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ORIGINAL PAPER

Jagadis Bose's panvitalism as intellectual history

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Abstract
No aspect of Jagadis Chandra Bose's science is more enigmatic than his concern with the relationship between the living and nonliving, explored from 1900 through 1902. Elsewhere this writer called this the 'middle Bose' period since it separated Bose the physicist (1894–1900) from Bose the plant physiologist (1903 and after). The essence of his insight developed in this brief period was formerly termed by this writer the 'Boseian thesis' and summarized as 'There is no discontinuity between the living and nonliving'. However, a more nuanced examination of three key texts published by Bose in this period, along with supplemental archival documents reveals that his articulation of the relationship between the living and nonliving evolved in subtle and daring ways culminating in an expression of the doctrine of *panvitalism*. This doctrine—that life pervades all matter—is an *idea* about the natural world. Thus, examining Bose's panvitalism takes us into the realm of *intellectual history*: the close study of the *meaning* of Bose's *texts* in order to understand his *intention* in exploring the relationship of the living and nonliving, the *context* of his investigation and its relation to the texts, and *how* he arrived at his panvitalist doctrine. The intellectual history of Bose's panvitalism is the subject of this paper.

Keywords Electrical responsiveness · Intellectual history · Jagadis Chandra Bose · Living and nonliving · Panvitalism

1 Revisiting the 'middle' Jagadis Bose

Jagadis Chandra Bose's work and mind together offer a remarkably rich laboratory for the science studies scholar, whether as historian of science, psychoanalyst, philosopher of science or creativity researcher. Even some 85 years after his death there is an enigmatic quality about him that continues to intrigue investigators of various stripes, including the present writer. And no aspect of his work is more enigmatic or intriguing than his concern with the relationship between the living and nonliving, explored between 1900 and 1902. This, relatively brief, period in his long career also served as a significant biographical marker, separating Bose the physicist (the 'early Bose', 1894–1900) from Bose the plant physiologist and biophysicist (the 'later Bose', 1903 and after). Thus, I have called this period that of the 'middle Bose' (Dasgupta, 2009; originally published 1999; p. 248 *et seq*.).

I originally named the essence of the relationship between the living and nonliving as articulated by Bose the *Boseian thesis* (p. 105 *et seq*), and had stated it as "There is no discontinuity between the living and nonliving" (p. 128). However, as we will see in this paper, a closer examination of Bose's own words suggests and reveals that his articulation of the thesis *evolved* in subtle and daring ways over the course of the middle Bose period. It is, thus, more accurate to speak of *five* Boseian theses that evolved into, and culminated in an expression of Bose's *panvitalism.*

The Boseian theses constitute a family of *ideas* about the natural world. Panvitalism—the doctrine that life pervades all matter—is also a powerful and controversial idea about the natural world. Thus, we are in the realm of *intellectual history*: a history of the *meanings* of these theses, *why* Bose proposed them at all and in what sense did they lead to his panvitalism. The intellectual history of Bose's panvitalism is the subject of this paper.

2 Interpreting intellectual history

Given the role it plays in this paper and on its subject matter, it behooves us to begin by examining, at some length, what precisely constitutes intellectual history.

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In fact, there is no consensus on this question. Stefan Collini (2016, p. 7) states baldly that "Intellectual history has no identity... if 'identity' is taken to indicate exclusive possession of a set of distinctive practices or a clearly defined territory." Yet Collini holds a chair in intellectual history in Cambridge, so there seems to be some quite explicit recognition of the existence of this branch of history.

Intellectual history used to be called *history of ideas*, a term that, at first blush, is fairly self-explanatory. Indeed, in this sense the long history of philosophy is itself a history of ideas of a certain kind, and insofar as ideas are thoughts, the history of ideas is also the history of thought. Thus, when R.G. Collingwood famously proclaimed that "All history is the history of thought" (Collingwood, 1956, p. 215) he seemed to be implying that all of history is intellectual history. But the twentieth century *locus classicus* of history of ideas is Arthur O. Lovejoy's *The Great Chain of Being*, originally the William James Lectures of 1933 at Harvard, in which he argued that any complex system of thought is really a combinatorial composition of a small number of basic elements he called 'unit-ideas', in analogy with the elements from which chemical compounds are formed (Lovejoy, 1964, pp. 3–4). Once a unit-idea is isolated, the task of the historian of ideas is to track the manifold pathways the unit-idea traversed the course of historical time—whether the unit-idea belonged to philosophy, science, literature, art, sociology, or whatever. Indeed, the history of an unit-idea may thread its way through multiple domains of thought. One such unit-idea would be the idea of 'progress' (Nisbet, 1994).

What Lovejoy conceived as history of ideas is now usually called intellectual history, though 'history of ideas' as a term still prevails. And while his concept of unit-idea has been largely rejected, intellectual history's concern still remains ideas. Yet there are many nuances and divergences to this core focus partly shaped by the diverse perspectives brought to bear on the matter.

We may begin, for instance, with John Burrow, holder of the first chair in intellectual history in a British university, for whom the discipline entails recovering "what people in the past meant by the things they said and what these things 'meant' to them" (quoted in Whatmore, 2016, p. 13). There is a distinction, of course, between the first occurrence of 'meant' in this statement and the second: what a person means in saying something refers to that speaker's *intention*; what that something means to the speaker refers to that utterance's *meaning*. Thus, we may believe that for Burrow, the speaker's intention in saying something and the meaning of what was said are what intellectual history is about.

