2012

Science

C. Mackenzie Brown
Trinity University, mbrown@trinity.edu

Hinduism and Science [Science in the published version]

C. Mackenzie Brown

In Hindu temples and cultural centers around the world, a visitor today often encounters not only traditional images of the gods and goddesses of the Hindu pantheon, but also a myriad of posters, panoramas, and brochures extolling the scientific discoveries of ancient Indian, particularly Hindu, seers and scientists. These include discoveries in medicine, chemistry, metallurgy, astronomy, and technology. For instance, the newly constructed, magnificent Swaminarayan Akshardham temple in Delhi boasts of a Disney-like underground boat ride during which visitors view displays of "the discoveries and inventions of the rishi-scientists of India" (Akshardham, 2005). Two of the dioramas "feature plastic surgery and a helicopter, showing the scientific advances of early Hindus" (Hamilton, 2011). I first encountered this phenomenon at the Hindu Temple of San Antonio. The Temple has displayed a number of science-posters published by the Hindu Swayamsevak Sangh, USA. One such poster cites the fifth-sixth century Indian mathematical astronomer Āryabhaṭa as effectively proposing the heliocentric model of the solar system (see fig. 1); another poster proclaims that Ayurveda "originated in the Vedas" (see fig. 2).

The point of these science displays and literature is clear: Hinduism is scientific in spirit, has a long history of scientific discovery, is fully compatible with modern science, and—though not always stated in such contexts—the most scientific religion in the world. This latter claim, with specific reference to the monistic strand of Hinduism known as Advaita Vedānta, was made famous by Swami Vivekananda (1863-1902) at the World's Parliament of Religions held in Chicago in 1893 (Brown, 2011, 209). The theme of harmony between Hinduism and modern science has become an important expression of contemporary Hindu identity and cultural self-

affirmation and is a common perception especially among urban professional Hindus in the U.S. and in India. This view, along with such notions that Hinduism is more a way of life than a religion and that Hinduism stresses religious tolerance, "have become so common that they comprise a 'generic Hindu' outlook that is unique to the late twentieth century" (Narayanan, 2006, 244).

The posters, dioramas, and brochures proclaiming the full harmony of Hinduism and science offer to many Hindus today a contrastive view to the notion of conflict between religion and science frequently seen as characterizing the relation of the Abrahamic traditions to modern science. But such models of harmony or conflict suffer from oversimplification. Both "are really hasty generalizations: there is indeed conflict in some historical periods, but not in others; and the same is true for harmony," according to historian and philosopher of science Maurice Finocchiaro (2001, 114). In addition, both models "tend to presuppose definitions of science and religion which are essentialist, anachronistic, or unhistorical" (Finocchiaro, 2001, 114).

There is currently a predisposition on the part of Hindu cultural nationalists to provide just such essentialist and unhistorical definitions of both religion and science. They regard Hinduism as the *sanātanadharma* (the eternal law, both moral and natural) consisting of truths, principles, and foundational norms that are universal and unchanging. But historically we find a breadth of Hindu perspectives on science, each with its own particular epistemological assumptions and metaphysical framework. These different assumptions and frameworks, themselves changing over time, have significantly impacted the various Hindu conceptions of what constitutes reality, on one hand, and science on the other. In this essay I will use the term *Hinduism* in its broadest sense to cover developments from the vedic period down to the present.

A nuanced and comprehensive understanding of the "Hinduism-science" relationship requires an examination of the social and historical contexts in which the classical and modern Hindu perspectives on science have developed, with special attention to their epistemological assumptions regarding knowledge about the empirical world. Comparison of these epistemic views with the methodological ideals and assumptions of modern science reveals a complex interaction between Hinduism and science that transcends any simplistic notion of harmony or conflict. Additional insights into the historic and contemporary tensions between Hinduism and science will be provided by looking beyond their respective metaphysical and epistemological assumptions to the underlying cognitive foundations of each.

Epistemological Tensions

Let us begin our investigation of the epistemological issues by returning to Swami Vivekananda, who claimed that ancient vedic (Hindu) seers had discovered many truths about both the spiritual and empirical realms. How did they make such discoveries? With reference to various ancient scientific yogis, including Kapila, legendary founder of the Sāṃkhya and discoverer of "evolution," the Swami claims:

> How wonderful his perceptions were, and if there is any proof required of the extraordinary power of the perception of Yogis, such men are the proof. They had no microscopes or telescopes. Yet how fine their perception was, how perfect and wonderful their analysis of things! (Vivekananda, 2003, vol. II, 445)

Vivekananda here reveals a major epistemic tension between his Neo-Advaitin perspective and the methodological approaches of modern science. The former privileges superconscious insight into the subtle workings of the material world, aided by an intuitive-deductive analysis, resulting

in certain knowledge. Modern science emphasizes a constant interplay between hypothesis formulation and empirical testing rooted in recognition of the primacy of sensory observation, itself increasingly extended by sophisticated scientific instrumentation. But the resulting scientific conclusions, aided by logical deductions, are ultimately rooted in inductions based on empirical data and thus remain, at least in principle, forever tentative.

An elder contemporary of Vivekananda, the Hindu nationalist writer B. Chattopadhyaya (1838-1894) called attention to this epistemic tension in a blistering critique of ancient and classical Hindu approaches to understanding the natural world. While noting that Hindu philosophy traditionally "was co-extensive in meaning with the knowledge of Nature" and "therefore included Science," he went on to observe:

> The Hindu laboured under the disadvantage of an erroneous method. An intense theological spirit rarely leads to anything but the deductive method, and the Hindu method was almost solely and purely deductive. Observation and Experiment were considered beneath the dignity of Philosophy and Science. Nor is even deduction as a rule pushed on its legitimate consequences. First principles are assumed on no grounds, and with the most perfect weapons of deductive logic at his command, the Hindu thinker contents himself with the most fanciful inferences. (Chattopadhyaya,1969, 146)

B. Chattopadhyaya, with his Positivist leanings, was naturally not willing to accept any superconscious technique like yogic perception as a valid means of knowledge.

To illustrate the difference between traditional Hindu approaches and that of modern science, B. Chattopadhyaya cited the example of the Italian mathematician and scientist, Evangelista Toricelli (1608-1647), inventor of the mercury barometer. Toricelli, aware that gardeners in Florence had been unable to raise water with a suction pump higher than ten meters,

reflected that the weight of the atmosphere on the water outside might be sustaining the column of water in the pump tube. He then figured that the same pressure should raise mercury in a tube as well, which he confirmed upon further investigation. And then Blaise Pascal, realizing that there is less atmospheric pressure at higher altitudes, took a column of mercury up a mountain and noted the lower rise of the mercury in the tube. B. Chattopadhyaya concludes:

> A Hindu philosopher in Torricelli's place would have contented himself with simply announcing in an aphoristic *sutra* that the air had weight. No measure of the quantity of its pressure would have been given; no experiment would have been made with the mercury; no Hindu Pascal would have ascended the Himalayas with a barometric column in hand. (Chattopadhyaya, 1969, 146-147)

Turning next to a parallel Indian example, B. Chattopadhyaya notes that the idea of the Earth's diurnal rotation, mentioned in the *Aitareyabrāhmaṇa*, was later affirmed by the great Indian astronomer Āryabhaṭa (b. 476 CE) in his great astronomical work, the *Āryabhatīya*. B. Chattopadhyaya quotes the famous astronomer: "The starry firmament is fixed…it is the earth which, continually revolving, produces the rising and the setting of the constellations and the planets" (1969, 147). But then, B. Chattopadhyaya sadly observes, the only "legitimate" conclusion from these and related "facts," namely the heliocentric model of the solar system, "was never positively put forward—never sought to be proved—never accepted and never followed out to the establishment of further laws of the universe" such as Kepler's laws and the "great law of Universal Gravitation" (1969, 147).

