After the Bomb: Science, Value and the Limits of Rationality

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Modern science was founded on principles which emphasized a commitment to both efficiency and progress. These concepts were incorporated into what Kuhn labels the scientific paradigm. The scientific paradigm serves to guide everything from the manner in which scientists are educated to the subjects they choose to research. Under this structure all scientific inquiry is perceived as an action, neutral in content. The moral questions which arise during scientific research are bracketed and left for others to consider. Thus, the major consideration of the paradigm is to "do" science and all other factors which interfere with this process are seen as threats to the progress of scientific research and are minimized.

In the lives of Andrei Sakharov and J. Robert Oppenheimer we can see not only an illustration of the power of the paradigm but, its partial disintegration as well. This paper serves as a case study of these two fundamentally important scientists, whose training and research, guided by the paradigm, employed the puzzle-solving method. A method in which the scientist chooses to research only those questions which have in them a presupposed answer. Oppenheimer and Sakharov both found the paradigmatic puzzle-solving method a satisfying structure, as it left the moral issues surrounding the distribution of power and the question of ethics to someone else. The success of working under such a structure convinced these scientists that science was unique to all other pursuits and as such did not need to contemplate the relationship between the social and scientific world.

However, Oppenheimer's and Sarkharov's participation in the creation of the atomic and the hydrogen bomb served to undermine their absolute belief in the paradigm. These men were not alone in their growing disenchantment with the paradigm as such eminent scientists as Linus Pauling and Leo Szilard also voiced their opposition to a science which did not consider the values of the social world. The detonation of these weapons of mass destruction changed the moral landscape of the world. After these totemic events scientists were forced to question the guiding scientific paradigm which had allowed them to make these devices. Oppenheimer and Sakharov came to realized that science was too powerful and its impact upon social whole far too great, for scientists not to adequately consider the social implication of their discoveries.

Thus, the detonation of the atomic and hydrogen bombs called into question the validity of the current scientific paradigm. They came to realize that the structure of the paradigm distanced them from practical issues, such as the moral implications of various discoveries. Oppenheimer and Sakharov gradually saw such practical issues are relevant since, regardless of what some of their contemporaries thought, social forces did determine what was researched and what was not. These other scientists, in staying clear of such debates, allowed political and economic power interests to control the overall structure of science. Thus, J. Robert Oppenheimer and Andrei Sakharov, the creators of the atomic and hydrogen bombs came to conclude, through the process of an ethical

journey, that scientists need to become more involved in the political discourse which decide how society and science relate.

I: The Scientific Paradigm

In The Structure of Scientific Revolutions, Thomas Kuhn describes the complex nature of the scientific paradigm which determines the parameters of the scientific community. He explores the structure of the paradigm which determines the manner in which scientists are educated and the importance of puzzle-solving in scientific research. He demonstrates how the puzzle-solving structure keeps science efficient and emphasizes progress above all else. Kuhn also shows how the paradigm, with its isolating nature, becomes all encompassing and takes on a fortress-like character keeping the scientist insulated from the larger social world. In order to understand the process of acculturation that molded both Sakharov and Oppenheimer into the archetypical scientists, it is necessary to have an in-depth understanding of the structure of the paradigm and the educational process which functions within it.

The paradigm serves as the structural model which guides the scientist's research. The paradigm is not, however, stable. As new data is uncovered the guiding paradigm often becomes less useful to the scientist and may be replaced by a newer one. This period of transformation from one paradigm to another is a period of crisis as the community of scientists must choose a new paradigm which will resolve the majority of their problems. The paradigm can only function within this closed, elitist, homogeneous, scientific

community which has little means of relating to the society. Therefore, in exchange for maximum efficiency the paradigm excludes many facts that are employed to guide the societal whole and creates an artificial narrative of progress which obscures the problems created by scientific discoveries as it focuses all of its attention on positive results.

Yet scientific phenomena cannot be interpreted in the absence of an intertwined theoretical and methodological structure. The creation of a standard language, the scientific paradigm, is necessary if the scientist is to derive scientific truths which the whole of the community of scientists will be able to debate. The creation of an educational structure served to standardize the language of science, which in turn produced a more homogeneous group of scientists. The educational structure provides scientists with a set of tools with which to describe their research. These tools are encapsulated within the structure of the paradigm and serve to guide the scientist's methods, to limit the of breadth of their field, and to standardize their solutions.

The paradigm breaks down when the normal technical puzzle-solving activity of scientific research ceases to function. Faced with an admittedly fundamental anomaly in theory, the scientist first attempts to isolate it more precisely and apply the accepted paradigm as far as it can go. From these attempts to stretch the current paradigm the scientist will generate speculative theories which if acceptable may disclose the new paradigm.[1] The scientist's

[1]Kuhn, p. 87

manipulation of the paradigm to elucidate a structure which explains an experimental anomaly occurs implicitly, as explicit recognitions of the breakdown of the paradigm by scientists are rare. In science, however, the conscious recognition of a problem with a paradigm is not necessary for a resolution of the crisis. The crisis period resembles the period before the guiding paradigm existed, in that there is a blurring of the well-structured rules which guide all scientists.[1] The crisis will be resolved in one of three ways. First, the scientist may be able to incorporate the anomaly into the old paradigm. Second, the scientist may set aside the problem for future generations to solve. Finally, the crisis may be resolved with the emergence of a new candidate for the guiding paradigm.[2]

The resolution of the crisis appears when the transition between the competing paradigms is complete. The transition is not a gradual one, made one step at a time, but, like the *gestalt* switch, occurs all at once.[3] Thus, a scientific theory is declared invalid only if the alternative paradigm is available to take its place. During these times of revolution, when the normal scientific tradition changes, the scientist's perception of her environment must be re-educated; she is forced learn the new *gestalt*.[4] The new paradigm allows the scientist to understand the subject of her research in an entirely new manner.[5].

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[1]Kuhn, p. 84
[2]Kuhn, p. 84
[3]Kuhn, p. 150
[4]Kuhn, p. 112
[5]Kuhn, p. 111

The paradigm transforms to incorporate the new findings in the scientific world. In order for the paradigm to function there are, however, losses as well as gains in these transformations. The scientists are usually blind to the losses involved in the switch from one paradigm to another and thereby believe that science does indeed function on an evolutionary model. Science often suppresses fundamental novelties simply because they conflict with the efficiency of the paradigm. Science has sacrificed its ability to deal with complex problems for the ability to conquer small focused problems with extreme efficiency.

The scientific paradigm limits the scientist's scope of exploration and focuses her upon the special problem she has been trained to study. Scientists are able to discuss with great clarity the intricacies of their particular guiding hypothesis. They are, however, little better than laymen in characterizing the established basis of their field.[1] Scientists are further limited by structure of the paradigm in that they can only employ it to examine puzzle-like questions; these are questions whose intrinsic value is the assured existence of a solution. Therefore, the scientist cannot examine truly pressing problems, e.g. whether or not to create weapons of mass destruction, because such questions are not puzzles; as these questions may not have any solution at all.[2] The only problems that the community will admit as scientific or encourage its members to undertake are those that fit the puzzle-like structure.[3] Other

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[1]Kuhn, p. 47
[2]Kuhn, p. 37
[3]Kuhn, p. 37

questions are simply too problematic to be worth the valuable time of the scientist.

The scientist is able to limit the scope of her research to the puzzle-like problems and thereby enhance the efficiency of science in part because of the unparalleled insulation of the modern scientific community from the demands of everyday life.[1] This insulation from society permits the scientist, unlike the physician or the engineer, to concentrate her attention upon problems that she has good reason to believe she can solve.[2] Rather than working for a heterogeneous audience of various members of society, the scientist is working for an audience of colleagues, an audience which shares her own values and beliefs. The scientist can therefore take a single set of standards for granted.[3] Unlike most groups in modern society, scientists do not seem overly concerned with the lay approbation of their work.

