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WHY DID SCIENTIFIC RENAISSANCE TAKE PLACE IN EUROPE AND NOT IN INDIA[§]

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Scientific renaissance in medieval Europe and its absence in medieval India can be explained in terms of several causal factors which were positively operative and negatively non-operative in the respective instances. Ancient Indian science had achieved some meritorious successes, but these advantages were squandered through casteism, vainglory and non-appreciation of several factors such as manual labour, mechanization and education at all levels of society. Additionally, India received the Islamic onslaught and civilization in its decadent state when it had little intellectual resource to offer to this sub-continent.

Europe on the other hand, had stressed on the importance of manual efforts, mechanical inventions, early capitalism, questioning and even defying, if necessary, the theological doctrines encroaching on the natural and social sciences, and lastly the infinite zeal to learn from other civilizations.

India had the chance to imbibe the spirit of scientific renaissance in Europe during its Mughal Era, but did not avail of this opportunity. The proposition that 'had the British not come to India', India would have automatically revived its national cohesion and scientific spirit is hardly tenable.

Key words: Scientific Renaissance, Europe, India, Causality, Necessary and Sufficient Factors, Ancient India and Medieval Islamic Science and their Decadence, Casteism, Invasion, Mechanical Inventions, Capitalism, Defiance and Critical Examination of Ancient Theological Doctrines, Criticality, Proof and Experiments, Pre-modern India and the Missed opportunities

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Introduction

India excelled, since the pre-Harappan eras, in the arts of minerals, metals and *rasāyana* or alchemy, till the 18th century, when the British took over and caused the impact of modern science onto this sub-continent. The European science had been hardly superior to the Asian (Indian, Chinese and Arab) sciences till the 12th century, but thereafter it rapidly improved in many areas of human knowledge including minerals, metals and chemistry. The European endeavours resulted in the transcendence of mineral processing art to elemental science or the modern chemical science. During the same time (1300-1800 AD), Europe excelled in other scientific and technological fields as well: printing, navigation, astronomy, physics, mechanics, mathematics, biology etc. It was indeed a spectacular phenomenon of scientific renaissance.

The Causality Factors

In the monograph on history, science and society in the Indian context[1], edited by the present author, 20 authors contributed 23 articles to unravel the complexity of the history of Indian science. the present author in particular, attempted[2,3] to understand the causality factors: why did scientific renaissance take place in Europe but not in India. Such attempts had been made earlier by Virendra Singh[4], Satpal Sangwan[5] etc. Sivin made an interesting approach[6] to this kind of problem which we would like to pursue in the paper.

It may be presumed that all facts, scientific or historical, are rooted in the principle of causality. E.H. Carr asserted[7] that 'the study of history is a study fo causes' and that a historian's duty is to look for a variety of causes underlying any given event, find their mutual relationships, if any, and arrange them in some kind of order of importance. Causal linkages may be analogous to an electrical circuit, sometimes sequential or in series, sometimes parallel or independent, and very often cyclic, inter-related amongst themselves rather than being independent. S.C. Gulfillan suggested. "the only concept of the history of science that will hold water is one of network of causation, with ideological, technical, social, biological, geographical and accidental factors intermingled and each causing the other". (quoted by Sangwan[5]). The digital and analogue computer approach may indeed unravel the mysteries of scientific and historical 'causes'.

Following the jargon of mathematics, we may label some causes or factors as 'necessary'. These necessary or external socio-political conditions have to be

fulfilled if a particular historical event such as a scientific discovery or progress has to take place. However, the 'necessary' factors alone do not ensure that the event would indeed occur, for which 'sufficient' factors or conditions must be fulfilled. These sufficient conditions are often internal and individual, the glory of human individual or genius, which cannot be tailor-made or cloned.

William Whewell, Master of Trinity College, published in 1837 his three volume essay *History of Inductive Sciences*, in which he suggested that men of genius arise now and then, ask the right sort of questions and suggest the right answers. The occurrence of such men is however a rare thing. Science progresses when these men arise, and languishes or stagnates when they are not there[4]. Similar views on the 'role of genius' have been advocated by Koestler, the author of *The Sleepwalkers*, by Whitehead, by Butterfield, the author of *The Origins of Modern Science*, and many other historians of science.

But it is evident from the historical facts that an isolated single genius like Archimedes or Leonardo Da Vinci could not usher in a scientific revolution which needs a cluster of very talented people working on some problems of common and abiding scientific interest[4]. Lavoisier was the undisputed leader heralding the birth of modern chemical science, but could he excel in a vacuous intellectual atmosphere, a society denuded of his esteemed fellow scientist. Thus, equally important ae the individual geniuses (internal factor) and the society (external factor) which binds and motivates them.

We may not be able to clone the geniuses or even to predict when they would emerge, but we can and should improve the psychological and socio-political factors which would be fully supportive and conducive to the geniuses when they emerge in frontier research[3]. We should be able to engineer speediest developments in science and technology and then utilize them for the whole of mankind.

Sivin's Approach

Let us now revert to the basic question as to why the scientific revolution took place in Europe but not in India. Sivin was asked to tackle a similar question related to the failure of the Chinese civilization, famous for its earlier contributions to science and technology, in engineering a scientific revolution as in Europe. In his celebrated Edward H. Hume Lecture[6] delivered in 1982 at the Yale University, Sivin candidly expressed his frustration in facing the question, which one cannot answer satisfactorily at the present state of our knowledge:

"Why didn't Chinese beat Europeans to the Scientific Revolution? It happens to be one of the few questions that people often ask in public places about why some thing didn't happen in history. It is analogous to the question of why your name did not appear on page 3 of to-day's newspaper. It may be a heuristic question encouraging exploration of a fascinating topic, but belongs to an infinite set of questions which have no direct answers. Why something did not happen.

"The (more useful) question that concerns us is: in what circumstances did the scientific revolution take place in the seventeenth and eighteenth centuries in Western Europe We have made very little progress so far in understanding how Europeans originally came to want modern science and its concomitants…Many of those like myself argue that the privileged position of the West came from a head start in the technological exploitation of nature and the political exploitation of societies not technologically equipped to defend themselves[8]."

Basically, Sivin's approach has been to accord priority to positive questions such as why someone's name has actually appeared on page 3 of to-days newspaper, why and how Europe succeeded in engineering the famous and unique scientific revolution. According to him the negative question, why something did not happen, why China, India etc. did not succeed in the grand task of scientific revolution, are heuristic and difficult to answer.

We do not believe that negative questions are useless or unproductive. Sivin himself did not say so. He merely insisted that he negative questions are better answered in the light of the answers to their positive counterparts. Failure of a student, for example, is better analysed in the light of success stories in the class. We have resolved that 'why' and 'why not'., the success and failure episodes are inseparable parts of a single phenomenon in the history of mankind. India's failure is better understood in the light of Europe's success. India's failure in the medieval period is better understood in the light of the human experiences in the earlier eras: India's success and Europe's failure. Therefore, we have put equal emphasis in our studies on India and Europe.

Attempts to explain scientific revolutions or their absence by mere enumeration of positive and negative factors, abstracted and divorced from contexts, have been severely and rightly criticized by Merton.[9] The contexts are extensively geographical as well as historical, covering very wide space and time-span. Europe and India cannot be considered in isolation, since the continent and the sub-

continent are parts of the same globe and have been immensely influenced by each other. The 17th/18th century scientific and technological renaissance in Europe and its absence in Asia cannot be explained unless we consider the events over at least five centuries (1300-1800 AD) and many more in deep antiquity.

Achievements and Positive Factors in the Ancient Indian Science

The present author has researched and deliberated upon the social factors inherent in the glorious success, as well as some lacunae and failures, in the sciences of ancient India[10-12].

In the Pre-Harappan and Mature Harappan eras, science and technology were developed through indigenous efforts as well as the factor of gradual diffusion of scientific knowledge and technical, know-how from outside the borders through trade contact. Whereas tin, turquoise, lapis lazuli etc. were imported, valuable ivory, carnelian beads, conch-shell products, copper and bronze artifacts, and even cultural concepts, religious and linguistic, were exported to the Western and Central Asia.

The phenomenon of the first urban revolution was the creation of 'exact and predictive sciences' (according to Gordon Childe) such as arithmetic, geometry and astronomy, as well as material technology with considerable sophistication. It appears that a critical measure of trade, cultural and even military contacts with neighbouring states provided vital stimuli to the growth of the Sarasvati-Indus Valley civilization, cities and technologies. Ecological (drought and flood) and military factors (civil war and not the so-called Āryan invasion) must have damaged the Harappan civilization, but its collapse was ultimately due to the loss of short-range and long-range trade links.

The phenomenon of the second urbanization in India (being in the early part of the first millennium BC) was not totally unrelated to the first urbanization, despite the contrary claims of the earlier scholars. The migrants from the Indus and the Sarasvati valleys took long time to acclimatize and rehabilitate themselves in the unfamiliar terrains of hills and forests inhabited by un-friendly people. But they carried with them traditions of pottery, beads of semi-precious stones, artifacts made of copper and its alloys and so on. At Bhagwānpura, we find Harappan pottery and Painted Grey Ware side by side and no broken skull! The fact of continuity of Indian civilization, even through the 'dark period' of second millennium BC cannot be wished away. The excavations at Atranjikhera in western Uttar

Pradesh indicate a continuous transition from 1400 BC: at first the Aharian chalcolithic culture using BRW pottery, copper alloys and even brass, and gradually evolving PGW, glass and (the wonder metal) iron technology. The recovered ecological and political stability once again made the conditions ripe for the emergence of power structure trade contact, new technology and urbanization.

The Ṛgvedic culture in the Sarasvati valley shared many Indus valley traditions such as pottery and bronze-making styles, use of burnt brick, use of seals, binary and decimal digits for standardization, geometry in altar construction, astronomy etc. The Vedic literature amply testified the spirit of enquiry. In the *Nāsadīya Sūkta* (*RV*.10.129), the origin of creation was discussed. The existence in nature of a self-supporting principle was inferred (*RV*.10.129.5).

In the *Atharvaveda* the genesis of conch-shell and pearl were speculated upon (4.10. 1-7). The *Śatapatha Brāhmaṇa* propounded a theory of material evolution (6.1.3 1-5). *Kaṭha Upaniṣad* mentioned atoms and molecules (1.2.20) Uddalaka Aruni a historical figure, who traveled form Taxila to North Bihar, and was mentioned in the *Chāndogya Upaniṣad*, was a materialist or hylozoist, who propounded that everything in the universe including man evolved out of three elements, and even mind is a product of matter. He preceded Theles of Greece by nearly two centuries, and has therefore been claimed by Chattopadhyaya to be the 'first scientist in the world.'[13,14]

The golden intellectual tradition in the Vedic Culture was darkened by the evil of casteism, which we would refer to later.

In the intellectual world there were many dissenters to the Vedic culture. Apart from Gautama Buddha (563-483BC), the Jainas, Ājīvikās and the materialists such as the Cārvākas or Lokāyatas protested against the Vedic ritualism and theological fundamentalism. The intellectual ferment resulted in speculative philosophy and logic.

Pāṇini (middle of the 5th century BC) not only elevated his work of grammar to the level of a science of languages but also deliberated on several scientific terms. *Padārtha* (*Aṣṭādhyāyī* 1.4.96) came to mean a well-defined material, and *sattva* meant the metallic essence (1.4.57). *Pramāṇa* indicated measuring standard, then authority and lastly scientific or logical proof (3.4.51). Pānini honoured the tradition of searching for truth by explaining that *upajñā* meant discovery of a new knowledge, not handed down by tradition. This new knowledge was supposed to give rise to a new enterprise or application, that is

upakrama (2.4.21; 4.3.115 and 6.2.14). Thus Pāṇini laid the philosophical foundation of science and technology.