Despite B. Chattopadhyaya dismissal of Āryabhaṭa's proclaiming any robust heliocentrism, there are frequent claims today on the World Wide Web that Āryabhaṭa had proposed the heliocentric theory one thousand years before Copernicus (e.g., "Aryabhatta," 2008; and "Indian

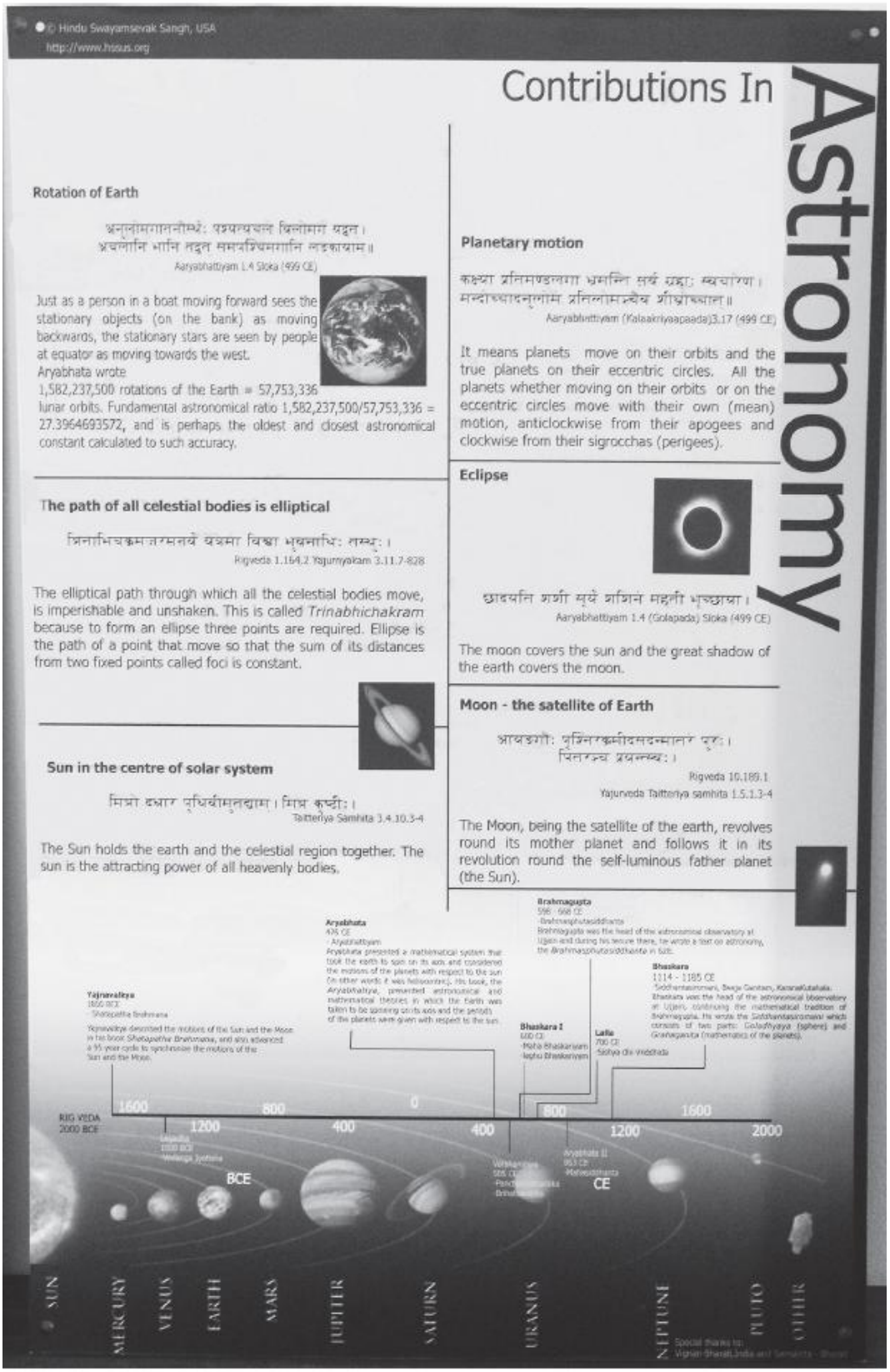

Fig. 1: Science poster on astronomy at the Hindu Temple of San Antonio (photo by C. Mackenzie Brown).

Astronomy," 2005), as well as on science posters such as the one at the Hindu Temple of San Antonio noted earlier. A more serious scholarly argument affirming Āryabhaṭa's heliocentrism has been put forward by the Dutch mathematician, B.L. van der Waerden. To be sure, van der Waerden (1970, 5) acknowledges that Āryabhaṭa did not expressly put forth a heliocentric system, but argues that even apart from his idea of the Earth's daily rotation, other parts of Āryabhaṭa's system indicate that it is based on a heliocentric model. But N. Swerdlow (1973, 241), an historian of ancient astronomy, rejects van der Waerden's claim as demonstrating "a complete misunderstanding of Indian planetary theory and is flatly contradicted by every word of Āryabhaṭa's description". Indeed, while Āryabaṭa recognized the relativity of motion as accounting for the appearance of the stationary stars moving westward for an observer on the equator of the rotating Earth (*Ārya*. 4.9), he also described the spherical earth as "situated in the center of space, in the middle of the circle of asterisms, surrounded by the orbits of the planets" (*Ārya*. 4.5; trans. Clark, 1930, 64 [=4.6]). Even more explicitly, he sets forth the typical ancient geocentric model in which the sun occupies the fourth celestial sphere—between Mars and Venus—above the stationary earth at the bottom or center, which Āryabhaṭa likens to a threshing post to which are tied circling oxen, representing the celestial bodies: "Below the asterisms lie Saturn, Jupiter, Mars, the sun, Venus, Mercury, and the moon, while the earth is below all of these, like a threshing post, in the center of space" (*Ārya*. 3.15; my trans.). And he utilizes epicycles (*vṛttas*) to explain various planetary phenomena, epicycles being relevant only in geocentric schemes of the universe (*Ārya*. 3.19-21). Āryabaṭa further states that the asterisms with the planets are blown westward by the "planetary wind" (*pravaha; Ārya*.4.10). Thus his proposal of a rotating Earth is irrelevant to the rest of his work, neither simplifying nor helping to explain any other ideas in the *Āryabhaṭīya* (Chattopadhyaya, 1996, 33). He seems to have taken

the idea of a planetary wind, and possibly even the axial rotation of the Earth, from puranic cosmology, without integration into the rest of his mathematical astronomy (Chattopadhyaya, 1996, 33). W.G. Clark, commenting on Āryabhaṭa's claim for a rotating Earth and stationary asterisms, notes: "Later writers attack him bitterly on this point. Even most of his own followers…refused to follow him in this matter and reverted to the common Indian tradition" of a stationary Earth (Clark, 1930, xiv). Thus W.G. Clark confirms in part Bankimchandra's own assessment of the lack of scientific temper—or at least scientific perseverance— in ancient India.

