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GOOD LIFE, SELF-SUFFICIENCY AND CHEMICAL KNOWLEDGE: THROUGH THE CHEMICAL WORLD VIEW OF LATE JNAN CHANDRA GHOSH

Prajit K Basu*

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Abstract

The essay attempts to interpret chemical research work pursued by Late Jnan Chandra Ghosh in the light of the cultural and political milieu within which Ghosh worked. His work in the area of photocatalysis and industry catalysis is to be understood as a response to the building of Scientific and Technological capabilities. The essay also attempts to set out a moral canvas within which Ghosh's chemical research in particular and his understanding of science and technology as the possibility of knowledge generation, and as the instrument for nation building is to be understood. Ghosh's engagement with the moral basis of science (leading to disillusionment regarding the nature of science) is to be understood in terms of a specific version of parity of reasoning that needs to inform the alleged good and bad use of science and technology. This engagement I suggest is a result of Ghosh's specific reading of the nature of Good Life and its cognate concept, in the specific context of colonial India, Self-Sufficiency.

Key words: Catalysis, Chemical Knowledge, Electrochemistry, Good Life, Meghnad Saha Moral Basis, Science and Culture, Self-Sufficiency.

1. Introduction

In this essay, an attempt is made to locate late Professor Jnan Chandra Ghosh's scientific work in the context of chemical research of his time and subsequently in the contexts of Indian independence struggle and post-independent nation building efforts. Thus, the first section delineates the trajectories of Professor Ghosh's scientific work carried out over forty years in the context of chemical research being pursued in India both in the larger International context and also in the context of building Science and Technology capabilities in India and research related to the application of Science and Technology to address various material demands of the society. In the second section, attempts to develop an outline of the larger social and moral contexts within which Ghosh's understanding of science and its applications to pre- and post-Independent society in India needs to be placed. Ghosh's preference for modern science and technology with its attendant maladies needs to be seen as nuanced in the sense that he confronted the moral issues related to pursuing science although was quite ambivalent as to how to mitigate the thrust of moral problems unleashed by the modern science and technology (read knowledge systems)

2. The Chemical World of Jnan Chandra Ghosh

Professor Jnan Chandra Ghosh (hereafter JCG) was (is still probably today) known among the chemical research world for his fundamental

* Department of Philosophy, and Centre for knowledge Culture and Innovation Studies, University of Hyderabad, Prof. C. R. Rao Road, Gachi Bowli, Hyderabad 500 046; Email: pkbsh@uohyd.ernet.in, prajitkb@hotmail.com

work on complete dissociation of electrolytes. He had published a series of three articles in the *Journal of the Chemical Society*, London, in 1918. These articles were titled "The abnormality of strong electrolytes". Although prior to these three, he had published in the area of electrochemistry in journals like *Journal of American Chemical Society* 1914 titled "Alternating Current Electrolysis" or "Influence of alternating current on electrolysis by a direct current" published in the same journal in 1915, the 1918 publications made the chemical community sit up and look at Ghosh's work with considerable interest and seriousness the research deserved.

Let us briefly recapitulate the theoretical contribution made in the three papers of 1918 mentioned above. During that period, Arrhenius' theory played an important role in the explanation of ionic conduction in both strong and weak electrolyte solutions. This theory assumed that the degree of dissociation of the solute molecules, both in the weak and the strong electrolytes, was proportional to dilutions. Although the theory worked rather well for weak electrolytes there were serious discrepancies in the explanations / predictions provided by the theory and the experimental results in the domain of strong electrolytes. Ghosh gave a quantitative formulation of electrolytic conduction based on a simple model. He suggested that there was complete dissociation in strong electrolytes. In such solutions there were only ions. And these ions were arranged much like a crystal lattice and each pair of oppositely charged ions formed an electrically charged neutral doublet. An ion was free to move only when the kinetic energy was greater than half the work required to separate from its partner. On the basis of these assumptions he set out his theory. It was a serious contender for the best theory for about five years eclipsing Arrhenius's accounts. He continued his work on electrolytes as a post-doctoral researcher in England and took up both theoretical and experimental work. Ghosh's most carefully researched results were brought out by his paper in 1921 published in *Z. Phys. Chem*. There was finally the well known Debye-Hueckel theory which was proposed in 1933 and was accepted by the members of the scientific community as more adequate. It needs to be borne in mind that Ghosh's work sharpened the questions much more and thereby gave impetus to both careful experimental work leading to anomalies to Ghosh's account and subsequent attempts to address those anomalies. Those of us who want to take pride in the relevance of past work in today's research may probably appreciate that many eletrochemists today think that Ghosh's model still have something to recommend. And he happens to be among the very few Indian chemists whose research work has been cited in Nobel lectures.

