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Author(s): B. M. Udgaonkar

Source: *Current Science*, Vol. 69, No. 2 (25 July 1995), pp. 197-206

Published by: Current Science Association

Stable URL: <https://www.jstor.org/stable/24097249>

Accessed: 10-11-2020 16:13 UTC

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Scientific tradition and other traditions*

B. M. Udgaonkar

In the 'Project of History of Indian Science, Philosophy and Culture' (PHISPC), our concern has to be with the trio science-philosophy-culture, in interaction with one another. This is where the uniqueness of this project would lie. Unidimensional discussions of any one of the trio should have no place in the volumes that result, except where they raise important questions at the interface(s). And in that case, experts in two (or three) dimensions should have sessions together to sharpen the questions and, to the extent possible, arrive at (even tentative) answers to these. This has already been emphasized by Chattopadhyaya¹. However, it bears repetition in view of the contents and presentation in some of the 'Occasional Papers' that have been brought out so far.

Indian civilization is about 4500–5000 years old (including the Indus Valley Civilization period; 8000 years old if one includes the pre-Harappan findings in Baluchistan). During this period, India has made many important contributions to science, technology, philosophy and culture. How did the developments in each of these areas influence one another? During this long period, what was the place of science in philosophy and in the civilization at large, at different epochs?

What role do the dominant scientific concepts play in the differential development of philosophy in different cultures? For example, Seal² observes that 'Hindu philosophy on its empirical side was dominated by concepts derived from physiology and philology, just as Greek philosophy was similarly dominated by geometrical concepts and methods', and adds that 'Comparative philosophy, then, in its criticism and estimate of the Hindu thought, must take note of the empirical basis on which the speculative superstructure was based'. This assertion would

merit a detailed discussion. Is the assertion true? Or is it an oversimplification with regard to both Hindu Philosophy and Greek Philosophy?

Established science at a given time influences philosophy and *vice versa*, though radically new developments do so usually with some time lag. How does one see these influences at work, in general in the Indian context? What were the positive and negative influences at different epochs? Chronology becomes important in this context. There are, however, serious chronological uncertainties in Indian history.

In the case of science, one tends to compare the Indian situation with the developments in Europe over the last few hundred years, is overawed, and it is not uncommon to hear loaded counterfactual questions like 'Why did India have no science? Is it because of its tradition?'. In asking such questions, the foreigner and, following him, many Indians, forget that science based on observation and empirical methods is to be found in the practice of the ancients in India, and that science is as much a part of our heritage as the greatly extolled mystical tradition^{3–5}. One has legitimately to take a longer time scale for any comparison, and counter the ethnocentric prejudices with facts.

The time scale of several thousand years also means that concepts may have changed with time. This has to be constantly kept in view. For the impact of any given concept, e.g. *Māyā*, one has to ask the meaning attached to it during different epochs.

Indian contributions to science and technology from the earliest times have begun to be documented^{3–5}, though there is no comprehensive work yet comparable to that of Needham and coworkers on China. It is, however, by now recognized that India's contributions to science and technology over the centuries are quite significant. This is, however, not the subject of our discussion. Rather, we will try to survey the reasons which have often been adduced as to why, in spite of a strong early base in science and technology, India failed to build on it during the last 500 years. Why did this happen?

Why did India lag behind in recent centuries?

The question often raised is: If Indians had the questioning attitude and the tradition of experimental and mathematical investigations at one time, and if they made significant contributions to developments in science and technology, especially up to about 1200 AD, and maintained their superiority in certain technologies, e.g. textiles, metal-lurgy, architecture, ship building, etc., right up to the 17th or 18th century^{6–8}, why did they fail to build further on this base? Why was it left to Europe to develop modern science? Were there some factors in our traditions which came in the way?

In history, such questions as to why something did not happen are difficult to answer. They are even treated as nonquestions by some historians. There are several questions of this kind that one could ask about Europe: e.g. why is it that none of the religions of today started in Europe? Why did they all start in Asia? Why did the early wave of science and philosophy in Europe not start in mainland Europe? Why did it start in an insignificant southeastern corner of Europe and in adjoining Asia (called *Asia minor*)? Why did the Europeans not discover zero? And why was Japan *relatively late* in joining the march of civilizations? And so on. One has no simple and straightforward answers to such questions.

China and the Arab world were also unable to build on the early head-start. Maybe different sociopolitical and historical circumstances were responsible in each case. These need to be studied in an unprejudiced manner, using such meagre data as are available and reconstructing where there are gaps (and there *are* many gaps), with a more open mind than has been customary. Many times hypotheses were made by Western scholars in the colonial period, and these have been echoed by Indian scholars even in the post-Independence era. A kind of colonial thinking has tended to persist, even if unconsciously, and so these hypotheses have to be looked at afresh.

*This article was originally prepared for the Project of History of Indian Science Philosophy and Culture of the Indian Council of Philosophical Research and was brought out as Occasional Paper 24 of the Project.

While listing some of the ideological or attitudinal factors which have been held responsible for India's inability to build on its early base, and making some comments on them, we would like to emphasize at the start that they do not strike us as having the status of anything more than speculations or prejudices, given the importance of the question being discussed. Much more detailed work is needed before any of the prevalent myths in this domain could attain the status of causal relationships *vis-à-vis* development of science in India. Wherever any of the factors have their counterparts in other civilizations, especially the European civilization, a comparative study would be called for.

It is to be hoped that the relevant sections on philosophy and culture in the volumes that will come out of PHISPC will deal with these questions in depth.

The supposed other-worldliness of Indian culture

It is alleged that early Indian culture was other-worldly, that it perceived the world as *Māyā* or illusion, and that the conceptual world-worthlessness led to a lack of interest among Indians in any worldly pursuits. Indians, it is said, were only interested in the liberation of the soul as a goal, and not in studying the external world.

It may be argued that a distortion of the concept of *Māyā* is involved in such an argument. Even if this is so, it would be useful to know the extent to which the distorted/corrupted interpretation of *Māyā* affected a young intellectual's choice of a field of study during different epochs of our long history. Were the brightest enquiring minds turned away from the study of worldly phenomena?

Related to the interest in other-worldly entities was the distinction made between what was called *parā vidyā* and *aparā vidyā*, the higher kind of knowledge and the lower kind of knowledge, and the influence such distinction would have had on the perception of what was really worth studying and worth respecting.

In the *Mundaka Upanisad*, we find the question put by an earnest student to a great teacher: 'What is that reality by

knowing which we can know all that there is in this manifested universe?'. The teacher replies: 'Two are the *vidyās* or sciences to be acquired by man, so say the knowers of *Brahman*. One is called *parā vidyā*, higher science or knowledge', the other is called *aparā vidyā*, ordinary science or knowledge'. The knowledge/search for the knowledge of the soul was considered the higher knowledge. Since what was considered *really worth knowing* was to be approached by turning the light inwards, this may have come in the way of the study of the external world. The best minds may have turned towards the exploration of the inner world – toward spiritualism and mysticism – which was placed on a higher pedestal in the name of *parā vidyā*.

