An Indocentric Corrective to History of Science

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In this essay, we have tried to expose the willfully propagated myths about the merits of the colonial legacy and to show how it distorted our history; we also highlight the Indian contributions to world science. We have also to assess Needham s monumental contributions to Chinese history of science, which is so relevant to India. Finally, we discuss some of the measures taken by Infinity Foundation to apply Indocentric correctives to the history of science.

We discuss these themes under five main headings:

1. Global Legacy of the Colonial Rule
2.
3. India s Scientific Heritage
4. Needham on India and China
5. History of Science and Infinity Foundation
6. Conclusions

1. GLOBAL LEGACY OF THE COLONIAL RULE

When Dinesh d Souza raised two cheers to the British for civilizing and educating the Indians, it became obvious to me that Indian scientific legacy lies buried and distorted under the heavy incrustations of the British legacy. We have therefore to expose the multi-faceted plunder, material as well as cultural, of the colonies by the European colonizers. It is obvious that no colonial power ever went to those inaccessible lands with a philanthropic motive. At the root of colonialism lay the greed to acquire wealth, land, minerals and even technology. The Europeans went to the America s, Arctic region. Africa and Australia to acquire land for farming and mineral wealth for exploitation. In their greed to acquire land and mineral wealth, they slaughtered the original inhabitants of the land and dismantled their Traditional Knowledge Systems. If any proof were needed, two recent books have devastatingly exposed motives and modes of the colonial expansion.

We see two global faces of Colonialism: One, the way they grabbed the lands of the hunter-gatherers of the continents of Africa, Australia and America. Two, the way they subjugated the civilized and more prosperous countries like India and China.

About their educating and civilizing   the natives, Hugh Brody (In *Other Side of Eden)* gives a chilling account. Brody informs that children as young as five or six were forced to go to the schools, staying there until they were teenagers. Siblings were either kept apart within a school or sent to different schools. Disregard for health, clothing, nutrition, and sanitation yielded appalling rates of disease and mortality. At one point early in the twentieth century, administrators of the schools discovered that 25 percent of their pupils died at school or soon after returning home. In such schools children were in rags, miserable with cold; they lived in squalor and were underfed to the point of widespread and chronic malnutrition. The regime in many of the schools also relied on fierce physical punishment: children were strapped, whipped, locked in dark rooms, chained The American Indian children, vulnerable and lonely, endured the erotic as well as the sadistic attentions of their "educators."

Residential schools like those in North America have been used in Australia for Aborigines, in Scandinavia for Saami, and in parts of Africa for Hadza. "Education" for many indigenous peoples has been a means of enforcing the things that Europeans believed in and getting rid of the things they did not. Educators spoke of the need for "improvement," "development," and "civilized religion." But the real objective was to break rather than to create. Exposing the motifs of the colonisers, Brody says, for the fundamental, irreducible commitment of the undertaking was to eliminate ways of life, and do so through getting rid of peoples' languages. Brutal and corrupt institutions managed this, but it is the intention, not corruption or brutality, that is the deepest wrong. Through such education , they not only deprived the natives of the lands but also dismantled their Traditional Knowledge Systems.

In North America, Australia, and parts of southern Africa, hunter-gatherers occupied large territories over which they moved with great freedom and ease. New settlers wanted land, which, through their European eyes, appeared to be empty at best, randomly and minimally occupied. They found their flexible use of land both bewildering and threatening. The Europeans were looking for a place to convert into home -- at least for a while, for a generation or two. The hunters seemed to be everywhere and nowhere, making sudden appearances out of the forest or from outback or hills, opposing the occupation and transformation of their lands, and causing trouble. At first, of course, these strange people were useful. They could show the newcomers where to find water and edible plants, how to travel difficult terrain, and how to hunt the animals of the region. They were even willing to get their understanding of the gods and spirits of the place. But once the newcomers had absorbed such vital knowledge, they could dispense with their teachers. The underlying, enduring issue was land. Rival claims to the earth itself had to be obscured or obliterated. Inasmuch as this is an explanation of genocidal tendencies on frontiers between farmers and hunter-gatherers, it is also a way of looking at the history of many modern societies, and of the languages these societies do and do not speak. Indigenous populations could raise questions about the rights of newcomers, asserting *their* rights to the land. A small family farm, isolated in wild country, is a vulnerable thing: a group of angry hunters could destroy a decade of hard work in a single quick attack. Any opposition to farming had to be checked, made impossible. The enemies of settlement had to be silenced or removed. This is the story of the United States, Canada, Australia, and much of southern Africa. The residential school was part of a process of ethnocide. The plan that shaped these schools, and the attitudes that informed the daily regimens, emerged from the agriculturalists' need to get rid of hunter-gatherers. These schools represent a dedicated and ruthless attempt to transform the personalities and circumstances of "native people" into. ..well, what? Farm-workers and industrial labourers (Brody 2001)!