What also needs to be highlighted here is the context of Ghosh's research. By the time he published his work he was 25 years old and just about finished his doctoral work and was to start his postdoctoral work in the UK. He had very little in the way of chemical community around him and even less so in the area of physical chemistry. While he had Acharya P. C. Ray as his mentor, it seems clear that Ray's influence on him in this particular research work was more inspirational than material. It needs to be investigated whether Ghosh's interactions with the researchers in Physics community (again a rather motley group) in the then Bengal and probably even in India played any important role in pursuing a rather theoretical work of high distinction. The issue assumes significance in the light of Ghosh's life long strong and abiding friendship with Prof. Meghnad Saha (who graduated and did his M.Sc. in Mixed Mathematics during the same years as Ghosh and his other illustrious chemist colleague Prof. J. N. Mukherjee). This also raises a further question in the history of scientific practice in early decades of scientific research in India. Was this a rather rare incident or was it a possibility that

presented itself in a significant way and could not be ignored? This is given the fact that research activity was less organized then rather than now. And a stronger interaction among various scientific disciplines might have seemed to be a way of obviating the difficulties of working in isolation. Or was this kind of interaction rare? And it happened in Ghosh's case because of Ray's affectionate indulgence for Ghosh, Saha and Mukherjee. Ray was seen as the *gurudev* by a large number of scientists of his time. Ray could have instilled a sense of camaraderie and friendship among his own students and also with others. This is somewhat speculative and I mention this more to raise questions which I think are worth investigating in the contexts of research and teaching practices of sciences in general and chemistry in particular during the pre-Independence era in India.

Ghosh's stay in England for his post-doctoral work in the laboratory of Prof. F. G. Donnan, University College, London, was for approximately two years. That Prof. Donnan was impressed and happy with his work is evident from his recommendation of Ghosh for an academic position in Dacca University. JCG during his stay in Dacca University for about 18 years (1920 – 1938) began a different direction of chemical research. He started with theoretical research in photochemistry but was more interested in photocatalysed reactions. In 1925, at the Twelfth Indian Science Congress, he gave a Presidential Address as the President of the Section of Chemistry. Two features stand out in that address. One is the switch from a lecture on 'topics of general scientific interest and organization', as had been the tradition earlier, to a topic which is part of chemical research work; and the second is the highlighting a research area Ghosh called photo-chemistry in which he had been interested 'for sometime'. There were also indications that he would take up catalytic reactions in general for his later research work. Thus, he tried to develop research work in the area like liquefaction of coal.

Ghosh had published 14 papers in the year between 1914 and 1921 in the area of electrochemistry. Between 1921 and 1925, his publications (11) are primarily in the area of photochemistry, photocatalysis and catalysis in general. Between 1926 and 1930, Ghosh's publications rose to 30, followed by 19 in the next five year period. By then his interest had shifted to catalytic research primarily in the area of photocatalysis. His publications in this area continued till he shifted to IISc. Bangalore. As a result, he had published approximately 70 papers in the area of photocatalysis by 1938. His research in IISc., Bangalore, and publications subsequently would be only in the area of industrial catalytic reactions. Two major areas of catalysis were his focus. One was related to the liquefaction of coal, specifically study of the formation of complexes involving the catalyst in the Fischer-Tropsch synthesis of liquid fuels from carbon monoxide and hydrogen. A large number of catalysts were studied including iron-copper systems incorporated with rare earth oxides, and the other was related to the study of stepwise mechanism of ammonia synthesis from its elements. This involved studies of adsorption of nitrogen and hydrogen and their mixtures by catalysts at high pressure. It should be obvious that one was related to the petrochemical industries and the other with the fertilizer industry. I shall comment on these relationships a bit later again.

Ghosh published 32 papers during the period between 1936 and 1940, 10 papers between 1941 and 1945, 25 papers between 1946 and 1950, 14 papers between 1951 and 1955, and 11 papers between 1956 and 1959 (year of his demise). And a large number of these papers are in the area of industrial catalysis as mentioned above. To summarize, Ghosh's total publications are about 184, of which 14 are in the area of electrochemistry, approximately 70 are in the area