In one sense, the exact nature and validity of Āryabhaṭa's propositions, especially as judged by modern criteria, are beside the point and may distract from the underlying methodological issues at stake. To illuminate such issues, we need to turn to the social and cultural contexts in which Āryabhaṭa, and other ancient Indian scientists, carried out their work. Let me pose three questions directly relevant to any discussion of the Hindu-science relationship in ancient India, and which will help illuminate aspects of the contemporary Hinduism and science discourse. These questions are the following: (1) To what extent did ancient Indian sciences derive from vedic religion? (2) To what extent was ancient Indian science Hindu science? And (3) to what extent did ancient Indian science share, not necessarily the conclusions of modern science, but its methodological perspective? We shall begin with a look at ancient Indian astronomy and Āryabhaṭa's special role in the history of that science, and then look briefly at ancient Indian medicine.

Hinduism and Astronomy in Ancient India

B.V. Subharayappa, historian and philosopher of science, regards ancient Indian astronomy as derived from vedic seers. He first emphasizes that the vedic sages had an intuitive

understanding of the universe as an ordered cosmos governed by "Vedic natural laws" encompassing both the moral and physical realms (Subharayappa, 2011, 196). Within this framework of vedic natural laws, astronomy assumed great importance to the vedic priests for ascertaining the proper times for various ritual and sacrificial performances. B.V. Subharayappa thus concludes: "Vedic astronomers generally belonged to a priestly class" who engaged in "prolonged observation of recognizable star-groups" (Subharayappa , 2011, 197). Turning to Āryabhaṭa, B.V. Subharayappa observes that his astronomical treatise, the *Āryabhaṭīya*, "states that the science of astronomy is a revelation from the creator Brahma, but apart from this passing allusion, there are no further references to religion" (Subharayappa , 2011, 197). (Āryabhaṭa declares that "this universally true science of astronomy… formerly was revealed by Svayambhū [Brahmā]" [*Ary.* 4.50; trans. Clark, 1930, 81].) Given the lack of references to religion, one is left wondering how vedic, or Hindu, Āryabhaṭa's astronomy really was—and perhaps how vedic the astronomy of ancient India in general was.

The great historian of ancient Indian science, D. Chattopadhyaya, takes a very different view of Indian astronomy, and of the astronomers of vedic times in particular. Like B.V. Subharayappa, D. Chattopadhyaya notes that the early astronomical texts—those of *jyotiṣa*, the Vedāṅga ("limb of the Vedas") dealing with astronomy—were used by vedic priests for determining auspicious times for their ritual performances. And he acknowledges that these texts also record remarkable observations of the positions and movements of the sun, moon, and various constellations. He regards those who made such observations as "taking the first step to astronomy" (1996, vi). But D. Chattopadhyay next claims that it could not have been the vedic priests themselves who took this step, as their theoretical orientation was quite different, being "quasi-religious and quasi-magical" (1996, vii). He points out that the priestly literature

repeatedly condemns direct observation in preference for "the obscure and mystic" (1996, vii). He speculates that the observational astronomical tradition pre-dates the arrival of the vedic peoples in India, and was possibly derived from the agricultural Indus Valley Civilization, where such observations were necessary for creating a farmer's calendar (1996, viii).

As for Āryabhaṭa, D. Chattopadhyaya, like B.V. Subharayappa, calls attention to the astronomer's statement that the science of astronomy was of divine origin (1996, x). But D. Chattopadhyaya notes a different tone in the *Āryabhatīya* text that B.V. Subharayappa overlooks, a tone that provides an explanation for why, in B.V. Subharayappa's words, "there are no further references to religion." As D. Chattopadhyaya explains:

> …as contrasted with the prevailing practice of proclaiming the astronomical views as but divine revelation Aryabhata boldly asserted that his book was of human origin, i.e. worked out by himself. This he announced in the very title he chose for his book, *Aryabhatiya*.
>
> (Chattopadhyaya, 1996, x)

D. Chattopadhyaya further points out Āryabhaṭa's delcaration (see *Ārya.* 4.49) that his astronomy, while it might be from the grace (*prasāda*) of God, was actually "the product of his own intellect [*mati*]" (Chattopadhyaya, 1996, x).

D. Chattopadhyaya extols Āryabhaṭa's achievement as surpassing that of all European astronomers until the time of Copernicus. Yet as D. Chattopadhyaya and W.G. Clark have pointed out, Āryabhaṭa was largely neglected by his Indian successors. Chattopadhyaya argues that the subsequent ignoring of Āryabhaṭa's work was due to his disregard of the prevailing "Brahmanical speculations and assumptions" (Chattopadhyaya, 1996, xi). Such disregard, D. Chattopadhyaya proposes, may well have been due to Āryabhaṭa's low-caste status, a status indicated by the "Bhaṭa" in his name. D. Chattopadhyaya then asks, might not Āryabhaṭa, being

possibly subjected to discriminatory treatment under Brahmanical class norms, have become "cynical of Brahmanical orthodoxy as such, and discarding the theological bias of the divine origin of astronomy worked for the development of a secular view of the science?" (Chattopadhyaya, 1996, xi). D. Chattopadhyaya finally suggests that Āryabhaṭa might have gained his remarkable learning and intellectual independence by accepting the Buddhist teachings that shunned prejudice against the lower castes. While D. Chattopadhyaya admits that such a suggestion is hard to confirm, he claims it is bolstered by the fact that another member of the low caste, another "Bhaṭa," the famous physician Vāgbhaṭa, came from a family of Buddhist doctors. Let us then turn to the case of the ancient Indian physicians and their possible ties to Buddhism, and to heterodox traditions in general.

Hinduism and Medicine in Ancient India

The early twentieth-century German Indologist, H. Zimmer, was rather ambivalent about the relationship of Buddhism, or at least its founder, to the Indian medical tradition. On one hand, he claims that the Buddha (ca. 500 BCE) modeled his teachings of salvation or spiritual healing upon the "the attitude of the Hindu physician" towards physical healing (Zimmer, 1948, 32). On the other, he remarks that the Buddha did not resort to the approach "of the priestly teacher," but rather "adopted the standpoint of a medical man on the spiritual plane" (1948, 34). Left unclear is the general identity of "the medical man," specifically, the extent to which he was really a "Hindu physician."