The group which chooses the paradigm which guides all scientific inquiry is not one drawn at random, but is a well defined community of professional scientists. In order for a scientist to be a member of this community she must follow certain distinct requirements regarding scientific conduct. As Rae Goodell comments in his book Visible Scientists, " a powerful system of social control operates within science to keep a tight rein on its members."[4] Although the scientist may have global concerns, the scientific community demands that the problems she examines be problems of

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[1]Kuhn, p. 164
[2]Kuhn, p. 164
[3]Kuhn, p. 164
[4] Rae Goodell, Visible Scientists, (Boston: Little Brown and Company, 1977)

detail and the solutions be more than personally satisfying. These solutions must satisfy the majority of the scientific community.[1] The community also prohibits appeals outside of the community of scientists to heads of state or to the populace at large in matters of scientific importance.[2] The very existence of science then depends on a rigidly defined community whose shared training and experience give them the power to choose between paradigms.

The scientist's feeling of community is reinforced by the rigid educational system by which new members of the scientific world are created. The effects of insulation from the larger society are greatly intensified by the nature of the scientific educational system.[3] While the student in other graduate programs is made aware of the immense variety of problems that members of her future community face, the future scientist is told an evolutionary narrative about the progressive nature of science. The education of the scientist is more rigid than any other discipline except perhaps orthodox theology.[4]

The student of science relies mainly on textbooks until around the fourth year of graduate school at which point her confidence in the scientific paradigm is already well established. Scientific education makes no use of history and the result is a drastic distortion in the perception the scientist has of her discipline's past. She comes to see it as leading in a straight line, an evolutionary process leading to the ultimate foundation of a body of

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[1]Kuhn, p. 168
[2]Kuhn, p. 168
[3]Kuhn, p. 164
[4]Kuhn, p. 166

perfect scientific understanding. Why would a student of physics, for example, want to read the works of Einstein or Schrodinger when everything she needs to know is simplified in the textbook in a more precise and more systematic form? The discipline promotes a faulty view of science, one which is homogeneous and linear in nature. The scientist's only link to society is through scholastic textbooks and popularizations of scientific data which record only the stable outcome of revolutions and thus reinforce the evolutionary narrative. The educational system is perfect for normal scientific work, work within the puzzle-solving tradition, but when a crisis arises the scientist find herself not so well prepared.

Given the confidence scientists have in their paradigms, few would even consider changing it. The scientist seems convinced that she may not abandon the paradigm because that would lead to chaos and the end modern science. However, it seems that change is necessary for science to function in a more beneficial manner. The prolonged crisis, requiring more than a simple application of the puzzle-solving technique, is becoming more common as science becomes more powerful. The current scientific training is not well designed to produce the scientist who will easily discover a fresh approach.[1] The community of scientists must incorporate members from outside the profession to bring the societal whole into the decision making process. Currently the scientists serve as the audience and the judges in deciding how their paradigm will guide scientific research.

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[1]Kuhn, p. 166

Oppenheimer and Sakharov were not exceptions to this process of development. Their journey as scientists follows the traditional path mapped out by Thomas Kuhn. In fact the very similarity in their individual experiences as a scientist in the modern world serves to reinforce Kuhn's concept of a universal model of creation for the scientist.

II: the creation of the scientist

Oppenheimer and Sakharov did not initially question the value system which was incorporated in the process of scientific discovery. On the contrary, Oppenheimer and Sakharov accepted the structure with little hesitation; only later would they become disillusioned with the scientific structure of their respective countries. Therefore, these men emerged from their university experiences with a great and consuming desire to "do" physics. All other interests were subordinate to this desire. Sakharov and Oppenheimer found that other subjects, such as politics and ethics, did not play a role in the scientific world, at least not at the functional level, and thus they largely ignored them. At this stage in their development their interests were confined to those subjects which could be addressed by the puzzle-solving model.

These two men's interest in science began early on, encouraged by their familial surroundings and their academic experiences. They were born into families which valued education, encouraged intellectual pursuits, and whom expected their children to become well educated professionals. Thus, both men were guided from the

beginning into the academic world. Both Oppenheimer and Sakharov chose adults involved in scientific pursuits as their role models and attempted to emulate them. Sakharov was influenced by his father who was a professor of physics. Although no one in Oppenheimer's family was involved in scientific pursuits, J. Robert Oppenheimer was able to find his scientific role models at the Ethical Cultural school in New York. In an interview with Thomas Kuhn, Oppenheimer acknowledged his debt to a teacher named Augustus Klock: "I think the most important change came in my junior year in high school...the teacher of physics and chemistry...was marvellous; I got so excited that after the first year, which was physics, I arranged to spend the summer with him..."[1] Sakharov's father taught him physics and mathematics and in doing so fostered Sakharov's love for scientific inquiry. Sakharov recalls that they did simple experiments and he was taught to keep a notebook: "I grasped ideas quickly...and was fascinated by the possibility of being able to reduce the whole gamut of natural phenomena to comparatively simple laws..."[2] These activities and small experiments marked the beginning of a long process of socialization into the world of science.

Oppenheimer found himself immediately drawn to the sciences, both chemistry and physics, when he entered Harvard. During the first years of his academic career he appeared to be searching for the right field, and his choice of subjects were tentative. While his goals were not yet fully defined, Oppenheimer began Harvard with

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[1]Robert Oppenheimer, Letters and Recollections, eds. Alice K. Smith and Charles Weiner, (Cambridge: Harvard University Press, 1980) p. 4

[2]Sakharov Andrei, Memoirs , trans. Richard Lourie (New York: Alfred A. Knopf Inc., 1990) p. 31

the belief that he wanted to be a physical chemist "because this was the thing whose glimmering I liked in elementary chemistry..."[1] During these years Oppenheimer explored other areas as well, but he always found himself drawn back into the realm of science. He appreciated the rigidity of the scientific community and the way in which the scientist examined problems in detail. He visited various clubs on campus, like the liberal club, but only felt at home in a "little" science club of which he was a member for two years. In fact this "little" science club is the only club listed on his activities transcript at Harvard. Oppenheimer's path became much better defined once he chose physics and as a result his time for classes unrelated to physics, chemistry and mathematics diminished precipitously.

Oppenheimer decided to concentrate his studies on physics rather than chemistry, when he came to realize that what he enjoyed about chemistry had to do with physics. He was fascinated by the study of order in the universe, and physics offered insightful answers to his questions.[2] Physics, with its direct reliance on mathematics, seemed to be based on order and logic rather than simply on experiment. He was also attracted to the world of physics by its beauty. Oppenheimer commented later that he came to see that what he liked in chemistry was very close to physics. " It's obvious that if you were reading physical chemistry and you began to run into thermodynamical and statistical mechanical ideas,' he explained

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[1]Oppenheimer, p.11

[2]Kunetka James, Oppenheimer: The Years of Risk (New Jersey: Prentice-Hall Inc., 1982) p. 10

to Thomas Kuhn, ' you'd want to find out about them..."[1] Slowly Oppenheimer began the gradual switch to the study of physics. In his interview with Kuhn, Oppenheimer recalled that it was during his freshman year that he began to read physics on a regular basis: "I don't believe that I audited a course, I don't believe that I went to any seminars in physics...but I petitioned the physics department for graduate standing...'[2] He was allowed by the department to take upper division courses and began to work with physicist Percy Bridgman in his laboratory.

Oppenheimer's work in the laboratory was an important step in his becoming a scientist. In the laboratory setting Oppenheimer was introduced to the method employed by scientists to solve problems, the scientific paradigm. He was also able to learn to employ the process of technical puzzle-solving to discover answers to scientific questions. Oppenheimer later commented that his time spent in Bridgman's lab was, " as far as science goes...the great point of my time at Harvard...Bridgeman didn't articulate a philosophic point of view, but he lived it, both in the way he worked in the lab...and in the way he taught..."[3] The personal interaction which Oppenheimer received from his job in the laboratory was much more important than the actual research. He was, through his interaction in the laboratory, learning the requirements for membership in the scientific community. Slowly Oppenheimer was being integrated into the complicated structure that constituted modern science.