Will *anything* a person says be of interest to the intellectual historian? The answer is "yes" so long as it is deemed significant or interesting or original relative to the intellectual historian's specific interest. The word 'intellectual' tends to draw our attention to the kinds of productions 'intellectuals' are commonly associated with: concepts, theories, laws, doctrines, principles, all subsumed under the umbrella word *ideas*. But, in fact, the speaker does not have to be an 'intellectual', at least not in the sense this word is conventionally used as a noun. Richard Whatmore begins his book *What is Intellectual History?* with a discussion of the (somewhat) cryptic messages carved onto stone slabs by an early nineteenth century master mason and wonders, What was the mason trying to mean by these messages? (Whatmore, 2016, p. 2).

For Whatmore, there is something more about the mason's messages that drew his attention: first, their cryptic nature, their very *unobviousness*; and second, the fact that the sayings of someone like a craftsman or artisan may simply be disregarded because they are not *expected* to articulate significant or profound ideas. And thus:

> Understanding the meaning of the mason's words underlines the capacity of intellectual history to reveal what is *hidden* from us in past thought, the ideas and arguments that are *neglected* because they have been abandoned or rejected by later generations (p. 5; italics added).

The task of the intellectual historian, he continues, is

> to restore a lost world, to recover perspectives and ideas from the ruins, to pull back the veil, and explain why the ideas resonated in the past and convinced their advocates (ibid).

In an influential paper, political philosopher Quentin Skinner collected what Burrow called 'things said' and Whatmore's 'messages', 'ideas' and 'arguments' into the term *text*. He argued that the focus of intellectual history is the *text and its meaning* (Skinner, 1969). By 'text' Skinner meant a linguistic entity, usually written but sometimes uttered. To understand a text one must determine what it was intended to mean. The intellectual historian's task in understanding a text is to "recover" the author's *intention* in producing the text. And this would entail identifying the entire range of intended communication performed by the writer/speaker and to establish the relation between the given text and the wider linguistic context.

If ideas—or the products of thought—are accepted as a core focus of intellectual history, yet another is to relate text with *context*. This relation is the very 'stuff' of intellectual history for LaCapra (1983), also an intellectual historian by trade. Like Skinner, LaCapra also emphasized the immediacy of language in this endeavor.

But LaCapra makes a distinction between 'documentary' texts and 'worklike' texts. As I understand him, 'documentary' refers to texts as entities that convey semantic information about the empirical world. 'Worklike' texts go beyond

the documentary, bringing to the table "commitment, interpretation and imagination", and is "critical and transformative" (pp. 29–30). Memorably, he writes, "One might say that while the documentary marks a difference, the worklike makes a difference" (ibid). Recalling T. S. Eliot's famous lines from his play *The Rock* (1934)—"Where is the wisdom we have lost in knowledge?/Where is the knowledge we have lost in information?" (Eliot, 1954)—we may say that LaCapra's 'documentary' is the information that his 'worklike' transforms into knowledge.[1]

LaCapra's emphasis on context was influenced by ethnographer Clifford Geertz's famous notion of 'thick description', a concept Geertz acknowledges to have adopted from philosopher Gilbert Ryle (Geertz, 1973, p. 6). For Geertz, thick description entails

> a multiplicity of complex conceptual structures, many of them superimposed upon or knotted into one another, which are at once strange, irregular and inexplicit, and which he must contrive somehow first to grasp and then render (p. 10).

Indeed, intellectual history theorists seem to be considerably influenced by the concept of thick descriptions. Thus Whatmore (2016, p. 7) likens the task of the intellectual historian to that of the ethnographer seeking thick descriptions. More specifically for LaCapra, a thick description reading of a text would entail relating the text to a number of possible distinct contexts between (i) the author's/speaker's *intentions* and the text, (ii) the author's/speaker's *life* and the text, (iii) *society* and the text, (iv) *culture* and the text, (v) the author's/speaker's *corpus* and the text. And, finally, (vi) *modes of discourse* and the text (LaCapra, 1983, pp. 36–56).

As we will see, at least a subset of this list are relevant to our present discussion of the Boseian theses and panvitalism.

There is a resonance between LaCapra's documentary/worklike textual distinction and a distinction due to another influential intellectual historian, White (1978). The latter distinguishes a text as being a 'chronicle' and an 'emplotment'. By 'chronicle', White meant the provision of "the elements of a *story* with a discernible beginning,... middle... and end." (White, 1978, p. 109). The historian's task then is to "[make] stories out of *mere* chronicles... by an operation... called 'emplotment'" (p. 83). "And by emplotment I mean simply the encodation of facts contained in the chronicle as components of specific *kinds* of plot structures" (ibid). White's four kinds of plots—Romantic, Comic, Tragic and Satirical—may be more appropriate to the literary, political or even social realms than to science or technology (my central concern in this paper), but the notion of 'emplotting' chronicle into story, bearing a parallel to transforming a documentary text into a worklike one, and to the notion of making knowledge out of information, is an important element of intellectual historiography, as we will explore further in the context of the Bose's panvitalism doctrine.

For some theorists such as Brett (2002), the way language is *used*—of past *ways of speaking*—is more the essence of intellectual history than the history of ideas per se, especially when ideas are wrenched out from the context of the language in which they are embedded.

