2016

Jagadish Chandra Bose and Vedantic Science

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'The real is one: wise men call it variously.'[1] Utilizing this celebrated declaration of the *Rig Veda* as an epigraph in his first scientific monograph, *Response in the Living and Non-Living*, (1902), the audacious Indian physicist Jagadish Chandra Bose (1858–1937) intimated to the Western scientific world that his electrographic discovery of the unity of life—that the animate and the inanimate world are one—was an affirmation of the insights of the ancient Vedic seers. In the year prior to publication of his monograph, Bose had already indicated the larger implications he saw in the elliptical epigraphic message. In a lecture-demonstration at the Royal Institution of Great Britain in London on Friday evening,10 May 1901,[2] he proclaimed with reference to his electrographic recordings or 'self-made records' of metal, muscle, and plant responses to various stimuli:

> It was when I came upon the mute witness of these self-made records, and perceived in them one phase of a pervading unity that bears within it all things—the mote that quivers in ripples of light, the teeming life upon our earth, and the radiant suns that shine above us—it was then that I understood for the first time a little of that message proclaimed by my ancestors on the banks of the Ganges thirty centuries ago—
>
> 'They who see but one, in all the changing manifoldness of the universe, unto them belongs Eternal Truth, unto none else, unto none else!'
>
> (quoted in Geddes 1920: 97–98)[3]

The young Indian scholar Susmita Chatterjee opens her article, 'Acharya Jadaish Chandra Bose' (2008: 65), with the same quotation and then summarises Bose's ambiguous and controversial impact in colonial and post-colonial India.[4] In colonial India he was perceived as 'the scientist who brought the ancient Indian wisdom of spiritualism into the domain of science' (ibid.). But in post-colonial India, she continues, Bose 'is remembered as the first of the Indian scientists who attempted to build up an Indian structure of science—as the propounder of 'alternative sciences' whose idiom sounds flat and out of date today—at best, a flawed genius' (ibid.). Bose's science, with his occasional references to scriptural notions of monism, was thus often regarded as 'a combination of science and metaphysics' (ibid.: 66). The ambivalent reception of Bose's scientific discoveries, both in India and the West, actually extends well back into colonial times, to the first years of the twentieth century when he journeyed to the West to expound his discovery of the unity of life.

The concluding comments in the Royal Institution discourse and the Vedic epigraph reveal Bose's concern to negotiate the meaning and relevance of the ancient Indian spiritual tradition vis-à-vis modern science. He was one of many English-educated Hindus, especially in Bengal, responding to the momentous challenges of modern science coming from the West. These responses were profoundly shaped by the colonial context of 19th- and early 20th-century India. Bose's role is especially significant as he was among the first generation of Indians trained in the methods of modern science and the first to gain international recognition for his discoveries, beginning with his work on microwave radiation. His reconciliation of Vedic wisdom and modern science helped to persuade Indians leery of western imports that there was no conflict for natives undertaking scientific research.

To understand Bose's attempt to assimilate 'Western' science while avoiding mere imitation, we shall first look at the major phases in his scientific career and the debates that swirled around the later phases regarding metaphysical biases.[5] We then turn to the development of Bose's religious perspectives and his sense of India's special contribution to science, followed by a brief look at recent attempts to vindicate Bose as a pioneer in the field of plant neurobiology. Finally, we examine the implications of Bose's science for the question of whether modern science as developed in the West is universal, or simply a 'Western' species of science with its own epistemological peculiarities, alongside other equally viable alternative sciences.

Major phases of Bose's scientific career

Bose's scientific career is commonly divided into three phases, his work on microwave radiation from 1894 to 1899 constituting the first. Bose's discovery of microwaves helped to complete the scientific understanding of electro-magnetic radiation begun under Clerk Maxwell. His invention of ingenious experimental instruments to carry out his work largely in isolation in India was remarkable. Yet Bose's science at this point 'was certainly not of a revolutionary nature. It was, in fact, no more than a Kuhnian mopping-up operation within the paradigm of electromagnetic theory' (Raina 2001:419).[6] Bose was soon to launch himself into a more revolutionary and controversial research program.

The second phase, 1899–1902, concerned his experiments with electrographic responses of living and non-living matter. This phase originated in the discovery that his microwave receiver experienced a period of fatigue following continued use, recovering after rest. Noticing the similarity of metallic fatigue and recovery with those of muscles, he began exploring the boundary between the living and non-living. He travelled to Paris in 1900 to announce his

discovery of the parallel responses of the living and non-living at the International Congress of Physics. This phase culminated in the 1902 publication of *Response* with its Vedic epigraph.