About the vulnerability of the natives, in the hands of the colonial powers, Hoagland makes a poignant comment, Sabrimathu reminded me of various aged Eskimos, American Indians and Africans subsistence specifics no one will know at all when they are gone, though nobody they had any contact with seemed to care much now about what they knew. They too lived wind-scented, sunlit, star-soaked, spirit-shot lives. Humble on one level, proud on another, Sabrimathu was vulnerable to exploitation and insult partly just because he was so tactile and open to everything else. Like those millions of American Indians, he was rooted-in place. He could be chopped like a tree or shot like a songbird (Edward Hoagland 1997: 39-58).

Henry Reynolds, in his scathing and revealing book, *Why Were We Not Told, gives a* blood chilling account from an old newspaper report of how the civilising whites slaughtered the natives to colonise Australia.

> They slept soundly those myalls (natives) after their long march, and could have had no thought of us being so close to them, for we were within our presence I was discovered, and then it was too late, for muddled with sleep, sore-footed, weary, and panic stricken they offered no resistance, and many of them were ’wiped out’ before they could gain their feet. Talk of the ’Furies of Hell’, that night’s work amongst those myalls with the white man’s rifle and tomahawk would make ’Hell’s Furies’ blush. How those gins and kiddies shrieked when we got amongst them. The blood of the white man was up and nothing with a black hide escaped death that night. ..for when we had finished our work and drawn off, and in daylight came to view the white man’s work of vengeance bucks, gins and piccaninnies were lying dead in all directions, and not a thing in camp moved or breathed.

Reynolds further writes about the two punitive expeditions.

> Both were concerned with creating a ’universal terror’. We will never know how many official punitive expeditions- conducted by the military or the police -set forth to punish the blacks between 1790 and 1928. But there must have been many. Throughout the nineteenth century there would have been at least a handful of expeditions every single year. As far as I know, no white soldier or policeman ever faced trial over actions taken as part of a punitive expedition The line of blood runs from 1790 to 1928, joining up all the disparate punitive expeditions, although they must have varied widely in effectiveness, duration, personnel and tactics. All were premised on the assumption that it was both necessary and legitimate to kill Aboriginal men, women and children without summons, trial or conviction, although parties often spuriously justified their actions by claiming they were merely trying to arrest offenders for whom warrants had been issued. The killing was always indiscriminate. The most fanciful and flimsy evidence was often used to identify those individuals deemed guilty of offences. It was universally thought sufficient to identify the right ’mob’ and to punish all and sundry, to assume collective guilt. Most expeditions were motivated by the desire for revenge because of attacks on settlers or more often on their property. The revenge was almost always disproportionate. It was never a case of an eye for an eye or a tooth for a tooth. There was almost universally a desire to raise the stakes -to use far more violence in return for whatever the Aborigines had done or were thought to have done. There was a constant refrain of the need to teach the blacks a lesson, to show them once and for all that resistance was both dangerous and futile, that acquiescence was the only answer.

With these devastating examples of the white man s civilising acts, I think even d Souza would admit that it was not at all a philanthropic civilizing mission on the part of the colonial powers.

The Europeans not only denigrated the colonised people and their cultural heritage whether they belonged to ancient civilisations like India and China or tribal societies, they plundered their wealth and land as in Africa, Australia, Arctic region, and the Americas, but they also propagated the myth that all science and technology emanated from Greece, thus giving rise to a very skewed Eurocentric history of science and technology.

Exposing such claims, Blout (1993) says,

> The purpose of this book is to undermine one of the most powerful beliefs of our time concerning world history and world geography. This belief is the notion that European civilization -"The West"- has had some unique historical advantage, some special quality of race or culture or environment or mind or spirit, which gives this human community a permanent superiority over all other communities, at all times in history and down to the present.
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> The belief is both historical and geographical. Europeans are seen as the "makers of history." Europe eternally advances, progresses, modernizes. The rest of the world advances more sluggishly, or stagnates: it is "traditional society." Therefore, the world has a permanent geographical center and a permanent periphery: an Inside and an Outside. Inside leads, Outside lags. Inside innovates, Outside imitates.
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> This belief is *diffusionism,* or more precisely *Eurocentric diffusionism.* It is a theory about the way cultural processes tend to move over the surface of the world as a whole. They tend to flow out of the European sector and toward the non-European sector. This is the natural, normal, logical, and ethical flow of culture, of innovation, of human causality. Europe, eternally, is Inside. Non-Europe is Outside. Europe is the source of most diffusions; non-Europe is the recipient.

Turning the tables on the Europeans, Pt. Madan Mohan Malviya had said, the de-industrialisation of India and the history of the industrial revolution in the West were integral parts of one process, that colonialism preceded and helped create industrialism in Britain.

In countries like India with a culturally rich past, a civilised state in the Third Millennium BC to boast of, the colonial powers played a different game. They gained power through divide-and-rule and other devious means. They learnt the local technologies and then dismantled them. They started copper and iron factories in Uttaranchal, and then passed orders to ban any such metal production. The tribal people who preserved the ancient iron technology were forced to retreat to the remote forests. They learnt our advanced technologies of making steel, copper alloys, textiles, and a scientific medical system, used them for their industrialisation and dismantled them in India.