of photochemistry and photocoatalysis, and approximately 100 are in the area of industrial catalysis. More as a curiosity I started collecting data about the citation patterns of these publications. The data has so far been collected from 1965 to 1995 from the SCI dataset. These are therefore somewhat preliminary and definitely incomplete. These tell a somewhat predictable story. Ghosh's work in electrochemistry has the highest number (50) of citations with citations continuing until 1995. The rest of his papers have 101 citations. His papers in the area of photochemistry and photocatalysis are rather less cited (approximately 35 citations). And the citations of majority of these papers had petered out by the end of 1960s. Although the work on industrial catalysis has fared somewhat better (66 citations for about 100 publications), and some of these papers had been cited even till the end of 1980s, the results are not as interesting as the first set. These results, of course, do not automatically reflect the quality of research work since the focus of the chemical community keeps shifting even within a narrow domain. Also, the work in this genre may be cited more by patents which have not been included in this collection of data. Yet it does seem to show that Ghosh's early work was extremely commendable and was received very well by the chemical community internationally. And the relevance of this work in the theoretical domain of electrochemistry is still not absent.

3. Good Life, Self-Sufficiency and the Moral Compass of (Chemical) Science

We now come to the second part of this essay. I wish to raise the issue as to what were the contexts in which Ghosh's later chemical research blossomed. What is clear is that he shifted to research in the area of catalysis. In order to develop an outline for the interpretative exercise, let us begin by considering how some of the Indian scientists saw themselves and their roles in the light of the colonial rule in general and also how they visualized the role(s) of scientists in the future when India is freed from the colonial rule. This is related to how India grappled with the very general question 'what is good life?'. This is a question, which every civilization, every country, continually has asked in some way or the other and has attempted to answer although not very clearly and cogently (since the scope of the question is vast) and subsequently set out its path. Here was an attempt, taken up quite earnestly, by the National Planning Committee established in 1938 (I think) by the then President of the Indian National Congress, Netaji Subhash Chandra Bose. This was established at least partially due to constant underscoring on the part of scientists, especially Professor Meghnad Saha, that modern free India will need a planning body which can chart out the paths for at least better material living. The Committee needed to ask what would be a reasonable picture of 'good life' for a nation like India and come up with some rough and ready answers. And that it did. And this was a result of past experiences of various members of the committee being constantly shaped and reshaped in the light of intensive debates among themselves. The committee consisted stalwarts like Professor Meghnad Saha, Professor J. C. Ghosh, from science, like Mr. M. Visveswarya, from technology, like Jawaharlal Nehru (who was the chairperson of the committee) from politics, and luminaries from the industry sector. The decision to make a political person the chairperson of the committee was probably the recognition that the sphere of politics was primary in that the years to come it would be the politics which would be the prime mover in making sense of the nation and its trajectory. Science is important but that its patronage is political was recognized even then. Is there something more to this? Is it a case of knowledge of nature and knowledge of control and intervention of nature genuflecting to knowledge of politics? If so, in what terms? Without answering this difficult question I proceed to develop as suggested above an outline of 'good

life' and how someone like Professor J. C. Ghosh might have seen himself in this endeavour and subsequently in translating the imperatives of 'good life' in science research.

One of the best places to seek an answer as to how Ghosh and his colleagues visualized what constitutes 'good life' is to look at how they characterised the goals of scientific research and subsequently means of achieving the goals. Although there is not much of writings by Ghosh, his participation in the National Planning Committee, his association with the *Science and Culture* group (a founder member), his continued association with various government agencies like the Board of the Council of Scientific and Industrial Research, the All India Council of Technical Education, and finally the National Planning Commission, give us a glimpse of the view he might have endorsed. I'll draw from the National Planning Committee related work and the *Science and Culture* group's arguments for some of my not yet fully developed views in this matter.

Science and Culture, a journal started in 1935, started a kind of debates among the members of the scientific community concerning the nature of science and its various roles in society. The aim was also to 'awaken the interest of the public in the methods of application of science to national regeneration'. As a result, there were several subjects discussed both editorially and in articles published by the specialists in the journal. For example, in the year between July 1937 and June 1938, some of the articles were published in the areas of Cheap Electricity, River Problems, Industrial Organization, Scientific Research Boards, A New Method of Agriculture discovered in Russia, etc. But Saha clinched the issue in the following way: the Indian Science News Association, which published *Science and Culture*, was trying to bring to the notice of the public, in simple language, the value of (modern) science to the country. Saha appealed to interesting examples cited in *Science and Culture* to highlight that the Indian society and people at large have a very low standard of living. The production of work per capita in India was twenty times less than in European countries. *Science and Culture* group suggested that India needs to increase its work output at least ten times of its present rate to achieve 'any decent standard of living' for people at large. Saha also pointed out that output of electricity was only 7 units per capita and 100 times less than in European countries. Saha drew the conclusion that this showed that 'the development of natural resources in power has been extremely meagre'. And even more interestingly, the *Science and Culture* group, according to Saha, pointed out that 'the number of museums in India was thousand times less than in a country like Sweden'. This was a pointer, according to the group, to 'the low standard of cultural level amongst the masses of India'. These examples are telling in that we have pointers to operational definitions of some of the facets of what constitutes 'good life'.