The third phase, ending with Bose's death in 1937, focused on the intermediate matter between animal and metal, the plant. Bose's claims became quite astonishing. For instance, he asserted—perhaps only poetically—that trees could grieve, suffer poverty, steal, assist others, form friendships, and sacrifice themselves for their children (Nandy 1995:46; Sen Gupta 2009: 38; Shepherd 2009: 151). Yet such poetic effusions, if that is all they were, appeared frequently in his writings and speeches. He affirmed, for example, that '[e]ven a speck of protoplasm has a faculty of choice' (Bose 1921: 58). And he spoke of the similarity of the death-experience in man and plant, both undergoing great contractile and electrical spasms as recorded by his 'Morograph' ('Death Recorder'). Regarding this unvoiced 'diary' of the plant, he concluded:

> These mute companions, silently growing beside our door, have now told us the tale of their life-tremulousness and their death-spasm, in script that is as inarticulate as they. May it not be said that this, their story has a pathos of its own, beyond any that the poets have conceived?
>
> (ibid.: 80)

Bose had a proclivity to recycle favourite passages of his, and this was one. In another iteration of the above, he went on to say, 'The barriers which separated kindred phenomena in the plant and animal are now thrown down. Thus community throughout the great ocean of life is seen to outweigh apparent dissimilarity. Diversity is swallowed up in unity' (ibid.:160). Does not science, he concluded, by revealing 'the infinite expanse of life' in plants lead us up a 'stairway

of rock which all must climb who desire to look from the mountain tops of the spirit upon the promised land of truth?' (ibid.). Needless to say, the results of this third phase apparently proposing that plants have will, feelings, and consciousness, along with the notion that science leads to some sort of transcendental spiritual truth, were as controversial as those of his second.

The issue of metaphysical bias in Bose's science

To what extent, if any, does Bose's science derive from his religious perspective and metaphysical assumptions? Subrata Dasgupta, one of the few scientists to evaluate the scientific merits of Bose's work, claims: 'The monistic presence in Bose reveals itself repeatedly in his various writings' (1999: 170). Chatterjee, on the other hand, argues that '[i]t would be wrong to suggest that Bose's science was not born from science alone and was a fusion of science and non-science' (2008: 76). She acknowledges that his metaphysical assumptions may have guided his choice of research subjects, but rejects the idea that 'Bose's metaphysical commitment and understanding of unity in diversity led to the formation of his scientific thesis' (ibid.).

What exactly was his scientific thesis—the 'Boseian thesis' in Dasgupta's terminology? Dasgupta defines the thesis as: '[T]here is no discontinuity between the living and the nonliving', citing Bose's 1900 address in Paris (1999: 128). Chatterjee, however, argues that '[t]he Boseian thesis was … not that there is a continuity between the living and the non-living. It was to show that there is no chasm between the living and the non-living in terms of response' (ibid.: 74). The actual words Bose had used were that there was a 'continuity of response in the living and the non-living' (1927a: 258; cited by Chatterjee 2008: 73), so on a literal level Chatterjee is correct. But the implications Bose often drew from the literal thesis seem more in accord with Dasgupta's analysis. For instance, in his 1901 discourse at the Royal Institution, Bose claimed

that ‘electrical response is regarded as the criterion between the living and non-living. Where it is, life is said to be; where it is not found, we are in presence of death, or else of that which has never lived...’ (1996: 209). He went on to add that advances in science ‘have been always towards a clearer perception of underlying unity in apparent diversity’ (ibid.: 217), and then closed with his famous statement about the wisdom of his ancient ancestors on the banks of the Ganges. Those ancient sages saw all of reality pervaded by soul or consciousness, and not just manifesting similar responses to various stimulations (cf. Yadugiri 2010: 975).

Chatterjee also argues that Bose used literary language—apparently including poetic, metaphorical, and metaphysical allusions—in his popular writings and speeches, but not in his scientific writings (2008: 78). Dasgupta disagrees, noting that ‘Bose allowed his metaphysics to intrude upon his scientific writings. His language of science was infused with the language of philosophy and, indeed, that of literature’ (1999: 171). Dasgupta cites the Rig Vedic epigraph in Bose’s 1902 monograph as ‘[p]erhaps the most pointed evidence’ attesting to his monistic philosophical bias (ibid.: 170).[7]

Such explicit invocations of metaphysical ideals largely disappeared at this point in Bose’s scientific writings, as he seems to have recognised the problems such references were causing. They seemed too likely to confirm long-standing British prejudices that Indians, while adept in languages and metaphysics, possessed no aptitude for science (Mukhopadhyay 1995: 35–36). Years earlier, for instance, when Bose had been appointed professor of physics in Presidency College against the wishes of certain administrators, Sir Alfred Croft, Director of Public Instruction of Bengal, had told Bose that ‘Indians do not possess the requisite temperament for exact sciences’ (quoted in Sen Gupta 2009: 21; cf. Kumar 2006: 218).