Dharampal (2002) points out, Whether the late 18th century elite was consciously aware of the then existing sciences and technologies of India or not, these were taken serious note of by European specialists during the 16th, 17th and 18th centuries, as and when they were looking for knowledge, information, design, technique, etc., in any particular fields. Examples of such European research, attention, study and borrowing are innumerable. The collection of Indian botanical texts by the Portuguese and the Dutch goes back to the early 16th century. The *Hortus malabaricus*, in 12 volumes, with illustrations of 750 species of Indian plants was published in Europe during 1678-93. It is said to contain certificates from four Kerala and Konkan pundits about the authenticity of the information in the 12 volumes. The design and function of Indian agricultural implements, especially the drill plough was as important to late 18th century British agriculture, as was the Indian practice of inoculation against smallpox and its rationale, or as the method and rationale of the artificial manufacture of ice in the Allahabad-Varanasi region had been a few decades earlier. Similar, or perhaps even greater attention was devoted to an understanding of Indian building materials and techniques, to various chemicals used in Indian industry and other processes and their sources, in Indian steel and its technology, in the prevailing Indian surgery, and even in the method of teaching in schools in India, especially in those in the south. The existence of petroleum wells and the use to which the oil was put to was first observed in Burma around 1797. The number of wells, in the area visited, was said to be 520, and their annual oil production about one lakh tons valued at over ten lakh Indian rupees.

It was difficult for the British to digest the fact that the people they had come to civilise already had the glorious Indus Civilisation in the III Millennium BC, when they themselves were in a barbarian state! They therefore downgraded the Indus Civilisation as an implant from Egypt and Mesopotamia.

In countries like India, with hoary cultural traditions, so many extant religious and ritual practices can be traced back to several millennia. Its strange but true that the type and style of bangles that women wear in Rajasthan today, or the vermilion that they apply on the parting of the hair on the head, the practice of Yoga, the binary system of weights and measures, the basic architecture of the houses etc can all be traced back to the Indus Civilisation. The cultural and religious traditions of the Harappans provide the substratum for the latter-day Indian Civilisation.

It fell to the lot of Dharampal, the great Gandhian and historian of Indian science and technology, to explode the myth that Indians were backward, poor and ignorant. Dharampal proved, that too from the writings of the British themselves, through his monumental work done in the libraries of London that India was technologically and industrially far ahead of Europe, and richer too before the colonial powers came to India.

Dharampal (1999: 28-31)says,

> India then had industry, the famous extensive cotton cloth industry (spinning, weaving, dyeing, finishing, etc.) producing cloth for ordinary wear, as well as for exquisite purposes. Further, there were the great building industries run by high professionals like experts in Vastu-sastra, also those who constructed tanks and irrigation channels and maintained them, and people who looked after the roads and rivers. There were the great cartiers like the Banjaras, the transporters who were said at times to have travelled on the roads in caravans of 10,000 carts. Then there were the boats and ships in the

rivers and on the seas, and those who built them, and those who sailed them in the rivers and seas around India, and to places in South east Asia and to East and South Africa.

Most parts of India produced very fine iron and steel from very early times. Around 1700-1800 it was perhaps the best steel in the world and distant countries like the Netherlands and Britain imported it and used it for special purposes. We of course used it for our agricultural purposes, and in tool-making, and in great temples as well as in great iron pillars, like the one in Delhi. Our annual potential of iron and steel production, around 1800, is estimated at 2,00,000 tons. The furnaces which manufactured such iron and steel were found in practically all regions of India, and were made by the iron-smelters themselves, used ores available locally, and charcoal made from specific trees, and the furnaces could carted from place to place.

There were scores of large and small industrial and other manufacturing enterprises even till A.D. 1800 and in many areas till much later. Around 1770 it was found that ice was manufactured from water by a man-made process in the Allahabad region. This was wholly unknown in Britain, and perhaps in Europe too, and so details of the process were conveyed to the British Royal Society in London by the British commander in chief of the Bengal army. The details were tested and analysed in Edinburgh by one Prof. Black, probably Edinburgh was the main centre for understanding the process. Prof. Black found that the Indian process worked in his laboratory too, and the confirmation of it, in due course must have led to the founding, patenting etc. of the earlier forms of modern-day refrigeration.

Incidentally, it seems that ice was made in India from water (and perhaps by the same or similar process) in the early 7th Century A.D. in the days of the celebrated Harshavardhana of Kannauj. This is referred to in the Harsha-Charitra by the great poet *Bana Bhatta*

Contrary to what the British assumed, especially Mr. James Mill, the historian of British India (1817), India seems to have been well endowed in the matter of the treatment of the body, largely through Ayurveda and its regional versions, and in surgery. Indian surgeons, disciples of the ancient Susruta, did surgery for many things including the removal of the cataract of the eye in Bengal (c.1790) and in mending noses, and perhaps, other limbs. The news of the process of the mending of noses reached the British Royal Society from Pune, and may be from other places also. There seems to have arisen some amazement, a sort of unbelief, but the details of the surgery were studied, and by 1810 Dr. Carpue of London was able to build up the technique of a new plastic surgery derived and based on the Indian method.

