violation of authority.

Brahmagupta, in his monumental treatise *Brahmasphuta-siddhanta* has devoted a chapter called *Tantraprakasha* exclusively to examine the correctness of different schools of astronomy prevailing during his time. Most of the verses in this chapter appear to be critically examining the Aryabhatan school. This is quite understandable considering the fact that the most popular school in the 7th century was that of Aryabhata. After pointing out the inaccuracies in some of the parameters and the theoretical entities employed in the Aryabhatan system, Brahmagupta refutes the theory of rotating Earth. Describing the effects of Earth's rotation he observes:<sup>9</sup>

If the Earth were to be spinning at the rate of one *kala* in four *prana*<sup>10</sup> then where and how would they (birds) live?

Brahmagupta first raises the question if the Earth were rotating at a tremendous speed<sup>11</sup>, how would birds that have left their nests be able to fly back to their own homes? This is one of the standard objections raised by astronomers in other traditions too. These objections could not be answered satisfactorily till the time of Newton, though Copernicus did make an attempt<sup>12</sup>.

Coming back to the Indian scenario, Sripati (c.999 AD) in his *Siddhanta-sekhara* gives a more graphic description of the events and mis-happenings that may take place if the Earth were to rotate at tremendous speeds amidst high speed winds:

If it were so, (i.e., the Earth were rotating) the birds, which fly into the sky, may not be able to return to their nests on account of the rotation of

the Earth. Alas! the clouds may not be able to incessantly pour as that place over

which they were residing would have long back shifted eastwards.

Also, the flags that are hoisted should always be pointing towards the west, because of the relative speed picked up by the air due to the rotation of the Earth.

And lastly, the peaks of the mountains and the top floors of the palaces may have to fall down (due to the terrible speed generated by the winds due to relative motion).

Therefore, it is the bunch of celestial objects (stellar sphere) that rotates and the Earth remains stationary.

Another astronomer Lalla (c.768 AD) in his famous work, interestingly titled *Sishyadhivridhdhida-tantram*<sup>13</sup>, besides giving similar reasons as Sripati for opposing the Aryabhatan theory, adds:

Notwithstanding the above contradictions, if you still wish to support the theory of rotating Earth, by stating that the Earth rotates very slowly (and hence, the speed of the wind is negligible) and therefore you do not see any of these events happenings, then you will land into more serious contradiction: 'the rotation will not get completed in one day!'

Anyone with a good understanding of the fundamentals of modern physics would be tempted to deride the arguments presented above and declare them ridiculous. However, one cannot deny the fact that they are based upon the close examination of certain phenomena and application of induction and deduction techniques.

Towards the end of the chapter titled *Tantra-prakAshAdhyAya*, Brahmagupta states, as the eclipses etc., are not being predicted properly by following the methods of Srisana, Vishnuchandra, Pradyumna, Aryabhata and Latasimha, it is evident that their systems would be faulty in the daily predictions too. Hence, the errors that have been pointed out (by me), in the Aryabhatan system using logic or schematic analysis (*yuktya*), should be understood to be applicable to the other systems (mentioned above) as well.

Here again we have a clear evidence to show that, particularly while refuting other schools of thought, jointly or individually, Brahmagupta does not seem to have swerved even an inch from pure reasoning. The explicit use of the term *yuktya*, which means resort to 'logical reasoning' must be noted.

Not only Brahmagupta, but all other Indian astronomers of later period have been completely scientific in their approach while disagreeing with other schools of thought. Few astronomers of yore have crossed ethical boundaries employed in the practice of science, either in the process of supporting or refuting one theory in favour of another.

## SUMMARY AND CONCLUSION

Notwithstanding the fact that India has been generally deemed religious, superstitious, etc., it is noteworthy that the practice of religion did not intrude into the practice of science or vice versa. In order to have a fuller understanding and appreciation of the fact that Indians clearly demarcated practices of science and religion, we need to make a thorough study of the history and philosophy of Indian Science. While some of the elementary texts on astronomy, mathematics, logic, grammar, and medicine have been studied in depth and analyzed by modern scholarship from different angles, many more texts are yet to be explored. Much of the evidence for discovering how India's ancient philosophers, logicians and scientists developed their theories lies buried in commentaries and polemical texts, many of which have not been looked into and more, not been studied in toto. For instance, some of the very important texts such as *Brahmasphuta-siddhanta*, of Brahmagupta, or *Aryabhatiyabhashya* and *Jyotirmamsa* of Nilakantha, have not at all been studied by scholars. Sadly, even good editions of these seminal works are not readily available for us to study. It is high time to take the initiative to preserve these seminal texts and also launch research programmes to study history and philosophy of Indian Science.

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### Notes :

1. Compiled from Dr. Ramasubramaniam's paper, and presentation on the subject delivered on October 13, 2006 at the seminar '*Into the Future with Knowledge from Our Past*', held in Bangalore, India.
2. What is 'apostasy'? Use a dictionary and find out.
3. Another word for you to look up what does 'diurnal' mean?
4. A place, supposedly on the equator. To be distinguished from Sri Lanka as we know it today. Some believe that the island of Lanka that Ravana ruled over was much bigger than its present size.
5. Aryabhatiya, Golapada, verse 10.
6. In *Vedanga-kyotisa* of Lagadha the earliest extant Indian astronomical text (~1400 BC), it is conceived that the sidereal day is caused by one rotation of the celestial sphere, called *khagola*, from the east to the west.
7. It was believed that a wind called Pravaha, flowing in the upper regions of the sky, was continuously and uniformly driving all the stellar objects. Astronomers of the Kerala school subscribed to this view till as late as 16th century!
8. The reasoning supplied by them may not stand scrutiny today, but we have no reason to deride them as they are valid objections, considering the knowledge of physics available then.
9. *Brahmasphuta-siddhanta*, chapter 11, verse 17.
10. This is approximately the time taken for a healthy man to inhale and exhale, and is taken to be one of the standard units of time in the Indian tradition. Sixty *pranas* constitute a *nadika* (~ 24minutes) and sixty *nadikas* a day.
11. Assuming the radius of the Earth to be approximately 6,400 km, the surface of the Earth would sweep about 28 km/minute.
12. ...these bodies being 'terrestrial' and consequently sharing the nature of the Earth, share also its 'natural' motion of rotation which co-exists in them together with their own proper motion....
13. The title means - 'text for enhancing the knowledge of the students'
14. *Brahmasphuta-siddhanta*, chapter 11, verse 46-7.1414