Given Bose's dominating desire to prove Indians capable of modern scientific research despite British attitudes, it is little wonder he chose to obscure his metaphysical commitments—at least in his scientific writings. Even so, the 'wisdom-of-the-ancients' passage from his Royal Institution discourse of 1901 appears again in his 1927 monograph, *Plant Autographs* (pp. 63–64), by which time he seems to have become less concerned about letting the impersonal mask of scientific dispassion slip to reveal the hidden man of metaphysics.

Evidence of his intentional shunning the metaphysical—at least ostensibly—appears in a 1924 speech in which he addressed the question, 'Do plants feel?' He indicated three possible approaches to answering this question: through sentiment (empathetic intuitions), metaphysical speculation, and 'scientific investigations of the behaviour of plants subjected to shocks from outside' (Bose 1997a: 9; Palit and Bagchi 2006: 93). Regarding metaphysical speculation, Bose noted claims by Henri Bergson—who had attended one of his lectures in Paris—that '[i]t by no means follows that a brain is indispensable to consciousness', and thus consciousness 'accompanies the nervous system down its whole descent' (Bose 1997a: 9). Bose commented,

> Consciousness and sensation are thus regarded as inseparably associated with the nervous system and nervous reaction. If this be so, then my recent scientific results prove beyond a shadow of doubt that many plants possess not merely a rudimentary, but a highly elaborated nervous system.
>
> (ibid.)

But then Bose immediately added, 'I have, however, to do, nothing with metaphysical speculations, but only with the behaviour of plants, and their muscular and nervous mechanisms'

(ibid.). Perhaps so, but we note the identity of Bergson's claim with Bose's own point of view. Why else would Bose quote Bergson with such transparent approval?

The majority of scholars, including Dasgupta already noted, detect the same philosophical bent in Bose (e.g., Arnold 2000: 174; Sen Gupta 2009: 35–36; Lordusamy 2004: 6, 103, 136; Nandy 1995: 46–48; Prakash 1999: 229). V.A. Shepherd, for instance, writes,

> Bose's insistence on the unity of the living and non-living arose from a deeply held philosophical position, Vedanta in inspiration, a monism that regarded the world as a single unified entity, where mind and matter were aspects of the same thing.
>
> (2009: 111).

Bose's fellow Indians like Swami Vivekananda, Rabindranath Tagore, and Sarvepalli Radhakrishnan, of course, clearly saw and delighted in the metaphysical aspects of Bose's research.[8] For instance, Tagore, in a 1938 memorial lecture at the Bose Institute, reminisced on his own early acquaintance with the Upanishadic ideal of the unity of life, and how he had eagerly anticipated Bose's scientific verification of this ancient truth (1996:1; 1997: 9).

Following a lecture that Bose gave at the first anniversary meeting of the Bose Institute in 1918, an Indian, English-language newspaper observed:

> The ancient thinkers knew well that life and mind exist everywhere in essence and vary only by the degree and manner of their emergencies and functionings. All is in all and it is out of complete involution that the complete evolution progressively appears. It is only appropriate that for a descendant of the race of ancient thinkers who formulated that knowledge, should

> be reserved the privilege of initiating one of the most important among the many discoveries by which experimental science is confirming the wisdom of his forefathers.
>
> (quoted in Bose n.d.: 253)

The notion of Brahman, the supreme consciousness, involving itself into evermore gross forms of matter, to eventually reemerge through a physico-spiritual evolution, was a common notion among Bengali intellectuals in Bose's time, epitomised in the writings of Aurobindo Ghose. And it deeply affected J.C. Bose.