There must be many more such instances of export of knowledge, processes, and techniques, in multiple fields which came to Britain, and perhaps to some other European areas, from 18th and early 19th century India. There were the details of the practice of inoculation conveyed firstly around A.D. 1732, and later in much greater detail in 1765 to the British College of physicians by Mr. Holwell, who was also a surgeon. Similarly the practices of Indian agriculture were described to London from various areas, and some Indian tools, particularly drill ploughs, were sent to Britain to help improve the British agricultural implements, all in the later part of the 18th century.

It may be of much surprise to the readers of this work to know that, according to recent estimates of world-wide industrial manufactures, 73% of world manufactures were done in the Chinese and the Indian regions around 1750. Even around 1820 these two regions produced some 60% of world manufactures.

Distortions of History

Laying the blame for the cause of the decline of the Indian industry at the door of the British, Dharampal (2002) says, However the erosion and decline of Indian industry and technology in the late 18th and first half of the 19th centuries had, as is well recognised today, little to do with factors relating to Indian technological practices and their economic efficiency. In these respects, many of them could have withstood foreign competition (as Indian cotton textiles did for many decades till about 1850). The decline and destruction was politically and fiscally induced by deliberate British policy.

About the Indian accomplishment in plastic surgery, Dharampal quotes no less an authority than J.C. Carpue, the founder of modern British surgery. Dharampal reminds us, As we now well know such an operation is described in detail in Susruta The narratives seem to have been responses to urgent and contemporary British need; and it may be assumed that India was one amongst several places where such enquires were conducted, published for specialist and scholars seem to suggest that what was relevant in them to contemporary British or European requirement was incorporated in the corresponding practice of the borrower, in time internalised and thereafter perhaps within a period of fifty years, the origin of the incorporated, at least in practice, quite forgotten (Dharampal 2002). Even small pox inoculation was done in India much before Europe. In fact, it was banned by the British here.

C.K. Raju (pers. comm.), the famous mathematician and historian of science, reinforces what Dharampal said. He says,

> 1. The classical grand narrative of the history of science traces science from a beginning in Greece, jumping to renaissance Europe. This suggests that science is intrinsically Western. Accordingly, many people speak of Western science , and feel that traditional knowledge amounts to a rejection of both science and the West.
> 2. I explain why the classical grand narrative has been regarded as a racist and fictitious account. Further, on the one hand, many of the great names--Euclid, Copernicus, Kepler, Galileo, Newton, Einstein, Hawking are fraudulent constructs of this racist history. On the other hand, from Copernicus to genetically engineered crops and artificial intelligence, science and technology have grown by appropriating and monopolizing common and traditional knowledge often from non-Western cultures.
> 3. As a striking example, knowledge of navigation was a key input to British colonisation and domination, and the algorismus and calculus imported from India, were key inputs to the development of navigation from 16th to 18th c. CE: specifically to the calendar reform, and methods of calculating latitude, longitude, and loxodromes.
> 4. Thus, advocacy of traditional knowledge ought not to mean rejection of science per se: traditional knowledge and science are not two parts of a dichotomy.
> 5. However, in the process of development of science and technology, the imported traditional knowledge was often adapted to aboriginal Western culture, and this may need to be undone. For example, the arithmetic and calculus, imported into Europe, were axiomatised, to make them compatible with the tradition of geometry as understood by Christian rational theology (as distinct from the earlier under-standing of geometry in Neoplatonism, and in Islamic rational theology). Such axiomatisation did NOT make either epistemologically more secure, but impeded the use of both as computational tools, and this cultural drag has become particularly apparent with the growth of computers. This cultural drag should be rejected irrespective of Western scholarly authority.
> 6. Additionally, aboriginal Western culture, like culture everywhere, was transformed, and continues to be so transformed, to suit the growth of science and technology, seen as key instruments of domination and consequent prosperity. Thus, the industrial revolution, by forcing men to adapt to machines, made life more mechanical. A similar cultural adaptation is easily visible in other urban-industrial concentrations, like Bombay and Delhi in India. It is an accepted principle of technology management that technology cannot develop without such a cultural transformation. Is traumatic cultural change and the resulting loss of identity an acceptable price to pay for the prosperity that might result from technology?