Then there was 'a powerful current' in Indian culture that 'the truths of the physical and supra-physical realities can be grasped, known and possessed by us through faculties which lie above the ranges of physical senses and rational intelligence' and that the knowledge obtained by development of those higher faculties, by yogic means, through meditation and intuition, is superior to that obtained by one's senses and reason'. The gods have sometimes been described as *pratyakṣa-dviśah*, i.e. as hating something that is acquired by the senses. How powerful was this current in *space and time*?

It has also been stated that the fact that renunciation was an accepted and respectable way of life fed these trends and came in the way of development of science and technology.

The *Karma* ideology has also been adduced as a cause – the idea of previous births and their consequences in the current life, and the resultant fatalism.

The influence of the *Bhakti-Marga*, which spread in the country through the emergence of a series of saint-poets after the eighth century in different emergent languages and their compositions, which became very popular, has also been mentioned.

While Indian culture has had such negative tendencies, it is not clear how widespread was their effect in space and time, in a large country and a stratified society whose intellectual history spanned three to four thousand years – especially as India has many important scientific discoveries to its credit over the centuries. This is a matter that needs

to be looked into carefully from the point of view of possible impact on the development of science. Vivekananda, one of the greatest of the modern exponents of *Yoga* and the *Vedānta*, has, for example, laid repeated stress on the experimental character of *Yoga* and on basing it on reason¹².

Referring to the flourishing trade between India and Rome during the period 200 BC to 300 AD, Thapar¹³ mentions Pliny's complaint that the Indian trade was a serious drain on the national income of Rome. The Frenchman Bernier, who travelled in India more than 1500 years later (1656–1668), says: 'It should not escape notice that gold and silver, after circulating in any other quarter of the globe, came at last to be absorbed in Hindustan'¹⁴. These are not observations supporting the other-worldliness of Indians over the centuries.

It is interesting to see what Vivekananda has to say about *Māyā*, especially in relation to scientific pursuits. Vivekananda refers to *Māyā* as 'one of the pillars upon which the *Vedānta* rests'¹⁵. He, however, warns us that the word *Māyā* is used incorrectly to denote 'illusion or delusion or some such thing'. Having said this, he proceeds to give a number of examples to illustrate what *Māyā* is, a couple of which are quite intriguing:

'A man of science rises, he is thirsting after knowledge. No sacrifice is too great, no struggle too hopeless for him. He moves onward discovering secret after secret of nature, . . . and what for? . . . Why should we give him glory? Why should he acquire fame? Does not nature do infinitely more than any human being can do? . . . Nature can hurl a thunderbolt of any magnitude to any distance. If a man can do one small part as much, we praise him and send him to the skies. Why? Why should we praise him for imitating nature, imitating death, imitating dullness, imitating insentience? . . . Yet we are all struggling after that. And this is *Māyā*'¹⁶. ' . . . so with our intellect. In our desire to solve the mysteries of the universe, we cannot stop our questioning, we feel we must know and cannot believe that no knowledge is to be gained. A few steps, and there arises the wall of beginningless and endless time which we cannot surmount. A few steps, and there appears a wall of boundless space which cannot be surmounted, and the whole is irrevocably bound in by the walls of cause and effect. We cannot go beyond them. Yet we struggle and still have to struggle. And this is *Māyā*'¹⁷.

'... Is there no hope then?' He continues, 'True it is that we are all slaves of *Māyā*, and live in *Māyā*. Is there no way out? No hope? ... on the other side, therefore, is the bold assertion that this is all nonsense, that this is *Māyā* ...'¹⁸

At another place, Vivekananda says,

'... the minds of the people from whom the *Vedas* came were intent upon following principles, discovering principles. They had no time to work upon details or to wait for them, they wanted to go deep into the heart of things. Something beyond was calling them, as it were, and they could not wait. Scattered through the *Upanisads*, we find that the details of subjects which we now call modern sciences are often very erroneous, but at the same time their principles are correct ...'¹⁹

We have chosen to quote at length from Vivekananda since he represents in a sense a link between ancient tradition (rather, the *Advaita* tradition) and modernity, and an important figure in the Indian renaissance towards the end of the last century. Is he also undervaluing the importance of scientific pursuits as we understand them? Do such views reflect the thinking about science in one important school of thought over the centuries? If so, could they have been partly responsible for nondevelopment of modern science in India? In science, what the Swamiji called 'details' are as important as 'principles'; 'details' are, in fact, an important path to 'principles' and have often led to the overthrow of earlier 'principles'. What does one mean by saying that details were erroneous while principles were correct? In science, no general principle is frozen as unassailable knowledge for all time. The strength of the scientific method is precisely in the openness to new principles in the light of new 'details' as they unfold themselves.

Thapar²⁰ has noted that 'Indians in the pre-eighteenth century never claimed that they were more spiritual than other people, or that the Indian way of life was concerned solely with things spiritual. The ideal of the earlier texts that the best life on earth is a balance between *dharma*, *artha* and *kāma* shows a healthy unconcern for any obsession with either the spiritual or the material'²⁰.

Works like the *Kautiliya Arthashastra* show the detailed interest taken by ancient Indian scholars in worldly

matters of government (which was not dominated by priesthood) in all its aspects.

Nehru has remarked: 'Probably the Semitic culture, as exemplified in many religions that emerged from it, and certainly Christianity, was far more other-worldly'. 'Indian culture taken as a whole', he adds, 'never emphasized the negation of life, though some of its philosophies did so; it seems to have done so much less than Christianity'²¹. Nehru points out that 'in India, we find during every period when her civilization bloomed, an intense joy of life and nature, a pleasure in the act of living, the development of art and music and literature and song and dancing and painting and the theatre, and even a highly sophisticated inquiry into the sex relation. It is inconceivable that a culture or view of life based on other-worldliness or world-worthlessness could have produced all these manifestations of vigorous and varied life. Indeed, it should be obvious that any culture that was basically other-worldly could not have carried on for thousands of years. The confusion seems to have arisen from the fact that Indian thought was always laying stress on the ultimate purpose of life. It could never forget the transcendental element in its make-up ... It taught detachment in life and action, not abstention from them'²¹.

Thapar²² has discussed the origin of the stereotype. 'The theory of the instinctive unconcern of Indians for worldly things is found particularly useful in minimizing such obvious factors as colonialism in economic underdevelopment. The explanation of Indian economic backwardness does not lie in simplistic generalizations on Hindu culture but demands a detailed investigation into the nature of pre-colonial and colonial society in India'²².