Bose's religious development

Bose's father was a devout follower of the reform-minded and monotheistic Brahmo tradition, with deep faith in Viswakarma (All-maker, World-creator), 'the second-order Hindu god of technology and scientific creativity' (Nandy 1972: 44). Years after his father's death, Jagadish recalled his father's concern with the economic future of India and his setting up of industrial and technical schools, noting:

> I remember the deep impression made on my mind by the form of worship rendered by the artisans [at the schools] to Viswakarma, God in his aspect as the Great Artificer: His hand it was that was moulding the whole creation; and it seemed that we were the instruments in His hand, through whom He intended to fashion some Great Design.
>
> (Bose 1921: 88)

The notion of Viswakarma's 'moulding the whole creation' resonated with the design argument of natural theology espoused by the founder of the Brahmo Samaj, Rammohan Roy. It was Roy, incidentally, whom Bose credited as 'the precursor of his ideas on the interaction of the East and the West on a basis of mutual dependence, exchange and enrichment' and as 'having first seen the "Unity of All Intellectual Life"' (Lordusamy 2004: 132).[9]

Bose's sympathies eventually strayed from the monotheistic ideals of his father's Brahmoism, coming to lie more with the pantheistic, or perhaps more accurately, panpsychic perspective of Advaita Vedanta, the monistic strand of the Hindu tradition stressing the all-pervading consciousness of the Supreme Brahman. This Brahman was allied in traditional Bengali religious consciousness with the ultimate supreme power, Mahashakti, the Great Goddess. This all-powerful maternal deity was apparently the object of faith of Bose's mother, who remained orthodox even after her husband adopted Brahmoism (Nandy 1972: 39). Perhaps inspired by the pantheistic Hindu orthodoxy of his mother, Bose later acknowledged that it is 'Mahashakti, by whom the nonliving and the living, the atom and the universe are all powered' (quoted in ibid.: 40), a view that certainly parallels on a theological-pantheistic level the conclusions of Bose's electrographic studies on metallic, plant, and animal responses to stimulation.

In this regard, it is interesting to note that a favourable review of Bose's 1902 *Response*, summarizing the physicist's discovery of 'the all-pervading unity of the universe', quoted the following deeper question: 'Who is He that sits within [matter] striking the molecules this way and that? Or what is He, "pure, free, ever the witness"…?' (M.N. 1902: 425; cf Anon. 1921: 40). The source of the quoted question is not explicitly identified but may well have been Bose himself, for the reviewer immediately added that 'Dr. Bose does well to end his lecture, given at

the Royal Institution, May 10th, with this striking passage…', the passage being the famous text referring to the wisdom of the ancient sages on the banks of the Ganges. If the quoted question is indeed Bose's, we may see here an indication of his intellectual migration from theism to monism, from an intervening deity moving molecules suggestive of a fusion of designer god Vishwakarma and the all-empowering Mahashakti, to the monistic notion of the supreme, inactive Brahman, traditionally characterised as a non-acting witness and identical with humankind's innermost essence or soul.

While Bose eventually went beyond the monotheism of Brahmoism, there were other Brahmo ideals he retained throughout his life. Especially significant was the Brahmo notion of the unity of science and religion. Keshab Chandra Sen, great Brahmo leader in the 1860s and 1870s, for instance, argued that 'both the ancient Vedic seers and modern scientists seek unity in nature, and ultimately the one primary force hidden behind nature' (Brown 2012: 108). Sen was thus led to proclaim: 'All science is religion, and all religion is science' (1940:356).

Bose himself later affirmed this same alleged unity of science and religion. Like many post-Cartesian scientists in the West, especially evolutionists like Darwin, Bose rejected any sort of vitalistic dualism. But for scientists, the ultimate unity lies in the physico-chemical. In Advaita Vedanta, it lies in the supreme spirit, the all-pervading consciousness of Brahman that involves itself into the forms of the animate and inanimate world. Bose attempted to fuse the two perspectives. When speaking in a primarily scientific voice, he observed that his experiments with living and non-living matter showed that 'the response of the more complex and unstable living matter is ultimately the expression of physico-chemical reactions' (1927a: i). But in more popular venues where his metaphysics often shines forth, Bose would proclaim that science had

shown him ‘how all matter was one, how unified all life was….There was no such thing as brute matter, but that spirit suffused matter in which it was enshrined’ (1997b: 53).

Such fusion may well have been inspired by the ancient Hindu evolutionary philosophy of Samkhya, according to which there are two distinct and eternal principles, Spirit (Purusha) and Nature (Prakriti). Science concerns itself with the latter. For early 20th-century Bengali intellectuals, modern biological evolution could easily be subsumed under the Samkhyan ideas of cosmic evolution from primordial Nature (Raina and Habib 1996: 21). Both Samkhyan and modern biological theories of evolution assumed a grand physico-chemical unity of the world, but Samkhya allowed for Spirit as well. It was relatively easy for Indian theorists like Benoy Sarkar, then, to fuse ‘“Samkhyan nature study” with “Vedantic soul search”’ (ibid.: 29).