7. Where the industrial revolution made man more like a machine, the information revolution is making a machine more like a man. Intelligent machines have two consequences. (a) The resulting dependence of man on machine, and separation of man from man, is easily witnessed in any IT-savvy household glued to its VDUt-s. (b) It is no longer science fiction that intelligent machines may dominate future human society. (Indeed, by forcing a cultural change, and transforming human behaviour, technology is already dominating man.) Is this an acceptable price and an acceptable risk for the domination that ownership of technology might help to achieve?
8. In my opinion: No. Thus, according to my theory of physics, spontaneity not only is possible, it is the very essence of life. On the other hand, spontaneity, since it involves order-creation, is impossible for a machine because of the entropy law. (The entropy law is also the reason why mechanical techniques of production are more wasteful than traditional techniques of production.) While waste could conceivably be traded-off for domination, the urge to dominate derives from the urge to survive. The urge to survive is not some ultimate principle, but relates to order preservation, so it is illogical to pursue domination by destroying spontaneity, the basis of order-creation. The conclusion is that if technology helps to dominate at the cost of dehumanizing its owners, then the strategic benefits of ownership of technology are overrated.
9. Thus, while a technological advantage may help to dominate, the alleged benefits of modern technology over traditional knowledge need to be re-evaluated in the light of the destructive long-term effects of unrestrained technology growth not only on the environment , but also on human culture and the very basis of life.
10. However, as already stated, rejection of the present-day technological model should not mean blind acceptance of traditional knowledge: traditional knowledge and traditional technology should, likewise, be subjected to a similar critical re-evaluation.

There were other indirect and more subtle effects of the colonial rule. For example, the communal schisms were the result of Mill s *History.*

Pannikar (2001) explains,

> An idea which persisted for long was Mill's periodization of Indian history in terms of Hindu and Muslim civilizations. Emphasizing the separateness of each of those periods the periodization led to a communal view of India's past, as it assumed that the separateness was innate to Indian society and that it began with the coming of the Muslims to India, terminating the earlier 'glorious' period of Hindu rule. It also 'encouraged the notion of distinct religious communities which were projected as the units of Indian society for political and socio-legal purposes'. Its effects are still to be seen in contemporary India in terms of providing substance to communal ideologies.
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> The construction of scripture-based Hinduism by upper-caste reformers during the colonial period was in effect an attempt to universalise the Brahminical tradition. At the same time, a search for traditions outside the Brahminical and the textual and an attempt to forge movements of reform within them, distinct from the upper-caste movements, were also afoot. The movements initiated by Narayana Guru in Keralam, Jotiba Phule in Maharashtra, and, Ramaswami Naicker in Tamil Nadu were indicative of this trend. Rejecting the upper-caste literate tradition, they tried to create social and religious practices without seeking legitimacy from Brahminical scriptures. Narayana Guru, an untouchable, himself consecrated idols in the temples he set up without performing rituals. By doing this he not only challenged the Brahminical tradition, but also contributed to the subversion of the upper-caste religious ideology. At the time of the first consecration he just picked up a stone from a nearby stream and installed it as the idol.
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> A 'Hindu' and a 'Muslim' tradition were thus constructed and appropriated. Consequently, the Vedas and the Upanishads became prescriptive texts for the Hindus and the Qoran and the Hadiths for the Muslims. This particularistic tendency continued through the entire colonial period and has gained further ground in contemporary India. The syncretic tradition of the medieval Bhakti movement

> invoked during the nationalist struggle did not succeed in off-setting the particularistic consciousness. An identity between tradition and religion therefore got embedded in social consciousness.

To present the Indian scientific legacy, and to correct the distortions induced by the foreign rule, this backdrop was I think necessary.

2. INDIA S SCIENTIFIC HERITAGE

In this talk we can only have a sample survey of the great innovations that were made in India in different fields of science and technology. Great innovations were made by India in the fields of hydraulics and engineering, metal technology, architecture, textile, myths, astronomy, medical sciences, chemistry, etc. In this brief review we would like highlight some of the significant contributions that India made to the world of science and technology, with special reference to the Indus Civilisation.

Metallurgy:

Iron: The fourth century iron pillar in the Qutub compound in Delhi has withstood the ravages of time without getting rusted. We are only now trying to figure out, how they achieved such technology to make rust-free iron.

What is less known is the technology of making *wootz* steel. It was a rust-free hard steel, which became famous in West Asia as Damascene steel. It was very popular with the Persian kings like Darius, Xerxes of the First Millennium BC.

Copper: The Harappans never wasted metal on non-functional artefacts. But they did have techniques to cast complicated images by using lost wax process, as exemplified by the famous dancing girl from Mohenjodaro. The Harappans were the first to invent hollow drills, true saws and the needle with the eye at the pointed end. These tools were reinvented in Europe four thousand years later! They could use sulphide ores to extract copper. They could control tin and arsenic alloying to increase hardness of the tool or the shine of the mirror. They could join metal through a variety of techniques. It is interesting to note that the Harappans preferred to import copper ingots and artefacts from Rajasthan. Was it that they wanted the polluting industries to be kept away from the towns?