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[1]Oppenheimer, p. 45
[2]Oppenheimer, p. 28
[3]Oppenheimer, p.69

Sakharov too choose physics "almost automatically." He was motivated both by his father, who was a physics teacher, and his "own deep-seated desire."[1] His earlier dream of becoming a micro-biologist quickly faded away in light of the possibility of studying theoretical physics. He too was drawn to physics for its ability to solve problems and beauty of its logic. Sakharov attended Moscow University for three years and he recalls that during those three years he singlemindedly pursued physics: "I devoted all my energy to physics and mathematics."[2] Most of Sakharov's memories of Moscow University involve the study of science. He recalls attending an informal student club that sometimes met outside the library: "students would emerge for a cigarette, others to stretch their legs and chat. I can't recall ever talking about anything except science during those breaks."[3] Sakharov skipped boring classes like Marxism-Leninism which he found difficult and a waste of time. Sakharov's early scientific experiences follow a very traditional educational route which stressed the concepts of the evolutionary nature of modern science and the importance of progress and efficiency in research. Sakharov leaned to abide by the distinct requirements of scientific conduct and the importance of the paradigm which guides the scientist's research projects. Sakharov pursued science with the same single-minded passion that Oppenheimer did and soon found himself becoming a member of the scientific community.

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[1]Sakharov p. 36
[2]Sakharov, p.35
[3]Sakharov p. 35

Sakharov too, became further indoctrinated in the scientific method through his independent research projects as he too worked in a laboratory. The outbreak of the Second World War, which led to the relocation of the University to the Ashkhabad suburb of Kishi, altered the nature of Sakharov's education. Despite the problems created by the war and relocation, Sakharov managed to learn the necessary subjects and received his degree in 1942. Sakharov was invited to continue on as a graduate student in theoretical physics, but he felt "it would be wrong to continue studying when [he] could be making a contribution to the war effort..."[1]

During the war years Sakharov had little contact with the subject of theoretical physics. Instead of the laboratory, Sakharov found himself working in the chief mechanic's department manufacturing cartridges. While the work he did had little directly to do with physics, the experiences were in some ways similar to Oppenheimer's in Bridgeman's laboratory. Sakharov learned more about the structure of research in the munitions laboratory than he had at the University. The work in the munitions laboratory introduced Sakharov to the concept of the puzzle-solving model, which emphasized researching problems in which the answer was implicit in the question. Sakharov found his first placement absurd as he had no experience in the mechanics of making ammunition: "I had no idea at all what manufacturing cartridges entailed...in any case I had no aptitude for that sort of engineering work."[2] Sakharov transfered to a laboratory which allowed him to combine his

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[1]Sakharov, p. 48
[2]Sakharov, p.51

knowledge of physics with his skills at inventing. Sakharov moved on to a central laboratory where he began working on a device that would check whether the cores of the armor-piercing bullets had been sufficiently hardened. Oddly enough, these experiences gave Sakharov first hand experience at using his newfound knowledge of physics for highly practical purposes. His work in the industrial laboratories provided him with insights into the working of electrostatic forces and applied mathematics: "I solved more problems in 1943-44. I did not publish results, but I was gaining confidence in my ability as theoretical physicist, something vital for a beginner."[1] Thus, his work during the war gave him time to develop his laboratory skills and to read the textbooks that he had bought in Ulyanovsk. By December of 1944, Sakharov had left the factory and began his graduate study of physics at FIAN, Physics Institute of the Academy of Sciences.

After the completion of their university training both Sakharov and Oppenheimer found themselves pursuing graduate degrees. They had been introduced to the conceptual framework of the paradigm though their classes and experience in the laboratory. During the time Oppenheimer and Sakharov had spent in the laboratory they had also become introduced to the puzzle-solving technique, a technique they would employ often in graduate school. The undergraduate period and the events before graduate school served as an introduction to the scientific world. Once these scientists entered

[1]Sakharov, p. 63

graduate school they became enveloped inside the paradigm and the rigid scientific community.

Oppenheimer was forced, as a result of the undeveloped state of physics in the United States, to go and study theoretical physics, at the graduate level, in Europe. This choice allowed Oppenheimer the opportunity to study with some of the important theoretical physicists of Europe. He left Harvard in 1925 for England to work with the physicists Ernest Rutherford, who was known for his work in radioactivity. Oppenheimer soon discovered that his work in the laboratory was futile and the results of his experiments were inconclusive. Despite his lack of success in the laboratory, Oppenheimer recognized the valuable information, regarding many of the latest conceptual problems, he received from his contact there with other scientists. Oppenheimer described his situation, in a letter, to close friend. "The business in the lab," he writes, "was really quite a sham but it got me into the lab where I heard, and talked, and found out a great deal of what people were interested in..."[1] . Oppenheimer was equally unimpressed with the social and political life in England. He was not interested in the causes being discussed around Cambridge as it distracted him from his work. Oppenheimer's foremost desire was to master physics, a desire which was all encompassing and left him little energy to talk about politics. He explained his distaste for English social life to Francis Ferguson, a friend from Harvard, in a letter: " I had been taken to all sorts of meetings. High maths at Trinity, a secret pacifist meeting,

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[1]Oppenheimer, p. 88

a Zionist club, and several rather pallid science clubs. but I have seen no one here who is of any use who is not doing science."[1] Oppenheimer went to England to learn physics and he perceived all the other activities as mere distractions. However, his time in England also provided him with a sense of the current topics in physics and the opportunity to meet some of the cutting-edge physicists of Germany. His meetings with these German theoretical physicists led to an invitation to leave England and to complete his studies in Germany at the University of Gottingen.

In Germany, Oppenheimer had the opportunity to work with many important theoretical physicists such as Wolfgang Pauli, a pioneer in the field of nuclear physics, and Niels Bohr, an atomic theorist. His conversations and relationships with these men shaped his views regarding the structure of science. Oppenheimer became caught up in the furious pace the German scientists set in their laboratories. New discoveries were being made consistently in the area of quantum physics and the scientists worked in their laboratories day and night. Oppenheimer appreciated the attitude of these scientists, who displayed absolute devotion to solving their research problems, and mimicked their style and their methodology. These scientists reinforced Oppenheimer's belief that science was the greatest pursuit in modern society. In 1926 he wrote to a friend how much he enjoyed being among this almost exclusively scientific group, which he describes as "working very hard and combining a fantastically impregnable metaphysical disingenuousness with the

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[1]Oppenheimer, p.88

go-getting habits of a wall paper manufacturer."[1] This image of the German physicist would serve as the blueprint for the scientist Oppenheimer was to be.

At Gottingen, Oppenheimer felt at ease and became incorporated into the community of scientists: "In the sense which had not been there at Cambridge and certainly not at Harvard, I was part of a little community of people who had some common interests and tastes and many common interests in physics..."[2] Oppenheimer realized, for the first time, the select nature of who was allowed to be a member of the scientific community. His initiation into the group at Gottingen served as an important guide for his development to a much greater degree then did the lectures he attended or the books that he read. He learned from these men the method to employ to discover the answers to scientific questions.

Oppenheimer found that his conversations with Pauli or Max Born, the director of the institute, were most influential in his becoming a successful physicist. He told Kuhn that, "...something... important began to take place; namely I began to have conversations. Gradually I guess, they gave me some sense and perhaps more gradually some taste in physics, something that I probably would not have gotten to...if I'd been locked up in a room."[3] While his work in the laboratory was important, it was his personal relationships which shaped his views on the scientific process.

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[1]Oppenheimer, p.100
[2]Oppenheimer, p.98
[3]Oppenheimer, p.97

The years in Germany were some of Oppenheimer's most academically productive times. During this time Oppenheimer published many papers. One such paper is the now famous paper he wrote with Max Born on the approximations involved in the theory of molecules. Oppenheimer characterized the work in the laboratory as intense and time consuming. The intensity of the scientific process had the effect of isolating Oppenheimer from the outside world. He spent so much of his time working in the laboratory that he had little time to devote to outside activities. Oppenheimer received his doctorate degree from the University of Gottingen in 1927 based on his dissertation concerning the application of quantum theory to transitions in the continuous spectrum.