There remains the question of what prompted Bose to move towards the monistic panpsychism of Advaita Vedanta. In pithier terms, what accounts for the appearance of the Rig Vedic epigraph in Bose’s 1902 monograph, *Response*? His religious-philosophical migration, as well as his shift in research from microwaves to the responses of the living and non-living, seems intimately linked to his friendship with the Irish woman Margaret Noble, Swami Vivekananda’s famous disciple. In 1898 Bose became close friends with Noble, or Sister Nivedita as known by the Swami’s followers. As Nandy describes the relationship: ‘Nivedita’s strong yet supportive personality and her burning faith in a science that would reflect Indian sensitivities must have given him a new faith in his work’ (1995: 47). Nivedita found implicit in Bose’s research scientific confirmation of the ‘vitalistic, organic monism’ of the Upanishads as interpreted in Vivekananda’s Vedantic version of Hinduism (ibid.).

Nivedita soon became a dedicated assistant and editor for Bose, going over the thousands of manuscript pages of his early monographs (Sen Gupta 2009: 45). Nandy specifically notes:

‘Bose’s best known book, *Responses in the Living and the Non-living*, reported his own researches but owed its elegant style as well as structure to Nivedita’ (1995: 48). It seems probable that Nivedita was at least partly responsible for the Vedic epigraph appearing in the work. In a letter to Tagore written the year after *Responses* was published, she wrote about her plans for a new book by Bose ‘in which that same great Indian mind that surveyed all human knowledge in the era of the Upanishads and pronounced it One’ will survey all stores of nineteenth-century knowledge of physical phenomena and show ‘to the empirical, machine-worshipping, gold-seeking mind of the West that these also are One—appearing as Many’ (Basu 1982: 558).

Vivekananda himself was a great admirer of Bose, whom he had met in Paris. The Swami often affirmed the ideal of harmony between Vedanta and science that surely appealed to Bose. In a speech delivered after returning to India from America in 1897, Vivekananda declared: ‘It seems to us, and to all who care to know, that the conclusions of modern science are the very conclusions the Vedanta reached ages ago; only in modern science they are written in the language of matter’ (1948:185). Vivekananda next cited the Vedic verse used by Bose as an epigraph, and then expounded upon ‘that eternal grand idea of the spiritual oneness of the whole universe’, an idea the whole world was wanting from India (ibid.: 188). Vivekananda then proclaimed

> how the modern researches of the West have demonstrated through physical means the oneness and the solidarity of the whole universe; how, physically speaking, you and I, the sun, moon and stars, are but little waves or wavelets in the midst of an infinite ocean of matter: how Indian psychology demonstrated ages ago, that, similarly, both body and mind

> are but mere names or little wavelets in the ocean of matter…and how, going one step further, it is also shown in the Vedanta that, behind that idea of the unity of the whole show, the real Soul is one. There is but one Soul throughout the universe, all is but One Existence.
>
> (ibid.: 188)

These ideas, reflected in the concluding passage in Bose's Friday Evening Discourse at the Royal Institution, point to the philosophical vision by which Bose fused his science and religion.

India's special contribution to science

For Bose, the unity of life expressed in his Royal Institution discourse pointed to 'the unity of all human effort', a unity that would include, of course, the efforts of the international scientific community (Bose 1921: 213). In a 1916 address at Benares Hindu University, Bose thus argued:

> Knowledge is never the exclusive possession of any particular race nor does it recognise geographical limitations. The whole world is interdependent and a constant stream of thought had been carried out throughout the ages enriching the common heritage of mankind.
>
> (Bose 1921: 26)

Bose's own career had shown that the old British prejudice regarding Indian incapacity for doing science was untenable.

From an historical perspective, Bose called attention to the intellectual achievements at the ancient Indian universities in Nalanda and Taxila with their international reputations (ibid.: 2, 100, 119). While recalling the past brilliance of Indian intellectual life, Bose was also adamantly forward-looking, warning students at Benares Hindu University, 'Let us not talk of the glories of the past till we have secured for her her true place among the intellectual nations of the world' (ibid.: 39). He pointed out that ancient Indian inquirers recognised that there were phenomena too subtle to detect with our normal senses. But they lacked 'a true recognition of the experimental side' of science and thus failed to develop the 'finer instruments' that have allowed modern science to go far beyond the ancients (ibid.: 28).