Out of the 177 artefacts analysed earlier from Mohenjodaro and Harappa, only 30% were alloyed. Tin alloying ranged from 1-12%; arsenic alloying 1-7%; nickel alloying 1-9% and lead 1-32%. Tin bronzes were more common than any other alloys. The Harappans knew the techniques of sinking, rising , running-on , cold work, annealing, riveting. lapping. closed casting, *Cire perdue* etc. (Agrawal 2001)

Zinc: In China brass does not seem to have become common before the 16th century. There is no firm evidence for the production of metallic zinc before the beginning of the sixteenth century (Craddock 1987/88:225-245). The first brass coinage seems to have been in the Hong Zhi period in the year AD 1505, and contemporary accounts note that they were made from copper and ‘new tin, that is zinc. One might suspect that knowledge of zinc had spread to China from India, possibly via a Portuguese ship, but the process used by the Chinese, (and still apparently used in remote areas of the south-west of China) was completely different (Craddock 1987/88: 225-245). Deshpande also informs that according to the new research by the Chinese scholars there is a clear indication that zinc smelting began in China in the Jiajing period (1552 - 1566 AD) of the Ming dynasty. Zinc was exported to Europe in the middle of the seventeenth century AD from China under the name *totamu* or *tutenag*. *Tutenag* possibly has its origin in the word *Tutthanaga* - a name of zinc in South Indian languages. A seventeenth century Chinese author has written that *Tutenag* is a word from some foreign language. Thus there is textual and etymological evidence of transmission of ideas regarding zinc between the two countries. These facts together indicate that zinc was smelted some three countries earlier in India than in China and these ideas were transmitted to China in the sixteenth century AD.

The installations at Zawar mines of Rajasthan seem to be a combination of the principle of mercury smelting and the form of the pottery kiln. Together, they led to one of the most advanced metallurgical operations of the mediaeval world (Craddock 1987:183-191). Thus it would seem that sometime in 16th century, in both Europe and China, zinc made its first appearance as an imported metal. Could the common source be India and the common carrier the Portuguese, the first to open up the oriental trade? Zinc could not be isolated from its ore in the West till 1736 AD, when W. Champion first produced metallic zinc from ore at Bristol, UK. The ancient smelting method had resolved the problem by smelting zinc ore through distillation and condensation technique using clay retorts.

Zawar can lay claim not only to the earliest high temperature distillation process in the world, but also to being the direct ancestor of all such techniques in use today. The Zawar process was certainly one of the most sophisticated and technically exacting process developed in the mediaeval world. One hesitates to use the term pre-industrial , for surely this process, with its appreciation of scientific techniques, and leaning towards mass production, should properly be considered as an early example of an industrial process in the modern sense (Craddock 1987:183-191). India can claim the beginning of industrial exports from the 12th-13th century AD.

The earliest firm literary evidence for the production of metallic zinc on a regular basis comes from India (Craddock 1987/88:225-245). There are references to burning a metal, *rasa*, to produce an eye salve, which should refer to zinc, placing its use in the last centuries of the first millennium BC. The *Rasaratnakara*, ascribed to Nagarjuna, the great Indian scientist who lived in the fourth century AD, but which was probably compiled in its present form in the seventh or eighth century AD, describes both the production of brass by the familiar cementation process, and of metallic zinc. The furnaces at Zawar were the industrial version of those outlined in the *Rasaratna-samuchchaya*, with banks of between three and seven furnaces, and each furnace held 36 retorts (Craddock 1987:183-191). Various zinc smelting processes were described in the Sanskrit works of medicinal chemistry and alchemy, viz., *Rasarnavam Rastantram* (500-

100 BC), *Rasratnakar* (2nd century AD), *Rasprakash Sudhakar* (12th Century AD) and *Rasratnasamuchchaya* (late 13th century AD) etc.

Samples of wood from the Zawar Mala mine in what is predominantly a sphalerite deposit gave ^{14}C dates of 2350 –120 years before present. The earliest dates for Zawar are from the mines at Mochina and Zawar Mala, which show that zinc, and some lead were being mined between the sixth and first centuries BC. The earliest dates we have for zinc distillation are from a white heap, which is of the 12th century AD (Craddock 1987: 183-191). It is reported that the timber ladder yielded an age (uncalibrated) of 2180 – 35 years before present. These radiocarbon ages suggest that the operations in Zawar were probably the earliest zinc extraction in the world.

Architecture:

The Great Bath at Mohenjodaro is a marvel of water-proofing engineering. Besides the different types of building architecture, the whole Harappan town was served by an underground drainage. The house plan allowed an open central shaft around which rooms were built, this tradition continues to this day. Such a plan insured air circulation in such a manner that cold air sunk in and warm air escaped. The Harappan houses always opened into the narrow lane, which ensured not only privacy but allowed only the cooler air of the narrow lanes to go in. The granaries were designed scientifically so that free air circulation was ensured. The world s first dockyard was probably built at Lothal, in Gujarat.

The credit for designing the first planned towns in the III Millennium BC goes to the Harappans. The streets were laid at right angles on the cardinal directions. The elite quarters seem to be dispersed all over the town. It is, however, clear that some sort of profession-based division of the town blocks was there. The cemeteries were outside the habitation. Each house had a bath and toilet. There were plenty of wells for potable water.