If we collect together the salient points from these different perspectives, we realize the following common and perhaps central features:

The central 'matter' or 'stuff' of intellectual history is the realm of past ideas; such ideas are represented by written expressions or utterances called texts—that is, linguistic entities—represented in the language of the time; the objective of intellectual history is to recover or discover the (often obscure or hidden) meanings of these past texts—and thus, of the represented ideas—taking into consideration the language in which texts are written or spoken; *such recovery entails relating the text to one or more (possibly complex and diffuse) contexts and, in particular other previously formulated or contemporaneous ideas; furthermore, what the textually represented ideas may mean will depend on what the author of the text intended to mean. Finally, the end product of a work of intellectual history is a narrative that explicates the discovered meaning of the text within a plot structure. Thus, a work of intellectual history takes as 'input' a text and produces as 'output' another text that explicates the meaning of the input text as a function of the subject author's intention and a contextual 'space' as environment.*

I will use this as my 'working definition' for what follows, recognizing that definitions pertaining to human activities are never complete, are often 'movable feasts' and prey to changing fashion or 'turns'. And it is because intellectual history as enunciated above plays a significant methodological role in our approach to understanding Jagadis Bose's middle period that we have expended what might seem an inordinate delay to entering the main subject of this paper.

3 The Boseian theses: the key texts

Let me then begin by laying out synoptically the key input texts that encode this work as stated in Bose's words.

The key source documents were: (i) the text (in French) of a lecture delivered at an international physics congress in Paris in 1900 (Bose, 1900a); (ii) an English version of that lecture published the same year in a widely read trade magazine called *The Electrician* devoted to electrical science and technology (Bose, 1900b); (iii) a Friday Evening Discourse delivered at the Royal Institution of Great Britain

[1] See Dasgupta (2016, pp. 5–7) for a brief discussion on the distinction between information and knowledge.

in London the following year (Bose, 1901); and, finally, (iv) a book-length monograph published the year after the Royal Institution lecture (Bose, 1902).

Here, I will draw upon the three English language documents as the key input texts. We note that the *Electrician* article was both the earliest and the briefest, the Royal Institution lecture was delivered several months later and was longer, and the book-length monograph, *Response in the Living and Nonliving* was still later and, as one might expect, much longer. Of particular note is that, as we will see, there is also an evolution in the *contents* of the three texts in the sense that the Royal Institution lecture is a further development of the *Electrician* article and *Response* is a greatly enlarged development of the Friday Evening Discourse. As we will also see, this is a reflection of the fact that Bose's *intentions* in writing these texts also evolved. Both these features are important in our attempt to elicit the intellectual history of Bose's panvitalism.

3.1 *The Electrician* article

Consider the opening passage in *The Electrician* article:

> In working with receivers for electric waves, I found that under continuous stimulation by the oncoming message, the sensitiveness of the metallic detector disappeared. But after a sufficient period of rest it regained once more its normal sensitiveness, In taking records of successive responses, I was surprised to find that they were very similar to those exhibiting fatigue in animal muscle. And just as animal tissue, after a period of rest, recovers its activity, so did the inorganic receiver recover after an interval of rest. Thinking that prolonged rest would make the receiver even more sensitive, I laid it aside for several days and was astonished to find that it had become inert. A strong electric shock now stirred it up into readiness for response. Two opposite treatments are thus indicated for fatigue from overwork, and for inertness from long passivity (Bose, 1900b, p. 139).

Bose then continues:

> A muscle-curve registers the history of the fundamental molecular change produced by excitation in a living tissue, exactly as the curve of molecular reaction registers an analogous change in an inorganic substance. *The two represent the same thing* (Ibid; italics added).

In this same paragraph, he adds, abruptly, an enigmatic comment: "An abyss separates the phenomena of living matter from those of inanimate matter" (Ibid).

In fact, nowhere in this article does Bose state *explicitly* his intention in writing this article. However, if we juxtapose his two somewhat contrary observations—that the inorganic and the organic responses are "analogous", and the presence of an "abyss" between living and inorganic phenomena, we can at least *infer* from the experiments that follow, involving the stimulation of iron oxide and the resulting response curves, and his comment that "The response curves of muscles" under similar conditions are similar in nature (Bose, 1900b, p. 141) that his intention was perhaps to show that there is no such "abyss" as was thought to exist. At the end of the article this is indeed what he claims:

> In all the phenomena described above there is no break of continuity. It is difficult to draw a line and say 'here the physical phenomenon ends and the physiological begins' or 'that is a phenomenon of dead matter and this is a vital phenomenon peculiar to the living'; such lines of demarcation do not exist (p. 143).

This was the Boseian thesis as articulated in this author's biographical study of Bose (Dasgupta, 2009). We may now identify it as:

> **Thesis I:** *There is no break of continuity (or demarcation) between physical (nonliving) and physiological (living) phenomena.*

However, it leaves unexplained what Bose meant by no "break of continuity" or "lines of demarcation" between physical and physiological phenomena.

The passages quoted from *The Electrician* article and the text that follows seem to suggest that he embarked on the experiments cited there *after* his "surprised" observation of the unexpected behavior of his radio wave receiver. Thus, the intellectual historian, examining this text is posed with the question: Did Bose's observation of the sluggish behavior of the receiver *first* lead to a tentative formulation of **Thesis I**? And thus, were the experiments reported in the article (and the preceding Paris lecture) designed to *corroborate* this initial idea?

We are reminded here of a principle well known to philosophers of science by the aphorism "All observations are theory-laden": that what one sees or notices or understands is driven by a prior theory or expectation (Popper, 1965, pp. 46–47; Hanson, 1972, Chap. 1). According to this principle, it is likely that Bose's experiments (controlled observations) were shaped by a *prior* theory—perhaps a hypothesis as basic as "there is a similarity in the response behavior between inorganic and organic matter". Indeed, if we read *The Electrician* article as a causally structured text, then we must believe that *first* was the surprising and wholly serendipitous observation of the non-responsiveness of the receiver; *then* the formulation of the similarity thesis, *then* the experiments whose results are presented, *then* a much firmer thesis—**Thesis I** stated above—based on these results. I will return to this issue later in the paper.