Alvarez²³ has observed: 'There is still no evidence to date that one line of thought was so dominant that it had become "orthodox": there was no single established view that set itself up against and above a number of other supposed heresies. The hypothesis that Hindu philosophy (wrongly identified wholly with the idealistic school) proved disastrous for India's technical capacity or economic activity should be relegated to the garbage heap; so too, the fashionable cliché that India spent too much of its energy in the pursuit of metaphysical speculations ...'

Suppression of the scientific spirit for political reasons

Chattopadhyaya²⁴ has argued that there was a systematic suppression of materialists – e.g. the *Cārvāks* – and of materialistic ideologies in ancient India. He has written extensively on this theme, and he, and before him Fillozat, has made a case study of medicine in ancient India.

Chattopadhyaya points out that already in the ancient period, some 2500 years ago, Indian medicine had taken the momentous leap from magico-religious therapeutics to rational therapeutics (from *daiva-vyapāsraya-bhesaja* to *yukti-vyapāsraya-bhesaja*). This was a very risky step, he says, the risk involved being political. 'To question even by implication – mysticism, ritualism and religion – necessitates also rejection of the very way of life all these tend to justify. It amounts to questioning the very norm on which a hierarchical society wants to thrive.' Further, the early medical men were looking for material, natural causes of diseases. Chattopadhyaya argues²⁵ that the view of the laws inherent in nature – technically called *svabhāva* – is essential for *Ayurveda*. Thus, the fundamental postulates of ancient Indian medicine are:

- (i) everything in nature takes place according to laws inherent in nature;
- (ii) though immutable, these laws are nevertheless knowable;
- (iii) the knowledge of these laws brings power over nature, which medically means ensuring a long and healthy life.

This emphasis on *svabhāva* rejects *adrstavāda* or *karmavāda* or any supernaturalism. Chattopadhyaya²⁶ argues that this natural cause and effect approach to human ailments and their treatment was considered subversive by the priests, and the Indian law-givers were 'obliged to denounce it as abject heresy'. This led to the downgrading of the practitioners of medicine in the social hierarchy, by the law-givers, and also to interpolations of theological/philosophical discussions in the *Caraka-samhitā*, which are inconsistent with its rational spirit.

The conflict between science and the counter-ideology was also present in

Europe in the middle ages. There was the inquisition, the burning at the stake of nonconformist thinkers like Giordano Bruno, the trial and humiliation of Galileo, and the indexing of books. How does one compare the conflict between science and the counter-ideology in India with that in Europe? Why was it that the counter-ideology could prevail in India, whereas Europe could get over its influence?

Is the argument of Chattopadhyaya regarding suppression of materialism in relation to Indian medicine overdrawn? It would be useful to have a fresh look at it. Medicine did thrive in India, did make advances²⁷ and even spread outside India down to the eighth century. Indian doctors were imported by the Abbasid Khalifas to supervise their own hospitals in the 8th century AD and Sanskrit medical texts were translated into Arabic²⁸.

A Spanish Muslim scholar, quoted by Chattopadhyaya himself, says in 1080 AD that Indian medicine was the best in the world.

Further, when Francis Buchanan carried out a survey of the state of medicine and surgery in 1807, under orders from the Court of Directors of the East India Company, he observed in relation to Bihar: 'Medicine is taught by several of the Pandits, some of whom also, though they are grammarians, practice the art... Besides the Professors of Medicine, about 700 families of Brahmins, almost all of Sakadwip, practice that art and are the only Hindu physicians who possess anything like science...' ²⁹ (emphasis added).

Conflict between science and religion

It is not unusual to find it claimed that unlike in Europe, there was no conflict between science and religion in India^{30, 31}, because there was no hostility to science or to new ideas in philosophy, on the part of religion; that even atheists were not persecuted in India. This was true in early times, when there was full intellectual freedom, a beautiful example of openness being the *Nāsadāya sūkta* in the *Rigveda*. There were as many as sixty-three systems of philosophy in the days of the Buddha, and very few of them cared to rely on Vedic authority for their hypotheses or their conclusions. Within the fold of the

orthodoxy itself there were the *Sāṅkhya*, *Mīmāṃsa* and *Nyāya* systems, which had hardly any appropriate place for the divine Creator in them. Buddhism and Jainism were not summarily dismissed as atheistic. But certain works came to be canonized some time around 600 BC, and an almost equal reverence came to be paid to the *Smrtis* and *Puranas* in the course of time. Theories began to be accepted or rejected according as they were in conformity with or opposed to statements of the sacred books³². Already by the time of Sankara, the pressure was quite strong. Intellectual giants like Sankara and Rāmānuja had to spend a disproportionate amount of time and energy to prove that their systems of philosophy were in conformity with and the natural outcomes of the *Upanisadic* hypotheses. Independent development of philosophies was affected. Instead, one only had commentaries on the revealed literature³².

The separation of philosophy from theology, and of science from philosophy, also did not take place. This separation would seem to have been an important step in European development. It enabled science to go ahead when theology and metaphysics stagnated.

Under such circumstances, there was not much scope left for research and originality in those matters where opinions were expressed in the sacred books, which now included *Smrtis* and *Purāṇas*. A glaring example is that of the mythological stories about *Rāhu* and *Ketu* temporarily overpowering the moon or the sun and thereby causing eclipses, which got canonized by inclusion in the *Purāṇas*. Aryabhata, (ca. 500 AD), Varahamihira and Brahmagupta (ca. 600 AD) knew the scientific explanation of eclipses but were powerless to explode the myths. In fact, Brahmagupta went to the extent of condemning Aryabhata, Varahamihira, Srisena and Visnucandra for expounding the unorthodox but scientific theory of eclipses. Alberuni has suggested that Brahmagupta made the compromise because a calamitous fate like that of Socrates had befallen him³³.

Was this also the reason why Aryabhata's suggestion that the earth revolves around its axis was not followed up by later astronomers? Or, for the fact, that the idea of impetus could not

develop into inertia, force, etc., – perhaps the most important developments in Europe that launched the scientific revolution?

Incidentally, it will be useful to have more light thrown on the process of canonization of scriptures, including the *Smrtis* and the *Purāṇas*, which made it impossible for even outstanding intellectuals like Brahmagupta to counter stories like those of *Rāhu*, *Ketu* and the eclipses, and also to document other instances of this kind. Is the view that there was no conflict between science and religion/spirituality a modern view, or does it go back to ancient times?

Swami Ranganathananda³⁴ quotes from Sankarācārya's commentary on the *Bṛhadāraṇyaka Upanisad*: 'Nor are the *Srtis* (the *Vedas*) supposed to have authority in matters which are contradicted by other means of knowledge, for instance, if they said, 'fire is cold and wets things'. Was such thinking widely accepted by scholars or people at large? During which epochs?