D. Chattopadhyaya is not ambivalent at all. The Indian medical tradition, in his view, developed initially largely outside of and in opposition to the priestly, vedic schools and their magico-mystical notions of healing. He readily acknowledges that a certain amount of

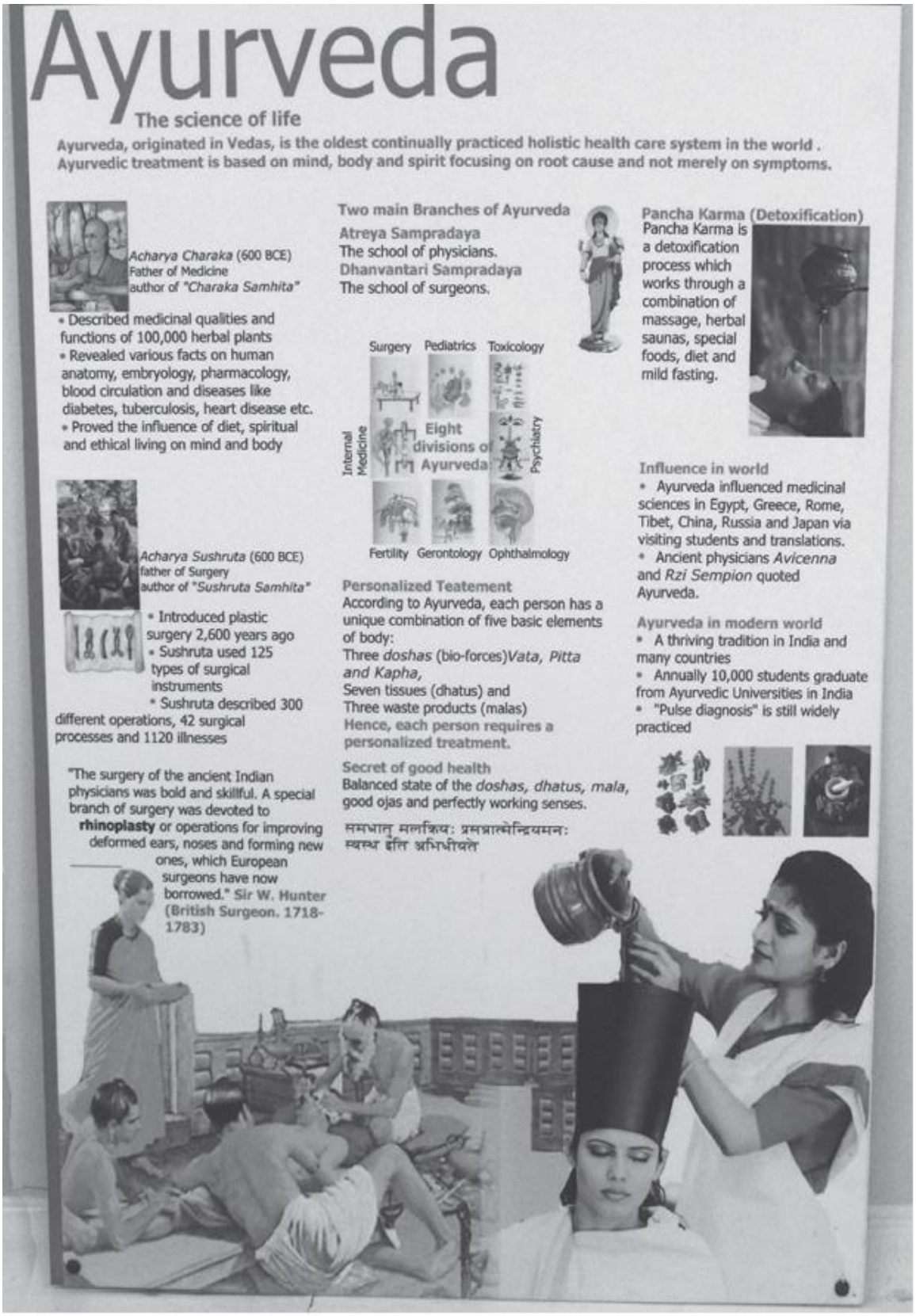

Fig. 2: Science poster on Āyurveda at the Hindu Temple of San Antonio (photo by C. Mackenzie Brown).

anatomical knowledge, so essential to the training of physicians, was gained from the ancient Brahmanical animal sacrifices, but such knowledge as was discovered led nowhere:

> the sacrificial slaughter of animals must have made available to the priests some amount of empirical data, which, rightly processed, could have developed into proto-anatomy of [the] ancient period. But the fact is that this did not and could not develop in this direction. (Chattopadhyaya , 1978, 274)

D. Chattopadhyaya attributes the scientific fruitlessness of vedic anatomical knowledge to the Brahmanical custodians of this knowledge who were "interested only in the monstrous mystification of it, so that it becomes part of their awe-inspiring ritual technique" (1978, 275). He then cites the *Śatapathabrāhmana* passage that indulges in correlating the parts of the sacrificial fire altar with the various parts of the animal body, concluding that in this ritual-mystical "rigmarole" not even a "semblance of interest in anatomy proper" remains (1978, 275).

The promotion of obscure, mystical knowledge in the ritualistic Brāhmaṇa literature was further developed in the metaphysical doctrines of the Upaniṣads, according to D. Chattopadhyaya. Their emphasis on a supra-rational and anti-rational approach to knowledge culminated in the idealist teachings of the Advaitin Śaṅkara and his rejection of reason (*tarkā*) as an independent means of knowledge, while accepting it as possibly useful "to rationalise what is already revealed in the scriptures" (Chattopadhyaya, 1978, 202).

In opposition to these antireason, antiscience perspectives of the metaphysicians, the actual physicians were developing a rational-empirical medical science in which observation and logical inference from the data were essential. Not only was such an approach based on an epistemology rejected by metaphysical orthodoxy, but the empirical methodology also involved contact with persons and substances considered polluting by the priestly authorities. We thus

find many condemnations of medical practitioners in the metaphysical literature and law codes of the Brahmanical authorities Chattopadhyaya, 1978, 97-98, 212-218; see also Zysk, 1991, 5). The French Indologist J. Filliozat claimed that such condemnations merely reflected a sectarian rivalry between two Vedic schools: "…one may believe that the *Taittirīyas* have fired a passing shot at the rival school of the Carakas…" (1964, 21). He connects the alleged Vedic "Carakas" with a medical lineage that eventually produced the great compilation of the *Carakasaṃhitā*. D. Chattopadhyaya soundly refutes such an interpretation. He argues that Filliozat ignores, even conceals "the fact that with the growth of the hierarchical aspirations in the Vedic tradition there takes shape an ideology that proves inimical to medicine or ancient science in its most promising form" (1978, 262). K.G. Zysk, renowned scholar of Indian medicine, sides with D. Chattopadhyaya:

> Chattopadhyaya has shown this view [of Filliozat] to be untenable and asserts that the root cause for priestly contempt of physicians derived from a clash of philosophical perspectives between medicine's fundamental empiricism and the priestly ideology that emphasized esoteric knowledge. (Zysk, 1991, 23-24)