There is, of course, a certain danger in postulating this particular 'plot structure'. Scientific texts almost never reflect the untidy cognitive processes scientists actually conduct. Scientific texts are cleaned up, tidied and idealized so that they manifest an inexorable logic, the sort Sherlock Holmes claimed for himself, and the lay person mistakenly believes about the way scientists think. It is because of this that Peter Medawar, in a BBC radio broadcast in 1963 called the scientific paper a 'fraud' (Medawar, 1990, pp. 228–233). The task of the *cognitive historian* is to elicit the nature of the actual cognitive process a scientist followed in an act of creation (Dasgupta, 2019). But, for the *intellectual historian* for whom the text is what matters most, the textual content is all that he or she must work with.

We find in the *Electrician* article hints of another, possibly more daring but *tacit*, hypothesis. None of the experimental results reported therein involve living matter. It is as if Bose was demonstrating experimentally that inanimate matter manifests certain attributes ('fatigue', 'lethargy') we normally ascribe, by way of our everyday experience, to living, in particular, animal matter. He was dragging nonlife *into* the realm of life. Thus, while the claim of non-demarcation between the living and nonliving at least suggests a kind of symmetry between the two, this tacit characterization of nonlife as having lifelike features suggests a certain asymmetry: as if the inanimate was *a kind of the animate.* Bose's more daring thesis—though implicit in the text—is the first hint of panvitalism in his thinking:

Thesis II: *The nonliving is a kind of living.*

3.2 The Royal Institution lecture

As in the case of the *Electrician* article, the intellectual historian is hard pressed to recover Bose's explicit intention in delivering the Royal Institution lecture. He begins without preamble on the responsiveness of "living muscle" to external stimuli—mechanical, electrical, thermal, and chemical. But then, well into the printed version of the lecture, he inserts the following paragraph:

> ... 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 (Bose, 1901, p. 209).

There is no reference or citation of his source or authority concerning this claim. Instead, his 'abyss' statement is reiterated: "...there is a great gulf fixed between the organic living and the inorganic or non-living" (Ibid). But then, soon after, he asks:

> ... is it true that the inorganic are irresponsive, that forces evoke in them no answering thrill? Are their particles for ever locked in the rigid grasp of immobility?
>
> As regards response, is the chasm between the living and inorganic really impassable? (Bose, 1901, p. 210).

Bose does not answer this at this point; instead, the next few sections describe experiments concerning "inorganic response" but compared to muscle behavior. The physiologically suggestive words "fatigue" and "tetanus" appear in describing the responsive behavior of metals, shown alongside analogous behavior of muscle. Following mechanical stimuli, Bose describes the effect of light on a galena (lead sulphide, PbS)-based "artificial retina"—which he had invented and for which he would later receive a U.S. Patent (Bose, 1904). Responsiveness of metal to chemical stimuli are shown and, once more, a biologically suggestive term, "poison" is used to describe how the response is "killed" by the stimulus of oxalic acid (Bose, 1901, p. 216).

Finally, the text reveals Bose's actual intention in delivering this lecture:

> I have shown you this evening autographic records of response of the living and non-living. How similar are their writings! So similar indeed that you cannot tell one from the other . . .
>
> ... Amongst such phenomena, how can we draw a line of demarcation and say, 'here the physical process ends, and there the physiological begins'? No such barrier exists (Bose, 1901, p. 216).

Recall his intention in writing *The Electrician* article. That is repeated here, but now there are significant and subtle refinements and additions:

One. Responsive behavior of metals and muscles are always by way of recordings of *electrical* response. The significance of this is revealed by Bose's remarkable statement 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" (Bose, 1901, p. 209).

Two. Tucked away in the text is a reference, for the first time, to *plants*: "I find that the electrical response seen in animal tissues is also strongly exhibited by the tissues of plants" (p. 209). He does not elaborate on this but promises that "[a] more detailed account of these responses" to the kind of stimuli inorganic matter had been subjected to will be forthcoming (Ibid).

Three. An assertion that the responsiveness seen in life "have been foreshadowed in non-life"; "that the physiological is, after all, but an expression of the

physico-chemical"; there is, thus, a "continuity" between the two (p. 217).

If in *The Electrician* article he had situated the inorganic *in* the organic, in the Royal Institution lecture he is doing the opposite: life processes are "foreshadowed" in nonlife. The physico-chemical lays the groundwork for the physiological. This is yet another Boseian thesis*:*

> **Thesis III:** *Responsiveness in the living is foreshadowed in the nonliving*

But what exactly did Bose mean by 'foreshadow'? It is one thing to say that the physiological is an expression of the physico-chemical; it is quite another to claim that responsiveness in life is "foreshadowed" in non-life. The former may mean that physiological processes can be *reduced* to physico-chemical ones, a very reasonable assertion to make in the realm of *fin de siècle* biology. The latter is, to say the least, scientifically perplexing. Bose seemed to be claiming that the world of the nonliving *recapitulates* the living world—a variation on Ernst Haeckel's law of recapitulation ("ontogeny recapitulates phylogeny") in biology (Medawar & Medawar, 1983, pp. 225–227). That is, **Thesis III** implies a temporal relationship between the living and the nonliving: that in some remote past inorganic matter *first* manifested electrical responsiveness to stimuli which was *then* manifested identically by living entities.