During his graduate work in Europe, Oppenheimer seemed unconcerned with the great political and social changes filtering through the Continent during the 1920's. Perhaps, this was due to a combination of the intense time and devotion needed to solve the difficult problems he was examining and Oppenheimer's usual disinterest in contemporary issues. Oppenheimer spent the little free time he had mastering Dutch and Italian rather than concentrating his attention on the rise of political groups in Germany. He was not blind to the mood in Germany. As he later commented, "although this society was extremely rich and warm and helpful to me, it was parked there in a very miserable German mood...bitter, sullen and I would say discontent and angry..."[1]

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[1]Oppenheimer, p. 103

After he received his doctorate in 1928, Oppenheimer remained in Europe working for two more years on post-doctoral projects with Wolfgang Pauli and Paul Ehrenfest, two of Europe's leading theorists. His work there honed his mathematical skills and Ehrenfest forced Oppenheimer to concentrate on the clarity of his calculations. After these two years of post-doctoral work were complete, Oppenheimer decided to return to the United States. He wanted to return because he " wanted to pursue [the new physics] myself, to explain it, to foster its cultivation."[1] Thus by this time Oppenheimer had been fully acclimated to the rules and structure of the western scientific world. He returned armed not only with firsthand knowledge of the latest developments in European physics and a highly coveted degree from the University of Gottingen, but with a tacit understanding of the scientific paradigm. Oppenheimer understood the importance of maintaining a cohesive scientific community and of following the puzzle-solving technique to elucidate the answers to scientific problems.

Oppenheimer returned to the United States with the desire to create an American equivalent to the important theoretical physics departments of Europe. He wished to recreate the furious pace of the German laboratories. When he returned to Harvard he commented mournfully, in a letter to a fellow physicist in Germany, that "here there is very little going on."[2] He could not practice science in the provincial theoretical laboratories of the east coast and therefore, he decided, the best plan of action was to accept a joint position at

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[1]Kunetka, p. 12
[2]Oppenheimer, p. 108

California Institute of Technology and the University of California at Berkeley. There Oppenheimer would build his new department from the ground up: "I visited Berkeley and I thought I 'd like to go to Berkeley because it was a desert. There was no theoretical physics and I thought it would be nice to try to start something..."[1]

Despite Sakharov's absence from formal studies, an almost two-year absence from academic life, he decided, in 1944, to return to obtain a graduate degree in physics. Sakharov's experiences during the war assisted him in his pursuit of a doctoral degree in physics. The time he spent in the factory laboratory indoctrinated him into the world of research, Sakharov began his intensive study of theoretical physics at FIAN under the famous Soviet physicist I.E. Tamm. Sakharov recalls that "for my part I had been ready to shift to pure science for some time. I was sorry to abandon my work as an inventor...but my craving for science outweighed all other concerns."[2] Sakharov began his graduate education at FIAN by studying Wolfgang Pauli's Theory of Relativity and Quantum Mechanics and a article by Leonid Mandelshtam, "Toward a Theory of Indirect Measurements." Pauli's book on relativity was, according to Sakharov, a superb survey of the subject of relativity with a detailed historical and experimental section.[3] These works served to focus Sakharov's thoughts on the major theoretical problems in modern physics and to expose him to the structure of the puzzle-like problems he would soon have to face. The other book on quantum

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[1]Oppenheimer, p. 114
[2]Sakharov p.67
[3]Sakharov, p.68

mechanics and the supplemental article by Mandelshtam provided Sakharov with excellent and insightful interpretations of quantum mechanics. After reading these works Sakharov had the proper vocabulary to discuss theoretical physics and a understanding of the the subjects which the laboratory was pursuing. Sakharov commented that in retrospect Tamm's choice of these two books appeared very appropriate "for it immediately pointed my study and research in a direction that would be productive for years..."[1] After this initial introduction Sakharov was able to take part in interesting work which would culminate in a doctoral degree.

Upon his matriculation to FIAN, Sakharov entered a world which emphasized the study of physics above all else. He became, as much out of necessity as by choice, deeply immersed in that society. In much the same manner as Oppenheimer, Sakharov became conditioned to think of life mostly in terms of physics. Along with the required topics in theoretical physics, Sakharov was learning the manner in which the modern scientist behaves. The relationships which Sakharov developed with Tamm and the other physicists at FIAN served much the same purpose as such relationships had for Oppenheimer. They brought Sakharov into the exclusive community of scientists which has its own rules of behavior and internal structure..

Sakharov and Oppenheimer had acquired much of their factual knowledge of physics through extensive reading, but this extensive factual knowledge failed to make them scientists. What made these

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[1]Sakharov p.70

men scientists was their participation in the rituals of laboratory science. One ritual Tamm enforced at FIAN was to have Sakharov and the other graduate students review published scientific literature and present it at group meetings. These activities served to bring the scientists into the community and reinforced the group's belief in the value of the traditional paradigm. Sakharov described, in his memoirs, the rigorous of attempting learn and relay the latest scientific discoveries. He recalls the feelings that often accompanied such reports: "...when I reported on Schwinger's work on the anomalous magnetic moment of the electron, I felt like the messenger of the gods."[1] Another requirement at FIAN, which served to socialize young scientists, was that they do some teaching. In the process of lecturing at the Moscow Energetics Institute, Sakharov was forced to solicit the advice of the older established physicists on how best to relay information to a class. In his memoirs Sakharov explained that "teaching at school may not have added to my expert knowledge, but the experience was very useful..."[2]

The period before Sakharov was drawn into military research was an intense and demanding one, as he attempted to solve complex theoretical problems. These last few years at FIAN were very important in providing Sakharov with the foundation of knowledge that he would use later when he would work on the hydrogen bomb project. For Sakharov this period was what the post-doctoral work in Germany and to some extent in California was for Oppenheimer:

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[1]Sakharov, p. 73
[2]Sakharov, p.75

the chance to work on the cutting edge of highly theoretical physics. In his memoirs, Sakharov recalls a feeling of loss when he was forced to give up his position at FIAN and go to work for the military: " later on, after I had been drawn into military research, I almost instantly lost the heights I had taken such pains to acquire. I was never able to return to it again, which is a great pity...I did rely to a considerable extent on knowledge acquired under Tamm's guidance..."[1] He was also able, during this period, to publish a few papers on topics such as "Meson Generation" and "Generation of the Hard Components of Cosmic Rays." The work described in these papers was fundamental for the creation of Sakharov the scientist: "My growth as a scientist came principally through the scientific work I did on my own and brought to publishable stage."[2] These years served to provide Sakharov with first-hand experience of working within the paradigm.

Sakharov received his doctoral degree in the summer of 1947 after a small problem with a mandatory exam in philosophy. It seems that Sakharov had not read certain works by the Russian philosopher Chernyshevsky and was given a "D" until he completed a test on the required reading. After receiving his degree, Sakharov made two forays into science. His first project attempted to explain nonradiative nuclear transitions and although the experiment failed, it served to raise other important questions and provided Sakharov with a sense of importance. "Recalling that summer of 1947, I feel that never before or since have I been so close to the highest level

[1]Sakharov, p. 79
[2]Sakharov, p. 75

of science - its cutting edge...I cannot help but exult in the great advances of science - and had I not once been a part of it, I would not feel this so keenly!"[1] Both Sakharov and Oppenheimer acknowledged that a complete understanding of scientific process was tethered to the individual's experience of that process.