Possibly connected with this concept of knowledge as captured and frozen in the scriptures is the picture of a traditional 'Brahmin' scholar today as a repository of knowledge in the books – rather than a free-wheeling creative intellectual, applying his knowledge to the exploration of new phenomena or providing improved explanations of the phenomena already known. When did the tradition of questioning as in the *Upanisads*, *Nyāya-Vaiśeṣika*, and other early texts lose its vigour and a static view of the learning of the learned emerge?

The belief that all knowledge is in the Vedas

Vivekananda refers to the belief prevalent in India that all that is called knowledge is in the *Vedas*³⁵.

It is not uncommon to find it claimed even today that the *Vedas* are the storehouse of all knowledge – *spiritual and secular*. For example, Jagadguru Swami Shri Bharati Krishna Maharaj has said:

'The very word *Veda* has this derivational meaning, i.e. the fountainhead and illimitable storehouse of all knowledge. This derivation, in effect, means, connotes and implies that the *Vedas* should contain within themselves all the knowledge needed by mankind relating not only to the so-called

spiritual (or other-worldly) matters but also to those usually described as purely secular, temporal or worldly, and also to the means required by humanity as such for the achievement of all-round, complete and perfect success in all conceivable directions, and that there can be no adjectival or restrictive epithet calculated (or tending) to limit that knowledge down in any sphere, any direction or any respect whatsoever.

'In other words, it connotes and implies that our ancient Indian Vedic lore should be all-round, complete and perfect and be able to throw the fullest necessary light on all matters which any inspiring seeker after knowledge can possibly seek to be enlightened on.'³⁶ (emphasis added)

One should note that this statement of the Jagadguru is quoted by a former President of the Association of Indian Universities in his Foreword to the book *Science and the Vedas*.

It will be useful to know how old this kind of belief is in our cultural/philosophical history. When and how did it get ascendancy? Such a belief, if widely held, could lead to stagnation or even decline in science and could, therefore, be an important factor inhibiting the growth of modern science in India. It could also have inhibited the healthy development of philosophy.

Tendency to accommodate conflicting opposites

Indian tendency to accommodate conflicting opposites has been mentioned as one of the causes. The faith of some of our modern scientists in miracle-making godmen is cited as a present-day example.

Alberuni, the scholar-traveller who visited India around 1000 AD was very critical of the Hindus on this score: '... you mostly find that even the so-called scientific theorems of the Hindus are in a state of utter confusion, devoid of any logical order, and in the last instance always mixed up with silly notions of the crowd, e.g. immense numbers, enormous spaces of time, and all kinds of religious dogmas, which the vulgar belief does not admit of being called into question. Therefore, it is a prevailing practice among the Hindus *jurare in verba magistri*; and I can only compare their mathematical and astronomical literature, as far as I know it, to a mixture of pearl shells and sour dates, or of pearls and dung, or of costly crystals and common pebbles. Both kinds of

things are equal in their eyes, since they cannot raise themselves to the methods of a strictly scientific deduction...' ³⁷

These are harsh words, possibly coloured to some extent by the arrogance of a person accompanying conquering Mahmud, but they should make us look introspectively at the cultural and philosophical milieu of that period.

Varāhamihira wrote in *Brahatsamhita* that the gems could have originated either from the bones of gods and demons, or on account of natural metamorphosis of rocks. The possibilities were given equal emphasis³⁸. Biswas³⁸ has given more revolting examples from *Rasa-Ratna-Samuccaya*, a 13th century text.

Kosambi³⁹ has observed: 'The "logic" advanced by the *Brahmins* took good care to avoid all reality. The end result is seen in the philosophy of the great Sankara (800 AD), who threw out the proposition that "a thing is either A or non-A", and viewed the universe as divided into metaphysical categories upon several planes. The highest plane was, of course, of speculation about and unity with eternal principles. Material reality did not exist. The philosopher was thus excused if he joined the common herd on the plane of ritual observation...'.

An oft-quoted example of this tendency as far as science is concerned is that Brahmagupta wrote the popular myth about the cause of eclipses (*Rāhu*, *Ketu* and all that) along with his calculation in terms of the correct astronomical explanation.

It is interesting to see what Saha⁴⁰ has said in this regard: '... in India, the votaries of the astronomical science apparently found it difficult to go against the scriptures. The Greek savants, with characteristic boldness and freedom of thought, had pooh-poohed the Homeric and Hesiodic cosmogony, they made light of the Olympic Gods. But the Indian savant never showed equal boldness. On the other hand, being accustomed to easy-going pantheistic tendencies, he was always ready to compromise and be accommodating in his views ... never courageous enough to propose a bolder theory of the universe in opposition to current ideas. Aryabhata of Kusumpur (Patliputra) (born in 476 AD) thought that the earth, by turning round its axis, caused day and night, but his successors did not

seem to be impressed with his ideas. It is, however, clear that they were keenly alive to the stupidity of public beliefs or utter inadequacy of the *śāstric* lore. "It is said", says Bhāskaracharya, "that the earth rests on the hood of a huge snake, which when it feels uneasy gives a shake and causes earthquakes. Well, the snake must have something to rest upon, let it be the tortoise, but this also must have something else to rest upon. So we have to assume the hypothesis of an endless string of the support and supporters. A better explanation would be that the earth has no support, i.e. is suspended in space". But the next sentence, he is careful to say, "but since these things are mentioned in the *Sastras*, there must be some truth in them"'.

Lest we are too harsh on Brahmagupta or Bhaskaracharya, we may note what Gould⁴¹ has to say about Newton and Whiston, his successor as Lucasian Professor at Cambridge.

'The Newton of our Pantheon is a sanitized and modern version of the man himself.' He greatly admired the book *New Theory* by William Whiston (1696), to such an extent that Whiston ended up as Newton's handpicked successor as Lucasian Professor of Mathematics at Cambridge. The full title of Whiston's treatise gives an idea of its contents. Whiston called his treatise *A New Theory of the Earth from its Origin to the Consummation of all Things, Wherein the Creation of the World in Six Days, the Universal Deluge, and the General Conflagration, as laid down in the Holy Scriptures, are shown to be perfectly agreeable to Reason and Philosophy*.

In trying to establish a consistency between the two great sources of truth as defined by his countrymen – the infallibility of the Scriptures, and the mathematical beauty of the cosmos, so recently recreated by Newton – Whiston implicated comets as prime movers.

'Whiston has descended through history', remarks Gould⁴¹, 'as the worst example of religious superstition viewed as an impediment to science'. '... We dismiss Whiston because he violated ideals of science as we now define the term. But, in Whiston's time, science did not exist as a separate domain of inquiry; the word itself had not been coined. No matter how we may view such an enterprise today, Whiston's mixture of natural events and scriptural traditions defined a primary domain at

the forefront of scholarship in his time . . . He did not view his effort as a work of science, but as a treatise in an important contemporary tradition for using all domains of knowledge – revelations of the Scriptures, history of ancient chronicles, and knowledge of nature's laws – to reconstruct the story of human life on our planet. The *New Theory* contains – and by Whiston's explicit design – far more material on theological principles and biblical exegesis than on anything that would now pass muster as science.'