While accepting the roles in society of technology, economics and religion (Vedic), Kauṭilya (fourth century BC) laid maximum stress on *ānvīkṣiki* or the critically investigative philosophy. The obscurant force of ritualism and priestcraft tried its best to subdue the materialist tradition of Lokāyata but the scientific spirit could not be exterminated.

The medical tradition of Caraka involved clinical observation, diagnosis and cure. This was initiated by Ātreya Punarvasu and Agniveśa at taxila, and the tradition persisted for centuries. Under Suśruta's care surgical instruments were invented, and in the post-Christian era, Nāgārjuna and others conducted alchemical experiments.

Thus, ancient India excelled in a large number of scientific and technological disciplines: arithmetic, geometry, trigonometry, astronomy, algebra, linguistics, chemistry, metallurgy, biology and so on.

The gupta period was the second golden age in ancient India after the Mauryas. Although it spanned nearly one and half century (Chandragupta I's ascension on the throne 320 AD and the end of Skandagupta's reign 467 AD), the kingdom was not as widespread as the Maurya empire. The first seventy years of the reign were spent in fighting with the Scythians (who were finally defeated by Chandragupta II in 388 AD), and the empire ultimately collapsed with the second Huna invasion in 495 AD.

The fourth to fifth centuries AD witnessed the compilation of the encyclopedic works on materials, metals, minerals, gems, textiles and other industrial products. The texts such as *Angavijja*, *Amarakośa*, *Bṛhatsaṃhitā* of Varāhamihira, the various *Ratnaśāstra* texts, etc. were compiled during this period, bearing witness to the prolific diversification of the crafts of the crafts and trade.

Much of the glory of the material cultures during the Maurya, Śātavāhana and the Gupta eras were due to the Graeco-Roman contacts which not only promoted trades and crafts but also enlightened the Indians through inflow of novel and at times scientific ideas. The Sanskrit words *kastira* (tin) and *arakuṭa* (brass) were derived from the Greek cassiteros and oreichalkos respectively. The Persians, Greeks and Romans were the first patrons of Indian iron, steel and brass. There was considerable Greek influence bearing upon the post-Christian era sculpture (on stones and metals) in India.

Yavaneśvara was a contemporary of the Scythian king Rudradaman. His Greek book (150 AD), translated into Sanskrit one century later, discussed various *dhātus*: *dhāmya* (bright) and *adhāmya* (dull). Significantly, the first category included steel, and the second *rasaka* or zinc ore, both of contemporary importance. While postulating the geological theory of the origin of gems (*Bṛhatsaṃhitā* or *BS*. 08.3) and demolishing the age-old Rāhu theory eclipses (*BS*.5.13), Varāhamihira acknowledged the wisdom of Graeco-Roman scholars (*BS*.2.32). Many Greek words were assimilated in the Indian texts on mathematics and astronomy. At the same time, Āryabhaṭa showed his original mathematical prowess a millennium before Newton.

The transition between the 'ancient' and the 'medieval' period has been tentatively placed at 1200 AD. The choice is however rather arbitrary; it has been suggested that one could think of medieval decadence having set in with the collapse of the Gupta empire (467 AD), death of Harṣavardhana (647 AD), the Muslim conquest of part of India (10th century) or its consolidation (1200 AD). While R.S. Sharma prefers the earlier dates, H.C. Ray insists on the later dates.

As a matter of fact, there is no single sharp transition date. The forge-welding tradition, exemplified in the Delhi Iron Pillar (fourth century AD Gupta Period), was continued for many centuries afterwards-vide the Orissa Iron beams at Bhuvaneswar (7th century), Konarak (9th century), the famous Dhar (near Indore) pillar of King Bhoja (1000-1055AD), 'the largest in the ancient world' etc. The brass technology of ancient India was invigorated in the 13th century Zawar (near Udaipur, Rajasthan). The bronze technologies of Bengal and Bihar (8th-9th centuries) and of Tamilnadu (9th-13th centuries) were linked with the supply of tin and gold from, and extensive trade contacts with South-East Asia. The glory of the Indian mathematics and astronomy, hailed by Severus Sebokht (662 AD), had been initiated by Āryabhaṭa (born 476 AD) and Brahmagupta (598 AD) and later sustained by Lalla (748 AD), Mañjulā (932 AD), Śrīdhara (1020 AD), Bhāskarācārya (born 1114 AD) etc. In other words, the flame of ancient Indian science and technology never died, it went on flickering.

The Decadence of the Hindu Science

As we have mentioned earlier, the positive sciences of the Hindus were thwarted to some extent by the retrograde institution of caste. Originally, there was the division of labour but no hereditary caste (*RV*.9.112.3)

Gradually, separation was introduced in the society by the dominating priestcraft, and this caused degeneration and the rise of *varṇāśrama* or hereditary caste (*RV*. X.90.12). The white *Yajurveda* referred to the *vaidyas* (medical men) in derogatory terms.

At a time when the potters had developed beautiful PGW and NBPW potteries, the *Maitrāyanī Saṃhitā* prescribed that the ritual milking pot should be prepared by one belonging to any of the first three social orders, but not by a potter to the lowermost caste! The *Śatapatha Brāhmaṇa* categorized people as well as metals in caste denominations (13.2.2.16-19), 13.3.4.5): the upper caste gold was meant for kings and Brāhmins whereas the lower caste iron was meant for ordinary people. This trend of catergorising even metals and other materials under the four 'castes' persisted for centuries. The Gupta era *Amarakośa* listed the metallurgical equipments under *śūdravarga*! Professional guilds degenerated into sub-castes, the social barriers of which rarely permitted the necessary exchange of technical information amongst themselves or with the Brāhmin scholars who would keep the Vedas out of bounds from the lower caste artisans. It has been well-said that 'the evils that caste system engendered cannot be over-estimated.'

Gradually some decadence had set in, and although Sharma puts the 'transition' at the demise of the Gupta empire, many symptoms of decay had been evident much earlier. The Śuṅgas and the Sātavāhanas had introduced the system of land grants to the Brāhmanic and the Buddhist world respectively. This practice was continued during the Gupta era. The late Gupta kings and the Vākāṭaka kings (5th Century AD) not only gave away whole villages to the brāhmans, but also surrendered the rights for administration and underground mineral resources. The feudal land-lords indulged in lease cultivation through landless exploited labourers. Often the cultivable lands were further fragmented and there was no effort for more efficient large-scale or collective farming. With the irresponsible middlemen in between, the state loosened its control over the masses and their welfare. The new feudal class could exploit the masses but had no responsibility to better their lot. Unlike Europe, India did not have sharply defined class of feudal barons organized in councils and assemblies[15].

Ever since the Manu Saṃhitā period of the Śuṅga dynasty, the caste system became gradually more repressive. After the third century AD, the land grant system further accentuated it. The Brāhman landowners inducted tribals and *śūdras* for tilling and thus created deep tension with the *vaiśya* community who

had the monopoly of agriculture during the earlier periods[15]. Many castes and sub-castes were invented.

The insular attitude in India resulted in over-compartmentalisation of technology. The Hindu law-makers distinguished between metal-workers and smelters. Only specific tribes (later equated as castes) like *muṇḍās* practiced iron-making (hence the term *muṇḍaloha*), *bhils* zinc-making, turis gold and diamond-washing, *kānsaris* bell-metal trading and so on. The different castes, practicing different aspects of trade, rarely exchanged information, only which could result in a faster growth of science and technology in India.

Basham has described the post-Gupta era in ancient India as 'the twilight of hindu independence', the history of the centuries after Gupta era being 'a rather drab story of endemic warfare between dynasties'. Sharma describes this age as 'the period of military camps or '*jayaskandhavāras*' with marketisation reaching a low ebb, money-supply dwindling and continuing decay of urbanism and technology[15].

The present author had discussed in details the social factors underlying the decay of ancient S & T, and recorded his major agreements and disagreements [10-12] with Chattopadhyaya's paradigm.[11,13]

Chattopadhyay had shown in his famous book *Lokāyata*, how much theoretical materialism there had been in ancient India, and how it had been systematically obscured and vilified by the theologians.[16] He extended his thesis ably, by explaining what is living and what is dead in Indian philosophy[17], and then making an incisive study on ideology and counter-ideology in the ancient Indian science.[18] P.C. Ray attributed the decline in the scientific spirit in India to the entrenchment of casteism in the society and the stranglehold of the priestcraft and anti-materialist philosophy.[19] We have supported this analysis[10-12]

The present author has endorsed Chattopadhyaya's basic thesis of a dialectical struggle between reason and anti-reason in the Indian thought-world with the rider that this struggle existed in all civilizations, and exists even to-day down to the psychological plane of an individual.[11] Thus calted the diameter of he moon in order to explain its eclipsing the sun, and yet gave tacit approval to the Rāhu theory of eclipse. The *Rasa-Ratna-Samuccaya*, a 13th century AD text, strongly endorsed accurate and careful experimentation, and yet strangely endorsed the view that free diffusion of knowledge was not desirable.

We disagreed [11] with Chattopadhyaya's paradigm [13] when he grossly undervalued the Vedic tradition, subscribing to the myth of Āryan intrusion into India, and suggesting that the credit for early science in India goes to the Indus valley people rather than the Ṛgvedic culture-as if the two were not contemporaneous and not part of a wider civilization. In the two volumes of his work [13,14], his consistent thread of argument has been that all the reason in ancient Indian science was borrowed or derived from non-Vedic sources and the Vedic literature had the monopoly of anti-reason. His Marxist protest against the extreme and oft-uttered expression… 'the Vedas contain all knowledge' was carried to the opposite extreme position and is untenable. Even Joseph Needham cautioned in his Foreword to the book by Chattopadhyaya [13] that one 'must beware of pouring out the baby with the bath-water'.

To counter the biased and one-sided view of Chattopadhyaya, we may cite the balanced opinions of Mahadevan [20] and Pande[21]. Mahadevan asserted that the orthodox systems such as *Nyāya-Vaiśesika, Sāṅkhya-Yoga* did make use of scientific concepts without defying the Vedic tenets. Caraka accepted scientific methodology (including observation and logic) as well as *Iśvara* (God); so did Newton. The Vedic orthodoxy might have extinguished *Lokāyata* literature (as alleged by Chattopadhyaya) but was not that powerful to curb the two others, almost equally old, heterodox anti-Vedic systems: Buddhism and Jainism. How could the decline of Indian science be attributed to the Vedic orthodoxy alone? Pande conclude that none of the Indian Philosophies-orthodox or heterodox-were anti-reason or anti-science. Of course, the intellectual philosophers (even the proponents of *Lokāyata*) contributed more to speculation rather than mechanical inventions and technology. Yet there was no obstacle against the phenomenal growth of medicine, metallurgy, mathematics and astronomy in ancient India.

An even more balanced picture regarding Indian science in the pre-Muslim period has been presented by Abu Rehan Al-Beruni (973-1048 AD) (henceforth mentioned as Alberuni), the brilliant Muslim scholar of the eleventh century.[22] Alberuni was a versatile scholar of the Persian, Arabic and Sanskrit literatures, author of 27 books on Indian atrocious invasion of India, without morally supporting it. His sole purpose was to deeply study the Indian civilization and sciences.

Alberuni's Observations

Writing in 1030 AD, Alberuni sharply criticized the contemporary state of Indian science, but deeply appreciated the earlier traditions of science of India.

Sachau wrote: "Alberuni felt a strong inclination towards Indian philosophy. He seems to have revelled in the pure theories of the *Bhāgavadgīt*ā"[22] Alberuni was full of praise for the mathematical and scientific abilities of the Hindu scholars, such as Āryabhaṭa, Brahmagupta etc., some of whom were 'enjoying the help of God' or 'inspired by God'.[22] The Gupta era intellectuals like Varāhamihira were broad-minded and deeply respected the compatriot Greek scientists.