No less important is the legacy of the native Traditional Knowledge Systems. Rishi Das (in press) informs,

> The western-central Himalayas are a seismically active region, and earthquakes and landslides are major hazards. Traditional rural housing in this region is adapted to these hazards, and construction styles like the *pherols* of Uttaranchal and *kath-ki-kuni* of Himachal Pradesh are exceptional examples of indigenously developed aseismic construction techniques. Reinforcement of door frames, diagonal bracing, tie-bands and the geometry of stable structures provide ample evidence of the prevalent knowledge of aseismic construction principles. Traditional houses and temples that are centuries old have survived several earthquakes, and stand as testaments to the durability of this construction. The synthesization of earthquake-resistant elements with religious, cultural and aesthetic values and practices in the region is a testament to the indigenous technical and creative capacities.

Hydraulics:

The Harappan town of the III millennium BC had the technology to provide underground drainage to the whole town, providing the necessary gradient for the flow off sullage water.

From the construction of the Great Bath, it is obvious that the Harappans had learnt the water proofing technology. The bricks of the Great Bath were alternately arranged horizontally and vertically in such a manner that water could not leak out. To make it totally leak-proof, they applied bitumen to the brick layers of the wall.

The Sringaverpur (near Allahabad, UP) water complex of the first century BC is a marvel of hydraulic engineering, which allowed the use of overflowing Ganga water for potable purposes by providing a series of steps to allow silt and sand to settle down. It served a bigger purpose of replenishing the water table by recharging the aquifers with the run-off water, a technique that we are still discussing in towns like Ahmedabad.

Ayurved:
The efficacy and scientific basis of Ayurved is now recognised the world over. The Ayurvedic system should date back at least to the middle of the First Millennium BC. *Sushrut Samita* describes elaborate techniques of surgery. They even performed plastic surgery, as late as 18th century AD. Its so well known now, we need not dilate on Ayurved here.

What is however less known is that this systematic medical knowledge derived from a still older indigenous system. We are studying the traditional Himalayan medical system and find that there are more than 330 herbs, which are used for various medicinal treatments of even incurable diseases. We have already mentioned that small pox inoculation was in practice in India much before the Europeans discovered it.

Astronomy
Aryabhatt (c. 5th Century AD) had made many remarkable discoveries:
1.The globe of the Earth stands (supportless) in space at the centre of the celestial sphere....The Earth is circular on all sides.
2. Earth rotates, not the celestial sphere
3. Rational approximation to pi
104 multiplied by 8 and added to 62000 is the approximate circumference of a circle whose diameter is 20,000. (That is, pi = 62832/20000 = 3.1416). In any case Aryabhata's value is better than that of Ptolemy (3.141666), who lived in Alexandria, in Egypt.

Despite close contacts of the Arab world with India, and of the Arab world with Europe, the Indian contributions of science were not recognized as such. Joseph Needham, however, proved beyond any shadow of doubt that Chinese contributions were simply great in most scientific fields and preceded Europe by several centuries. Though Needham specialised on China, he was equally aware about India s scientific heritage.

3. NEEDHAM ON INDIA AND CHINA

Through his monumental series of books, *Science and Civilisation in China*, Joseph Needham proved beyond doubt that a whole lot of science and technology was invented in China during the last several millennia. In the course of his researches Needham also came across many contributions that India made to the world of science and technology.

Joseph Needham is famous mainly for the formidable magnitude and scholarship of his work on science in China. In the years between 1920 and 1942 Needham was a well known biochemist, before he became simply obsessed with the ancient science and technology of China for almost half a century. But few people know that he was equally impressed by the achievements of India in the field of knowledge and learning. In his lecture to the students of Cambridge University in 1963 he gave full compliments to India s intellectual heritage. He said, it is good to remember, therefore, that our own pious founders were not the only men, and that Christiandom was not the only culture, to set on foot great and noble institutions of learning where successive generations of students assembled to get the benefits of education and research. When the men of Alexander the Great came to Taxila in India in the fourth century BC they found a university the like of which had not then been seen in Greece and was still existing when the Chinese pilgrim Fa-Hsien went there about AD 400. Later the torch of learning moved to Buddhist Nalanda in Bihar, as we know from the account of that other great pilgrim Hsuang-Chuang in the seventh century. In China the foundation of the Imperial University goes back to 165 BC and by the beginning of the Christian era it had no less than 3,000 students. In turning to the arts and sciences of Arabic culture, Needham reminds his listeners of a provocative Islamic saying, the ink of science is more precious than the blood of Martyrs . Emphatically deprecating the Eurocentric ways of thinking, Needham wants them to be humble and asks, How are we to look upon all these achievements of people who were neither British nor European, neither Christian, nor white ? Today, at a time when international political tensions are intermingled with racial factors, it is more than ever essential that we approach people of other cultures with the conviction that they have at least as much to give us as we have to give to them (Mansel 1990).