So who were those ancient Indians who took the first steps to develop a rational-empirical medical science? During the several centuries between 800 and 100 BCE, this radically new approach to healing was pioneered by "wandering physicians" who were excluded from Brahmanical circles (Zysk, 1991, 5). Ostracized by the orthodox hierarchy, they found acceptance among the heterodox groups of ascetic mendicants, and "unhindered by brāhmaṇic strictures and taboos, began to conceive an empirically and rationally based medical epistemology " (Zysk, 1991, 5). The means and goals of these new medical healers shared an affinity with the Buddhist ideal of the Middle Way, of avoiding extreme self-denial and

maintaining bodily health in equilibrium with the environment. K.G. Zysk points out that the "symbiotic relationship between Buddhism and medicine" not only facilitated the spread of Buddhism in Asia, but also led to Buddhist monastic communities playing a major role in "[t]he codification of medical practices within the monastic rules [which] accomplished perhaps the first systematization of Indian medical knowledge" (1991, 6). He summarizes the relationship between the wandering renunciants and the new breed of physicians:

> The connection between heterodox, particularly Buddhist, asceticism and medicine is perhaps best illustrated through anatomy. The approach of the early Buddhists and the physicians to an understanding of the human body reflects both a commitment to materialism through empiricism and rationality and a firm rejection of brāhmaṇic orthodoxy. (Zysk, 1991, 34)

Regarding the attainment of anatomical knowledge, one of the earliest accounts of how to perform a human dissection is provided in the *Suśrutasaṃhitā* (extant form dating to the seventh century CE at the latest [Chattopadhyaya, 1978, 43-44]). This text insists upon the necessity of direct observation (*pratyakśa* [*SuśrSa.* 3.5.53]) of the body, including the dissected corpse. The *Suśrutasaṃhitā* gives explicit directions for preparing a body for dissection, including the squeezing out of excrement from the intestines (*SuśrSa.* 3.5.54; quoted in Chattopadhyaya, 1978, 95; Zysk, 1991, 35-36). As D. Chattopadhyaya points out, such instructions fly in the face of the Brahminical advocacy of reliance on scripture, as well as flouting orthodox purity rules (1978, 97; see also Zysk, 1991, 36).

The *Suśrutasaṃhitā*, along with the *Carakasaṃhitā* (extant form dating to around the fourth to sixth centuries CE [Chattopadhyaya, 1978, 32]) are the two major classical texts of Ayurveda, often seen as epitomizing traditional "Hindu" medicine. D. Chattopadhyaya notes

that "[t]he form in which the source-books of Indian medicine reaches us is apparently very strange. It is the assemblage of science and its opposite" (1978, 363). The French anthropologist F. Zimmermann also notes the intermingling of "the medical discourse" with "the imaginary," and sees these as part of a "single, homogenous discourse" (1987, 208). Thus, for him, such distinctions have been introduced by western interpreters who fail to see that "Ayurveda must be taken en bloc: it stands as a whole and single 'myth,' a whole and single 'science'" (Zimmermann, 1987, 208). While he sees myth and science as a single entity in traditional cultures, he also notes that such myth-science is quite different from modern science. For instance, regarding traditional Indian classifications of animals as found in the ancient bestiaries and reflected in ayurvedic catalogues, he first observes that there is "a lack of differentiation between the real and the fabulous and a subordination of the biological to the spiritual" (Zimmermann, 1987, 196). Then he makes the following conclusion: "But I fear that there is no masking the fact that India proceeded no farther than the bestiary, whereas others [in the Greco-Latin tradition] managed to escape from the enchantments of *dharma*, that ritualistic vision of the universe, and invent the natural sciences" (Zimmermann, 1987, 196). Accordingly, in traditional Hindu classifications of animals, which were pervaded by the idea that all are subject to the cycle of rebirth, "the position of each category of beings is fixed by its function in the system of *ritual* activities," with minimal reference to "strictly *biological* classification" (Zimmermann, 1987, 196).

F. Zimmermann's emphasizing the different conceptions of science in traditional and modern societies reminds us of M.A. Finocchiaro's caution about the use of "essentialist, anachronistic, or unhistorical" definitions of both science and religion. At the same time, more than one conception of what constitutes science may exist in any given society. While the extant

texts of the classical Ayurveda may represent some sort of myth-science, the actual history of the texts and their internal contents points to a different explanation from F. Zimmermann's for the intermingling of the medical and the imaginary. For the texts have undergone repeated editing, some parts being lost while others have been added, and there is no assurance that the various editors, redactors, and compilers had the same goals in mind. This becomes especially clear in light of the two contrasting and irreconcilable epistemologies in the texts themselves: the mystical-magical of Brahminical orthodoxy, and the naturalistic methodologies of the wandering physicians.

Like the *Āryabhatīya*, the extant Ayurvedic texts are said to be divinely revealed. But as G. J. Meulenbeld says, "the divine character of *āyurveda* has been imposed upon it during a particular state of its development and has not always been one of its characteristics" (2001, 2). To the extent that Āyurveda is regarded as revealed, he suggests, it is not really science, as it tends towards a closed system not open to "the progressive acquisition of knowledge" (Meulenbeld, 2001, 3). But it was not completely closed, and thus "the doctrine of its divine origin does not belong to its hard core" (2001, 3). K.G. Zysk similarly argues:

> Probably during the early centuries of the common era, Hinduism assimilated the storehouse of medical knowledge into its socioreligious intellectual tradition and by the application of an orthodox veneer rendered it a brāhmaṇic science. (Zysk, 1991, 6)

Likewise, D. Chattopadhyaya regards the orthodox veneer as a defensive reaction by the physicians, "a show of apparent piety as a protective crust for science" (1978, 363). He provides several examples from the *Carakasaṃhitā* that deal with spiritual liberation, but he sees these as merely "salvation superimposed on healing" (Chattopadhyaya, 1978, 372). Regarding these references to salvational knowledge, he concludes: "Though redundant to medicine, their

presence in the medical corpus is not purposeless, for they are presumably of the nature of ransom offered to the counter-ideology without which it is not easy for the doctors to save their science" (Chattopadhyaya, 1978, 375). At the same time, it was greatly to hinder the further development of medical science. It was apparently not until 1836, at the new, British-established Calcutta Medical College, that Hindu medical students again began to dissect human cadavers as part of their training in practical anatomy—thereby ushering in modern, "rational scientific medicine in India" (Bhattacharya, 2011, 1227). Nonetheless, the ancient texts, especially the *Carakasaṃhitā*, retain the criteria for separating superstition from science (Chattopadhyaya, 1978, 201-209). These criteria include commitment to empiricism, causal law, rigorous reasoning, and "intra-disciplinary discussion and debate" (Chattopadhyaya, 1978, 208)—the latter perhaps an ancient equivalent to today's peer review. The tensions apparent in the *Suśrutasaṃhitā* and *Carakasaṃhitā* between Brahmanic orthodoxy and medical empiricism point clearly to the fact that religion and science are social practices, at times overlapping, but often resulting in conflict, however veiled (compare Stenmark, 2010, 292).