However, the intellectual climate in India had deteriorated in a few centuries for various reasons, while the Arab/Muslim science was ascendant. We may record some of the caustic comments on the contemporary Hindu Science made by Alberuni:

"Folly is an illness for which there is no medicine, and the Hindus believe that there is no country but theirs, no nation like theirs, no king like theirs, no religion like theirs, no science like theirs. They are haughty, foolishly vain, self-conceited, and stolid. They are by nature niggardly in communicating that which they know, and they take the greatest possible care to withhold it from men of another caste among their own people, still much more, of course, from any foreigner. According to their belief, there is no other country on earth but theirs, no other race 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 Khurāsān and Persia, they will think you to be both an ignoramus and liar. If they traveled and mixed with other nations, they would soon change their mind, for their ancestors were not as narrow-minded as the present generation is. One of their scholars, Varāhamihira, in a passage where he calls on the people to honour the Brāhmans, says: "The Greeks, though impure, must be honoured, since they were trained in science, and therein excelled others. What, then, are we to say of a Brāhman, if he combines with his purity the height of science?" In former times, the Hindus used to acknowledge that the progress of science due to the Greeks is much more important than that which is due to themselves."[23]

Alberuni had some respect for Varāhamihira, but did not altogether spare him, 'a self-lauding man giving himself airs as doing justice to others', who was equivocal, strangely giving equal emphasis to the scientifically correct theories a swell as the mythological beliefs related to the eclipses, the origin of gems, minerals and metals etc.

Alberuni was even more severe on Brahmagupta, who in his words 'is (was) certainly the most distinguished of their (the Indian) astronomers, and (yet) shirks the truth and lends his support to imposture'. In the first chapter of his *Brāhma-sphuṭa-siddhānta* (628 AD), Brahmagupta had criticized Śrīṣena, Āryabhaṭa and Viṣṇucandra 'for maintaining that the eclipse is not caused by the Rāhu's Head, but by the moon and the shadow of the earth'; this was in direct opposition to the Vedas and the *Manusaṃhitā*.

Alberuni was aghast at this intellectual dishonesty of one of the greatest astronomers that India had produced, who was adored by the Arab intellectuals, and whose algebra had been learnt and propagated to the Europeans by the Muslim scholars in Spain. Alberuni sternly rebuked the spirit of Brahmagupta:

"If people must under circumstances give up opposing the religious codes (as seems to be your case), why then do you order people to be pious if you forget to be so yourself? Why do you, after having spoken such words, then begin to calculate the diameter of the moon in order to explain her eclipsing the sun, and the diameter or the shadow of the earth in order to explain its eclipsing the moon? Why do you compute both eclipses in agreement with the theory of those heretics, and not according to the views of those with whom you think it proper to agree?[24]

Brahmagupta certainly mixed up true science with myths and superstitions, in the words of Alberuni, who continued his trenchant analysis of the miserable state of the philosophy of Hindu science during his era:

"The Greeks had philosophers who, living in their country, discovered and worked out for them the elements science, not of popular superstition, for it is the object of the upper classes to be guided by the results of science, whilst the common crowd will always be inclined to plunge into wrong-headed wrangling, as long as they are not kept down by fear of punishment. Think of Socrates when he opposed the crowd of his nation as to their idolatry and did not want to call the stars gods! At once eleven of the twelve judges of the Athenians agreed on a sentence of death, and Socrates died faithful to the truth.

"The Hindus had no men of this stamp both capable and willing to bring sciences to a classical perfection. Therefore 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 the 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."[25]

Alberuni was probably the first to notice the struggle between ideology and counter-ideology in the ancient Indian science, a topic on which Debiprasad Chattopahyaya has made an incisive study.[18] We have indicated earlier in this chapter our agreements and disagreements with Chattopadhyaya's views.[11]

The ancient Hindu thought-world was profoundly and adversely influenced by *Manusaṃhitā* (2.11) which declared the scholars using reason and logic to criticize the Vedic tenets as *hetuvādī*, heretics and atheists. Ancient science was appreciated, but could not be allowed to challenge the theological obscuriant tenets. Many centuries later, Galileo was told by papacy that he was free to pursue his celestial mechanics but not to question the statements in Bible!

The greatness of Alberuni lay in the fact that he had criticized the orthodoxy of Muslim traditions as well. The *Ulemā* (theologians) of his time equated the study of science with heresy. He condemned them categorically: "The extremist among them would stamp the sciences as atheistic, and could proclaim that they lead people astray, in order to make ignoramuses, like him, hate the sciences. For this will help him to conceal his ignorance, and to open the door for the complete destruction both of sciences and the scientists"[26]

Alberuni was cognizant of the fact that despite its ascendancy, the Islamic or Muslim science of his era contained the seeds of decline which we would discuss shortly. Moreover, the rise of Islam and the invasions, according to him, had already damaged the Zoroastrian civilization in Persia and the Buddhist civilization in the Western and Central Asia, and were about to produce catastrophic effects on the Hindu science and civilization in India. Alberuni wrote:

"No Muslim conqueror had passed beyond the frontier of Kābul and the river Sindh until the days of the Turks, when they seized the power in Ghazna under the Sāmānī dynasty and the supreme power fell to the lot of Nāsir-addaula Sabuktagin. This prince chose the holy was as his calling, and therefore called

himself Al-ghaxi (i.e. warring on the road of Allah.) In the interest of his successors he constructed, in order to weaken the Indian frontier, those roads on which afterwards his son Yamin-addaula Mahmūd marched into India during a period of thirty years and more.

"God be merciful to both father and son! Mahmūd 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 the people. Their scattered remains cherish, of course, the most inveterate aversion towards all Muslims. This is the reason, too, why Hindu sciences have retired far away from those parts fo the country conquered by us, and have fled to places which our hand cannot yet reach, to Kashmir, Benares, and other places. And there the antagonism between them and all foreigners receives more and more nourishment both from political and religious sources."[27]

We have quoted Alberuni in detail because he has been one of the very few critical and impartial historian-scientists who commented on (a) the glory of ancient Hindu Science (b) its sad decline, a part of the global decline in the scientific tradition, not excluding the Islamic and lastly (c) the pernicious influence of the Islamic invasions (ironically 'Islam' means peace) on the science and civilization in the Indian sub-continent. Sachau has penned a rare tribute to Alberuni which we quote:

"Alberuni, the author of *Kitab-al-Hind*, has nothing in common with the Muhammadan Ghāzī who wanted to convert the Hindus or to kill them, and his book scarcely reminds the reader of the incessant war between Islam and India, during which it had been prepared, and by which the possibility of writing such a book had first been given. It is like a magic island of quiet, impartial research in the midst of a world of clashing swords, burning towns, and plundered temples."[28]

The barbarity of the early Muslim invaders in India shocked even the Arab and Persian intellectuals. Shaikh Bu Ali Sina, also known as Ibn Sina, a respected physician and biologist, refused to come to India with Mahmūd, whose plunder and loot, he felt, was destroying Indian science. These facts were ignored by Debiprasad Chattopadhyaya[13,14] while commenting on the decline of the Indian science, even though his predecessor Pramatha Nath Bose had deliberated on the Muslim as well as the British colonialism affecting the scientific performance of the Indians, and the Hindus in particular.[29]

In his otherwise masterly treatments on history of science and technology in ancient India, Chattopadhyaya often jumped onto the modern period castigating 'Hindu revivalism', and the phoney proponents of Vedic science in the modern era-entirely by-passing the medieval period, the millennium of Muslim invasion, colonialism and fundamentalism.[13]

For the sake of historical accuracy and authenticity, it is necessary to combat pseudo-secularism and show that Hindu obscurantism, Muslim fanaticism and the British colonialism have all contributed towards the decline of Indian science, and that the centuries of *jihad* against those who did not have dogmatic faith in the tenets of the *Quran,* hurt not only Hindu science and civilization itself.

The Decline of Islam Influencing Subsequent Events

Although the Islamic civilization was born outside India, its decline seriously affected India, since the Muslim powers invaded and ruled over the sub-continent for centuries. For each of the civilizations based on great religions, some progress was achieved on the basis of unity of those who practiced it. But this advantage was often frittered away on account of the losses of mutual tolerance, liberalism, pluralism, sense of social justice and rational scientific thinking, causing damage to the external world as well as the internal milieu.

The Prophet Mohammad died in 632 AD and within a century after this date, the banner of Islam was carried across three continents, the Central and Western Asia, North Africa and Europe. The province of Sind in India as well as part of Spain and France in Europe were occupied by the Muslim forces in 712 AD. Since the Abbasid Caliphate rule in 750 AD, the Islamic civilizational centers around Baghdad, Damascus and Cordoba (in Spain) came in contact with Greek, Alexandrian, Buddhist and Hindu scholars and administrators, and promoted the cultures of liberalism and science. As a matter of fact, for three to four centuries, the Arab science synthesized the Hindu, the Greek and the Chinese contributions and remained in the fore-front; it produced great scholars such as Jabir Ibn Haiyan al-Sufi (722-803 A.D.), Al Khwarizmi (800-850), Al Kindi (800-873), Al Razi (850-923), Alberuni (973-1054), Ibn Sina (980-1037) and later Ibn Rushd (1126-1198 AD). The last two were known as Avicenna and Averroes in Europe and widely revered for centuries.

The Europeans accepted Muslim science but not the domination of Islam. The Crusade Wars started in 1095 AD and in 1236 the Muslim Cordoba in Spain

had fallen to the Christians. But in 1245 AD Robert of Chester translated Al Khwarizmi's Algebra which itself was derived from Brahmagupta's Sanskrit work. At that time Roger Bacon had Muslim scholars in Spain as his teachers and greatly appreciated the Chinese discovery of gunpowder. Around the same era, the Hindu India had been denied of political independence as well as the beneficial influence of Islamic Spain. Islam itself had turned its back on science after Ibn Rushd's death in 1198 AD.

Why did Islam turn its back on science? Its honeymoon turned sour after Harun-al-Rashid's reign in Baghdad, when the Buddhist Barmecides or Baramukhis (*Pramukhs*), advisers from *Nava Bihar* monastery, were banished and there was the onslaught on reason by the Sunni theologians, who could not tolerate any pluralistic view. Al Mutawakkil (847-861 AD) reversed Al Mamun's liberalism to the non-Muslims.

The *Mu'tazilites* and the Aristotelian philosophers believed that justice and goodness have a real existence, independent of anyone's will or the injunctions in a sacred book such as *Qur'an* or *Koran*, which was not eternal but written by ordinary human beings. They also believed in unity of mankind and one God, who could be followed by all people, even those without any scripture or prophet. The community of 'Sincere Brethren' also believed in science and liberalism. These dissenters were declared as heretics and persecuted by the Sunni theologians. A similar group of liberal scientists came up in North Africa and Spain during the 12th Century; they were known as Al-Mohedi or *Muwaḥḥids*, Unitarians or monotheists, believing in one God and unity of mankind. Raja Rammohan Roy had great respect for the *Mutazilites* and *Muwaḥḥids*; as a matter of fact he started his career by writing a book in Persian (1804) entitled *Tuhfat-ul-Muwaḥḥidin* a Tribute to the Unitarians, which was translated into English in 1884 and into Bengali in 1949. The great saint Kabir claimed himself to be a Unitarian, but Akhbar-al-Akhyar, the oft-cited biographical dictionary of Indian Sufi's queried 'Can a *Muwaḥḥid* like Kabir be a Muslim?'[30]

Like Hinduism, Islam has never been monolithic politically. The conquered nations maintained their identities and never accepted Arabic domination and monolithic interpretation of the Koran. The Shia-Sunni rivalry and the Arabic-Persian conflicts have persisted till the present era. Right from the time of the Prophet, there have been parallel and antagonistic streams in the Islamic tradition, of liberalism, syncretism, pluralism on the one hand and conservatism dogmatism

and intolerance on the other. Even Sufism, a brilliant mystic tradition, has not been monolithic; it got embroiled in the dialectical struggle of politics and occasionally sided with one or the other antagonistic streams.[30]

Ibn Sina (980-1037), Al Ghazzali (1058-1111), Ibn Rushd (1126-1198) and Nasir al-Din Tusi (1201-1274), coming one after another in the pages of history, played crucial roles in the Islamic dialectical struggle involving scientific reason and anti-reason. Of them, Ibn Sina was the first and foremost [31-33], who was adored by Roger Bacon and many other progressive minded Europeans for centuries.