In his address at Benares Hindu University, Bose also argued that despite the universal nature of science, 'certain aspects of it gained richness by reason of their place of origin' (ibid.: 26–27). India had her own special contribution to make that would be firmly based in experimental demonstration—thereby avoiding purely metaphysical speculation—but would provide a critical complement to Western approaches (Krishna 1992: 65). As Bose claimed:

> India is, perhaps through her habit of mind, better fitted to realise a wider synthesis. One of the greatest contributions in the realm of science would undoubtedly be the establishment of a great generalisation, not merely speculative, but based on actual demonstration of an underlying unity amidst bewildering diversity.
>
> (1921: 33)[10]

The intuitive and synthetical Indian understanding of life, according to Bose, allowed Indians to develop more sensitive approaches to their subject matter than Western scientists

'whose approach was aggressive and crudely materialistic, and whose tendency constantly to subdivide scientific fields precluded them from seeing the underlying unity' (Arnold 2000: 174). Bose had often blamed the excessive specialization of western scientists, in particular those in the fields of physics and plant physiology, for his struggles in winning over those scientists to his insights on the unity of life (e.g., Bose: 1921: 92).

Bose worked tirelessly to establish an institution in India where such integrated researches would be possible. The scientists in such a research facility would be completely dedicated and detached from worldly concerns. As he noted in a 1915 speech:

> There will soon rise a Temple of Learning where the teacher cut off from worldly distractions would go on with his ceaseless pursuit after truth, and dying, hand on his work to his disciples. Nothing would seem laborious in his inquiry; never is he to lose sight of his quest, never is he to let it go obscured by any terrestrial temptation. For he is the Sanyasin [renunciatory] spirit, and India is the only country where so far from there being a conflict between science and religion, knowledge is regarded as religion itself.
>
> (Bose n.d., 149; cf. Arnold 1999: 170)

The 'Temple of Learning' was the Bose Institute in Kolkata which he established in 1917.

There is little doubt that Bose was a critical figure in advancing indigenous scientific research in India and in achieving international recognition for Indian scientific accomplishments. But what has been the long-term value of his own scientific contributions? Most scientifically informed critics of Bose like Dasgupta see his second and third phases of research, at least in terms of their larger, pan-vitalistic or pan-psychic conclusions, as basically a

failure from a scientific point of view. As Sen Gupta observes, Bose's deep philosophical convictions 'possibly motivated him to take mental leaps to arrive at some of his scientific conclusions…' not all of which have 'stood the test of time…' (2009: 10). Still, certain recent scientific observers argue that in many ways Bose was ahead of his times and see his plant researches as pioneering efforts in the emerging field of 'plant neurobiology'. Let us look more closely at such claims.

Post-Boseian plant neurobiology

In 1973 a popular and broadly anti-intellectual, pseudoscientific book ushered in the recent revival in 'plant neurobiology' with claims not only that plants have feelings, but that plants can communicate with animals, and can even read the minds of human caretakers. The book, *The Secret Life of Plants*, by Peter Tompkins and Christopher Bird, reiterated the claims of Cleve Backster, a polygraph expert who, in a series of experiments in the late 1960s, used lie-detecting technology to interpret electric responses of plants. The book also contained a chapter on J.C. Bose's work, leaving the impression that Bose was the first to carry out important experiments on plant physiology.

A 1979 review of the book by two expert plant physiologists, Arthur W. Galston and Clifford L. Slayman, thoroughly debunked Backster's claims, noting that his experiments had been unrepeatable. The review, 'The Not-So-Secret Life of Plants' appearing in *American Scientist,* also discredited the idea that Bose was the first to conduct significant electrophysiological experiments on plants. At the same time, Galston and Slayman duly credited Bose's scientific accomplishment: 'Bose quite properly pointed out *functional* similarities between electrical/mechanical responsiveness, or irritability, of plant and animal tissues…' but

this is far from demonstrating that plants perceive the world in any way akin to that of animals, as Bose claimed and Tompkins and Bird argue (ibid.: 338). Galston and Slayman conclude that 'While Bose's thought was very advanced in some respects, it was rather primitive in others', and his contemporary American plant phsyiologists 'were far closer to a proper physical understanding of electrical events in plants' (ibid.).

The sort of mistake that Backster made in reaching his conclusions, Galston and Slayman argue, is the 'classical semantic confusion of identity', taking resemblance—in this case between the electrical responses of human and plant tissues—as signifying sameness, specifically, the ability to feel human emotions (ibid.: 340). This is like arguing that since dark patches on the moon resemble 'a human face, there must be a real man in the moon' (ibid.). Interestingly, an early review of Bose's 1907 book, *Comparative Electro-Physiology*, makes essentially the same critique. The reviewer notes that parallel responses 'in metal wires, plant and animal tissues' do not mean all these possess sensibility, any more than the parallel responses of letting off steam by a traction engine (steam tractor), a dung heap, and a team of horses heated from plowing indicates that all three have sensibility (L.H. 1908: ii–iii).