I noted above that Śaṅkara subordinated reason to scripture. All the Vedāntic schools, including Advaita, subordinated not just reason, but perception as well, effectively enshrining a critical epistemic tension between Vedānta and modern science. Deepening this tension was the notion put forth by some philosophers such as Udayana of the Nyāya-Vaiśeṣika school that there are two kinds of perception: supernatural (*alaukika*) and ordinary (*laukika*; Brown, 2012, 45). The former, call it transcendent vision, intuition, or yogic perception, available only to the disciplined and virtuous, provides direct and immediate experience of God and reality, unmediated by reasoning or scripture. At the same time, Nyāya and other philosophers critically

examined the epistemic liabilities of experience in general, including such direct experience as yogic perception.

In concluding this section on ancient and classical science in India, let me draw once again on D. Chattopadhyaya. He calls attention to a very early debate in Hindu philosophical speculations regarding the ultimate causal agents underlying the manifest universe. In the *Śvetāśvataropaniṣad* (6.1-2) the possible agents named include God, time, chance or accident, and innate nature (*svabhāva*) (Chattopadhyaya, 1991, 55-61; see also Brown, 2012, 15-16). This latter view insists that the universe and its constituent elements evolve by their own inherent power and causal efficacy, independent of any manipulating God or emanating supernatural consciousness. This naturalistic perspective, D. Chattopadhyaya reasonably asserts, underlay the development of natural science in classical times, and is clearly seen in the case of early Indian medical science (1991, 70). D. Chattopadhyaya further comments: "In the clash between 'the doctrine of God' and 'the doctrine of nature'[*svabhāva*], therefore, we have perhaps the earliest glimpse of the conflict between religion and science that took place in Indian history" (Chattopadhyaya 1991, 60).

Yet outright conflict may not have been inevitable. While the *Śvetāśvataropaniṣad* may have pointed to a clash, the *Muṇḍakopaniṣad* suggests another possible model for the Hinduism and science relationship. The *Muṇḍakopaniṣad* (1.1.5) sets forth the notion that there are two *vidyās* or "sciences" hierarchically arranged. The higher knowledge (*parāvidyā*) is that "by which one grasps the imperishable [*akṣara*; the ultimate reality known generally in the Upaniṣads as *brahman*]" (Olivelle, 1998, 437). The lower (*aparāvidyā*) consists of the four Vedas and their six traditional ancillary limbs: phonetics, rituals, grammar, etymology, prosody, and astronomy. The lower science, or sciences, incomplete in themselves, promotes attaining

knowledge of the higher science of *brahman*. This line of thought was further developed by Śaṅkara, who posited two levels of knowledge—(1) the worldly, in which subject and object are experienced as separate, and (2) the ultimate level in which one realizes the unity of all being, the identity of subject and object, of self and *brahman*. Perception and inference are competent only for dealing with the somewhat illusory empirical world but fail to warrant any metaphysical truth (Hiriyanna, 1932, 358). This subordination model, while perhaps avoiding outright warfare, hardly provides much inducement for the pursuit of the lower natural sciences, nor does it eliminate possible incompatible teachings about the empirical world on the part of religion *vis-à-vis* scientific claims, whether the religious teachings are derived from scripture or from inspired visions of ultimate reality. In the colonial period the "two sciences" model was to be taken up and revised by Hindus as a major strategy in dealing with the challenges of modernity and modern science arriving from Europe.

Hinduism and Science in the Colonial and Postcolonial Periods

Many of the epistemological and metaphysical issues of the ancient and classical periods lay dormant for many centuries, until the coming of the Europeans. Under colonial rule, these issues soon revived, as the English-educated Hindus faced the dilemma common to "any elite that accepts the task of integrating the religion, the values, and the social systems of a traditional society with the thought and practices exported from the colonial centres in Europe" (Brekke, 1999, 204). Among the many challenges, that of modern science with its inherent skepticism towards traditional knowledge, along with the accompanying technology, was the most momentous (Halbfass, 1988, 399).

B.V. Subharayappa notes that the first impression Indians had of "western science" was through the various "botanical, zoological, geological, meteorological, and geographical" surveys commissioned by the colonial administration (2011, 199). He adds that "[t]he European investigators brought with them a commitment to experimentation, observation, and rational thinking. Their superior methodologies highlighted the inherent weakness of traditional knowledge" (Subharayappa , 2011, 199). The Indian elite in the nineteenth century sensed their own current scientific backwardness, combined with an intense admiration of, and an often unquestioning acceptance of the authority of modern, evidence-based science. These attitudes intermingled with the conviction that India's subjection to and oppression by western colonial power was due, at least in part, to the West's superior mastery of science and technology.

The conviction of their scientific inferiority soon led the Hindu elite to call for British investment in science education for the natives. As early as 1823, Rammohan Roy petitioned the British administration for the instruction of Indians by European teachers in the subjects of "Mathematics, Natural Philosophy, Chemistry, Anatomy, and other useful sciences…" (Roy, 1978, 472). At the same time, Roy insisted that the world was indebted to India where the knowledge of science, as well as of literature and religion, first dawned (1978, 906; Brown, 2012, 87). With Roy we see the first manifestation of one of the overriding problems pervading the Hinduism-and science-discourse in colonial India: the tension between the image of science as a free and universal inquiry "unaffected by its historical and cultural locations," on one hand, and its advancement of such claims "only in its particular history as imperial knowledge," on the other (Prakash, 1999, 71).

To meet the challenges posed by modern science, Hindus developed various modes and models of cultural negotiation in their attempt to reaffirm traditional religious and social values

within some sort of universal, scientifically sanctioned—or at least scientifically compatible—framework. We find among the various negotiating strategies six persistent and often interrelated or overlapping themes (compare Halbfass, 1988, 399).

The first and perhaps earliest was that India was the fountainhead of all sciences and culture, although such a magnificent past is obscured by India's present state of degeneration. This notion, as we have seen, was already proffered by Rammohan Roy and reflected the idea of an ancient Vedic Golden Age proposed by European Orientalists early in the nineteenth century. Later elaborations of this model led to the idea of vedic science and the radical scientizing of the vedic tradition, finding in the ancient scriptures such modern technological inventions as electricity, airplanes, telegraphy—as in the writings of Dayananda Saraswati—and more recently, transplant surgery and subatomic physics. Basic scientific discoveries were also uncovered in the ancient scriptures and sayings of the seers, including, the law of gravity, of the conservation of energy, and of evolution—the latter two emphasized in Vivekananda's writings. Advocates of vedic science seek to find vedic equivalents to modern scientific ideas and discoveries, but are almost always forced to make quite arbitrary and unconvincing linkages based on highly subjective textual interpretations, or rely on vague surface similarities.