A gifted free-thinker, much in the line of Āryabhaṭa to Galileo, Ibn Sina was persecuted in his own time. He believed in the eternity of Nature, the natural laws in geological and biological evolutions, and the principle of causality operating in all natural events and sciences. According to his peripatetic or Aristotelian views, the activity of God is confined to the single creation of the universal intellect, which contradicts the Islamic theological concept of God's continuous and permanent interference with the world's affairs.

Mohammad al-Ghazzali, the most outstanding theorist of *kalām* or scriptural law and a *mutakallimūn* (expert in scholastic theory), condemned the *falāsifa* (rationalists and scientists, the philosophers). He felt that philosophers like Iban sina who deprived God of his qualities of omnipotence, free-will creation, omnipresence and omniscience, had brought Him closer to the state of a dead man who knows nothing of what happens in the world.[34] Ghazali's *Tahāfut-al-Falāsifa* (The Destruction of the Philosophers) was pitted against the rational scientific philosophy of Ibn Sina, and Ghazali's diatribe was supported by the *sūfiyya* or the Sufi's (eclectic mystics) as well.

Ghazali's 'Destruction of Philosophy' was rebutted half a century later by Ibn Rushd in Spain writing on 'Destruction of Destruction' (*Tahāfut-al-Tahāfut*) but the die had been cast. While the Christian Europe continued adoring Ibn Sina, Ibn Rushd and their scientific philosophy, and eventually launched a death-blow to theological obscurantism during Galileo's era, the Islamic world turned its back to the spirit of rationalism and scientific philosophy after the 11th century. For asserting the Vedāntic truth 'Ana'l Haqq' ('I am the Truth'). Al Hallaj was 'whipped, crucified, decapitated and cremated'. Irshad Manji has documented [34b] that 'the trouble with Islam that exists today' started a generation after the demise of the prophet.

The Islamic Decline Affecting Indian Science

The glorious traditions of Muslim science, which flourished in the tenth-twelfth century Spain, benefiting the emerging European science, had little impact on the intellectual climates in Arabia, Persia or India. Irfan Habib has been very candid that the Islamic decline had a negative effect on the Indian science:

"That time (after the death of Ibn Rushd or Averroes AD 1198) science received a setback throughout the Islamic world. There was a heavy onslaught on reason and philosophy in which Ghazali (d. 1111) played an important part. In medieval India, therefore, Islam was received when the scientific tradition in it was in the process of decay. Abul Fazl at the end of the 16th century was to mourn: 'the blowing of the heavy wind of *taqlid* (tradition) and the dimming of the lamp of wisdom. Of old the door of 'how' and 'why' has been closed; and questioning and enquiry have been deemed fruitless and tantamount to paganism'(*Ani-i-Akbari*, Vol II, p.3).

"The Mughal Empire has produced not a single worthwhile text on crafts or agriculture, how many volumes of poetry of histories it might have to its credit.

"The Indian rulers' refusal to respond to western science and thought was thus at par with their indifference to technology. Both added up to an enormous intellectual failure of the ruling class. That failure must always be assigned its due share of responsibility for what did not happen in India: a quickening of technological change even remotely reflecting, if not independently corresponding to, the accelerating progress of Europe".[35]

Irfan Habib mentioned about the 'heavy onslaught on reason and philosophy' which began during the early part of the 11th century, but did not dwell upon the heavier physical onslaught of invasions which had started at the same time. Ibn Sina and Alberuni condemned the barbaric invasions of the Arabs and Turks. The invaders have always done their worst in ruining science throughout the ages. Muhammad Bakhtyar Khalji invaded and sacked the Buddhist monastery of Odantapuri in 1199 AD, burning a great number of books in the libraries. *Tabakāt-i-Nāsirī* narrated that earlier in 1190 AD the universities of Nālandā and Vikramśîlā had been devastated, the Buddhist monks slain and all the books burnt.

Within twenty years, the horrible Buddhist revenge came down upon the Islamic world. Genghis Khan (1162-1227) belonged to the Shamanite (Buddhist)

society of Mongolia, and while invading the Muslim empire of Khwarezm, declared: "Let us ride out against the Islamic people, to gain vengeance". Before destroying the city of Bukhara, he told the Muslims: "I am the punishment of God; if you had not committed great sins, God would not have sent a punishment like me upon you"[36]. In 1258, Baghdad with its libraries and laboratories was totally ruined. 'The formidable combination of nomadic cavalry and siege weaponry had never been before'. The causes of decadence of Hindu science (after 5th century AD) and of Muslim science (after 10 century AD) were remarkably similar: loss of scientific idealism, vainglory, theological obscurantism, fundamentalism, all internal factors, and then the external factor, invasions from outside.

Referring to the medieval age collapse of the Hindu civilization in India, Swami Vivekananda, the great patriot-saint, wrote in one of his epistles (19 November, 1894): "The Hindus had been conquered by the Mohammedans due to the Hindus' ignorance of material civilization, gunpowder and cannon".[37] The patriots like Jawaharlal Nehru tried to 'discover' a secular India. Nehru wrote: "It is wrong and misleading to talk of a Muslim invasion of India or of the Muslim period in India. Islam did not invade India…There was Turkish invasion (Mahmud's was a foreign Turkish invasion), an Afghan invasion, a Turco-Mongol or Moghul invasion etc …The invaders became absorbed into India …India continued to be an independent country".[38] We wish that Nehru could persuade his compatriots like Veer Savarkar and M.A. Jinnah to wear the same spectacle as he did! In his erudite work, Muzaffar Alam has documented that there were persistent attempts to Islamise India, countered by feeble liberalism of two kinds (a) political and (b) spirtual.[30]

The real architect of political liberalism in the Muslim world was Nasīr Al Din Tūsī (1201-1274 AD) who flourished during the violent days of Mongols invading the Muslim world. The Mongols were non-Muslims, and realizing that the conqueror and the conquered may often belong to different religions, Tūsī advocated in his famous Akhlāq-i-Nasīrī (1235-1259 AD) that love and mutual tolerance must be the bedrock of social and political justice. The perfection of man is to be achieved by the admiration and adulation of divinity, but it is impossible to attain that without a peaceful and just social organization. Justice can emerge only from mutual love (*maḥabbat*). 'If love among the people were available, *inṣāf* (justice) would not have been needed'. Muslim and *kāfir* both enjoy divine compassion (*raḥmat-i-Ḥaqq*) in equal measure. 'But the man of faulty politics

resorts to coercion, takes ri'āyā (the defeated) as his slaves, even the women, and becomes himself a slave of greed and wealth'.[39]

The Nasirean ethics of Tūsī deeply influenced the Mongols and the later-day Timurids and Mughals, but did not enter India before Babur, and had little appreciation in India before Akbar and Abul Fazl. What ruled in India for so many centuries between Sultan Mahmud and the last important Mughal, Aurangzeb, were the Sunnite orthodoxy and the feigned political and theological superiority of Islam, a fact which Nehru did not want to 'discover'!

The earliest Indo-Islamic political theory was enunciated outside India in Fakhr-i-Mudabbir's *Ādab al-Harbwa'l Shujā'a* and dedicated to Sultan Iltutmish who reigned in India (1211-36). The finality of the word of Islam was emphasized in that treatise. All other faiths were deemed annulled. One chapter was devoted to the merits of *jihād*, the sacred battle to defeat the infidels for the glory of Islam. Another chapter was devoted to elucidate how the defeated *zimmis* or non-Muslims should be treated; they should be considered as inferior to the Muslims and not given any civil liberty. The Hindus, according to the theologians' *shari'a*, were to be given the option of '*imma'l islam, imma'l quatl'*, i.e. 'either Islam or death'. Iltutmish's response to this demand was evasive; he sought a reprieve, saying: "At the moment, the land has just been conquered, the Hindus here are in such an [overwhelming] number that the Muslims in their midst are like salt [in a dish]. If this injunction is enforced, they may unite and raise a commotion. The disturbance will be widespread, all around; we will be too weak to [suppress it]. However, after some years when in the capital and in the provinces and small towns, the Muslims and their army grow in strength, I shall then give the Hindus the choice of 'Islam or death'"40

At that time, the Muslim invaders were surrounded by a hostile population in India, while the Mongols under Gengiz Khan were tearing apart the fabric of Muslim power outside India. Ziya al-Din Barani (1285-1357 AD), the 14th century historian, whose hero was Mahmud of Ghazni, and who detested the liberal Mutazilites and the philosophers like Ibn Sina, gave an account of Jalal al-Din Khalji's uneasiness in being surrounded by 'enemies of God passing below his place, beating cymbals and blowing conch shells to perform idol worship on the banks of the Jamuna'. Hamadani (died 1384) wrote in his Zakhirāt al Mulūk that Kafirs should not carry weapons and must not build new places for their worship.[30]

Badauni and Sirhindi disliked non-Sunni ideas and the Mughal Liberalism towards the Hindus. Shaikh Ahmad Sirhindi, the famous saint-theologian to the early 17th century, ruefully observed:

"The spread of the illustrious *sharī'a* comes from the efficient care and good administration of the great sulṭāns, which has lately slackened, causing an inevitable weakness in Islam. The infidels of India [thus] fearlessly destroy mosques and build their own places of worship in their stead. In Thanesar in the Krukhet [Kurukshetra] tank there was a mosque and a shrine of a saint. Both have been pulled down by the infidels and in their place they have now built a big temple. Again, the infidels freely observed the rituals of infidelity, while Muslims are unable to execute most Islamic ordinances. On the day of *Ekādashī* when the Hindus abstain from eating and drinking, they see to it that no Muslim bakes or sells bread or any other food in the bazzar. On the contrary, in the blessed month of *Ramazān*, they cook and sell food openly. Due to the weakness of Islam, nobody can stop them from doing this. Alas, a thousand times alas!"[41]

The Muslim historians have themselves described the 'wonderful exploits' in India of the early invaders since Mahmud of Ghazni, the subsequent resistance from the Hindu and Sikh emperors and leaders, and even the retaliatory acts at the grass-root level such as those described by Srihindi. The demolition of the Babri Mosque at Ayodhya during the 1990's had many precedents!

The so-called secular Indian historians have tried their best to ignore the dark side of the medieval period. Nehru was desperately bold in categorically denying that there had been any 'Muslim invasion' in the past or any 'Muslim Period' in Indian history; he wrote such statements in1945 (which we have quoted)[38] and within two years he was confronted with Muslim theocratic India that is Pakistan and even its invasion in Kashmir!

The *Sūfiyya Silsilas* of Spiritual Liberalism

We have mentioned that there had been the dialectical struggle between the Islamic invasion and domination on the one hand and the two feeble trends of liberalism on the other. The political liberalism or the Nasirean ethics of Tūsī reached India much too late during the reign of Akbar. The spiritual liberalism of the Sūfi tradition had reached India much earlier, but had little impact either on Indian power politics or on Indian science.