Indian Science News Association also approvingly held Saha's view that India was going through regeneration and this movement must be properly guided by 'a new philosophy of life which will renew the springs of our civilization and culture'. Saha, in the Indian Science News Association third annual meeting, in 1938, chaired by Netaji Subhash Chandra Bose, argued quite forcefully in the following way:

> May I put some questions to Mr. Bose? …. May I enquire whether the India of future is going to revive the philosophy of village life, of bullock cart, thereby perpetuating servitude, or is she going to be a modern industrialized nation which having developed all her natural resources will solve the problem of poverty, ignorance and defence and will take an honoured place in the comity of nations and begin a new cycle in civilization?
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> (Indian Science News Association Third Annual Meeting Report, 1938, p.2)

Saha continued in the same vein,

> Is India going to be one nation or going to be divided in a patchwork of ill-defined provinces and states and communities separated by a babel of tongues and sentiments and artificial political restrictions?
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> (Indian Science News Association Third Annual Meeting Report, 1938, p.3)

That the *Science and Culture* group was attempting to set out a picture of developed India wherein modern knowledge systems replace the old knowledge systems and employ the modern knowledge organization process to continue to develop the new knowledge system and apply the new knowledge system in solving the problems afflicting the Indian society and also in raising the standards of living of people at large is too obvious to miss. That the focus of attack was also a pro-village, less technologised, more decentralized way of life probably cannot be missed. This is set out in the famous civilizational differences. And I suggest that some aspects of this difference is characterized in the way idea 'good life' is characterized.

Whether it is Buddha or Aristotle or Gandhi, one can begin to see an account of 'good life' which seems to sit ill at ease with the kind of science and technology research and their applications that were being suggested by the *Science and Culture* group. Thus Buddha taught that to achieve *nirvāṇa* one must eschew attachment to things in the world. Desires return again and again and attempts to fulfill them again and again are futile. Aristotle suggested that good life consists in instructing one's soul to desire rightly. For them, as well as for Gandhi, achieving 'good life' does not involve controlling nature but in purifying or perfecting the soul. Technology, as a result, is not an essential feature of 'good life'. They were not against technology per se and were in favour of technology that humans employ to use their bodies or on their bodies and soul to attain happiness. Technologies are not (at least important) determinants of good life. While someone like Buddha or Aristotle or Gandhi would mean by 'development' by 'formation of character', for the Science and Culture group or the modern day vision of Science and Technology the term means something quite different.

I had alluded above to the formation of National Planning Committee. The committee visualized planning as a 'technical coordination, by disinterested experts, of consumption, production, investment, trade and income distribution, in accordance with social objectives set by the bodies representative of the nation.' Planning should include in its focus 'the raising the standard of living, cultural and spiritual values and the human side of life.' The aim of planning is National *Self-Sufficiency* for the country as a whole and doubling the standard of living within a prescribed time limit. The committee also suggested that a basic minimum education and training of the mind and the body be made available for 'imbibing a basic minimum of enlightenment to the future citizens of India'. The committee also recognized that the ideal of village *self-sufficiency* has broken down. And the argument was that it was uneconomical given the market-based economy and claimed village self-sufficiency 'has little room in modern economy, and none in the future'. The committee came to the conclusion that the 'introduction of money economy has made the rehabilitation of the villages as a self-sufficient unit impossible to restore, and unprofitable to maintain'. The committee saw that it was not only desirable but also easier to achieve national self-sufficiency. One passing observation is that the notion of self-sufficiency pans out in the pursuit of science and technology, impingement of science and technology on society within the 'development' discourse and moral improvement of individuals in the sense of imbibing modern enlightenment view. (Shah, 1948, pp. 1-19)

And the *Science and Culture* group, of which Professor J. C. Ghosh was an important member, championed a very similar version of *self-sufficiency*. Probably it should be said that the *Science and Culture* group articulated the various elements of *self-sufficiency* and helped in the subsequent articulation of *self-sufficiency* in the National Planning Committee deliberation.