The interesting thing in the context of our discussion is the fact that Whiston's work was highly thought of by no less a person than Newton.

It is also well known that at the same time that Newton was working on the *Principia*, he was also spending a substantial fraction of his time on investigations in alchemy and theology. On the other hand, he did not publish anything on either of these subjects.

Complacency developed during the period when the Indians had attained a high level of civilization

Another line of reasoning puts the blame on the complacency that the Indians had developed over a period of time: they began to think that they had attained the highest knowledge that humans were capable of and they progressively lost the questioning attitude and openness to knowledge from other sources (*ā no bhadrāḥ kratavo yantu visvataḥ*). In this context one often quotes Alberuni, who says the following about the attitude of Hindus of his time:

'They are haughty, foolish, vain, stolid and self-conceited. According to their belief, there is no other country on earth but theirs, no other race of man but theirs, and no created beings besides them have any knowledge or science whatsoever. Their haughtiness is such that, if you tell them of any science or scholar in Khurasan or Persis, they will think you to be both an ignoramus and a liar. *If they travelled and mixed with other nations, they would soon change their mind, for their ancestors were not as narrow-minded as the present generation is.*'⁴² (emphasis added).

*Gargi Samhita*⁴³ says: 'The yavanas (i.e. the Greeks) are indeed barbarians, but astronomy originated in them and for this they must be venerated as Gods.'

Aryabhata and Varāhamihira also did not have the attitude described by Alberuni, though one probably sees the beginning of such an arrogant and exclusive attitude in *Varahamihir* when he says: 'The Greeks, *though impure*, must be honoured, since they were trained in sciences, and therein excelled others. *What then are we to say of a Brahman if he combines with his purity the height of science?*'⁴⁴ (emphasis added).

When did the vain, self-conceited attitude start dominating? How did it continue in spite of the humiliating defeats that the Hindu society had to accept from successive invaders?

The complacency or intellectual lethargy that had developed continued even after the Moguls came to power. Javaharlal Nehru refers to the curious fact that Akbar did not take any interest in building sea power, though Vasco de Gama had reached Calicut, via the Cape, in 1498, and established Portuguese sea power in the Indian Ocean. What is more, this lack of interest continued even after the Portuguese started extracting tolls from traders and from pilgrims going to Mecca. He or the 'jewels' in his court also took no interest in printing⁴⁵, though the Jesuits presented him with a printed Bible. The Mogul army and the armies of other states in India depended on foreign experts for their artilleries. Why did Akbar or anyone else not send his own men abroad for training, or interest himself in the improvement of the artillery by encouraging research work? Why did they not take interest in developing Indian clocks, though imported clocks were very popular with the Mogul nobility?

Over the centuries, during the Gupta period and later, India imported horses from Arabia, Iran and Bactria. For some strange reason, India never took to the breeding of horses and training the veterinarians. Mentioning this, Thapar⁴⁶ remarks: 'The fact that India never bred sufficient horses of quality, the best blood having always to be imported, was to have disastrous consequences on the cavalry arm of Indian armies, eventually making the cavalry ineffective, especially in comparison with Central Asian hordes.'

Rigidity of the caste system

A factor that needs some discussion is the growing rigidity of the caste system

in India, which led to the separation of the head from the hand⁴⁷. Theoretical and philosophical studies (including the speculative aspects of science) were the prerogative of the *Brahmins*, whereas the practical arts and crafts were relegated to the other castes. These lower castes, moreover, did not have the benefit of formal education. This prevented the coordination between science and crafts, and theory and experimentation/experience. Also, the accumulated theoretical knowledge was accessible to *Brahmins* in Sanskrit while the common technicians, who knew only one of the Prakrits, had no access to it. It would be useful to compare and contrast with a similar problem in medieval Europe, where the accumulated theoretical knowledge was the prerogative of the Latin-knowing clergy and aristocracy and not accessible to common artisans. Also, when did the caste system become rigid from the point of view of separation of the head from hand? Altekar observes that after 800 AD, primary education became restricted to the higher strata of society; the vast majority of workmen and artisans became illiterate by this time and knew only the traditional processes of their profession⁴⁸.

The ban on foreign travel

Foreign travel seems to have got banned around the 8th century⁴⁹. This is usually attributed to the increasing rigidity of the caste system, and the ideas of purity and impurity, especially in relation to mixing with foreigners and observing food taboos. Vivekananda in one discussion attributes the ban to a desire to prevent the Hindus from mixing with the surrounding Buddhistic nations. He says: 'The one great cause of the downfall and degeneration of India was the building of a wall of custom – whose foundation was the hatred of others – around the nation, and the real aim of which in ancient times was to prevent the Hindus from coming into contact with the surrounding Buddhistic nations.'⁵¹

Whatever be the cause, banning of foreign travel could not but have had a very adverse impact on the exposure to fresh ideas and new techniques, so essential for growth of science. Sharma⁵² has discussed the possibility that Raja Jai Singh may have received wrong advice from his foreign consultants, the Jesuits, with regard to the state-of-the-

art in astronomy in Europe. Though their delegation visited Europe on his behalf, the Jesuits, because of their own theological beliefs and prejudices, may not have presented the Copernican revolution to Jai Singh in its true perspective. The European books which Jai Singh got translated into Sanskrit included the already obsolete *Almagest* of Ptolemy and not *The Revolution of the Heavenly Spheres* of Copernicus or *The Harmonies of the World* of Kepler or *Dialogues Concerning Two New Sciences* of Galileo or *The Principia* of Newton, all of which had been in existence for quite some time. Jai Singh also does not seem to have benefited from the developments in telescopes taking place in Europe, in planning his observatories. 'Unfortunately', says Sharma, 'The Raja seemed to have had no alternative but to send a team of foreigners on his fact-finding mission in Europe as no high-born Hindu of his days would dare *'cross the ocean'* and thereby risk *'losing his caste'*'.⁵² This unfortunate predicament of the Raja need not diminish our admiration for his vision and his contributions to astronomy.

A handicap of the oral tradition?

The Indian tradition is said to have been largely an oral tradition, from the earliest times when the *Vedas* were not written but passed on by recitation from the *Guru* to the disciple, with explanations in the course of the transfer. Later when writing was developed (ca. 400 BC), the style was usually aphoristic, so that the intermediary of a *Guru* was needed for an understanding of the meaning of the esoteric texts. While commentaries helped to some extent, they often did not throw light on the rationale of the problem tackled or provide an insight into the mental working of the scientist, whose results were given cryptically in a *Sūtra*. Added to this was the secretive aspect of the tradition, which again, meant that if the symbolic language with secret meaning, or recipe, or special formula, was not transferred by a *Guru* to his (favourite) *Śiṣya*, that piece of knowledge disappeared.⁵³

Effect of invasions?