III: Science and the Social World

The relationship between the scientific and the social world is not a fluid one. It is mediated through the paradigm which maintains a permeable boundary between the two social communities. On the one hand, there are science questions which pertain solely to the internal process of resolving issues in physics. On the other hand, there are the social questions which revolve around utility, the net effect of a discovery, and ethical considerations. Oppenheimer and Sakharov both had the opportunity to bridge the gap between the scientific and social, but they both made conscious efforts to the maintain the division. Thus, Oppenheimer and Sakharov were not unaware of the occurrences in the larger social world. They had experienced some of its elements during their university years through brief introductions to various political clubs and other campus institutions. During the years following their post-graduate work, both Sakharov and Oppenheimer had more time to consider the occurrences of the social world. However they always attempted to keep the two worlds, that of science and that of society, separate;

[1]Sakharov, p. 85

and when these scientists became involved in military research, the separation became complete.

Despite Sakharov's and Oppenheimer's individual desire to concentrate on their scientific research, certain events made it impossible to realize this plan. During their doctoral and post-doctoral academic years, the realm of the social world was difficult to ignore. For Oppenheimer, it was the rise of fascism and the problems due to the depression. For Sakharov, politics and concerns about the interplay between science and the state commanded his attention. In the Soviet Union, there was little chance to escape interference from the political and the social world. Oppenheimer was not bombarded to the extent that Sakharov was with dilemmas from the social world. Therefore, it was more difficult for Sakharov to maintain the barrier between the social and scientific world than it was for Oppenheimer. This process of asking questions regarding the nature of science and society was not a breakdown of the Kuhnian model, as the scientist did not question the central structure of the scientific community. While Sakharov and Oppenheimer may have doubted the political leaders of their countries, their actual dissent would come later.

Oppenheimer had many opportunities to consider the relationship between the scientific and the social world at his new positions in California. In 1929, Oppenheimer left Zurich, where he was doing post-doctoral work for California. There he entered a new social world. However, in many ways, his world hardly changed. By 1932 Oppenheimer was living a life in which he lectured three times a week along with a few special seminars. As he said in a letter to

his brother Frank, physics remained his most important concern: " I can't think that it would be terrible of me to say - and is occasionally true - that I need physics more than friends..."[1] What was foremost in Oppenheimer's mind was the spread of theoretical physics and the improvement of his programs. He worked very hard to improve his teaching skills and he became increasingly interested in nuclear phenomena. Physics, while not his sole pursuit, provided him with a sense of accomplishment that no other pursuit could. Oppenheimer believed that "doing" physics was the only truly beautiful experience, an idea he expressed his brother in a letter written in 1932, "...physics has a beauty which no other science can match, a rigor and austerity and depth."[2] Oppenheimer appreciated the fact that every question in physics had an answer hidden within it and this realization strengthened his belief in the value of the paradigm.

Despite his intense research, Oppenheimer became more aware of the occurrences in the larger social world, and he did begin to respond to these during his years at Berkeley. The rise of Hitler in Germany and the fiscal problems of his students forced Oppenheimer to take an interest in the social world, a world made up of politics which he had formally been completely uninterested in. Oppenheimer described his change in attitude to interviewer Thomas Kuhn:

> Beginning in late 1936, my interest began to change. These changes did not alter my earlier friendships...or my devotion to physics; but they added something new. I can discern in retrospect more than one reason for these changes. I had had a continuing, smouldering fury about the treatment of Jews in Germany...I saw what the depression was doing to my students...I began to feel

[1]Oppenheimer, p.135
[2]Oppenheimer, p.135

> the need to participate more fully in the life of the community. But I had no framework of political conviction or experience to give me perspective in these matters.[1]

Oppenheimer found himself drawn into a world with which he had no formal experience. Oppenheimer was exposed the the problems of the social world yet he chose to keep them separate from his scientific concerns; he chose not to bridge the gap. A problem he found was that these pressing issues did not fit into the puzzle structure at all. This realization fueled his intense belief in the value of science and enabled his to have direct contact with political structures and moral problems of the larger society, without making the connection of a need for a moral order in the scientific community.

The powerful social and economic changes that had swept through Europe and then America had been of little interest to Oppenheimer: " I was not interested in and did not read about economics or politics. I was almost wholly divorced from the contemporary scene in this country..."[2] He did not connect his readings from the classics of literature or his other outside interests with science. Oppenheimer described this phenomena rather eloquently: "I was interested in man and his experience. I was deeply interested in my science; but I had no understanding of the relations of man to his society."[3] During this period Oppenheimer read neither newspapers nor current magazines.[4] To many of his non-

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[1]Oppenheimer, p.196

[2]United States Atomic Energy Commission. In The Matter of J. Robert Oppenheimer: Transcript of Hearing before Personnel Security Board and Texts of Principal Documents and Letters. Cambridge: MIT Press. p. 8

[3]Kunetka, p.13

[4]U.S.A.E.C., p. 8

scientific friends, this behavior seemed bizarre, but Oppenheimer devoted most of his time to science. As he said to a student, Leo Nedelsky: "What does politics have to do with truth, goodness, and beauty?"[1] Thus, despite his broad readings in literature, his interest in a few social causes and a knowledge of many languages, Oppenheimer was not able to allow the two worlds, the scientific and social, to come together.

Sakharov too chose to keep the social world and the scientific world in separate categories. As is clear in his memoirs, Sakharov was quite aware of the extent to which he closed his mind to all problems and concerns outside of physics. Sakharov describes his graduate and post-doctoral work as "essentially a single enormous bubble."[2] Sakharov's reference to existing in a bubble works might have described Oppenheimer's formative experiences as a professional scientist as well. Yet, the metaphorical bubble which surrounded these men was not impervious to the outside world. It was porous and Sakharov was not completely cut off from the political and moral dilemmas of his country.

Sakharov could not, as Oppenheimer did, avoid the politics of his society. He was forced to play politics over simple things like acquiring housing. Politics was a distinct part of life in a totalitarian society and Sakharov was constantly harassed by external governmental forces. Once when Sakharov was at the laboratory, the KGB came to see his first wife, Klava. They asked her

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[1]Kunetka, p.16
[2]Sakharov, p.73

if she would "cooperate by reporting all his [Sakharov's] meetings..."[1] He was also confronted with the paradox of the director of FIAN, Sergi Vavilov and his better-known brother, a biologist. The more talented brother, the biologist, had been arrested and had died in prison while the other brother became the head of a research institute. Sakharov later comments that the "fates of the two brothers - one dying of hunger and cleaning slop pails in Saratov prison; the other president of the Academy and heaped with honors...summed up the whole era."[2] Despite his exposure to the interaction that went on between the social and scientific questions, Sakharov failed to bridge the gap between the two worlds. The overwhelming problems of Soviet society interfered with Sakharov's research and his life but he attempted to maintain order and efficiency by keeping the two worlds separate.

The power structure in the Soviet Union, in which the government possessed the majority of the power, allowed the government to control even the most important Soviet scientists. The lack of power which plagued the scientific community is dramatized by Sakharov experiences regarding attempts to get a paper published in the Soviet scientific journal. He had to get the mandatory references and fill out pages of paperwork all to get a article in the area theoretical physics. The amount of censorship served to remind the scientific community how little power they possessed. Despite Sakharov's introduction to many of the social problems in the Soviet scientific community, including groups of

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[1]Sakharov, p.77
[2]Sakharov ,p.78

Lysenkoites attempting to destroy biology and interfere with physics, the powerful and raw nature of his education kept him from losing faith in the validity of the paradigm and allowed him to maintain the boundaries between social and scientific questions.