There are theories of 'good life' or well-being of humans. The first is the 'happiness or the cognitive state' theory. This takes the view that 'good life' is to be related to happy states of mind an individual is in. It is taken to be a hedonistic account of well-being (Mill 1998). Desire fulfillment theories or the preference satisfaction theories give us an account of good life by suggesting that well-being lies in the fulfillment of desire. Objective list theories identify a set of objective conditions which contribute to our well-being whether we are aware of it or not. There are varieties of list. Several lists underscore knowledge as an objective condition and may also include practical reasonableness, aesthetic experience, deep personal friendship, play, etc (Parfit 1984). What items in the list have in common is their contribution toward realization of human nature. Martha Nussbaum suggests a capability theory of well-being wherein she enumerates capabilities which are real possibilities to be or do something (e.g. take care of others). She acknowledges that one need not be able to actualize all the capabilities all the time and sometimes may focus on one rather than the other (Nussbaum, 2000). These accounts begin to give us a way of capturing the notion of *self-sufficiency* in a certain sense which seems to account for only the individual scenario.

Let us start by making a few comments about some of Acharya P. C. Ray's interesting views about science and technology and its impact on society. Ray suggested that scientific knowledge follows from industrial or practical knowledge. This is brought out in his criticism of Visveswaraya's suggestion that a technological university needs to be set up. Ray argues that universities are where scientific knowledge are taught and technological knowledge cannot be taught to be relevant for society. Although the notion of *following* is rather unclear in the above claim, what is clear is that Ray's idea is antithetical to the idea that applied science follows pure science. What was Ray suggesting? One of the ways to capture that could be to recognize Ray's support for *charkhā*. Was he suggesting that artisanal technologies or industries are morally sanctioned since these industries and the knowledge these industries produce have a direct bearing on who we are? These instantiate human autonomy, knowledge, agency, etc., and thereby underscore *self-sufficiency* and 'good life'. Gandhi preferred machines that help humans perform their labour better (Gandhi, 1908).

Ghosh's later scientific research is best seen as compatible with a reconfigured notion of *self-sufficiency* which is to be disambiguated from the view of P. C. Ray mentioned above. Ghosh's view was in consonance with Saha and other members of the Indian Science News Association. He probably followed Prof. J. N. Mukherjee's view that both pure science and applied science can be pursued in an academic institution. Ghosh's view was clearly at odds with the quasi-Gandhian view of what is implicated in the notion of *self-sufficiency*. His view was morally loaded in an interesting way as we will see below. However, his view can be simplistically also read as science, being a result of a method, to be value neutral; and this value neutrality being an input for applied science is implicated in value judgement if at all. Ghosh probably treated *self-sufficiency* differently in different kinds of research. In the realm of theoretical work, it will probably be the contribution to international (and universal) knowledge pool. To be able to do that as equals seem to be the driving force. In the realm of the industrial research, it might seem that the

instrumentality probably carried a part of the burden of *self-sufficiency*.

Ghosh published a series of articles in the newly established journal *Science and Culture* about which had been alluded earlier. The journal was first edited by M. N. Saha. Although a majority of the papers, published by Ghosh, primarily dealt with planning of technological activities in Bengal and other parts of India, he also argued for reorganization of Science and Technology research activities in the light of Science and Technology practices in the western (and as Ghosh himself admitted developed or advanced) countries. Ghosh's Presidential address to the Indian Science Congress in 1938 and several addresses as the President of National Institute of Science in India highlight Ghosh's understanding of the strong interdependent relation among the Government of India (read the State), the Industry, and the Science and Technology led Academia, as an essential aspect for the material growth for the people of India. Ghosh also seemed to accept that this material growth would set the basis for the over all improvement including the moral improvement of people at large and the nation. The place of Indian nation, as a result of this improvement, as an equal member among the International community of nations seemed to be seen as a corollary.

Ghosh made several important and interesting claims. In his article "A Century of Progress in Scientific Thought" published in *Science and Culture* in 1935, Ghosh began by highlighting various progress in scientific achievements. The examples included railways, electricity, communication, war fare techniques. Ghosh suggested that economic protectionism was hardly a solution to economic problems a nation would encounter. He strongly argued that 'application of scientific principles and methods' would have to play an important role for economic development. He said:

> Measures of protection can only be palliative. The only bed-rock on which lasting prosperity can be built is the continuous application of scientific principles and methods, as they are discovered, to problems of industry and agriculture. A nation, which fails to do so, is destined to be pushed to the background.
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> (Ghosh, 1935, p. 123)