Successive invasions meant not only devastating destabilization of the func-

tioning of the society, and loss of prosperity, it also meant loss of centres of learning, including their libraries. Alberuni⁴² describes the effect of Sultan Mahmud's invasions: '... Mahmud utterly ruined the prosperity of the country, and performed there wonderful exploits, by which the Hindus became like atoms of dust, scattered in all directions, and like a tale of old in the mouth of people... This is the reason why Hindu sciences have retired far away from those parts of the country conquered by us, and have fled to places which our hand cannot yet reach...'.⁴³

India had at one time flourishing universities at Takṣaśīla, Vikramāśīla, Valabhi, Nālandā, etc. Within a couple of hundred years of the above account by Alberuni, the 700–800 years old University of Nālandā, to which scholars came from various parts of the country and from abroad, was destroyed by Bakhtiyar Khilji. Bakhtiyar Khilji also destroyed the famous University of Vikramāśīla. These were the last of the great Indian universities to disappear. No great universities came up in the centuries that followed, either under the Afghans and the Moguls in the North, or under the Vijayanagar and other kingdoms of the South.

One may say that one had the *Gurukul* system. But such a *gharāṇā* system had its weak as well as strong points. It could not be a substitute for universities.

It would not be an accident that the bright period for Indian science and philosophy was also the period in which some of these universities flourished and attracted scholars from far-off places. One notes in this context the role played by the universities of Cordova, Cracow, Tübingen, Paris, Oxford, Bologna and Padova in the revival of learning (science in particular) in Europe. Some of the great architects of the scientific revolution in Europe had been at Padova at important periods in their career – Copernicus, Galileo, Harvey and Vesalius, to mention a few.

Even the great Akbar does not seem to have applied his mind to the setting up of universities. Why?

Just around the time when India's great universities were disappearing, new universities were coming up in Europe.⁵⁴ This was followed by the setting up of Academies/Royal Societies, which also were to play an important role in the intellectual life of Europe.

The effect of centuries of unsettled conditions that prevailed before a multi-religious composite culture could emerge needs to be analysed dispassionately without allowing either Hindu or Muslim chauvinism to distort the view of the happenings.

The British had stepped in before India could find its feet again.

Influence of Buddhism?

Going back to an earlier period, what were the positive and negative impacts of Buddhism on the development of science in India? The Buddha himself stressed the importance of the spirit of enquiry:

'Believe nothing
Merely because you have been told it,
Or because it is traditional,
Or because you yourself have imagined it.
Do not believe what your teacher tells you,
Merely out of respect for the teacher.
But whatever, after due examination and analysis,
You find to be conducive to the good,
The benefit,
The welfare of all beings,
That doctrine believe and cling to,
And take it as your guide.'

It is interesting that he said this around the time that some of the Hindu scriptures were getting canonized. Can one trace the healthy impact of this on science?

Later, things changed. As Chatto-padhyaya points out in the course of his discussion of the vicissitudes of *Ayurveda*, while the concept of causality is absolutely crucial for *Ayurveda*, Nāgārjuna, the founder/exponent of the *Mādhyamaka* school of philosophy, popularly known as *Śūnyavāda*, denied causality and condemned experience and reason as sources of right knowledge. What impact did this have on science?

It is curious that the decline of Indian science seems to have started around the time or in the centuries following the victory of *Ādi Śaṅkara* over the existing Buddhistic doctrines and other materialistic and nonmaterialistic schools of Indian philosophy in the 8th century. Did this victory imply the reestablishment of spirit over matter, lead-

ing to a down-grading of creative science⁵⁵?

Did the *Prāmānyavāda*, which followed in the succeeding centuries, have an adverse effect?

One hopes that an objective discussion of the positive and negative impacts will be forthcoming⁵⁶.

Too big a load from the past?

Was the continuity in Indian civilization a handicap? Europe lost its Graeco-Roman knowledge and tradition in the dark ages, and then recovered these a thousand years later through the Arabs, along with the knowledge which the Arabs brought from India. When this happened, the Europeans had a chance to have a fresh critical look at the old heritage. Such a critical look started already in the 13th–14th centuries with the scholastics, and was an important factor leading to Renaissance. Was the absence of discontinuity a disadvantage for the Chinese and the Indians?

The load from the past has been summarized by Kosambi: 'The absence of logic, contempt for mundane reality, the inability to work at manual and menial tasks, emphasis upon learning basic formulas by rote, with the secret meaning to be expounded by a high *Guru*, and respect for tradition (no matter how silly) backed by fictitious ancient authority had a devastating effect upon Indian science.'⁵⁷

The various corrosive factors seem to have been operating from the last centuries of the first millennium, though their effect was seen much later. As Nehru⁵⁸ has remarked, during Akbar's time, 'India to all outward seeming presented the spectacle of not only a brilliant court, but of thriving trade, commerce, manufacture and crafts. In many respects, the countries of Europe would have seemed backward and rather crude to an Indian visitor then. And yet the dynamic quality which was becoming evident in Europe was almost wholly absent in India . . . A civilization decays much more from inner failure than from external attack. It may fail because in a sense it has worked itself out and has nothing more to offer to a changing world, or because the people who represent it deteriorate in quality and can no longer support the burden worthily . . . '.

Some comments on the western traditions supposedly responsible for the rise of modern science in Europe

Finally, it may be appropriate to comment very briefly on some of the contributory factors that are often mentioned in the context of the rise of modern science in Europe.

Rise of modern science was a unique happening, that took place in Europe. There has been a lot of post-facto rationalization of this development⁵⁹. The search has been for developments which took place uniquely in Europe, so as to make a case that modern science could arise only as a concomitant of such developments and, therefore, in Europe and nowhere else. Developments like Reformation and Renaissance are often mentioned as contributory or triggering factors. It is good to remember, however, that Copernicus was not only a catholic but a canon in the Roman Catholic Church and that high dignitaries of the Church were associated with the publication of his book. Galileo was also a Roman Catholic and ventured into the realm of theology by attempting to show that the Copernican system was consistent with a fair interpretation of the words of the Scriptures. And Martin Luther mounted a vicious attack on Copernicus. The Catholic Church, it is well known, put the books of Copernicus and Galileo on the *Index*.

Anthony⁶⁰, a biographer of Newton, quotes Butterfield to make the point that the ancient Greek thought, through Arab translations, Renaissance, Reformation, etc., did not change the mode of thinking of people as scientific revolution itself did.