After these scientists left their university appointments and went to work on military projects, these opportunities to bridge the gap between the social and scientific disappeared completely. Their isolation from the social world increased when these scientists entered into military research. Questions surrounding the larger social world almost disappeared completely. Despite the differences in both time period and geographical location, Sakharov's and Oppenheimer's experiences while working military projects, the atomic and the hydrogen bomb are strangely similar. While working for the military they had no choice but to cease to ask questions regarding the social and scientific world. Neither scientist had planned to participate in military research and entered into this type of research to meet the demands of their respective countries. Oppenheimer choose to give up his prestigious positions at California Technical and at the University of California to head the Los Alamos complex because he believed in the importance of the project to national security. In recruiting other scientists, Oppenheimer attempted to relay these feelings of "interest, urgency, and feasibility of the Los Alamos mission."[1] While Sakharov was given little choice but to leave FIAN and report to the Installation, he too believed that the work at the installation was of utmost

[1]U.S.A.E.C., p.12

importance to the security of the Soviet Union: "...the recent war had also been an exercise in barbarity; and although I hadn't fought in that conflict, I regarded myself as a soldier in this new scientific war."[1] Sakharov commitment to the project was centered around this desire to defend his country. These military complexes stressed security, the value of isolation and the importance of centralization of work, which sped the production of the atomic and hydrogen devices.

The new scientific world which resulted from the social regulations imposed by the military was one which emphasized scientific progress over all other considerations. The result of this shift was to create an extreme version of the scientific paradigm characterized by a concise, almost obsessive, focus on the process of scientific problem-solving. The scientific world that these scientists had become accustomed to was altered to exclude all non-scientific relationships.

While the threats of war and the defensive needs of their countries were central to their motivation to work on these military projects, Oppenheimer and Sakharov were also enticed by the opportunity to do research on the frontiers of theoretical physics. Sakharov described in his memoirs how certain scientific reasons played an important role in maintaining his commitment to the project: "one reason for [participating in the hydrogen project] was the opportunity to do superb physics." [2] Therefore, despite being ordered to the Installation in 1950, Sakharov displayed little

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[1]Sakharov, p. 97
[2]Sakharov, p.96

resentment and kept a positive attitude while he worked on the hydrogen bomb project: "In 1948, no one asked whether or not I wanted to take part in such work. I had no real choice in the matter, but the concentration, total absorption, and energy that I brought to the task were my own."[1] These institutions provided the scientist with only one goal, only one concern, that the scientific questions surrounding the bomb be resolved. The structure and organization of these complexes followed a similar ethos, one which attempted to focus the scientist solely on the project. Oppenheimer recognized this rare opportunity and spoke of the advantages inherent in this unique type of research, the "exhilarating sense of mission and of comradeship" that came out of the organization of such projects.[2] Thus, it was more than just a desire to protect their countries that provided the impetus for these scientists to work on the bomb projects. They were intrigued by the opportunities and the resources available to them and the possibility of working on science uninterrupted by the outside world.

IV. The Bomb Years

During the years these scientists spent working on secret projects for the military, the intensity of the scientific work increased. Oppenheimer and Sakharov no longer had the free time to go to dinner with friends. In fact, all non-scientific contact was forbidden at their respective research institutions. Social contact

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[1]Sakharov, p.96
[2]Oppenheimer, p. 252

and travel to other areas were forbidden and the information coming from the larger social world was limited to the news provided by the government. The structure of the scientific paradigm became more intense and rigid in its application and the separation between social and scientific world complete. As a result of this new system, Sakharov and Oppenheimer became completely involved in employing the puzzle-solving methodology of the paradigm attempting, to create and perfect their respective devices.

The laboratory at Los Alamos was created to focus the scientists involved in the American effort to create an atomic device. Oppenheimer believed that for the American effort to succeed, the laboratories involved needed to be consolidated in one area: "we began to notice how very much the little laboratories were suffering from their isolation."[1] The creation of Los Alamos would eliminate the frustration and error of these many separate laboratories and provide the scientists involved with a place where they "could talk freely with each other, where theoretical ideas and experimental findings could affect each other..."[2] These scientific discussions were limited only by the necessary security precautions. Therefore, a scientist could converse with another scientist in the same field in order to resolve a particular problem. Oppenheimer created a complex that followed the structural outline of the paradigm exactly. The complex isolated the scientist from the social world, while it created a intimate social community, and it promoted the paradigmatic puzzle-style process for insuring

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[1]U.S.A.E.C., p. 28
[2]U.S.A.E.C., p. 12

maximum efficiency. The entire complex reinforced the traditional values which Oppenheimer had learned from famous theoretical physicists in Germany.

The experiences of the scientists at Los Alamos laboratories mirrored in many ways those at the Soviet Installation. While the complex at Los Alamos was designed solely for research purposes, its rules were very similar to those at the Soviet complex. Oppenheimer described the strict rules which guided conduct at these laboratories and the problems created by these rules: "restrictions on travel and on the freedom of families to move about [were] severe; and no one could be sure of the extent to which the necessary technical freedom of action could be actually maintained by the lab."[1] While past sympathies to communist and other questionable organizations did not necessarily disqualify a man from working at Los Alamos, they were factors. Oppenheimer made the rules concerning political interaction at Los Alamos clear in a letter written to physicist Ernest Lawrence, "I doubt very much whether anyone will want to start at this time a [communist and labor] organization which could in any way embarrass, divide or interfere with the work we have in hand."[2] The rules guiding the conduct of the scientists at Los Alamos were clearly as strict as those employed at the Installation. Nothing was allowed to interfere or distract those men working on the creation of the atomic bomb. Thus, the dilemmas of the outside world were left behind when the scientist

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[1]U.S.A.E.C., p. 12
[2]Oppenheimer, p.114

entered Los Alamos and one was expected to devote all of one's faculties to the problems at hand.

The work at Los Alamos went quickly and the many demands placed upon Oppenheimer forced him to focus on the scientific problems at hand, leaving him little time to ponder moral questions. The intensity of the research was, as he recalled during an interview with Thomas Kuhn, almost overwhelming: "A time so filled with work and with the need for decision and action and consultation, that there was room for little else."[1] Despite the overwhelming nature of the project, Oppenheimer was still motivated by the "sense of excitement, of devotion and of patriotism" that the scientists showed towards the project.[2] In many ways, Los Alamos became Oppenheimer's privileged prison in which he was responsible for pulling together the many disparate parts of scientific work.

Oppenheimer worked exhaustively both night and day but he had " a remarkable community inspired by a high sense of mission, of duty, and of destiny, coherent, dedicated and remarkably selfless" which inspired him to meet the daily challenges. His desire to complete the project superseded all other concerns. From late 1944 until the end of the war he was preoccupied with correlating the interlocking parts of the bomb project and with the July test of the implosion device this preoccupation only increased.

Oppenheimer was aware, despite his distance from Washington and global planning, of the pressure from within the Manhattan project to support the exchange of atomic information with other

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[1]U.S.A.E.C., p. 14
[2]U.S.A.E.C., p. 13

countries. Both Niels Bohr and Leo Szilard were quite outspoken about the need to share atomic secrets with all nations.[1] Oppenheimer believed that these were issues that would have to wait until after the war. He was most concerned with the successful creation of the atomic bomb. A colleague, Robert Wilson, remembered convening an 'impact of the gadget' meeting, probably in the spring of 1944, but thereafter he yielded to Oppenheimer's plea that attention should not be distracted from completing the bomb.[2] There were some in the larger community of scientists who wished to talk about the implications of the bomb, but were forced by Oppenheimer to wait until after the war.

Oppenheimer's views were gradually changing as the project neared completion. Earlier in the development of the atomic bomb he had stated that the decision to drop the bomb should be made by the politicians and not by the scientists:"We didn't think that being scientists especially qualified us as to how to answer this question of how the bombs should be used or not..."[3] Oppenheimer was still working within the paradigm. He believed that scientists should concentrate solely on questions regarding science; all other issues must be left to other groups operating in the social whole.

Oppenheimer argued with Leo Szilard, late in 1944, about this same subject. A few months had passed since his report to the commission and his comments betrayed a developing disillusionment with the bomb. Although he told Szilard that he still believed in the

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[1]Kunteka, p. 67
[2]Oppenheimer, p. 290
[3]U.S.A.E.C., p. 34

use of the bomb on Japan, he commented that, "the atomic bomb is shit." He also told Szilard that "this is a weapon which has no military significance. It will make a big bang - a very big bang - but it is not a weapon which is useful in war."[1] Oppenheimer's beliefs were in the process of being challenged. He began to consider issues surrounding the bomb which were not solely based in scientific research. Thus, it is possible to see these comments as proof of the changes which were occurring in his views.