V.A. Shepherd, a plant electrophysiologist, has recently argued that the newly emerging and 'somewhat controversial' (p. 126) field of plant neurobiology vindicates much of Bose's research. She notes Galston's and Slayman's harsh critique of Backster, but without grappling with the specific experimental and logical flaws levied against him (ibid.: 126–27). Nor does she acknowledge the problem of 'semantic confusion of identity'. Rather, she claims:

> Bose's contention that plants have…a nervous system, a form of intelligence, and are capable of remembering and learning, was not understood or accepted in its time. However,

> a hundred years later, concepts of plant intelligence, learning, and long-distance electrical signalling have entered the mainstream literature.
>
> (ibid.:101–2)

Regarding plant brains, located by some plant neurobiologists in the root systems, Shepherd concedes that '[o]f course, no-one is saying today that there are mini-human-like brains in the root system of a plant' (ibid.: 128). This last statement suggests that all such talk by plant neurobiologists about plant nervous systems, brains, memory, and learning is merely analogical. Shepherd herself often puts terms like 'plant brain' in quotation marks, indicating their analogical nature. And even if plants have a form of intelligence, like the artificial intelligence of computers, it is not the same thing as having sensibility, feeling, or consciousness. Like Bose, Shepherd focuses on similarities while ignoring significant differences.[11]

In a postscript Shepherd reveals something of her own religious-philosophical inclinations. She notes that many past cultures have regarded trees as sacred beings, suggesting 'a psycho-spirituality common to humans' that supposedly provides some sort of justification for Bose's comments about the life histories and feelings of trees (ibid.: 151). But such psycho-spirituality may also be seen as simply the biologically evolved tendency for human beings to see the world in animistic terms, without any regard to objective reality (cf. McCauley 2011: 81–82).

Shepherd next refers to Whiteheadian process philosophy, in which 'mind cannot be considered a mere product of human brains and neuronal firing, but is inherent in Nature' (2009: 151). She ends by quoting from C. de Quincy's 2002 book, *Radical Nature: Rediscovering the Soul of Matter*: 'We need a vision of nature in which all parts of the ecological-cosmological system are innately meaningful, in which sentience or experience is all-pervasive, resulting in a

profound sense that the world itself is sacred' (ibid.: 152). Such ideas resonate deeply with Bose's metaphysical outlook and his claim that 'Even a speck of protoplasm has a faculty of choice' (Bose 1921: 58). But this is religion or philosophy, not science.

Ideologically-driven science

From the 1870s, the role of scientists in emerging Indian nationalism was far from trivial, promoting a cultural rather than overtly political agenda (Krishna 1992: 69). International recognition of Indian scientific achievements would bolster the view that Indians were capable of self-rule. But many Indians were suspicious of 'Western' science, seeing it as the means of their own subjugation to the British, as embedded in pernicious ideals of materialism, greed, and aggression, and as destructive of traditional spiritual and moral values (Raina and Habib 1996: 29–33; cf. Arnold 1999: 169).

Bose was a pioneer in persuading fellow Indians that since '"science" was not "western", but originally "eastern" and now universal, it could be successfully and legitimately regarded as indigenised for use' (Zachariah 2001: 3694). For Bose, incorporating indigenous perspectives would help to integrate and humanise 'western' science (Prakash 1999: 230). The attempt to indigenise and morally legitimate science was accomplished in large part 'by preserving the theological cosmos of the Indians, while simultaneously rendering modern secular science commensurate with it' (Raina and Habib 1996: 32). But is the theological-philosophical cosmos of India, including the Vedantic version of Vivekananda and Bose, really commensurate with the discoveries of modern science? The question intertwines with epistemic issues. As Gyan Prakash notes, Bose's 'claims for Indian universalism…challenged the dominant view that Western

science's epistemology transcended its cultural location' (1999: 230). How successful was this challenge?

The answer depends partly on one's definition of Western scientific epistemology. The Sinologist A.C. Graham, following Joseph Needham, notes that medieval 'proto-science with its Galenic humors in Europe and yin and yang and Five Elements in China is culture-bound…' (1973: 65). But once science modernises its methodology, becoming 'mathematicized and experimentally testable it acquires the cultural universality of mathematics and logic' (ibid.: 65–66).