Butterfield has, in fact, observed, 'since that (i.e. scientific) revolution overturned the authority in science not only of the middle ages but also of the ancient world – since it ended not only in the eclipse of scholastic philosophy but also in the destruction of Aristotlean physics – it outshines everything since the rise of Christianity and reduces the Renaissance and Reformation to the rank of mere episodes, mere internal displacements within the system of medieval Christianity . . . '⁶¹.

The question then arises if one has been overemphasizing factors like Renaissance, Reformation and changes in the mode of thinking of people as the prime contributors to the rise of modern science in Europe.

And Bertrand Russell has observed:

'Although science was what interested (Francis) Bacon, and although his general outlook was scientific, he missed most of what was being done in science in his day. He rejected Copernican theory', even after the work of Kepler. 'Bacon appears not to have known of the work of Vesalius, the pioneer of modern anatomy, or of Gilbert, whose work on magnetism brilliantly illustrated the inductive method. Still more surprising, he seemed unconscious of the work of Harvey, although Harvey was his medical attendant!'⁶².

It is also interesting to note the comments of Thomas Huxley on the influence of Baconian philosophy:

' . . . I do protest that, of the vast number of cants in this world, there are none, to my mind, so contemptible as the pseudo-scientific cant which is talked about the Baconian philosophy. To hear people talk about the great chancellor – and a very great man he certainly was – you would think that it was he who invented science, and that there was no such thing as sound reasoning before the time of queen Elizabeth . . . The method of scientific enquiry (did not originate with Bacon or his age) originated with the first man whoever he was, . . . '⁶³.

Butterfield⁶⁴ has commented that one of the aspects of history that is not sufficiently emphasized is that '*from the fourth to the twentieth century, one of the most remarkable aspects of the story – the most impressive conflict that spans 1500 years – is the conflict between Europe and Asia, a conflict in which down to the time of Newton's Principia, it was the Asiatics who were on the aggressive*'.

It is clear that some of the contributory factors held responsible for the rise of modern science in the West and for the East lagging behind need a fresh look.

Mukhopadhyaya⁶⁵ has written about two metamorphoses of the mind in the recent centuries, one among the Europeans, who appropriated science as a purely western product, as a most typical creation of thought of the Western civilization, and the other suffered by the colonial people, Indians in particular, which persuaded them that science was not a part of their civilization.

Mukhopadhyaya's thesis calls for a closer look.

Concluding remarks

It should be clear that the Project on the History of Indian Science, Philosophy and Culture should constantly keep in view the changing sociocultural-philosophical milieu in which science could have flourished in India during certain periods, and in which Indian technology could have been at the forefront internationally in certain domains down to the eighteenth century, and in which both became stagnant or declined during other periods. What were the external factors and what were the internal failures which must not be allowed to repeat? Were the internal failures on a broad front (science, philosophy, literature, art, architecture, ...)? To the extent that the Project will succeed in unravelling these complex intertwining factors, it will provide a landmark in the history of the development of Indian science, philosophy and culture.

1. Chattopadhyaya, D. P., On the nature of the interconnection between science, technology, philosophy and culture, Occasional Paper 1 of the PHISPC; also the Project Document.
2. Seal, B. N., *Positive Sciences of the Ancient Hindus*, Motilal Banarasidas, Delhi, 1958.
3. Chattopadhyaya, Debi Prasad, *The History of Science and Technology in India: The Beginnings*, Firma KLM, Calcutta, 1986.
4. Sen, S. N., History of science in relation to philosophy and culture in Indian civilization, Occasional Paper 6 of the PHISPC.
5. Bose, D. M., Sen, S. N. and Subbarayappa, B. V. (eds.), *A Concise History of Science in India*, Indian National Science Academy, New Delhi, 1971.
6. Dharampal, *Indian Science and Technology in the Eighteenth Century: Some Contemporary European Accounts*, Impex India, New Delhi, 1971.
7. Alvarez, Claude, *Homo Faber*, Allied Publishers, Bombay, 1979.
8. Udgankar, B. M., Scientific culture and ideological influences on history of science in India, Occasional Paper 16 of the PHISPC.
9. *Mundaka Upanisad*, I.1.1-2.
10. Joshi, Kireet, Significance of Indian yoga (an overview), Occasional Paper 10 of the PHISPC. (It would be useful for Kireet Joshi to discuss the impact of such a thinking on the development of science.)
11. Related to this is the fact that in India, where mythology continues to play an important role in people's daily life, stories of mythological (and today's) personalities acquiring supernatural knowledge, skills, powers by *sadhana* continue to be believed by many people. We even have the phenomenon of a Prime Minister addressing an academic gathering and making a reference to our ancients having visited *Candraloka*.
12. Nehru, Jawaharlal, *The Discovery of India*, John Day and Co., New York, 1946, p. 180.
13. Thapar, Romila, *A History of India*, Penguin Books, Harmondsworth, England, 1966 (Reprinted 1981), p. 115.
14. Bernier, François, quoted by B. V. Subbarayappa in ref. 5, p. 485.
15. Swami Vivekananda, *Jnana-Yoga*, 15th edn, Advaita Ashrama, Calcutta, 1980, p. 47.
16. Swami Vivekananda, *Jnana-Yoga* 15th edn, Advaita Ashrama, Calcutta, 1980, pp. 91-92.
17. Swami Vivekananda, *Jnana-Yoga* 15th edn, Advaita Ashrama, Calcutta, 1980, p. 93.
18. Swami Vivekananda, *Jnana-Yoga* 15th edn, Advaita Ashrama, Calcutta, 1980, pp. 98-99.
19. Swami Vivekananda, *Jnana-Yoga* 15th edn, Advaita Ashrama, Calcutta, 1980, p. 49.
20. Thapar, Romila, *The Past and Prejudice*, National Book Trust, 1975 (Reprint 1990), p. 7.
21. Nehru, Jawaharlal, *The Discovery of India*, John Day and Co., New York, 1946, pp. 72-73.
22. Thapar, Romila, *The Past and Prejudice*, National Book Trust, 1975 (Reprint 1990), pp. 18-19.
23. Alvarez, Claude, *Homo Faber*, Allied Publishers, Bombay, 1979, p. 48.
24. Chattopadhyaya, Debi Prasad, *Science and Society in Ancient India*, Research India Publication, Calcutta, 1977.
25. Chattopadhyaya, Debi Prasad, Science, philosophy and society in ancient India, Paper presented at the XVIth International Congress of the History of Science, Bucharest, August 26-September 3, 1981.
26. Chattopadhyaya, Debi Prasad, *Science and Society in Ancient India*, Research India Publication, Calcutta, 1977.
27. Unfortunately, soon after Susruta's time, dissection of human bodies went out of vogue, to the great detriment of the progress of medical science (ref. 28, p. 178).
28. Altekar, A. S., *Education in Ancient India*, The Indian Bookshop, Banaras, 1934, pp. 180-181.
29. Sen, S. N., *Scientific and Technical Education in India 1781-1900*, Indian National Science Academy, New Delhi, 1992, pp. 26-27.
30. Swami Ranganathananda, *Science and Spirituality*, Ramakrishna Math, Hyderabad, 1982; also *Science and Religion*, Advaita Ashram, Calcutta, 1982.
31. It is not our intention to belittle the valuable efforts being made by Swami Ranganathananda to build bridges between religion and spirituality on the one hand, and science on the other, in the context of modern needs. The question, however, is what happened in history.
32. Altekar, A. S., *Education in Ancient India*, The Indian Bookshop, Banaras, 1934, pp. 342-346. Altekar also discusses the narrowness that developed in the educational system over the centuries.
33. Alberuni, in *Alberuni's India*, (ed. Sachau, Edward), Popular Edition, 1914, vol. II, p. 112.
34. Swami Ranganathananda, *Science and Spirituality*, Ramakrishna Math, Hyderabad, 1982.
35. Swami Vivekananda, *Jnana-Yoga*, 15th edn, Advaita Ashrama, Calcutta, 1980, p. 166.
36. Jagadguru Swami Bharati Krishna Maharaj, quoted in the Editor's Foreword to *Sciences and the Vedas* (ed. Patel, Ishwarbhai, Former President, Association of Indian Universities), Somaiya Publications, 1984.
37. Alberuni, in *Alberuni's India* (ed. Edward Sachau), Popular Edition, 1914, vol. I, p. 25.
38. Biswas, A. K., *Indian J. Hist. Sci.*, 1987, 22(1), 29.
39. Kosambi, D. D., *The Culture and Civilization of Ancient India in Historical Outline*, Vikas, New Delhi, 1977, p. 163.
40. Saha, M. N., *Collected Works of Meghnad Saha* (ed. Chatterjee, Santimoy), Orient Longman, Bombay, 1982, vol. I, pp. 83-84.
41. Gould, Stephen Jay, in *Bully for Brontosaurus*, Penguin, 1992, pp. 367-381.
42. Swami Ranganathananda, *Science and Spirituality*, Ramakrishna Math, Hyderabad, 1982; also *Science and Religion*, Advaita Ashram, Calcutta, 1982, vol. I, p. 22. Note, however, that Alberuni has elsewhere praised the Hindus and their contributions to the science. He even learnt Sanskrit and translated some of the works.
43. Quoted by Majumdar, R. C., in *History and Culture of Indian People*, Bharatiya Vidya Bhavan, New Delhi, vol. II, Chapter XXIV.
44. Varahamihir, quoted by Alberuni in Ref. 33, pp. 22-23.
45. Daniel, J. Boorstein has drawn attention to the fact that 'despite an uncanny reverence for the written word, the Arabic world resisted the opportunities of the printing press', and remarks that 'fear of blasphemy and heterodoxy kept the printing press out of the Muslim world for centuries'. See Boorstein Daniel, J., *The Discoverers*, Vintage Books, 1985, pp. 539-547.