About the significance of his contributions, we would also like to quote from Sivavishvanathan s (2001) scintillating review of Needham s work and philosophy. Sivavishvanathan says,

> Civilisationally it was Greece that was the origin and source of myths. Prometheus, Narcissus, Oedipus, Athena dominate the imagination, becoming the equivalents of Maxwellian demons in the way they determine our narrative. Greece was origin, Greece was a cornucopia of myths. Yet Greece was a kind of ethnocentricity. Ethnocentricity is a style of pre-empting narratives. When you talk of the origin of intellect, you begin with Greece. When you write a genealogy of science, first is Greece. The Arabs, the orient, the tribal are also-rans. What Needham realizes inventively is that what one needs is not an unravelling of one myth, but an exorcism of Greece itself. The category Greece had to be relativized through the idea of siblingship.
>
> Needham realized that Western science in relation to the other has been hegemonic, particularly in relation to traditional knowledge. The other was never scientific. Whether it was systems of medicine or architecture or agriculture, the other always fell short.
>
> Equally public was his celebration of China. The rhetoric of strategies he uses here is fascinating. Needham wishes to persuade us that China was a source of fecund ideas, of inventions, and he

presents a monument of archives to sustain this. In his work, China is the lost sibling, twin, other, mutant. China is also that which will redeem the West.

> Needham's*Science and Civilization* stands as one of the great monuments of the twentieth century. While it is monumental, it cannot be treated as a monument. It is not a statue on which an intellectual sparrow can inflict itself and move on. It is more like a Henry Moore sculpture, to be explored, opened up, shuffled again, gossiped about. It is a celebration of life and the plurality of cultures. It is an open work full of ambiguities, contradictions, and yet, because it was always crossing boundaries, it became a protean work, an archive of a civilization that becomes an invitation to the future.

4. HISTORY OF SCIENCE AND INFINITY FOUNDATION

Towards the end of the talk, I would like to invite your attention to the efforts made by Infinity Foundation to correct the Euro-centric bias. It is done by dissemination of India s scientific legacy through essays, reviews, bibliography and other features. It has sponsored seminars on Traditional Knowledge Systems to be held in India in 2002 and 2003. It has also commissioned six books covering different aspects of science and technology, and about a dozen more titles on other themes are being negotiated. It also proposes to make popular CDs, VCDs and booklets to disseminate the contributions of India towards the world science. There is a proposal to start a full-fledged journal of Traditional Knowledge Systems and other Indic studies, and also a small research centre.

5. CONCLUSION

We have tried to peep into the rich scientific heritage of India, by removing the thick colonial incrustations. We did highlight some of the main contributions of India to the world science. We have tried to argue that India was technologically and industrially far superior to Europe before the 19th Century. Despite such great strides made both by India and China, why did we lag behind? There may be many reasons for it, but the main cause was that the British deliberately dismantled India s scientific and industrial infrastructure.

We have also to remember that science does not begin with civilisation. It goes back to hunter-gathering societies. Only later it gets codified and systematised by the literate societies. The indigenous knowledge is therefore a rich source of science and technology.

But when we are talking about the India s contributions, or Needham talked about China s achievements, are we moving towards a chauvinistic chaos. We would like to emphasise that we want an unbiased global history of science and technology, which gives due recognition to all nations and even indigenous societies. We agree with Sushant Goonatilake (1999: xvii & 258) that we have to move towards a global science. We would like to conclude with his words,

> As the world shifts in its mooring to become simultaneously global as well as local, it is also shifting to Asia. In this shift, India starts with many handicaps. But it has one overarching civilizational advantage. It is the only cultural region to have seriously considered elements of its past intellectual tradition as fodder for its development Nevertheless, it has had some serious discussions on the relation of science and technology to its past. In these discussions, India was

> ahead of the other two major Asian entities - Japan, which essentially rejected its past intellectual tradition, and Marxist-Leninist influenced China, which did the same, except for the more pragmatic uses.
>
> The global future will necessitate cultural inputs from Asian countries. South Asia has a strong potential for this It is both a record of South Asian civilizations contributions, and a cry of and for the future. Therein, I believe, lies a future for South Asia, for Asia, and ultimately the globe.

Varela et al, the authors of *Embodied Mind,* (in Goonatilake 1999: 258), state, It is our contention that the rediscovery of Asian philosophy, particularly of the Buddhist tradition, is a second renaissance in the cultural history of the West, with the potential to be equally important as the rediscovery of Greek thought in the European renaissance. How far this may be true is for the future to decide. However, a strategic alliance of feminist approaches, ethno-knowledge, and regional civilizations knowledge is probably in the making. Through their combined efforts the results of millennia of human enquiry, which have been lost from the Euro-patriarchal view could be resurrected. A true global science, taking into account multicultural politics of facts, would result. Undoubtedly the knowledge system would become less chauvinistic and less parochial, while maintaining the rigor developed in the last few centuries.

Let us hope that conferences like this and the multiple efforts of Infinity Foundation would eventually lead us to a true global science.

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