Consider now Bose's assertion in the Royal Institution lecture that electrical response is regarded as the demarcation criterion between life and non-life. He stated this without proof. But given this assertion, **Thesis II** might be retroactively interpreted to mean the outcome of the following syllogism:

> The nonliving manifests electrical responsiveness;
> electrical responsiveness is a criterion of the living;
> *therefore* the nonliving is a kind of living.

So now we have a paradoxical contrast between **Thesis II** and **Thesis III**: on the one hand, that the nonliving is a kind (or a subset) of the living; and, on the other, that the nonliving manifested life before the living did! These two assertions can be reconciled by postulating a *panvitalist* thesis:

> **Thesis IV:** *All matter is living.*

3.3 Electrical responsiveness as criterion of life: Augustus Waller's authority

Whose authority was Bose appealing to in asserting, in the Royal Institution lecture, that electrical responsiveness is the criterion—the 'sign manual'—of life? Bose was particularly notorious in his reluctance to refer to other scientists' work in his published writings, especially in the 'middle Bose' and 'later Bose' periods. Reviewers of his books frequently expressed annoyance at this and, in the rare case references were present, would note that they were severely out of date.[2] The non-reference to the source of his electrical response comment in his Friday Evening Discourse is consistent with this trait.

An answer emerged, fortunately, in *Response in the Living and Nonliving* (1902), Bose's first book. This work is the quintessential scientific monograph. It is not entirely an original text, rather, it synthesizes his earlier work reported in *The Electrician* and the Friday Evening Discourse with a plethora of new, previously unpublished results.

In *Response*, for the first time in his published texts Bose refers to the British pioneer of electrophysiology Augustus Waller. Bose had met Waller in late 1900, as he reported in a letter to Rabindranath Tagore, dated November 1900 (Sen, 1994, pp. 40–41), had visited and admired his laboratory, become acquainted with the apparatus Waller used in his experiments with plants and, according to Waller (1903), had even repeated some of the latter's experiments.

As it would happen, in 1902 Bose and Waller would engage in a contentious and very public dispute in the pages of the journal *Nature* over the priority of the discovery of 'vegetable electricity'—electric responsiveness of not just sensitive plants but ordinary plants and vegetables (Dasgupta, 1998). But at the time Bose was writing *Response*, Waller was his source of authority on physiological matters; and, in particular on the significance of electrical responsiveness as a criterion of life. Thus, after stating, early in *Response* that:

> From these observed facts — that living tissue gives response while a tissue that has been killed does not — it is concluded that the phenomenon of response is peculiar to living organisms (Bose, 1902, p. 13).

— he provides a supporting footnote wherein he quotes at some length from one of Waller's papers published in the spring of 1900 which concludes with the sentence "The most general and most delicate sign of life is the electrical response" (Quoted in Bose, 1902, p. 13, *n1*).

3.4 The monograph *Response in the Living and Nonliving*

So we can now understand Bose's intention in writing *Response in the Living and Nonliving*. Studying electrical responsiveness was a means to a much grander end. His intention was to systematically and synthetically corroborate experimentally **Thesis IV** with Waller's scientific authority behind him. There was, however, another (and for Bose, powerful) *non-scientific* authority he drew upon. At the very

[2] See Dasgupta (2009) for several references to this trait.

front of the monograph, preceding the dedication page ("To My Countrymen") is a line from the *Ṛg Veda*: "The real is one: wise men call it variously." The purpose of an epigraph prefacing a piece of text is to tell the reader the broad theme of the text that follows. In this case the "one" is life itself; life is the universal principle of matter: **Thesis IV**. Privately, in a letter to Tagore written in August 1901 he had uttered this theme, in more exalted terms: "All is One!" (Sen, 1994, p. 82).

Response in the Living and Nonliving was the culminating and the definitive text in Bose's exploration of the relationship between the inorganic and organic. It also stands apart from his *Electrician* article and the Royal Institution lecture in a significant way in its attention to plant life.

As noted above, in his Royal Institution lecture Bose had made a passing mention of plants: "I find that the electric response seen in animal tissues is strongly exhibited by the tissues of plants" (Bose, 1901, p. 209). Some plants, he remarked, exhibit 'fatigue', others don't. But there was nothing further about plants in this lecture, save to tell his audience, that this was a promissory note, that his findings about plants will follow.

This promise was kept with a vengeance in *Response in the Living and Nonliving.* The chapters are divided about equally between plant and inorganic responses; animal muscles merit hardly a mention. In hindsight one sees here the beginnings of Bose's future devotion to plant physiology and biophysics.

The most salient points presented in *Response* are the following:

(1) The universality of electrical responsiveness.
(2) One should not confuse inanimate matter with dead matter. The assumption that inorganic matter is irresponsive, like dead matter, and is incapable of being excited by stimulus is refuted by his experiments.
(3) *Vitalism* postulates a "dualism" between life and nonlife in that it postulates that physico-chemical forces are not sufficient for life; rather, the latter demands "an all-controlling unknown and inscrutable 'force hypermechanique'" (Bose, 1902, p. 182)—what philosopher Henri Bergson would call *élan vital* and embryologist Hans Driesch would later term 'entelechy'.[3] In fact, the demonstration of "similar effects of inorganic substances" to those of organic matter shows "the necessity of theoretically maintaining such dualism in Nature must immediately fall to the ground" (Ibid). *So* Bose *eschewed dualistic vitalism but espoused panvitalism*. As far as the natural world was concerned, he was a monist, not a dualist.
(4) The phenomenon of electrical responsiveness under stimulus is not confined to animal tissue but is observed also in vegetable matter; and "the same electrical variations as in nerve and muscle were obtained [in]... vegetable tissues". Likewise, under "similar experimental arrangements" the same kinds of electrical responses were found in metals (Bose, 1902, p. 183).
(5) A variety of kinds of, and variations in, stimuli—mechanical, chemical, thermal, optical (in the case of the 'artificial retina')—yielded photographic recordings of identical electrical responses.