Ghosh subsequently moves on to raise an entirely different but significant question. He claims that question to be more *fundamental* and poses it as "What is it in the external world that is necessary to sustain the process of life?" and suggests that the answer is "there must exist in the external environment energy that is not in equilibrium – energy which can be made available for performing work" (*Ibid.* p. 124). By labeling this question more fundamental Ghosh was probably signaling that scientific knowledge had a primacy or priority (not merely temporal) over its application. It is suggested that he was also pointing out what should be the nature of the world such that scientific knowledge of that world is possible and that knowledge can be implicated in the physical world of industry and the physical world of agriculture. (It might seem like a view quite anti-thesis to the homeostasis view of the world which seems to underscore equilibrium as the hall mark of nature). That these two views would set out quite different accounts of what are the possibilities that are actualizable and what are the morally acceptable possibilities should not surprise us. This can be developed further but I intend to do that another time. In the same paper Ghosh went on to suggest that the matter-energy reversible transformation would open up the possibility of looking at the universe as a whole and not as a series of unconnected events. For him, the modification of matter whether in the industrial application or in agricultural practices – allegedly the most practical activities to ensure a better material life required energy that is not in equilibrium. And this energy can transform matter

and or transform itself into (new forms of) matter. Ghosh seemed to see the three levels (the practical application of knowledge, knowledge needed for practical application, and the knowledge of the fundamental nature of the empirical world) of the world of science and yet these levels were, for him, seamlessly interrelated.

In his article titled "Science and Modern Life" (Ghosh, 1942), Ghosh attempts to offer a comprehensive picture of his view about science. He begins by pointing out that, for people, at large "the most spectacular contributions are the tools which it [science] has provided for the progress of mankind" (*Ibid*., p. 380). The material progress has been possible for the western countries "due to the genius of the people in harnessing the knowledge that science has placed at their disposal" (*Ibid*.). Ghosh was also optimistic that "next to USA and Russia, [India] has the greatest potentialities for developing a *self-sufficient* economy" (*Ibid*). This notion of *self-sufficiency*, we had seen earlier, had been echoed by the other members of the Indian Science News Association and also of the National Planning Committee. One of the most vociferous articulators of *self-sufficiency* not only in economy or material well-being but of the nation at large was M. N. Saha. I had alluded to his views earlier.

Ghosh further suggests that to achieve *self-sufficiency* "the utmost cooperation of the individual with the State will be necessary" (*Ibid*). Ghosh was, however, clear that he was thinking about industrial reorganization of the nation. And to achieve that India's "resources in technical ability and raw materials" (Ghosh 1942, p. 381) were *sine qua non.* Industrially backward India with a large population was in itself a great menace to world peace. Ghosh was also clear that the "chains which bind us to a dead past are as much body and soul killing as the chains that bind us to an inglorious present" (of 1942). He, therefore, sought to steer clear of what might be called any form of revivalism as much of complete colonial genuflection. He saw modern science and technology as a key aspect of the modern anti-colonial and anti-revivalist state. He also believed that the pursuit of modern science and technology would be a worthy intellectual activity that any state must promote. This probably underscores one of the strands of the intellectual aspect of *self-sufficiency*.

In the same paper of 1942, Ghosh briefly discussed the outlines of his form of Baconian methodology of science (Ghosh 1942, p. 381). This is a view which he also shared with early Acharya P. C. Ray. Ghosh also thought that "the fundamental unity of modern civilization is the unity of its intellectual life" (*Ibid*). Here Ghosh is not merely articulating a global nature of science. He is also suggesting that to live as an educated and cultured people of the world, pursuit of science is extremely important. He wrote that science "is an exalted state of the mind of man. It is a method, a confidence, a faith" (*Ibid*) "It is a method of controlled observations and experiments recorded with absolute honesty. It is a confidence that truth can be discovered. It is a faith that truth is worth discovering" (*Ibid*). It is not hard to recognize various layers of moral commitment at the level of 'self' that Ghosh was highlighting. The last claim is worth pondering about since it is a result of (unconscious?) analysis of what constitutes 'good living'. The second claim is a result of a realist belief that the empirical world is such that it can be known. The very possibility of knowledge needed two kinds of entities: the knower and the objects of knowledge. But this divide requires a moral commitment from the knower in the way(s) pursues her / his objects of knowledge. An analysis of 'good living' needs, therefore, to step in again to underwrite at least the instrumental value of the way(s) of knowing. One aspect of this value is the following of a method, being unbiased and unprejudiced, and exemplifying personal honesty (the moral worthiness of a pursuer of knowledge). The very possibility of pursuing science binds the

knower with her objects of knowledge in a peculiarly reflexive way. Scientist must be honest to pursue truth. And science as a pursuit inculcates a 'moral discipline' in its practitioners. The practitioners need to be committed to 'detachment' and be ready to 'suspend judgement' in appropriate situations. This 'mental discipline' shows up in the 'weighing of evidence'. Ghosh's use of the notion of 'weighing evidence' and also of the notion of 'crime', if there is a moratorium on truth, reflects an employment of legal concepts (more as a way of analogy probably) to provide important insights into the nature of scientific enterprise.