Pervez Hoodbhoy, a Pakistani physicist, takes direct issue with those who argue that modern science is somehow a sign of western cultural or genetic superiority. Regarding the human species, he notes simply that 'the human mind is capable of reason and abstraction' and thus science was almost inevitably going to develop somewhere, sometime, and it makes little difference in the long run where or when (1991: 20). He concludes: 'Science is indeed the intellectual property of all humankind, and part of the universal cultural heritage. We need pay no heed to those who say it is otherwise' (ibid). Hoodbhoy obviously agrees with Bose's view that science belongs to no race or country. Unfortunately, European colonisers often failed to realise this universality, regarding their colonised subjects as overwhelmed by superstition or mysticism, unable to practice science.

Hoodbhoy, however, would have problems with Bose's spiritualised, Vedanticised science. With regards to Islam, Hoodbhoy raises the question: Can there be an Islamic science? His response: 'The answer to this question, in my opinion, is simple. No, there cannot be an Islamic science of the physical world, and attempts to create one represent wasted effort' (Hoodbhoy 1991: 77).[12] Hoodbhoy further argues that all alternative sciences, whether driven by cultural,

political, religious, or philosophical ideologies, have failed miserably. He points to Marxist science, illustrated by Lysenko's socialist biology that was disastrous for Russian agriculture. And Third World science is equally problematic: 'Third World science, regarded as a quest for a new epistemology for science, is an illegitimate concept which is nothing but a waste of time…' that only '…accelerate[s] the backwardness, poverty, and ecological destruction of Third World' (ibid.: 83–84).

Attempts to spiritualise science undermine scientific integrity, as they subvert critical approaches both to one's underlying philosophical assumptions and to one's scientific conclusions. Metaphysical inspiration for guiding the formulation of scientific questions is not in itself problematic, so long as one then critically analyzes the 'inspired' scientific discoveries, especially their interpretation, for confirmation bias is a well-known problem. In Bose's case, he failed to question both his Vedantic assumptions and his scientific conclusions. We may recall how much of Bose's interpretation of his discoveries depended upon resemblances and analogies. Dasgupta concludes that for Bose, 'analogical insight was everything', and thus 'the test of critical scrutiny' superfluous (1999: 250; cf. 171).

Bose was aware of the problems of confirmation bias and self-deception, pointing out

> how necessary it is for the discovery of truth to maintain a spirit of absolute detachment and perfect freedom of mind from all preconceived bias. The hardest struggle is to protect oneself from being self-deceived, and one has to guard against it and keep vigilant all the time.
>
> (1921: 37)

Bose’s scientific career is noble testimony to the extraordinary difficulty of that struggle.

[1] *Rig Veda* 1.164.46.

[2] Accounts of the venue and date of this lecture-demonstration are often inaccurate. Geddes (1920: 97), Arnold (1999: 169-70), Dasgupta (1999: 126), and Sen Gupta (2009: 36) give the correct information.

[3] The complete discourse minus the conclusion appears in Bose 1996: 205-217.

[4] Chatterjee's version differs slightly from Geddes'. She attributes the passage to a 1900 address at the Royal Society.

[5] For non-hagiographical biographies of Bose, see Dasgupta (1999), Lordusamy (2004: 100-42), and Sen Gupta (2009). Nandy (1972; 1995: 22-61) provides psychoanalytically oriented interpretations.

[6] Cf. Dasgupta 1999: 46.

[7] Deepak Kumar also notes the Vedic epigraph in the context of Bose's mysticism (2006: 212-13).

[8] See Sen Gupta 2009: 33-34; Radhakrishnan 1996: 198.

[9] On mutual exchange as one response of Indian elites to the challenges of modern science, see Halbfass 1988: 399.

[10] A slightly different version appears in a 1913 speech at the University of Lahore: "India, perhaps through its habit of synthesis, was apt to realise instinctively the idea of unity and to see in the phenomenal world an universe instead of a multiverse" (Bose n.d.: 118).

[11] Shepherd writes: "...auxin is thought to be secreted from cell-to-cell, neurotransmitter-like, via vesicle trafficking" (p. 128). As my colleague James Shinkle (a plant physiologist at Trinity University) comments on this statement: "The secretion of auxin is nothing like the secretion of

neurotransmitters. In fact the cell to cell transport of auxin in plant tissues is unlike anything among vertebrates" (private e-mail, 8 August 2013).

[12] See also Taner Edis' assessment of "Islamic science" (2007: 132-34).

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