The panvitalist thesis that all matter is living (**Thesis IV)**, is not especially mysterious for Bose according to his interpretation of Waller—that electrical responsiveness is *the* criterion of life. Like organic matter, inorganic matter manifests electrical responsiveness, hence like organic matter, inorganic matter is living. And since electrical responsiveness is a physical phenomenon, to say that all matter is living is to say that the same *physical law* of electrical responsive behavior, characteristic of life, acts across the inorganic and organic worlds.

Bose then goes a further step. The experiments reported in *Response* were all concerned with the electrical responsive behavior of animal, plant and inorganic matter. But by an act of induction he *universalizes* this narrow realm of physical regularity to *all* realms of regularity in the natural world. And so he concludes his book with a final thesis (p. 191):

> **Thesis V:** *The same unchanging physical laws act equally and uniformly throughout the organic and inorganic worlds.*

Herein Bose's panvitalism is justified by nothing less than the laws of physics themselves.

4 Jagadis Bose's panvitalist doctrine as intellectual history

In this and the next section I review Bose's panvitalism as a case of the intellectual history of a scientific event according to the tenets of intellectual historiography presented earlier in this paper.

The task of the intellectual historian is not to pass whiggish judgement on the event at hand.[4] Thus, to judge whether

[3] See Dasgupta (2009, pp. 131–135) for an extensive discussion of the status of vitalism in *fin de siècle* biological thought.

[4] Whiggism is the tendency to judge a historical event or act according to criteria or values or conditions of a later time; in particular, to the historian's own time (see Dasgupta 2021).

Jagadis Bose's panvitalist story, according to *later* thinking about dualism in nature, about panvitalism, about the very idea of electrical responsiveness as the criterion of life, about what *is* life, and so on, is not the stuff of intellectual history as I see it. As the 'working definition' presented early in this paper tells us, it is ideas and texts that matter, and the intellectual historian's aim is, having elucidated the author's intention, to extricate the meaning of his or her ('input') text, paying close attention to the language of the text, to the definitions presented, and the context in which the text must be understood; and to produce an 'output' text that unravels the meaning of the 'input' text according to an emplotted narrative. If any judgement is to be passed it must be solely relative to the context of the time the text was created or the idea was invented.

The 'Waller context'. There is no doubt that the most significant contextual element in this story is Bose's *interpretation of Waller's statement about electrical responsiveness*, as quoted in the book. A fuller part of the quotation from Waller is as follows:

> ... an ordinary nerve . . . separated from its natural termini, isolated from the rest of the organism, gives no sign of life when excited, either in the shape of chemical or thermic changes, and it is only by means of an electrical change that we can ascertain whether or no it is alive. The most general and the most delicate sign of life is then the electrical response (Quoted in Bose, 1902, p. 13, *n1*).

Bose evidently understood Waller's assertion to mean that electrical responsiveness was a *sufficient* criterion determining the presence of life. Judging from Waller's *Eight Lectures on the Sign of Life from the Electrical Aspect* (1903), delivered at the Royal Institution and published the year after *Response* was published, Waller seemed to have claimed something else: that electrical responsiveness was *one of several* interconnected phenomena, though it is "the most delicate" way of determining the presence of life (Waller, 1903, p. 3). Furthermore, "electrical signs *by themselves* should not be divorced from other signs"; for otherwise they are "of comparatively small general importance" (Ibid; italics added). In fact, as I have noted elsewhere (Dasgupta, 2009, pp. 129–130), in his other prior writings, Waller, an authority and pioneer in the realm of electrophysiology was quite circumspect. In his textbook *An Introduction to Human Physiology* (1896), Waller stated three conditions which *collectively* determined the living: the organism's deoxygenating capacity, its ability to exhale carbon dioxide, and its excitability (Waller, 1896, pp. 385–386). In 1897, Waller delivered a set of lectures on 'animal electricity' at the Royal Institution; in the preamble to his first lecture Waller noted that "Animal Electricity, after having failed to make good its title as *the* vitalizing force of animated beings, has taken upon itself the more modest and more prosaic duty of spelling out a few more syllables in the physical and chemical phenomena of living matter" (Waller, 1897, Preamble. Italics added).

If Waller's writings are a significant component of the context of Bose's text then we are left with the very uncomfortable conclusion that Bose 'cherry picked' what suited his own theses concerning the relation between the living and nonliving; that he may have willfully ignored Waller's statements that contradicted the context he (Bose) desired. In a very real sense, Bose's *belief in Waller's theory was a case of false consciousness.*

Intentions. This study of the Boseian theses and Bose's panvitalism also sheds some interesting light on the nature of the text-context relationship in intellectual history, especially in the realm of science. One such kind of relationship described by theorists is between the author's intention (or goal) and the author's text. In Bose's case, the intentions in composing his three texts were never explicitly stated, and certainly never occur as preambles to the main texts. Rather one had to extricate Bose's intentions *from* the texts themselves. They had to be inferred.

Note the use of the plural. The specific nature of Bose's intention hovered around a general theme but varied in specificity from one text to the next.