Recognizing that the notion of evidence in science has its historical root in the notion of evidence in jurisprudence, it is important to point out that jurisprudence is not completely devoid of moral ideas. Ghosh, therefore, may be seen as arguing for what it is to be a good individual (scientist) and a good citizen of a nation. Without such people democracy, in a nation, is at stake.

Ghosh also argued that the moral compass within a pursuer of truth must be attuned to the miseries attendant with modern science. Ghosh is clear that merely apportioning the blame, for these miseries, to an evil doer will not be enough to absolve a scientist from the moral turpitude (s)he must confront in those situations where science is a concomitant to an evil action. Thus he says while considering the evil that science has led to and may lead to in future.

> These are distressing symptoms. They point to the possibility that the ascent of man may have to go back to the stage of cave-dwellers rather than grow in the light of nature and expand in the love of beauty and of God. Men of science cannot escape responsibilities even for the evil fruits of their labours. It will not merely do to say that the scientific power which can be used by the evil politicians to do evil can also be used by men of good will to do immense good. It will not be odd to point out that sulphanilamide, the most amazing development of modern medical science came from German dye industry as did the most insidious poison, the mustard gas. We have got to ponder deeply over the problem that the scientific search for truth has not assured the progress of civilization.
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> (Ghosh, 1942, p. 384)

He is also clear that scientific knowledge is worth pursuing both for its own sake and for its employment for the betterment of human lives – material progress. He is also equally emphatic that the pursuit of scientific truth makes an individual not only a possessor of knowledge, but also a morally capable and superior individual who is committed to the well-being not only of her immediate local neighbour or nation but also of the global community of humans. That individual is morally responsible to her fellow beings and (s)he discharges her / his moral duty by pursuing knowledge gathering activity sanctioned by scientific method. This is an important aspect of the *self* in *self-sufficiency* that Ghosh may also be alluding to.

Ghosh's moral worry at the global level was to ask how to morally respond to the evils attendant with pursuing science. He raises the issue with an honesty which brings out the deeper issues that underlie science as a moral practice. If a scientist cannot absolve herself / himself from the evils resulting from the knowledge (s)he has produced, then the view that knowledge producer's moral commitment is logically independent of the knowledge employer's moral commitment is questioned. One is reminded of the story that after the Hiroshima / Nagasaki disaster Einstein was supposed to have said that he would rather have been a plumber than a scientist. This is a reflection of deep moral feeling that a scientist expresses and cannot be wished way merely by employing the distinction between the producer and the user of knowledge and thereby absolving the former of any wrongdoing. Although Ghosh grapples with this problem he is unsure as to how to resolve the same. He considers several options.

First, that knowledge may be produced unfettered but the scientific community must be circumspect in disseminating that knowledge and ensure that only the morally responsible people have an access to that knowledge. Ghosh saw the problem with this solution in that it would violate the accessibility and shareability aspect of knowledge at large and therefore would be unwelcome. He also saw in this solution the problem that traditional India spawned by restricting production and dissemination of knowledge. Ghosh claimed that "such secretiveness had stultified the growth of science" in India (Ghosh, 1942, p. 384). There was another alternative which Ghosh considered and went on to dismiss the same. For him, this alternative is worse than the first. Let me quote the succinct point that the first alternative:

> is less drastic than the prescription of Mahatma Gandhi that conscious non-violent suffering would melt the heart of the brute and bring peace and good will to all men and nations on earth (Ghosh, 1942, p. 384).