46. Thapar, Romila, *A History of India*, loc. cit., p. 149.
47. Bose, D. M., Sen, S. N. and Subbarayappa, B. V. (eds.), *A Concise History of Science in India*, Indian National Science Academy, New Delhi, 1971, pp. 484-485.
48. Altekar, A. S., *Education in Ancient India*, The Indian Bookshop, Banaras, 1934, pp. 198.
49. How effective was the ban until the 13th century? Until then, Indians had close interaction with West/Central Asia and SE Asia⁵⁰. And it could not have affected Muslim scholars and traders. The Gujaratis were, in fact, the dominant ship-owning and trading community at Malacca at the end of the fifteenth century (see, for example, *The Suma Oriental of Tomé Pires*, Hakluyt Society, London, 1944, 2 volumes, translated and edited by Armando Cortesão, quoted in *South-East Asia: Its Historical Development*, by John F. Caŕy, Tata McGraw Hill, New Delhi, 1976).
50. Habib, Irfan, in *Science and Technology in Indian Culture - A Historical Perspective*, NISTADS, New Delhi, 1984.
51. Swami Vivekananda, *Teachings of Swami Vivekananda*, Advaita Ashrama, Calcutta, 1971, 5th edn, p. 154.
52. Sharma, Virendra N., *Indian J. Hist. Sci.*, 1982, 18, 333, 345.
53. It is a pleasure to thank B. V. Subbarayappa for a discussion on the contents of this paragraph.
54. It is interesting to read the announcement of the founding of a new University at Toulouse in 1229, which made a special mention that 'those who wish to scrutinize the bosom of nature to the inmost can hear here the books of Aristotle, which were forbidden at Paris'. Ref. 'New University-1229' in *A Random Walk in Science*, Institute of Physics, London, 1973, p. 15; the item being condensed from: Thorndike, Lynn, *University Records of the Middle Ages*, Columbia University Press, 1944.
55. Ray, P. C. said in this context: 'The Vedanta Philosophy, as modified and expounded by Sankara, which teaches the unreality of the material world, is to a large extent responsible for bringing the study of physical science into disrepute. Sankara is unsparing in his stricture on Kanada and his system ... Among the people ridden by caste and injunctions of the Vedas, Puranas and Smritis and the like, cramped and paralysed, no Boyle could arise.' (quoted by Debi Prasad Chattopadhyaya in Ref. 3)
56. See Sen, S. N., History of science in relation to philosophy and culture in Indian civilization, Occasional Paper 6 of the PHISPC, for a brief discussion.
57. Kosambi, D. D., *The Culture and Civilization of Ancient India in Historical Outline*, Vikas, New Delhi, 1977, pp. 174-175.
58. Nehru, Jawaharlal, *The Discovery of India*, John Day and Co., New York, 1946, p. 261
59. Singh, Virendra, *Asia-Pacific Phys. News*, 1987, 2, 20-24, for a recent review and several references.
60. Anthony, H. D., *Sir Isaac Newton*, Abelard Schuman, London, 1960.
61. Butterfield, H., *The Origins of Modern Science*, Collier Books, New York, 1962, pp. 7-8.
62. Russell, B., *A History of Western Philosophy*, Simon and Schuster, p. 544.
63. Huxley, Thomas Henry, Six Lectures to Working Men, 'On our knowledge of the causes of phenomena of organic nature', 1863, reprinted in *Darwinia*.
64. Butterfield, H., *The Origins of Modern Science*, loc. cit., p. 189.
65. Mukhopadhyaya, P. K., History of science and two metamorphoses of mind, Occasional Paper 9 of the PHISPC.

ACKNOWLEDGEMENT. I thank Dr B. V. Subbarayappa for a critical reading of the manuscript.

B. M. Udgaonkar is in Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mankhurd, Bombay 400 088, India.