A second approach called for mutual supplementation often involving the idea of exchange between India and the West. Europe could teach to India its science and technology, while India could benefit the West with its spirituality, an approach well exemplified by Vivekananda. While impressed by the dazzling radiance of evidence-based "Western" science and its potential to help India's poor, Vivekananda took it upon himself to bring the wisdom of Vedānta to what he saw as the spiritually impoverished West (Brekke, 1999, 204). A variant of this perspective was to advocate the adoption of western technology but to eschew the "scientific

temper" with its corrosive skepticism and materialist predisposition—an approach evident in the contemporary Hindutva movement and dubbed by Meera Nanda as "reactionary modernism" (2003, 37).

A third strategy was to disarm Western science by relegating it to a sphere outside or below a higher, spiritual science. This was accomplished in part by acknowledging the superiority of European study of the external world, but insisting on the pre-eminence of Hindu investigations of the inner world of consciousness. This resonated with and was accommodated to the ancient *Muṇḍakopaniṣad* idea of two hierarchical sciences, resulting in the notion of a higher, spiritual science and a lower, material (modern, "Western") science. Modern science is thus not wrong but limited.

This model of two hierarchical sciences we already see developing with Debendranath Tagore (1817-1905), who maintained that God is invisible to the outer senses but visible to the inner eye of knowledge. This inner eye he commonly referred to as intuition based on inner conviction (*ātmapratyaya*), which itself is grounded in our innate knowledge of god (Brown, 2012, 97). Debendranath's notion of inner conviction utilizes European ideas of intuition and self-evident truth, and is a radical reinterpretation of the Upaniṣadic notion of inner conviction focused on non-dual knowledge of the one Self (Halbfass, 1988, 224, 396, 570n). He then related this to the notion of the two *vidyās* of the *Muṇḍakopaniṣad*: the higher knowledge of the ultimate attained through intuition, and the lower knowledge of the empirical and rational sciences. He expanded the lower sciences to include such natural sciences as geology, medicine, and psychology, as well as philosophy and theology (Halbfass, 1988, 98). This model of the two hierarchical sciences was further developed by Vivekananda and became a standard strategy of twentieth- and twenty-first-century Hindus dealing with the challenges of modern science,

especially Darwinian evolution. Interestingly, recent researches in consciousness or meditation studies have sought to obtain verification from the natural sciences of the contemplative truths of the inner science and thus to prove "the concordance of both approaches" (Halbfass, 1988, 399).

A significant modification of the two-sciences model, in which the methodological approaches of science and religion are equated, results in a further scientizing of tradition encompassing both substantive claims and epistemic processes. This modified version, the fourth approach, identifies yogic or contemplative experience with scientific empiricism. Religion and science are thus viewed as one, not as two different sciences (compare Prakash, 1999, 76-77). But whereas scientific empiricism is conjoined with rigorous peer review and an openness to disconfirming evidence and arguments, yogic experience is not similarly open-ended. Rather, yogis, while at times comparing subjective experiences, have no real means for testing the true equivalence of such personal experiences, and in any case, are strongly predisposed merely to confirm truths already known and promulgated by the ancients (Brown, 2012, 230-231). In addition, different contemplative traditions frequently come to radically different conclusions regarding what the nature of the reality is that is immediately experienced. The Hindu classical tradition was well aware of the problematic nature of personal experience and of the psychological sense of certainty that may result from such experience. In particular, Nyāya-Vaiśeṣika thinkers did not fail "to distinguish very clearly between psychological factuality and epistemological validity" (Halbfass, 1988, 394).

The fifth strategy, not so common but still significant, was selectively to accept certain findings of modern science while rejecting others as either not scientific, or at best, misinterpretations of scientific data. Thus, cosmic evolution may be acceptable, while organic evolution is not—as seen in Dayananda Saraswati and his followers, and among later

conservative theistic movements like International Society for Krishna Consciousness and the International Society of Divine Love.

The sixth and last strategy developed by the Hindu elite was to accept the superiority of modern science to traditional forms of knowledge, while still finding aspects of the tradition that were not in conflict with modern science (Prakash, 1999, 57-58). Such was the approach of B. Chattopadhyaya, whose critique of ancient Indian science we have already encountered. At the same time, he saw in the Hindu Trinity of Brahmā, Viṣṇu, and Śiva a doctrine of creation, preservation, and destruction in accord with Darwinian theory, in contrast to what he saw as conflicting Christian notions of an omnipotent god (Prakash, 1999, 57-58; Brown, 2012, 77).

Regarding certain of these strategies, D. Chattopadhyaya notes that the attempt to read modern science into the Vedas, on the basis of the supposed penetrating intuitive insights of the ancient seers, was understandable in the colonial period. But such a perspective in post-Independence times "has lost its relevance" and is "a factor inhibiting the real development of modern science in India" (Chattopadhyaya, 1986, 399).

Conclusion: Social Contexts and Cognitive Foundations

M.A. Finocchiaro stresses that the relationships between science and religion have been "much richer and more complex than the notions of conflict and harmony can convey" (2001, 114-115). He notes that recent scholarship has suggested a wide variety of possible relationships between the two ventures, including separation, dialogue, integration, and subordination. And within these, there are many more significant distinctions. The Hindu traditions nicely illustrate these complex, and changing, relationships.

At the same time, we have found that among the various conceptions of science and/or knowledge emerging at various times in India's history, something akin to the modern notion of science as a rational-empirical enterprise has been present from ancient times. And both in classical and colonial/post-colonial periods, strategies were developed to deal with conflicts and tensions, in order to effect some sort of reconciliation. The orthodox Hindu philosophers of the classical period were able to diminish tensions by comprehending natural science and its radical epistemic methods within an overarching and supernaturalistic metaphysical framework that effectively tamped down conflict, but at the price of undermining the scientific enterprise. Conflict was concealed. Science is a fragile social enterprise, and it was simply not sufficiently robust in ancient and classical times to withstand the Brahmanical takeover. During the last two centuries, science has been too impressive, successful, if you will, both in its prowess in creating technological spinoffs and in its ability to explain the natural world to be dismissed or disarmed in quite so facile a fashion.

To explain the fragility of the scientific enterprise, the philosopher of science R.N. McCauley points to the cognitive foundations underlying both science and religion. He notes on the one hand that religion is "primarily dependent on the natural proclivities of the human mind," and thus is found in all cultures (2011, 236). Specifically, this natural proclivity includes an extreme sensitivity for detecting intention or conscious agency in phenomena and events that—while serving survival needs—may well over-detect or intuit conscious agency where none exists. Science, on the other hand, is dependent on comparatively rare social arrangements that foster "mastery of both norms of reasoning and radically counterintuitive conceptions" and "public availability of the pivotal processes, products, and evidence" (McCauley, 2011, 236). Science thus requires considerable institutional support, but its disciplined skepticism combined

with its frequent, radically counterintuitive conclusions tends to undermine social, political, and religious (and even scientific) vested interests, thereby risking loss of support and endangering its persistence (McCauley, 2011, 280-281). Such a dynamic is precisely what we see in the development of science in ancient and classical India.