His intention in writing *The Electrician* article was to show that there was, in fact, no 'abyss' or 'gulf' between the living and nonliving. His intention in delivering the Royal Institution, Friday Evening Discourse was somewhat more complex: it was an expansion of his *Electrician* intention that included the goal to show that electrical responsiveness is the common element between the living and nonliving. Finally, Bose's intention in writing *Response of the Living and Nonliving* was to present a comprehensive body of experimental evidence in support of his thesis (**Thesis IV**) that all matter is living.

Personal beliefs and knowledge as context. We discover that the 'Waller context' cannot be placed in a natural way in any of Dominick LaCapra's list of contexts. Rather, the Waller context belongs to Bose's *personal* body of beliefs and knowledge. It is important to note that while Waller's key texts such as *An Introduction to Human Physiology* (1896), his Royal Institution lectures on animal electricity (1897) and the paper in the journal *Brain* (1900)—which Bose directly quotes in *Response*—belong to the public domain, and thus might be said to be in the realm of the scientific *culture* of the time (hence in LaCapra's list), Bose's interpretation of Waller is a *private* belief. Like intention a personal belief or piece of knowledge belongs to the realm of *cognition*. And, like intention, such personal belief/knowledge has to be excavated from the text itself.

Language of discourse. By the beginning of the twentieth century the language of scientific discourse had developed into a distinctive form—emotionless, objective, jargon-filled. The early Bose—the physicist—followed this mode of discourse meticulously in both his lectures and papers. The discourse of the middle Bose, in contrast, was infused with metaphorical language, especially referring to the responsiveness of inorganic matter. When he speaks of the "answering thrill" of metals in response to stimuli (Bose, 1901, p. 210), their particles "for ever locked in the rigid grasp of immobility" (ibid), of "administering poison" to "kill inorganic response" (p. 215), of the "growing exaltation" of the response of tin to chemical reagents (ibid), of "electric throb" of a piece of metal (p. 216), "of autographic records" of the response of living and nonliving (ibid), Bose is already engaging in the realm of **Thesis II**, *the nonliving is a kind of living*. It is quite reasonable to claim that Bose's metaphorical language was intended to facilitate the reader's understanding of both the Boseian theses and Bose's panvitalism.

5 Emplotting the history of Bose's panvitalism

Hayden White's notion of situating an intellectual history within a 'plot structure' or thematic is, in fact, particularly pertinent in the realm of science. No serious intellectual historian can unravel the meaning of a scientific idea or text in the absence of a prior *model* of scientific inquiry. Such a model not only affords a context in which to 'frame' the scientific (that is, 'input') text but also as a means of emplotting the historian's (that is, 'output') text.

The literature on the scientific process has a long history, reaching back to Aristotle and is rich in debates and disagreements. In particular, since the Second World War, a number of significant models have emerged, the most influential of which are due to Popper (1968, 1972), Kuhn (2012), Laudan (1977), Lakatos (1978), Langley et al. (1977) and, from the postmodern camp, Latour (1986, 1987)—along with variants and refinements thereof.

Each provides a plot structure the historian of science can draw upon or even pragmatically and selectively combine and construct.

However, when we examine closely Jagadis Bose's three texts individually and collectively we are hard pressed to find any one of the aforementioned models in which Bose's work can be situated. We find no evidence, for instance, of the presence of Popper's conjecture-and-refutation-based evolutionary model, or Kuhn's paradigm-situated problem-solving model, or Latour's socio-anthropological model, or Langley et al's heuristics-search-based computational model in Bose's texts. When it comes to the middle Bose period, he seems to be an island of his own as far as theories and models of science are concerned.

But *no* scientist can work in a vacuum; *every* scientist (contra Popper, 1994, pp. 33–64) operates within a framework of beliefs, knowledge, values, metaphysics, operational principles, and so on—which Kuhn called a paradigm, Laudan a research tradition, and Lakatos a research programme. When Bose entered his middle period he obviously possessed such a framework, most dominantly comprised of the classical physics of the time, including properties of radio waves to which he himself had contributed. We also know that he was familiar with certain aspects of biology, by way of his natural science tripos training in Cambridge and his readings, much later, of such prominent physiologists of his time as John Burdon–Sanderson and Augustus Waller on 'vegetable electricity' and 'animal electricity'. Collectively, (following Laudan's term) let us call this Bose's *personal research tradition*.

But hereafter a very different kind of *modus operandi* appears to emerge in Bose's middle period. Recall his assertion "There is no abyss between the living and nonliving" stated in *The Electrician* article. Let us label this as **P**. We realize that this became the source of a very *personal problem of interest* for Bose:

> Justify the proposition **P**: "*There is no abyss between the living and nonliving*".

I use the word 'justify' deliberately. There is no evidence in his texts that for Bose this was a *conjecture*, or that he was interested in *refuting* this proposition in the Popperian sense. Nor is there any evidence that Bose had embarked in his middle period in a program of paradigm-based *normal science* in the Kuhnian sense. Rather, for Bose the proposition **P** was of the nature of an empirical and quite dramatic, even revolutionary *axiom.* Normally, of course, axioms are taken to be 'self-evident truths', but in this case Bose's problem of interest was to deliver empirical evidence to justify this axiom.

What followed in the course of the three texts was *one long argument justifying* **P**, rather like a proof of a theorem is offered as its justification, except that because **P** is in the nature of an empirical axiom, Bose offered a plethora of experiments, first in the realm of metals and muscle, then extended to plants, along with intervening conceptual arguments, to justify **P**. And just as a long mathematical proof is often *structured* by way of lemmas and corollaries, so also Bose's justification is structured by way of his theses.