The Sūfi tradition had been essentially mystic and spiritual with strong earlier inputs from Buddhism, neo-Platonic Hellenism, Vedāntism and Zoroastrianism. This tradition produced many saints outside and within India, and provided spiritual solace to the defeated people clinging to the *bhakti* cult of worship. Some of the early alchemists like Jabir ibn Hayan were Sūfis. In the 10th century, the Sūfis produced the scientific encyclopedia, *Rasail* the *Epistles of Brethren of Purity*, containing treatises on religious as well as natural sciences.[42] However, ever since the days of Al Ghazzali (11th century), the *Sūfiyya* or the Sūfi order (*silsila*) sided with the *Mutakallimun* (The scholastic conservatives) against the *falāsifa* or the scientific philosophers like Ibn Sina, who believed in discovering and using the principles of natural science independent of God's will. Since that time, Sūfism turned its back on Islamic science; thus having entered India, it could enrich only Indian spirituality but not Indian science.

The first Sūfic centers in north India were built in the wake of Ghaznavid rule over Punjab during the 11th/12th centuries.[43] Subsequently, the movement was institutionalized into different *silsilas* (orders) such as Chisti, Qadiri, Naqshbandi, Suhrawardy etc. and confined into their *vilayat* (domain). Thus, the Sufi movement in India was far from being monolithic. Muzaffar Alam has given many examples as to how some of the order and leaders of the movement engaged themselves in Islamization of the sub-continent and collaborating with the conservative ulema and autocratic rulers.[30] The liberal hagiographies of the earlier Sūfi saints were distorted to make them appear as *jihādis* for the Islamic faith and better miracle-mongers than the Hindu *Yogis*. "The Sūfis could not completely free themselves from the hegemony of orthodix, juristic Islam. Sūfism could not extend the circle of Islam to include even the monotheists like Kabir"[44]. The liberal *waḥdat al wujud* cult of 'unity of all beings and faiths' (propagated by Qadiri Sūfis) was opposed by some other groups of Sūfis such as Naqshbandis propagating wahdat al shūhūd (superiority of Islam over other faiths). Aurangzeb supported the orthodox Sūfis and persecuted the liberal Sufis including his elder brother Dara Shikoh.[45]

Thus the Sūfi movement was not monolithic and its liberal component failed to counter the Muslim orthodoxy in promoting Hindu-Muslim unity (Akbar was detested by Badauni and the orthodox Sunnis; Abul Fazl and Dara Shikoh were murdered), in injecting political liberalism.

Now we come to the end of our present discussion and conclude that the decline in Islamic civilization adversely affected Islamic science outside India, and

then Indian science was also affected through invasions, lack of political liberalism and pluralism and the lack of success of the golden Sūfi idealism. We started the previous section with a quotation from Irfan Habib's writings.[35] Some more articles on this topic have been complied and edited by A. Rahman.[46] George Sarton had provided a masterly treatment of the glorious history of Islamic science till the eleventh century.[47]

Rahman does not accept Sarton's remarks about the decadence of Muslim science after the twelfth century and its insignificance after the fourteenth century. But the data compiled by Sarton[47] and even by Rahman himself[48] clearly substantiate Sarton's views. The amount of original scientific literature in Arabic and Persian after fourteenth century is indeed very small. Rahman admits that 'there is some evidence of translation from Sanskrit to Arabic and Persian, and to a *lesser extent* from Arabic and Persian to Sanskrit'.[49] Two parallel cultures thus co-existed in India under considerable strain. We quote Rahman's conclusions in some detail;

"The pluralistic tradition of Hinduism and the pluralistic ethos created by Sufism led to the co-existence of the two streams…It appears that the two different processes remained at work during the period, one towards integration of the two traditions and the other keeping them apart. The counter to the process of integration was led by conservative ulemas who endeavoured to convert India into an Islamic State. They were opposed to the Sūfi pluralistic and liberal tradition.

"The elite failed to diffuse their rationality amongst the people at large. The division between science and technology continued, arts and crafts remaining with the less privileged groups. There was no institutionalization of education, no continuity. Education being organized around scholars, with the death of the Master, the school often dispersed. Frequent changes of dynasties and kings with different approaches to knowledge also came into the way of continuous growth of institutions and accumulation of knowledge around them.

"Despite the general ethos of bilingualism and plurality, all that was achieved was the availability of translations. Despite many books written combining the two traditions, an integrated simple tradition did not develop to create a base for further development of science to a new stage of development or providing a new direction".[49]

Thus, Rahman has been more or less in agreement with what Sarton has pointed out[47] and the phenomenon Irfan Habib has written about regarding 'what

did not happen in India', quoted earlier[35]. This would be clearer as we proceed to summarise our observations on what did happen, and why, in the medieval Europe, namely the unique scientific renaissance. Thereafter we would record our parting observations on the science and technology in the two centuries of the Mughal era (1550-1750 AD).

Scientific Renaissance in Europe and India: Why and Why Not?

In the beginning of this chapter we referred to Sivin's approach and our considered opinion that with regard to a particular phenomenon such as scientific renaissance, the questions as to why somewhere and why not elsewhere, are deeply interrelated. These may be considered together with great profit, and that exercise we intend to undertake now.

The erudite Western scholars have not so far delved deeply into the glory of ancient Indian science and technology and the miserable decline in the medieval era. They have however recorded with remarkable precision (a) the technological superiority of the East over the West throughout the classical period, and during the greater part of the Middle Ages[50], and then (b) since the era of renaissance, the rise of the West[51].

We have argued in the earlier chapters that the 'rise of the West' did not suddenly take place in 1500 AD or during the era of Renaissance. As early as 1200-1500 AD there had been a perceptible trend of rise in the West and gradual decline in the East. Even before 1200 AD, Europe was not inferior, and probably equal or superior to the East at least on two counts: (a) mechanization (b) propensity for acquiring new knowledge from other civilizations.

Ever since the days of Archimedes, the Greco-Roman world learnt the utility of mechanization and actively promoted the subject. As beautifully argued by J.D, Bernal[52], the European advance started with the Roman water-works, water-mills, river-valley agriculture, which not only solved the problem of shortage of labour but also generated surplus of labour out of which cities could be built and craftmen fed. Bernal suspected that professional scientists had a hand in the development of machinery, in the design of gears, screws and pumps. It is true that the medieval adoptions such as horse-collar, stern-post rudder, trip hammer, mechanically driven bellows etc. owed nothing to science. But some of these curiosity inventions or pre-science technologies had led to science itself. In the 12th/13th century, gunpowder and cannon led some European scholars to speculate

on chemical energy and ballistics; later, spectacles and lenses led to telescopy, microscopy, astronomy and biology; compass to the nature of magnetism; compass clock and new astronomy to the new art of navigation which opened up the Pandora's Box, the mysteries of new science and more science. Over so many centuries (500-1500 AD), mechanical curiosity and inventions (pre-science technologies) led to the unique kind of intellectual curiosity that is 'science'.

All these centuries, the East did not pay much attention to the role of mechanization, and emphasized instead on manual labour. The Hindu world despised manual labour and invented the horrible traditions of 'caste'; the lowermost caste had to perform most of the dirty and arduous jobs. The ancient Greek world also had 'slaves'. The Muslim world had a large number of non-Muslim 'zimmis'. The surplus of humiliated labour in the East dimmed the necessity of further inventions and mechanizations. As a contrast, ever since the collapse of the Roman civilization, the Germanic tribes exhibited their love for independence, manual work as in the mines and individual entrepreneurship.

The other area in which Europe excelled, even before 1200 AD, and continued to excel ever since, was in its sincere effort to learn from others. We have amply documented this point. A.R. Hall has candidly remarked:

> "Most civilizations (like the Chinese) have tended to be xenophobic, and to have resisted confession of inferiority in any aspect, technological or otherwise. Europe has readily adopted (in S & T) whatever seemed useful and expedient. The European civilization could not have progressed so rapidly, had it not possessed a remarkable faculty for assimilation: from Islam, from China, and from India. No other civilization seems to have been so widespread in its roots, so eclectic in its borrowings, so ready to embrace the exotic"[53].

The Christian Europe often struggled against, and yet learnt from their adversaries. Roger Bacon, a monk, appreciated *Bible* as well as the knowledge of gunpowder coming from the Mongols. The Hindus of the Ancient India had similar temperament of learning from their adversaries such as the Greeks, the Scythians etc., and that is the reason why their S&T excelled between the Maurya and Gupta eras. Subsequently they developed xenophobia, stopped traveling abroad, particularly after the rise and phenomenal growth of the Islam. The Europeans suffered from the Turks, Constantinople fell in 1453 AD, the last Turkish seize of Vienna occurred as late as 1683, but the Italians, Spanish, the Portuguese and later the Dutch and the British had never stopped their intercourse with the New World, learning from and dominating over it.

Immediately after the fall of Constantinople, the Greek scholars took refuge in Europe triggering new arts and crafts and the sciences, and above all the spirit of Renaissance heralded by Leonardo da Vinci and many others. Everlasting benefit was done through the introduction of printing in Europe. Literacy was spread like wild bonfire. Ordinary people started reading not only *Bible* but also books on mining, assaying and science in their own vernaculars. We have chronicled in our earlier chapters, the glorious era of 'Mineral Processing and Openness of Knowledge' championed by Agricola and Biringuccio which was nearly one century ahead of the age of Kepler and Galileo.

It is true that the Christian Church played a nefarious role at the time of Bruno and Galileo,but it is also true that earlier, for many centuries, it had played a strong unifying role in Europe, particularly during the War of Crusades, and also supporting the university system in the continent. J.D. Bernal recorded very many early universities in Europe, particularly in the southern coasts of Spain, France and Italy, many of them having Muslim and Jewish scholars teaching Hindu mathematics and medicine.

The Buddhist India had similar tradition of universities at Nālandā, Vikramśīlā, Odantapurī etc. but these were destroyed by the Muslim invaders at a time when the Islamic institutions of learning at Spain and Egypt were destroyed by adversaries and the wonderful academic set-up at Baghdad by Mongols. We have specifically mentioned that the wonderful Islamic tradition of scientific philosophy namely *falāsifa* was destroyed by Islam itself (the *fatwā* of Al Ghazzāli) which propounded that *falāsifa* was heretical and anti-God. It is tragic to note that Ibn Sina and Ibn Rushd, the great scientist-philosophers, adored by the Christian Europe for centuries, were vilified by the mullahs of Islam. The damage caused by Al Ghazzāli to the Islamic science could not be matched even by the marauding Mongols. This damage hurt India indirectly; as Abūl Fazl and Irfan Habib have been quoted earlier[35], Islam had lost its scientific vitality when it reached and entrenched itself in India; and at that time, the Hindu science as well as civilization was running hither and thither for cover!

At this stage we may quote the great historian of science, George Sarton, answering the self-raised question:

"How did it come to pass that after having traveled together until the Renaissance, Eastern and Western people separated at that point, the former

standing still or unlearning what they had learnt, the latter proceeding faster and faster along the road of discovery? The explanation of this is very simple. Western and Eastern peoples were subjected to the great scholastic trial (the onslaught of theology). The Western people weathered it, while the Eastern failed. The Western people found the cure, the only cure, the experimental method. The Eastern people did not find it. Why not? To this it is impossible to answer'[54].

Sarton's statements are indeed 'simplistic'. With the huge amount of historical data that he has unearthed, he could have gone much deeper into this problem. It seems that he was in a hurry and found it 'impossible to answer' anything more. The fact is that the East and the West did not 'travel together until the Renaissance'. They had parted company in the intellectual plane much earlier. The death of *falāsifa* or scientific philosophy in Islam had take place in the 12th century itself. Fortunately, Thomas Aquinas (1225-1274 AD) rendered some synthesis of the Catholic Christian doctrine and Aristotelian philosophy, and his view was accepted in the Church. In the Hindu thought-world, the *aparā vidyā* (secular knowledge) had been considered to be inferior to the *parā* (spiritual knowledge). Thanks to Thomas Aquinas, secular knowledge found a place of honour in the church-sponsored universities.