One approach to handling these conflicting interests that currently attracts many within the Hindu community is to adopt an updated version of the two-sciences model, an approach called by S.J. Gould NOMA ("Nonoverlapping Magisteria"). For instance, S. Menon, a researcher in consciousness studies sympathetic to the Advaita Vedānta perspective, proclaims that: "[f]aith is not opposed to reason since they deal with different domains" (2006, 11). More specifically, she regards "reason and experiments" as characterizing the domain of science, while "self-purification," as well as "inner transformation, and ontological insights" she sees as refined means of knowledge pertaining to the domain of religion and spirituality (Menon, 2006, 10). From her Advaita perspective, the supreme reality, the *parabrahman* that is pure consciousness, transcends all dualisms such as matter and spirit, God and world, and thus there can be no ultimate conflict between science and religion.

R.N. McCauley, however, critiques S.J. Gould's NOMA principle as inevitably unsustainable in practice, since religious thinkers of a NOMA bent sooner or later backslide into making empirical claims that invoke the necessary agency of some trans-empirical entity. But this transgresses any strict adherence to the NOMA principle, which regards the trans-empirical agent—and thus its effects in the empirical world— as basically inaccessible by scientific means (McCauley, 2011, 244-245). In the Hindu context, that trans-empirical entity may well be the non-dual Brahman or God of Advaita rather than an extra-cosmic creator god. As Menon states: "Hindu enlightenment is seeing God in every bit of the world…" (2006, 11), but science sees no

such presence, as it is undetectable, and in any case, an unnecessary hypothesis for explaining how the world works. Accordingly, some level of tension seems inevitable between science and religion, including Hinduism, for as McCauley concludes: "Religions presume that the most penetrating accounts of the world will always, ultimately, look to agent causality. Science does not" (2011, 236).

Bibliography

Akshardham, "Photo Gallery," http://www.akshardham.com/photogallery/index.htm, 2005. Accessed 5/25/2012.

Āryabhaṭa, *Āryabhaṭiya with the Commentary of Bhaskara I and Someavara, Critically edited with Introduction and Appendices by Kripa Shankar Shukla*, New Delhi, 1976. Available at: http://www.wilbourhall.org/pdfs/Aryabhatiya.pdf. Accessed 5/25/2012.

"Aryabhatta," at: http://india-awesome.blogspot.com/2008/07/aryabhatta.html , 2008. Accessed 5/25/2012.

Bhattacharya, J., "The first dissection controversy: introduction to anatomical education in Bengal and British India, *Current Science*, 101/9, 2011, 1227-1232.

Brekke, T., "The Conceptual Foundation of Missionary Hinduism," *The Journal of Religious History*, 23, no. 2 (June 1999), 203-214.

Brown, C.M., "Vivekananda and the Scientific Legitimation of Advaita Vedānta," in: J.R. Lewis and O. Hammer, eds., *Handbook of Religion and the Authority of Science*, Leiden, 2011, 207-248.

_____, *Hindu Perspectives on Evolution: Darwin, Dharma, and Design*, London: 2012.

Chattopadhyaya, B., *Bankim Rachanavali*, J.C. Bagal, ed., Calcutta, 1969.

Chattopadhyaya, D., *History of Science and Technology in Ancient India*, Amsterdam, 1978.

_____, *History of Science and Technology in Ancient India: The Beginnings*, Calcutta, 1986.

_____, *History of Science and Technology in Ancient India: Formation of the Theoretical Fundamentals of Natural Science*, Calcutta, 1991.

_____, *History of Science and Technology in Ancient India: Astronomy Science and Society*, Calcutta, 1996.

Clark, W.G., trans., *The Āryabhaṭīya of Āryabhaṭa: An Ancient Indian Work on Mathematics and Astronomy*, Chicago, 1930.

Filliozat, J., *The Classical Doctrine of Indian Medicine, Its Origins and its Greek Parallels*, D.R. Chanana, trans., New Delhi, 1964.

Finocchiaro, M.A., "Science, Religion, and the Historiography of the Galileo Affair: On the Undesirability of Oversimplification," *Osiris*, 2nd Series, vol. 16, 2001, 114-132.

Halbfass, W., *India and Europe: An Essay in Understanding*, Albany, 1988.

Hamilton, A., personal communication, 11 December 2011.

Hiriyanna, M., *Outlines of Indian Philosophy*, London, 1932.

"Indian Astronomy," at: http://www.spacetoday.org/India/IndianAstronomy.html, 2005. Accessed 5/25/2012.

McCauley, R.N., *Why Religion is Natural and Science is Not*, Oxford, 2011.

Menon, S., "Hinduism and Science," in P. Clayton and Z. Simpson, eds., *The Oxford Handbook of Religion and Science*, Oxford, 2006, 7-23.

Meulenbeld, G.J., "Reflections on the Basic Concepts of Indian Pharmacology," in G.J. Meulenbeld and D. Wujastyk, eds., *Studies on Indian Medical History*, Delhi: 2001, 1-16.

Nanda, M. *Prophets Facing Backward: Postmodern Critiques of Science and Hindu Nationalism in India*, New Brunswick, New Jersey, 2003.

Narayanan, V., "Hinduism in Pittsburgh: Creating the South Indian 'Hindu' Experience in the United States," in: J. S. Hawley and V. Narayanan, eds., *The Life of Hinduism*, Berkeley, 2006, 231-248.

Olivelle, P., trans., *The Early Upaniṣads: Annotated Text and Translation*, New York, 1998.

Prakash, G., *Another Reason: Science and the Imagination of Modern India*, Princeton, 1999.

Roy, R., *The English Works of Raja Rammohun Roy, with an English Translation of the "Tuhfatul Muwahhiddin,"* New York, 1978.

Stenmark, M., "Ways of Relating Science and Religion," in P. Harrison, ed., *The Cambridge Companion to Science and Religion*, Cambridge, 2010, 278-295.

Subharayappa, B.V., "Indic Religions," in: J.H. Brooke and R.L. Numbers, eds., *Science and Religion around the World*, Oxford, 2011, 195-209.

Suśruta Saṃhitā: Text with English Translation, a Full and Comprehensive Introduction, Additional Text, Different Readings, Notes, Comparative Views, Index, Glossary and Plates, in three volumes, K.K. Bhishagratna, trans, L. Dwivedi, ed., Varanasi, 1998.

Swerdlow, N., "A Lost Monument of Indian Astronomy," review of *Das heliozentrische System in der greichischen, persichen und indischen Astronomie*, by B.L. van der Waerden, *Isis*, vol. 64, No. 2 (June 1973), 239-243.

van der Waerden, B.L., *Das heliozentrische System in der greichischen, persichen und indischen Astronomie*, Zurich, 1970.

Vivekananda, *The Complete Works of Swami Vivekananda*, 9 vols, in *Swami Vivekananda: Life, Works & Research* (multimedia CD), Calcutta, 2003.

Zimmer, H.R., *Hindu Medicine*, L. Edelstein, ed., Baltimore, 1948.

Zimmermann, F., *The Jungle and the Aroma of Meats: An Ecological Theme in Hindu Medicine*, Berkeley, 1987.

Zysk, K.G., *Asceticism and Healing in Ancient India: Medicine in the Buddhist Monastery*, New York, 1991.