The breakdown of the paradigm and the gradual change in Oppenheimer's belief system came immediately following the explosion of the atomic bombs. After the test of the implosion bomb at Alamogordo on July 16, Oppenheimer displayed a sense of awareness that the real atomic device would change the scientific landscape completely. After the test Oppenheimer stumbled out of the shelter and recited a line from the Hindu *Bhagavad-Gita*: "I am become death, the shatter of worlds."[2] While all around the scientists of Los Alamos broke into cheers and rounds of congratulations, Oppenheimer was immediately questioning the prudence of his creation. These thoughts were further focused by the dropping of the uranium bomb on Hiroshima on August 6, and by the dropping of the plutonium implosion bomb on Nagasaki on August 9. The detonation of these bombs caused a shift in Oppenheimer's thinking as he slowly began to question the moral structure of the scientific world. After the successful use of the bombs, Los Alamos

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[1]Leo Szilard, Leo Szilard: His Version of the Facts, eds. Spencer Weart and Gertrud Weiss Szilard, (Cambridge: MIT Press, 1978) p. 185
[2]Kunetka, p. 71

had celebrated with a party. Oppenheimer recalled during the party having stumbled upon a usually cool-headed young group leader vomiting in the bushes outside and his only comment was "the reaction had begun."[1] Thus, while the rest of the complex celebrated, Oppenheimer saw this vomiting man as the symbol of his newfound moral distaste for the atomic bomb.

By 1948, Sakharov had left the cosmopolitan, open atmosphere of FIAN for the isolated military complex called the Installation. Only two years earlier, Sakharov had turned down a chance to work for the military establishment as he "hadn't left the munitions plant for FIAN and the frontiers of physics, only to abandon everything now."[2] His mentor and the director of his studies, I. E. Tamm, shared these feelings and told the men ordering Sakharov to the installation that, "to limit [Sakharov] to applied research would be a great mistake, and not in our country's best interest." Despite these appeals, Sakharov found himself forced to join the installation. Sakharov's visit to the Installation, however, changed his opinion that military research would be necessarily a step down from the abstract theoretical physics he wished to do. But once he became aware of the amount of resources available and the community of scientists who had been recruited for the job, Sakharov saw the move in a more positive light.

The Installation was a work camp near a small village which had been transformed for secret military work. It embodied a curious symbiosis between an ultra-modern scientific research

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[1]Oppenheimer, p. 292
[2]Sakharov, p. 93

institute and a large labor camp.[1] Upon his arrival, Sakharov gave up a relatively free life for an extremely structured one. There was to be no travel to visit relatives or contact with the outside world. The importance of maintaining the total scientific environment was of paramount importance to the creators of the installation. Sakharov describes the restrictive environment that these young scientists had to adapt: "young specialists were not allowed to leave at all during their first year of work, and had to spend their first vacation in the nurturing productive setting."[2] One scientist explained to Sakharov the reason for all the security and complex procedures: "there are secrets everywhere, and the less you know, that doesn't concern you, the better you'll be...there's quite enough for us to do for now in the theoretical department."[3] This advice is symptomatic of the prevailing attitude that dominated the Installation and represents a desire to limit the scope of the scientists for two important reasons: security and efficiency. The Installation was an extreme form of the paradigm in action which focused the scientist's attention firmly on the problems at hand and did not allow any kind of deviance from that problem.

The Installation, like the complex at Los Alamos, focused the group of talented scientists on the problem of a controlled thermonuclear reaction and the subsequent creation of a thermonuclear device. Sakharov became fixated on the problem the moment he learned the nature of the project. Even on his way to the

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[1]Sakharov, p. 113
[2]Sakharov, p. 115
[3]Sakharov, p. 108

Installation Sakharov could not sleep: "It was not that I was mulling over distressing events or my own mistakes...what kept me awake was a new and challenging idea, the possibility of a controlled thermonuclear reaction."[1] Sakharov's overriding desire to solve problems dominated his thought even when he was being forced to move to an isolated military complex. The scientists worked with a "fierce intensity" and Sakharov described their new world as "bizarre and fantastic, a striking contrast to everyday city and family life."[2] The atmosphere was professional and even friendly yet unlike science in the university, the work went on around the clock. Their extreme concentration on a single goal not only drove the colossal project to completion, but served to impose a specific view of the world on the scientists who worked on it. The scientific paradigm was pushed to an extreme where the rules governing scientific discovery became even more structured. The scientist had no choice but to accept this extreme version of the paradigm and become more isolated from the social world. Sakharov described the psychological effect of such a focused environment: "It would require the passage of many years and radical upheavals for new currents to effect a shift in [my] view of the world."[3] The Installation had a profound effect on Sakharov and further shaped his views on science.

The hydrogen bomb project became the only issue in Sakharov's life once he entered the Installation. The scale of the project and

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[1]Sakharov, p. 107
[2]Sakharov, p. 96
[3]Sakharov, p.116

sense of drama, combined with the fantastic scientific discoveries, drove these men to work feverishly on the project. Between 1950 and 1953, the Installation committed the major portion of its resources to preparations for testing the first thermonuclear charge. During the later half of 1950, Sakharov was made the head of the theoretical department and his group was responsible to interact with both of the research tracts, the theoretical laboratories and the Practical laboratories, at the Installation: "The theoretical groups were also responsible...for assigning tasks to other departments at the Installation and affiliated organizations..."[1] He became immersed in scientific research and his relationships with scientists increased ten-fold. Sakharov described his visits to the Installation's experimental section and the opportunities it provided him to have scientific exchanges: "they [the experimental scientists] would all turn up when they knew I was coming, and we would discuss the results of their experiments..."[2] In 1953, Sakharov and the rest of the scientists prepared to test the first hydrogen device. In his memoirs Sakharov recalled that "in early August , an atomic device was tested; this would have ordinarily have been a great event for me, but I was so completely absorbed in the forthcoming thermonuclear test that I barely noticed it."[3] The intensity of the Installation, with its demands of extreme concentration and commitment to the project drew Sakharov deeper into a world in which the project was the only concern.

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[1]Sakharov, p. 157
[2]Sakharov, p. 157
[3]Sakharov, p. 173

The culmination of three years of work was the explosion of the device on August 12, 1953. Sakharov describes the tension and excitement when the device detonated:

> "We saw a flash, and then a swiftly expanding white ball lit up the whole horizon. I tore off my goggles, and though I was partially blinded by the glare, I could see a stupendous cloud trailing streamers of purple dust. The cloud turned gray, quickly separated from the ground and swirled upward, shimmering with gleams of orange. The customary mushroom cloud gradually formed, but the stem connecting to the ground was much thicker than those shown in photographs of fission explosions...The shock wave blasted my ears and struck a sharp blow to my entire body; then there was a prolonged, ominous rumble that slowly died away...Within minutes, the cloud, which now filled the sky, turned a sinister blue-black color.[1]

Sakharov witnessed his first thermonuclear explosion and was struck by its mutation in appearance from something strangely beautiful to something sinister and dark. The successful test of the device should have been a great day for Sakharov as he was one of the project leaders. Yet, when he attempted to recall how he felt after the test when he was being congratulated he said, "I rose from my seat and bowed, but I can't recall what I was thinking at the time."[2] This test is an important moment in the destabilization of the current paradigm. Sakharov's first experience with the power of these weapons forced him to begin asking new questions. The first explosion did not undermine immediately the years Sakharov had spent working within the traditional paradigm, but it did begin the process. After the test, a slightly troubled Sakharov affirmed his desire to continue the project, but not without some trepidation for what might occur in the future.