The socio-cultural life in Europe had been of centuries favourably pluralistic with several vital centers of power: the church, the emperors often fighting against each other and yet uniting in the name of the Pope and the Crusade, the princes of the city states, powerful traders and navigators, feudal overlords, early capitalists, fierce independent minded (German) self-entrepreneurs etc. The universities were controlled by multiple leavers and thus enjoyed a modicum of autonomy. The universities had different levels of specialization (in theology, law, biology, medicine, mathematics, astronomy, alchemy etc.) and reputation undergoing wave-like fluctuations. The political situations were definitely turbulent, but the scholars and intellectuals could adapt themselves in difficult conditions by moving from one place to a more favourable place of learning. Such a stimulation pluralistic academic/ intellectual atmosphere did not exist anywhere in the East, certainly not in India, after the 12th century.

The onslaught of theological obscurantism and papal dictatorship continued in Europe over centuries (1200-1500 AD) resulting in many bloody conflicts, and matters came to a head during the 16th/17th centuries[55]. The era of Renaissance brought into Europe many new and inter-connected ideas: anti-Aristotelian views

or new science, anti-papal views or Protestantism, later anti-Biblical views, capitalism etc. None of these could be considered to be the single or prime causative factor in the evolution of subsequent European history, since these were all inter-connected, originating from a common single source, difficult to define, may be historical inevitability, spirit of the times, Zeitgeist, Renaissance, call what you may.

Virendra Singh has cited[56] Zilsel's treatise on early capitalism promoting modern science through the combined efforts of the academies and superior craftmen. The early entrepreneurs insisted on calculation and measurement, quality and quantity of raw materials and output products. Copernicus wrote on the reform of the monetary system.

We have deliberated in our earlier chapters, on the complex relationship between the Renaissance in Europe and the early emergence of capitalism, Protestantism, and modern science heralded by da Vinci, Copernicus, Agricola, Biringuccio etc. It is not necessary to repeat our observations. Suffice it to say as Sivin has mentioned, that the unique phenomenon of scientific renaissance, arising out of a complex set of favourable factors, took place only where and when it did and nowhere else. Sarton having compared the scientific developments in the East and in the West till the era of European renaissance, did not extend his comparative exercise beyond this era, since 'there was no comparison'.

But questions still persist. The Portuguese arrived in the Indian sub-continent before the Mughals did, at a time when Agricola, Paracelsus, Biringuccio, Copernicus etc. were pursuing their illustrious careers; printing had been firmly established in Europe. St. Francis Xavier arrived in Goa, established academic institutions and compiled books in Tamil. Even in the 16th century some European visitor-scientists compiled data on Indian flora and fauna. Several latitudes and longitudes in Indian sites were determined. Indian sky was explored astronomically to discover new stars. Paracelsus received samples of the mysterious Indian metal *yaśada* and proceeded to evaluate the properties of the new metal 'zinc' and its alloys such as high-zinc brass which were being manufactured in India only. Europe kept learning from India (while trying to dominate over it); why did India fail to complement and learn from the golden European renaissance?

There were certain interaction: the medieval *Rasaśāstra* texts referred to *syphilis*, the venereal disease carried by the Portuguese navigators, mercurial remedies (mentioned by Paracelsus as well), *cobcīnī*, opium (*ahiphena*) and

other remedial drugs, the profound use of strong mineral acids, the discovery and first use of which are still shrouded in mystery. Why did the East not learn more from the Western scientific renaissance? Bhattacharya has quoted[57] the tribute of Copernicus (1473-1543) to the Indian numerals, in his words, *indicae numerorum figurae*: "This numerical notation certainly surpasses every other, whether Greek or Latin, in leading itself to computations with exceptional speed". Why did the Indians fail to advance the earlier traditions in mathematics and astronomy initiated by Āryabhaṭa, Brahmagutpa. Ibn Sina, Alberuni etc., now picked up by Copernicus? The Mughals had just entered India. Were the Hindu and Muslim intellects at that time atrophied and moribund?

Sarton assures us that: "The great intellectual division of mankind is not along geographical or racial lines, but between those who understand and practise the experimental method and those who do not understand and who do not practise it"[54] Then he elaborated that whereas Japan was becoming more and more a part of the West or the scientific tradition, some European nations (need not be mentioned by name) were preferring argument to experiment and getting intellectually immobilized. Sarton never typified all civilizations of the East in one category, and never indulged in 'Orientalism' that Edward said referred to. During the 16th century, the nation of Āryabhaṭa, the nation of Ibn Sina were locked in fruitless internecine struggle, in the hopeless process of 'intellectual immobilization'. Four centuries later, they could bounce back and produce scientists of the stature of Jagadis Chandra Bose, C.V. Raman, Abdus Salam and many more.

We have deliberated in detail on the Agricola-Biringuccio era (which preceded that of Galileo and Kepler) vindicating new spirit of enquiry and fearless questioning of the Aristoletian dogmas, critical studies on the mineral world and its processing, the scrutiny of ancient alchemy, scholar-artisan interaction through materials printed (for the first time) in vernacular, the phenomenal openness to knowledge, appreciation of entrepreneurship with manual labour and uninterrupted efforts for inventing newer techniques of mechanization which would save labour and increase productivity, concern for capitalistic growth which would continually lower cost of production, lastly a supreme concern for book-keeping of the quantities, assay of the raw materials and products and the quality of the products. The last topic gave rise to the re-adoption of the Platonic tradition of mathematics, already adored by Copernicus in his astronomy, into the gradually emerging science of elements and compounds.

Biringuccio observed that iron ores yielded a definite range of weight percentage of iron metal, some specific ores (purer) the maximum. This kind of systematic study led to stoichiometry and the idea of chemical composition. Why did the Indian smelters not weigh the raw material and the product and compare the weights? Biringuccio's motto: 'weigh everything and trust nobody' was capitalistic, but it gradually led to modern chemistry. The medieval scientists of Europe were startled to find that the weight of a piece of lead increased by a definite percentage when this was heated in a flame in presence of air. They could not explain it for centuries, since they had the set Aristotelian notion that material when put to fire would lose a part of it (phlogiston) and hence the dubious 'phlogiston' must have negative weight if the quantitative result had to be explained. However, two centuries of persistent alchemical experiments on gases, air water etc. brought them to the eternal truth of modern chemistry. How did the Indian alchemists, the *Rasaśāstra* authors, who studied smelting of metals, fail to report the *quantitative* aspect of their *rasāyana*? Why did not they question the ancient Hindu/Greek postulate that 'earth, water, fire or energy, air and ether are the only elemental substances, and not argue (as Robert Boyle did) that none of these can be extracted even in minuscule quantity from a piece of pure gold? What made them declare in their texts, without citing any experiment or measurement, that air has no weight?

When the Mughals entered India, the knowledge gap between the West and the East was already big, though not unbridgeable (many Europeans were in India before the Mughals), but as time rolled on, the gap became bigger and bigger, and there was no conscious effort to bridge it. In 1560 the Italian physicist Giambattista della Porta (1535-1615) founded the first scientific association, not trusting the church-controlled universities, but this was later closed down by the Inquisition. Giordano Bruno was burnt at the stake in 1600 AD, Galileo's trials and tribulations are too well-known to be recounted.

It was not easy for the European society to establish its tradition of free-thinking and objective science. John Calvin and Martin Luther introduced radical forms of anti-papal Protestantism, and the struggle went on for two centuries through bloody wars. The scientific leadership moved on to the Protestant countries of Germany, Netherland and England. In 1620 the English philosopher Francis Bacon (1561-1626), the founder of the modern scientific method, published his famous treatise, and in 1662 AD, the Royal Society of England established for the

first time the profession of 'scientists' with the motto-*Nullius in Verba*-take nobody's word, see for yourself. Those were the days of the last 'great' Mughals; the Hindus and the Muslims would hardly agree with the motto of the Royal Society, they would not question the words of the *Vedas* and the *Quran*; they would rather cut each others' throats and pave the way for the British invasion and domination. So much for their sense of independent thinking, patriotism and national unity.

For centuries, the Europeans had struggled against foreign invasions in defence of freedom of thought both in the scientific and the religious planes, and lastly for democracy, socio-political justice and decentralization of power centers a la atoms. What has been the Indian tradition in this regard till the downfall of the Mughals?

As early as 1215 AD, the English King John was made to sign the Magna Carta. There were many battles in Europe against the papal armies. In 1642, the British Parliament waged a civil war against the King Charles I who was executed in 1649 AD. Forty years later when Isaac Newton was an established scientist, the English Parliament passed the Bill of Rights, and then during the next year (1690 AD), John Locke (1632-1704) the eminent social philosopher, published his *Essay Concerning Human Understanding*, in which he propounded that the people had inalienable right to defy and overthrow despotic rulers in their land, and restore their own rights of life, liberty and property. Locke's idea inspired Europeans and Americans and even Raja Rammohan Roy in India who opined that the British rule in India was autocratic, but the Muslim rule had been much worse. Raja Rammohan had high regard for Francis Bacon and Johan Locke, and hoped that their scientific and social philosophy and the newly emerging modern science,spread through English education, would rejuvenate India while the struggle for full political independence would go on inexorably towards success. His vision and optimism have not been misplaced.

Indian S&T During the Mughal Era (1550-1750 AD)

Abdur Rahman objected to use of the word 'decline' in the context of science and technology in medieval India, since there has never been a decrease in the knowledge-content accumulated over the ages, but our use of the term denotes a decrease in the rate of knowledge-accumulation or scientific improvement in medieval India specially in comparison with what was happening in Europe.

India was still good in certain areas of pre-modern S&T related to minerals and metals[58]. It is also known that the 18th century India was the best in the metallurgies related to zinc, high-zinc brass bidri, high-carbon crucible steel wootz etc. But these were exceptions, and even on those items, the Europeans were trying to understand the basic principles whereas we were utterly empirical and falling behind in the race for basic sciences and scientific renaissance.

Dharampal has listed some 18th century accounts related to Indian S&T: in the areas of astronomy, mathematics, medicine, surgery, metallurgy, ice manufacture, mortar making, advanced agricultural practices[59]. It would be useful to understand, as Dharampal suggests, how pre-modern S&T functioned in India before the European dominance. But we do not agree with him for several reasons, when he writes that 'unthinking transplanting of European S&T in India have resulted in retarding and blunting of indigenous innovation and creativity'. Firstly, the indigenous creativity' had been retarded in India long ago, long before the Europeans came to India, and the reasons thereof Dharampal did not care to investigate. Secondly, there was little indigenous innovation, or adaptation of the available European S&T. As a matter of fact during 1498-1707 AD, as Qaisar has pointed out[60], the Indian response to European technology and culture (including basic sciences) was casual, apathetic and very poor. Thirdly and lastly, some thinking transplanting in India of the basic culture of scientific renaissance had to take place some day, since technology may be regional, but the basic sciences are universal. As Needham has pointed out, modern science ceased to be European in character after Isaac Newton, it became global. India got back its own mathematics (of Āryabhaṭa) through Newton, got back its own chemistry (of Nāgārjuna) through Lavoisier. Fortunately, Raja Rammohan Roy captured and articulated the new spirit of the age which was misunderstood and misinterpreted by Dharampal.