Eventually, the justification arrives at his panvitalist doctrine, **Thesis IV:** *all matter is living.* The final **Thesis V** is doubly interesting: not only does it justify **Thesis IV** (as noted before), but it also further strengthens the justification of **P** by way of a genuinely *empirical* proposition. Of the five Boseian theses this is the only one that is, in principle,

falsifiable—although Bose himself showed no interest in falsifying it.

6 Postscript

In my biographical study of Jagadis Bose (Dasgupta, 2009) I had indicated that the central product of the middle Bose's science was an assertion about the continuity between the living and nonliving—an assertion I had called the Boseian thesis. In this paper, examining the texts from the perspective of intellectual history, we have found that *several* Boseian theses relating the living and nonliving can be identified. Most significantly, they speak to the clear emergence of a form of panvitalism, the idea that there is life in all matter.

It became clear that the three seminal texts of Bose' middle period, which began with the proposition that there is no "abyss" between the living and nonliving, constituted one long argument (to borrow Darwin's famous phrase) to justify this proposition; and that this proposition was strengthened in the course of his argument into a panvitalistic doctrine. Referring to one of the tenets of intellectual historiography, this *empirical axiom-and-its justification* strategy was the 'plot structure' underlying this narrative.

As it happened, Bose's panvitalism, in particular as encapsulated in *Response in the Living and Nonliving*, was greeted with a deafening silence from within the relevant scientific community. Elsewhere I have offered an explanation why this was so (Dasgupta, 2009, pp. 166–169). One reason, as mentioned earlier in this paper, was that Bose misinterpreted Augustus Waller's statement about the relationship between electrical activity and life. Waller did not assert that electrical responsiveness was a sufficient sign of life but, rather, that it was a necessary factor. Bose transformed this to a sufficiency claim. Another, not insignificant, reason was, probably, that Bose's panvitalism could find no scientific home in his time: it belonged neither to physics nor to biology; rather than straddling the two disciplines it fell between them. Yet a third reason is that Bose allowed the philosophical doctrine of monism to intrude upon his scientific objectivity.

So there remains the question: What was the *scientific* significance of Bose's middle period, 1900–1902? Why should his panvitalism merit any attention at all from perspective of the intellectual history of science? Why did I write this paper?

One answer should be clear from the foregoing material. Several pages at the beginning of this paper were devoted to an explication of the nature of intellectual history. There was a reason for this. It has allowed a more nuanced examination of the key texts of Bose's middle period than has been attempted in the past. The tenets of intellectual historiography has facilitated a clearer understanding of the *evolution* and emergence of Bose's panvitalism across a number of Boseian theses.

There is yet another answer to my foregoing questions. *Response in the Living and Nonliving* was the last publication pertaining to Bose's panvitalism but it was not his last *text* on the topic. In January 1903 Bose wrote to Rabindranath Tagore that he was engaged in a search of "a very great truth" (Sen, 1994, p. 116). He did not further clarify but it is tempting to believe that he was alluding to further amplification of his panvitalist theses.

In December 1903, the Royal Society in London received from Bose a 131-page manuscript titled "On Mechanical and Electrical Response in Plants" (Bose, 1903–1905). This paper would undergo a tortuous path through the refereeing process (Dasgupta, 2009, pp. 183–184) but the outcome was that it was never accepted for publication by the Royal Society.

The manuscript's continuity with the work reported in *Response* was alluded to briefly at its beginning. But his intention here, as he stated, was twofold. First, to show that various kinds of plant phenomena were identical irrespective of whether mechanical or electrical responsiveness was the irritability criterion. This was a clear nod to his continuing search for more evidence of unity in the natural world except that here the unity was between mechanical and electrical responsiveness.

The second intention was directly implied by the first. Mechanical response was manifested only in the so-called 'sensitive' plants, such as *Mimosa pudica.* If indeed mechanical and electrical responsiveness were indistinguishable insofar as outcomes of plant phenomena were concerned, one could use electrical responsiveness to study *all* plants, "ordinary as well as sensitive." Once more, none of the 'standard' models of scientific problem solving (Popperian, Kuhnian, Langleyan, etc.) are on display. Once more a narrative of this work shows the empirical-axiom-and-its-justification plot. And we see yet another version of his panvitalist thesis. As he concludes:

> A unity of phenomena, as between animal and plant . . . as has been shown to exist, point unmistakably to some basic properties of protoplasm common to the two, manifested by both alike, by the same response effects under stimulation (Bose, 1903–1905).

Protoplasm—the term was coined in 1839 by Johannes Evangelista Purkinje—was believed in the later nineteenth century by such biologists as Thomas Henry Huxley as the 'living substance' or the 'physical basis of life'. Thus, the unity of animal and plant phenomena that Bose had demonstrated suggests some common properties of protoplasm in both. But then, given his panvitalist **Thesis IV**, does Bose imply the presence of something like protoplasm in inorganic matter also? He does not explain.

Finally, he concludes, given this unity of phenomena between plants and animals, and given that plants are "simpler and more manageable" as a means of investigation, they may serve as a kind of surrogate for the more recondite problems in animal physiology. The study of plant physiology thus becomes an experimental vehicle for physiological research. The middle Bose's panvitalism paved the way for the later Bose's research program that continued to the very end of his life.

In sum, Bose's middle period, 1900–1902, merited a close scrutiny not for its significance in the history of world science per se but for its place in Bose's *personal history* as a scientist: first for clarifying the emergence of his panvitalist doctrine; and second for answering the question: why and how did Bose the well-established physicist metamorphose into Bose the neophyte plant physiologist?

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