This is a rather interesting comment if seen in isolation. As it is, the point may be captured as follows. Ghosh seems to hold that knowledge contains within itself the possibilities of both good and evil. Scientists' responsibility lies in recognizing this. A piece of knowledge, discovered by a scientist, subsequently is used by another. The moral force and prescription of the use of that piece of knowledge does not rest completely on the user. The discoverer of knowledge must recognize her part in the moral equation. Thus, the social history and the genealogy of that piece of knowledge by one scientist is also implicated in the moral determination of its subsequent use by others. There seems to be a moral parity argument with an analogical argument following it for this claim to have any substantive bite. The moral parity argument can be briefly outlined as follows. A piece of scientific knowledge, produced by a scientist, X, to be worthy of consideration for any member of the scientific community, needs to be used by others in the scientific community. The praiseworthiness or the blameworthiness of that piece of knowledge rests at least in part on whether and how that piece of knowledge was used to produce more knowledge acceptable to the members of the scientific community. But the adequacy for the success (or lack of it) in producing more knowledge also rests on the capability of the user. Surely, a good scientist can use it well rather than a mediocre or less than a mediocre scientist. Thus, there are two components to the praiseworthiness or blameworthiness of a piece of knowledge produced by a scientist, X. One of these is directly attributable to X in that the knowledge she produced led to the production of more adequately accredited knowledge by her or other members of the scientific community. The citations, quite often, pick out this aspect. If that does not happen or if the use of that knowledge goes along a path not acceptable to the members of the scientific community, then a part of the blame accrues to the scientist who had produced that relevant piece of knowledge. This is reflected, in part, in the lack of citations. The point is thus of moral parity. If the good use of a scientific result to produce more scientific result is to be considered praiseworthy not merely because of the good use but also because of the nature of the starting result, a failure can then be seen as resulting in apportioning some of the blame to the starting result. And now analogically, in the areas of practical applications of scientific knowledge, if knowledge of nuclear fission is praiseworthy by virtue of helping produce nuclear energy, then by the parity of reasoning, it needs to take the blame for nuclear weaponry systems. Ghosh's recommendation was that knowledge users also be responsible such that evil possibilities are not actualized.

What Ghosh did not want was to adhere to a different civilizational trajectory suggested by Mahatma Gandhi. That trajectory attempted to

develop a notion of 'good life' which sat ill at ease with the notion of 'good life' that members of the Science and Culture group or the members of the members of the National Planning Committee or the members of the English educated Indian middle class. Ghosh's paraphrasing (almost a caricature) of Gandhi's view is as follows:

> It will be a mistake to ignore the fact that there are powerful leaders and a well-organized party in India who have been so impressed by the evils of the modern world, that they do not hesitate to declare that the introduction of western methods for increasing our national income should be resisted, that it is no business of the State to help scientific and technical development which have led to two such world catastrophies in the course of 25 years. They would prefer non-violent non-co-operation to armed resistance against aggression. They would prefer the culture of cottage industries, peasant farming, and living on subsistence level with its inevitable doses of famine and pestilence, to the immense wealth but maladjustment and inhuman greed of modern societies.
>
> (Ghosh, 1943, p. 3)

When Ghosh talked about science and technology it was obvious that he was referring to the modern science and technology of the west. For him, knowledge that was produced by the Gandhian alternative was not amenable to any further change and modification. Such knowledge had lost its emancipatory force. He seemed to equate the ability of the 'old knowledge' to make cottage industries or peasant farming or living at the subsistence level possible. This 'old' way of organizing knowledge and hence society inevitably leads to famine and society. In what sense of inevitability Ghosh did not make clear. Ghosh, to be fair, of course, saw maladjustment and inhuman greed of modern societies as the ills of modern societies. Why did he still opt for the latter? If these ills of the modern societies, he thought could be curbed, then why did he think that the inadequacies of the competing model could not be. He saw inevitability of the ill effects in the Gandhian model but the new model did not seem to carry any ill effect inevitably. This lack of parity is unexplainable. There is an interesting irony here. While examining knowledge production in the modern science and technology context, Ghosh argues (somewhat vacillatingly) that scientists are responsible also for the ill effects that knowledge produces, he does not extend this possibility for a Gandhian scientist who produces knowledge and can also be said to be responsible if the subsistence level does not improve or if the famine and pestilence are not avoided. If he did, the argument from inevitability would not perhaps work.

4. Conclusion

In this essay, I have tried to present late J.C. Ghosh's scientific work both within the context of the chemical research pursued during his time in India and Internationally. I have highlighted the three phases of Ghosh's chemical research each of which is significant in its own way. While this theoretical research, during the first phase, on electrochemistry brought him international recognition and his work is still cited, his research in photochemistry during his second phase of research which brought him to the third phase on catalysis were decidedly less cited. These experimental work had a profound significance on Ghosh as a chemical researcher who was attuning his research to practical applicability which India, according to Ghosh, would need in the near future. The nature of theoretical work in the first phase and the experimental work in the next two phases contributed significantly towards his formulation of a policy of organizing science and technology in India. This is an area I have not discussed in this essay. Instead, I have tried to develop an understanding of the moral underpinning of theoretical research and the practical research that Ghosh seemed to be somewhat ambivalently committed. I have tried to show how Ghosh very perceptively saw that

there is parity of reasoning in ascribing normative value to scientific ideas whether it is applied to good or evil use by others.

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