As Irfan Habib has documented[61,62], India did have some traditions in technology and equipment-making over the ages. Rotary quern, oil mill etc. were probably Hellenistic contributions. India was probably the earliest user of the *noria* type water-wheel with containers fixed to the rim of the wheel. But the earliest explicit description of the gearing mechanism of the 'Persian wheel' or geared *sāqiya* is from the pen of Babur (1526 AD). The crank and the cranked well-hoist probably came from China after 13th century. India was the origin of scotch bow or cotton carder's bow whereas spinning wheel originated in China

and its knowledge diffused first to the Islamic world, and then to Europe and India. The Shaikhan Dheri (Pakistan) Gandhara stills (150 BC to 150 AD) were essentially retorts and the earliest distillation stills. We have mentioned that India had been the pioneer in zinc distillation technology.

But these are only few examples and do not negate the general phenomenon of decline and stagnation of Indian S&T during the medieval era. The reputed historian Tapan Raychaudhuri could not defend the lackluster achievement of Mughal India.

"Mughal India had little curiosity about the laws of Nature; neither the elite nor the mass of producers manifested any curiosity, utilitarian or otherwise, about things mechanical. The marvels of Mughal architecture were achieved without the aid of wheelbarrows…Both early modern Europe and medieval China were ahead of mid-eighteenth century India in such crucial fields of technology as the use of wind and water power, cast iron technology, paper and printing, nautical instruments, and basic tools and precision instruments. The pattern in India was not one of total stagnation, but rather of a general indifference to labour-saving devices"[63,64].

Irfan Habib tried to delve deeper into this phenomenon:

> "There was an inherent weakness in both civilizations, Islamic and Indian, viz, the absence of any scientific observation, systematization and communication of technological principles followed in the crafts. This is in contrast to what one begins to notice in the West European civilization from Agricloa (early 16th century) onwards"[65].

We have surveyed the European phenomenon of pre-science technology leading to curiosity driven basic science and then to scientific technology (scientific renaissance 1500-1800 AD) in great details. This entire renaissance was missed in India which did not know (during 1500-1700 AD) how to positively respond to what had happened and what was happening in Europe!

In his detailed survey, Qaisar failed to observe any single pattern of Indian response to the European commodities[60]. For example, there was ample interest in artillery items, small and big cannons, shipbuilding, iron nail. The Mughals often bought finished items rather than manufacturing them, and relied upon European technicians for operating or manoeuvering them. The response to clock and watch was negative. Regarding looking glass, lens, pump, pistol, grenade etc., the response for use was somewhat positive but the interest for manufacture was negative. The interest for the use of paper and printing press was strangely lukewarm.

Qaisar submits that there was no 'built-in resistance' to the adoption of European technology, and yet no positive inclination for it either. He rejected several 'cliché' explanations for negative response but failed to provide better reasons for this strange phenomenon. The negative response to printing technology was astounding, and Qaisar admitted: "We are hard put to it to explain the indifference"(p. 134).

From Babur to Aurangzeb

Ever since Babur invaded India in 1526 AD, artillery and gun founding started in the sub-continent. Many technicians came from Turkey and Persia to boost gunpowder and cannon technology. Amir Fathullah, a reputed mechanical inventor came from Persia and served Akbar's founding establishment[66] during 1584-1590 AD. New types of portable iron guns, matchlocks and *banduks* were made. A mechanically driven wheel was invented by the motion of which 16 gun-barrels could be cleaned in a very short time. Gun barrel was made up of perforated discs of wrought iron joined together by forge welding. The expertise in forging techniques diluted the need for casting technology; the Mughal India did not care to learn cast iron technology from the Chinese, the Turks or the Europeans. For Akbar the Great, the enemies were not the Europeans but the people of Mewar, Rana Pratap who would not part with the secret knowledge of zinc distillation technology unique in the whole world.

Akbar and Jahangir were aware of accurate time-measurements by clocks and watches and map-making by careful measurements of latitudes and longitudes; in these topics they were hardly interested. Many of these devices to them were curiosity items with little utilization value. Shah Jahan destroyed one city clock established by the Jesuits in Agra since the bells were too loud for the whole city! Mulla Mahmud Jaunpuri (died 1652 AD) was an astronomer who wanted to build an observatory but was prevented to do so by Shah Jahan's executives. Danishmand Khan, another unique scholar from Persia (died August 1670), had Francois Bernier as his assistant translating for him the scientific works of Descartes, Gassendi, William Harvey etc. Later, Danishmand was criticized for his devotion to European science and *falāsifa*[33]!

Akbar had been almost an illiterate, but Aurangzeb woke up to the awareness of the hopeless education that princes of his generation had received. He chastised his erstwhile teacher Mulla Salih: "Mullaji, did you tell me about the

monarchies of the world, the Turks, the valour and ingenuity of the European Franks, who with small means met and repelled the forces of the powerful Ottomans? Would it not have been better to teach me in my mother-tongue what you taught me in Arabic?"[67] The disciple went on: "Did you inform me that one day I should be forced to take the field, sword in hand against my brothers? Did you teach me the rules for equal distribution of justice, the way of capturing a people's love"[67,68]

We pity the erstwhile teacher in Aurangzeb's court. He had merely transmitted to his disciple the Islamic ignorance about the rest of the world and the Arabic Sunni hatred for science liberalism and all non-Muslim people like Hindus and Hindu-lovers such as Akbar, Abul Fazl, Aurangzeb's elder brother Dara Shiko, the sufi saints, many of then murdered. There was little provision in that kind of education for teaching 'equal distribution of justice, the way of capturing a people's love'! Jaggi has provided an account of the educational atmosphere (miserable to say the least) during the Mughal era (Reference No. 68, chapter 2, pp. 7-20). The pathetic decline in the standard of Indian education has also been depicted by Satpal Sangwan who 'failed to discover in medieval India any progressive middle class, spirit of enquiry, anything beyond old mathematics, astronomy and medicine'[5].

To Aurangzeb, the formidable adversaries were his own brothers, Shivaji, the other rebels from the Hindu and the Sikh world, thoughtlessly humiliated by him, and not the Potuguese, Dutch, the French, the British, humiliating the Mecca pilgrims at will. Aurangzeb was fully aware of the Dutch technologists refining saltpeter of Bihar by fractional crystallization and smuggling the refined gunpowder across the sub-continent, falsely labelled as 'bags of sugar'. He did very little to stop this trade. Nor did he take steps to indigenously manufacture the variety of armaments he was buying from the Europeans. In 1690 his *farman* granted the British the right to duty-free trade in Bengal and also *zamindārī* right in three villages around Kolkata. Yet, four years later in 1694 Aurangzeb's biggest ship, *Ganj-I-sawāī* armed with 80 cannons and 400 muskets, fell an easy prey to a British ship much smaller in size and carrying less then one-fourth the quantity of arms and ammunitions.

Strategically it was not so much a matter of the number of cannons or battle ships but their maneuverability, the skill in their use. Aurangzeb was given an 'occular demonstration' how a small Italian ship could be manipulated by

European technicians and moved in all directions using the sails and discharging cannons. In Manucci's words,

'Aurangzeb concluded that to sail over and fight on the ocean were not things for the people of Hindustan, but only suited to European alertness and boldness'. (vide Ref.No. 67, quoted by Qaisar, Ref. No. 60, pp. 44-46)

Who handed over the reign of Hindustan to the British, if not the last 'great' and the last few not-so-great Mughal emperors? Shivaji at least attempted to blow up the British castle of Surat by detonating a mine. Long after the 1765 AD humiliating Treaty of Allahabad, according to which Shah Alam, the Mughal emperor bestowed the British East India Company the *diwānī*, the revenue collecting rights of Bengal, Bihar and Orissa, valiant people of Maharashtra, Mysore, Punjab, Nepal, Afghanistan went on, though separately, fighting the British-led armies. So much for the great Mughal dynasty and its leadership. Bandyopadhyay has aptly mentioned: "The Mughal empire has been described as a 'war-state in its core'; no form of impersonal loyalty, national, ethnic or religious, could develop in Mughal India"[69]. Some Gandhian patriots like Jawaharlal Nehru and Dharmapal have held somewhat different view with regard to the 18th century India when the British stepped in, and we should quote them at this stage.

"Had the British Not Come to India"

They raised such an emotive and hypothetical speculative question. Nehru quoted Robert Clive saying that in 1757 AD the city of Murshidabad was as rich as London. There were other great cities in India. "The economy of India had advanced to as high a stage as it could reach prior to the Industrial Revolution …It was ripe for a change (though) the change itself required a revolution within its own framework …It is not inconceivable that if Britain had not undertaken this great burden in India (had not come to India), India might not only have been freer and more prosperous, but far more advanced in science and art and all that makes life worth living"[70].

Nehru presumed that during the 18th century, the 'revolution' and progress would have taken place spontaneously, and ignored the fact that the urban rich was awfully counterpoised by the poverty and ignorance of the masses. (We would shortly quote Bernier on this point). Dharampal was more assertive than Nehru. He remarked:

> "It is possible that the link between the practitioners of the various techniques or professions, and the professors of the theoretical knowledge relating to them had largely snapped in India by the end of the 18th century …It is very probable that in a changed political climate such links would have been re-established or newly forged …In most respects, the S&T of India had reached a desirable balance and equilibrium much before the 18th century …With the beginning of European dominance in India, the resurgence got transformed into depression and unimaginable disorganization …Unthinking acceptance and transplanting of European S&T in India have mainly resulted in retarding and blunting of indigenous innovation and creativity"[71].

Like Nehru, Dharampal also indulged in wishful thinking. Everything would have been alright according to them, if the British had not come to India. Dharampal went one step further, and quoted Voltaire: "If the Indians had remained unknown to the Tartars and to us (the Europeans) they would have been the happiest people in the world"[72]. We have presented some information about the tartars coming to India and causing havoc, but Nehru and Dharampal do not seem to have been much interested in the subject. Why did they ignore the vivid description of Bernier outlining the miserable socio-political scenario in the 17th century Mughal India? The poignant observations of Bernier deserve to be quoted:

> "In the Mughal kingdom, the nobles, and above all the king, live with such ostentation that the most sumptuous of European courts cannot compare in richness and magnificence. The masses however did not participate in or enjoy the prosperity of the ruling class…The king and the possessors of the land have absolute authority over the peasantry. An importunate artist or tradesman could be mercilessly punished by *korrah*, that long terrible whip hanging at every Omrah's gate…[73]

"A profound and universal ignorance is the natural consequence of such a state of society as I have endeavoured to describe. It is possible to establish in Hindustan academies and colleges properly endowed? Where shall we seek for founders? Or shall they be found, where are the scholars? Where are the individuals whose property is sufficient to support their children at college? Where are the benefices, the employment, the offices of trust and dignity, that require ability and science, and are calculated to excite the emulation and the hopes of the young student?

"The country is ruined by the necessity of defraying the enormous charges required to maintain the splendor of a numerous court, and to pay a large army

maintained for the purpose of keeping the people in subjection. No adequate idea can be conveyed of the sufferings of that people. The cudgel and the whip compel them to incessant labour for the benefit of other; and driven to despair by every kind of cruel treatment, their revolt or their flight is only prevented by the presence of a military force. This debasing state of slavery obstructs the progress of life of every individual.

"Actuated by a blind and wicked ambition to be more absolute than is warranted by the laws of God and of Nature, the kings of Asia grasp at everything, until at length they lose everything. If the same system of government existed with us, where should we find princes prelates, nobles, opulent citizens, and thriving tradesmen, ingenious artisans and manufacturers"[73].

Jaggi concluded after quoting Bernier in detail: "The medieval period in India was thus marked by the prosperity of the rulers and poverty of the masses. This seems to have been one of the major factors which hindered the progress of science and technology"[74]. Why did Nehru and Dharampal totally ignore the valuable observations of Bernier?

What we accept from Dharampal's thesis is the fact of brutal economic and political exploitation of the Indian people by the British (much like the rulers through centuries, from Mahmud to Aurangzeb) who took over the sub-continent in the latter half of the 18th century as a free gift from the great Mughal dynasty; but that is the period of transition when our dissertation ends with the spectacular discoveries of Lavoisier. Up to that point in history, there was no chance of a socio-political or scientific progress in India, nor anything of scientific renaissance or an industrial revolution.

However, we are in perfect unison of thoughts with Dharampal in the legitimate pride that was in the indigenous industries and traditions in pre-modern India. In their dexterity, diligence and general intelligence, the artisans of India have been great throughout the ages. But they never received theoretical instruction at any level. The medieval socio-economic structure and the ruling class failed to supply the incentives, the motivating leadership[5]. Satpal Sangwan has also explained [75] that whereas the Indian response to European technology was decidedly lukewarm, if not negative, during the Mughal era, it became positive and enthusiastic during 1757-1857. Even the intellectuals like Raja Rammohan Roy came up with positive visions. Radhanath Sikdar proceeded to measure the altitude of the tallest mountain peak in the world. Ramachandra correlated Hindu algebra with modern

calculus. The artisans mastered newly invented mechanical systems with great intelligence. Irfan Habib and Dhruv Raina have also noted [76] warm and positive response to modern science in 19th century India.

The science enthusiasts appeared on the Indian scene after the temporal end-point of our dissertation but the artisans had been with us for millennia. Thus the bulk of the credit for the long tradition of indigenous technologies in India goes to the indomitable artisans representing so many castes, religions, languages and sub-cultures. They exhibited gallant and persistent craftsmanship. Their vitality was sustained through centuries, and could not be extinguished either by the Hindu obscurantism, Muslim fundamentalism or the British oppressive colonialism. The British at least unwittingly triggered scientific thinking in India, just as the Muslims did, centuries ago, not in Hindustan, but in the Christian Spain.

Concluding Remarks

We endorse E.H. Carr's assertion that 'The study of history is a study of causes; all facts, scientific or historical, are rooted in the principle of causality.' Such an approach has enabled us to explain the positive phenomenon of scientific renaissance taking place in medieval Europe, and the negative counterpart namely its absence in medieval India.

This appraoch is applicable not only in the spheres of the natural sciences and technology but also in the arena of social sciences and their evolution. It can, by its methodology, not only explain the sequence of historical facts, but also intelligently plan the future, avoiding the pitfalls and ensuring the 'necessary' and 'sufficient' factors underlying the prosperity of human civilization.

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24. *Ibid*, Vol. I, p. 376 and Vol. II, p. 111

25. *Ibid*, Vol. I, pp. 24-25

26. *Tahid Nihayat …al Masakin* by Alberuni, English translation by Tamil Ali, Beirut, 1967, p. 2 quoted by S. Maqbul Ahmad, Alberuni as a Synthesizer and Transmitter of Scientific knowledge, *IJHS*, 10.2 (November 1975) 244-248. Most scholars have either unwittingly missed or deliberately ignored such a historical remark!

27. Reference No. 22, volume I p.22, Alberuni's comments.

28. *Ibid*, p. xxiii

29. Pramatha Nath Bose, *A History of Hindu Civilization during British Rule*, 3 Volumes, 1894, reprinted Asian Publishing Services, New Delhi, 1975

30. Muzaffar Alam, *The Languages of Political Islam in India (1200-1800 AD)*, Permanent Black, Delhi, 2004, pages 161& 169

31. Muhamad Asimov, The Life and Teachings of Ibn Sina, *Indian Journal of History of Science*, 21(3), 1986, pp.220-243

32. A.K. Bag, Ibn Sina and Indian Science, *Ibid*, pp.270-275

33. S.A.A. Rizvi, Ibn Sina's Impact on the Rational and Scientific Movements in India, *Ibid*, pp.276-284

34. Ibn Sina was the target of a tirade from both the *ulama* and *Sufis*. Even later, Al Din Barani (1285-1357 AD), the well-known Muslim conservative historian, wrote: "Had Ibn Sina fallen into the hands of Mahmud of Ghazna, he would have been torn to pieces and his flesh thrown to the vultures. Ibn Sina remained underground for fear of Mahmud". Ibn Sina had refused to come to India with Mahmud, whose plunder, he (as well as Alberuni) thought, was ruining Indian science. Ibn Sina was aware of the invectives against him but he dismissed them in the following quatrain:

    "A man like me cannot be vainly and superficially dubbed as a heretic,
    There can be no faith superior to mine,
    In the whole world I amd unique and even if I am a heretic,
    Then in the whole world there is not a single Muslim." (Quoted by Rizvi, Reference No. 33, p. 277

34b. Irshad Manji, *The Trouble with Islam Today : A wake-up call for Honesty and Change*, Vintage Canada, Random House, Indian Edition, 2005, Oxford Book Stores. vide pages 56-73. The 'Pact of Umar', in the name of the Prophet's second successor, stipulated humiliating treatments for non-Muslim al-dhimma or zimmi's. Al Mamun's liberal stand (ninth century AD) was reversed in his own life-time. Irshad Manji pleads for the revival of *ijtihad*, the golden Islamic tradition of independent reasoning and respectful tolerance for other faiths.

35. Irfan Habib, 'Capacity of Technological Change in Mughal India', in *Technology in Ancient and Medieval India*, edited by Aniruddha Roy and S.K. Bagchi, Sundeep Prakashan, Delhi, 1986, pp. 1-13. The quotation is from pages 10-11.

36. John Man, *Genghis Khan: Life, death and resurrection*, Bantuam Press, Transworld Publishers, London, 2004, pp. 211-212 and 272.

37. *Letters of Swami Vivekananda*, Advaita Ashrama, Kolkata, 1981 edition p. 174. The letter to Alasinga Perumal was dated 19 November 1894.

38. Jawaharlal Nehru, *The Discovery of India*, Signet Press, Calcutta, Fifth Printing, September 1948, pages 193, 194 & 196.

39. Nasir al-Din Tusi, *Akhlaq-I Nasiri*, edited by Mojtaba Minavi and Ali Riza Haidari, Teheran 1976; English translation by G.M. Wickens, *The Nasirean Ethics*, George Allen & Unwin, London, 1964. A very useful exposition of Nasirean ethics has been provided by Muzaffar Alam, Reference No. 30, p. 46-73.

40. Quoted by Barani. Vide Reference No. 30, p. 83.

41. Reference No. 30, pp.77-78. Muzaffar Alam has quoted Sirhindi's letter No. 92 to Mir Muhammad Nu'man

42. S.A.A. Rizvi, *A History of Sufism in India*, 2 Volumes, Munshiram Manoharlal, Delhi, 1978

43. Reference No. 30, p. 82

44. *Ibid*, p.161

45. *Ibid*, pp. 151-171

46. A. Rahman edited, *History of Indian Science, Technology and Culture* AD 1000-1800, PHISPC Volume, General Editor D.P. Chattopadhyaya, Volume III Part 1, Oxford University Press, New Delhi, 1998. Specific articles in this Volume:

    A. Rahman, Introduction, pp.1-4; A Perspective of Indian Science, pp.7-31; A Perspective of Technology in India, pp.241-260; Science, and Social Movements: Bhakti and Sufi Movements, pp.415-436

    Arun Kumar Biswas, Minerals and Metals in Medieval India, pp.275-313

47. George Sarton, *Introduction to the History of Science*, Volume I, *From Homer to Omar Khayyam*, Carnegie Institution of Washington, 1931, Reprinted 1962

48. A. Rahman, *Science and Technology in Medieval India- A Bibliography of Source Materials in Sanskrit, Arabic and Persian* Indian National Science Academy, New Delhi, 1982

49. A. Rahman, A Perspective of Indian Science of 10^{th}-18^{th} Centuries, in Reference No. 46, pp.28-29.

50. *A History of Technology* edited by Charles Singer, E.J. Holmyard, A.R. Hall and Trevor I. Williams, Oxford at the Clarendon Press, 1982. Vol II. From Ancient Era upto 1500 A.D. Charles Singer, Epilogue, East and West in Retrospect, pp.753-776.

51. *Ibid*, Volume III, From the Renaissance to the Industrial Revolution (1500-1750 A.D.), A.R. Hall, The Rise of the West, pp.709-721.

52. J.D. Bernal, *Science in History*, Watts, London, 1957, pp.871-73.

53. Reference No. 51, pp.716-717

54. Reference No. 47, pp.28-29.

55. There has been no such intellectual turmoil in the Hindu World (after Gautama Buddha) questioning the infallibility of the Vedas and other scriptures, and in the Islamic World questioning some tenets of the Quran. It remains to be seen how the 21st century Hindu and Muslim theologians reconcile the scriptural dogmas with the modern science.

56. Reference No. 4, pp.347-349; E. Zilsel in *Origins of the Scientific Revolution*, edited by H. Kearny, Longmans, London, 1964, pp.86-99.

57. Ramakrishna Bhattacharya, 'Copernicus's Tribute to the Indian Numerals', *Journal of the Asiatic Society*, Vol. XL VII, No. 2, July 2005, pp.96-97; Nicholas Copernicus, *De Revolutionibus orbium coelestium* written in Latin (1543) facsimile reprint from Poland, 1965, pp.12-13; Edward Rosen, *Complete Works* of *Copernicus*, Macmillan, London, 1978, Vol. 2, p.27.

58. Arun Kumar Biswas, *Minerals and Metals in Pre-Modern India*, D.K. Printworld Pvt. Ltd, New Delhi., 2001.

59. Dharampal, *Indian Science and Technology in the Eighteenth Century*, Academy of Gandhian Studies, Hyderabad, 1971, Reprint of 1983.

60. Ahsan Jan Qaisar, *The Indian Response to European Technology and Culture* (1498-1707 A.D.), Oxford University Press, Delhi, 1982.

61. Irfan Habib, *Medieval Technology Exchanges Between India and the Islamic World*, No. 6, Aligarh Oriental Series, Viveka Publications, Aligarh, 1985, pp.1-26.

62. Irfan Habib, 'Joseph Needham and the History of Indian Technology', *IJHS*, 35.3 (2000) 245-274.

63. Irfan Habib and Tapan Raychaudhuri edited, *The Cambridge Economic History* of *India*, Volume I (1200-1750 A.D.), Cambridge University Press, 1982, reprinted Orient Longman Ltd., New Delhi, 1993, p.307. Cited writings in References 63 & 64 are from the pen of Tapan Raychaudhuri.

64. Dharma Kumar and Meghnad Desai edited, *The Cambridge Economic History of India*, Volume II, Cambridge University Press, 1982, pages 18-21, 31-35.

65. Reference No. 61, p.25.

66. M.A. Alvi and A. Rahman, *Fathullah Shirazi-A Sixteenth Century Indian Scientist*, INSA, New Delhi, 1968.

67. Niccolao Manucci, *Storia do Mogor*, 1653-1708, translated by William Irvine which has been quoted by Jaggi[68].

68. O.P. Jaggi, *Science and Technology in Medieval India* (13th to 19th century), Atma Ram and Sons, Delhi, 1977.

69. Sekhar Bandypadhyay, *From Plassey to Partition-A History of Modern India*, Orient Longman Private Ltd., New Delhi, 2004, pp.2-3

70. Reference No. 38, pp.234-237.

71. Ref. No. 59, pages 43 and 52-54.

72. *Ibid*, p.50.

73. Francois Bernier, *Travels in the Mogul Empire*, 1656-1668 translated by A. Constable, reprint, S. Chand & Co., New Delhi 1968, pages 202, 224, 225 and 230.

74. Ref. No. 68, pp.1-6.

75. Satpal Sangwan, 'Indian Response to European Science and Technology 1757-1857', *British Journal of History of Science*, 21 (1988) 211-232.

76. S. Irfan Habib and Dhruv Raina, 'Copernicus, Columbus, Colonialism and the Role of Science in Nineteenth Century India', *Social Scientist*, 191 (1989) 51-66.