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[1]Sakharov, p. 174
[2]Sakharov, p. 175

The next test of the hydrogen bomb was a complete success. At the test site Sakharov witnessed the same sinister mushroom cloud and experienced the extreme power of the bomb. While shock waves crashed along the ground a fellow scientist, Zeldovich ran over and gave Sakharov a hug. The entire time he was yelling, "It worked! It worked! Everything worked![1] The test had been a great success. It had solved the problem of creating high-performance thermonuclear weapons, but the test had also served to raise questions in Sakharov's mind regarding his personal belief in the system.

> "The experience we had acquired [at the test site] opened the way to the creation of advanced weapons, but it also made me more aware of the human and moral dimensions of our work. It was of course, just a beginning, but I have continued ever since to ponder these questions..."[2]

Sakharov began to consider the moral implications of the weapon he had just created. While he did not immediately reject the scientific paradigm, his belief in its society had been shaken.

During the final test of 1955, Sakharov was to experience a feeling of sorrow when the test resulted in the death of some of the nearby inhabitants. The force of the explosion had collapsed a nearby trench which was sheltering a platoon of soldiers, and one, a young boy in his first year of service had been killed. Another death occurred when a little girl who was playing with blocks in the bomb shelter was killed when the shock wave collapsed the shelter. These events affected the way in which Sakharov felt about the bomb.

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[1]Sakharov, p. 191
[2]Sakharov, p. 179

> "We were stirred up, but not just with the exhilaration that comes with a job well done. For my part, I experienced a wide range of contradictory sentiments, perhaps chief among them a fear that this newly released force could slip out of control and lead to unimaginable disasters. The accident report and especially the death of the little girl and the soldier, heightened my sense of foreboding. I did not hold myself personally responsible for their deaths, but I could not escape a feeling of complicity."[1]

Neither Sakharov nor Oppenheimer were directly responsible for the deaths these weapons caused but a feeling of complicity forced them to evaluate the need for a missing ethical component in the scientific process.

V. The Ethical Journey

The detonation of hydrogen and atomic devices acted as catalysts which allowed, perhaps even forced, Oppenheimer and Sakharov to question the validity of the structure of the paradigm. After the explosions, both Oppenheimer and Sakharov found that their belief in the stable, unquestionable nature of modern science and its paradigm were at best problematic. As they further questioned the nature of the paradigm, Oppenheimer and Sakharov found themselves without the landmarks to which they, as scientists, had been accustomed. Gradually, both Oppenheimer and Sakharov began to be perceive the traditional paradigm as invalid. They realized that the integrity and "goodness" of modern science was being compromised by the confining and isolating nature of the paradigm. The absolute conviction which these men had possessed for the traditional process of problem-solving was simply no longer possible. After the bomb, neither Oppenheimer nor Sakharov could in

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[1]Sakharov, p. 194

good conscious "do" science in the way they had before, yet they were unable to abandon the scientific paradigm. Oppenheimer and Sakharov felt themselves adrift while they searched for a new structure to replace the old paradigm. Thus, the elimination of the traditional paradigm was a gradual process which involved a search for something to take its place, a new structure which could grapple with the ethical problems created by these inventions. Oppenheimer and Sakharov were forced to undergo an ethical journey to search for a new structure, one which had a moral component.

The search for a new paradigm which could retain its efficient nature while containing a moral component was extremely difficult. Oppenheimer was almost paralyzed by the process of breaking with the traditional paradigm. His dogged uncertainty over which plan of action would create a new and just science made a complete break from the paradigm impossible. Each attempt Oppenheimer made to move beyond the realm of the role of the "inside scientist" through radical suggestions was counterbalanced by the pull he felt from the traditional paradigm. The result of this struggle between the two forces was his suggestions became less radical and often less useful. Sakharov on the other hand, was to complete the journey through a complete rejection of the old paradigm and his political environment. He too was "inside scientist" with the ability and power to talk directly to leaders like Khrushchev but he was able to reject this role and assume a position of leadership from the position of a dissident. These men did not have a choice as to whether to follow this path towards a new, less paradigmatic scientific world; they were compelled by what they had seen. In

some sense, the detonation of the bomb forced them to choose between retaining the status quo or to search for a new science which would better serve humankind.

Oppenheimer's belief in the paradigm had, after the explosion of the atomic bombs, become increasingly dubious. His monomaniacal devotion to science was called into question by the moral dilemmas created by the bomb. Instead of a man filled with pride for his creation, Oppenheimer felt great sadness and guilt. He was troubled with the recent developments regarding the expected uses and control of the atomic bomb. Oppenheimer felt that it was his responsibility to find the answer to the lack of an ethical component in science, but he lacked the structure to find it. These feelings were captured in his correspondence with fellow scientists. In a letter of 1945 to Dr. Monroe Deutsch, the provost of the University of California, Oppenheimer expressed these unfamiliar feelings: "you will understand that...this enterprise of the atomic bomb has been heavy with misgiving and concern..."[1] Oppenheimer was clearly struggling with his conception of scientific inquiry, as all of the things he had liked about science, its beauty and inherently logical nature, had disappeared, and left him without support and direction. The great advances in physics had failed to create something positive; physics could indeed be used to create evil. In a letter to Herbert Smith, the headmaster of the Francis W. Parker school, Oppenheimer wrote again of his misgivings:" They are heavy on us today," he writes, "when the future which has so many elements of

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[1]Oppenheimer, p. 295

high promise, is yet only a stone's throw away from despair."[1] Oppenheimer seemed unable to find a plan of action and was and spent the months following the detonation of the atomic bomb searching for some structure which would not only resolve the dilemmas created by the bomb but return a sense of stability to his life.

Oppenheimer found that the relationship between scientific discoveries and their employment were, under the current paradigm, largely out of the control of the scientist. His experiences in Washington, supporting the May-Johnson bill to establish a domestic atomic energy commission and thus eliminate the total control the United States Army had over information regarding the atomic process, left him deeply worried about how his government would use its new power.[2] Despite his worry about the scientific community lack of control, Oppenheimer never doubted his own personal power. He seemed to believe that he was an "inside scientist" who could, through his personal relationships with politicians, alter the structure of science.

On October 16, 1945 Oppenheimer retired from the position of director of Los Alamos and began to work to create an international structure to control the possession of atomic weapons. He went to Washington to discuss the need to educate policy makers and attempted to use his personal power to create such a structure. Oppenheimer fought against the Presidential injunction which forbade atomic scientists from participating in public discussion on

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[1]Oppenheimer, p. 297
[2]Oppenheimer, p. 302

atomic weapons. Oppenheimer succeeded in eliminating the presidential injunction and convinced the new secretary of war, Robert P. Patterson, to state publicly that with due regard to security, American scientists "should feel it is proper for them as citizens to join actively in public considerations of the political and social implications of atomic energy." He still, however, had yet to abandon the traditional structure and replace it with a new paradigm.[1]

On the evening of November 2, 1945, Oppenheimer addressed the members of the Association of Los Alamos Scientists, at Los Alamos. The month spent working in Washington had enabled him to focus his thoughts on the need for change in the scientific community. In his speech to the scientists, most of whom had worked with him on the atomic bomb project, Oppenheimer outlined some changes which he believed could provide structure to a scientific world in disarray. The new structure would, Oppenheimer hoped, answer the moral challenges created by the detonation of the atomic bomb. He began the speech by outlining the dilemma created by the development of atomic weapons. Oppenheimer compared the threat to the scientific world posed by the creation of the atomic bomb and atomic weapons to the threat the Christian church posed to physical sciences during the Renaissance: " [the atomic bomb] is not just an idea - it is a development and a reality - but it has in common with the early days of physical science the fact that the very existence of science is threatened."[2] Thus, Oppenheimer

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[1]Oppenheimer, p. 311
[2]Oppenheimer, p. 316

believed that the creation of the atomic bomb had demonstrated the dangerous potential modern science had for getting out of humankind's control.

Despite Oppenheimer growing distaste for the scientific paradigm, he did not, in his speech to the scientists of Los Alamos, attempt to dismantle the paradigm directly. Oppenheimer's suggested reforms were not radical, they merely attempted to transform some of the paradigm's structural foundations. He concluded, for example, that research is driven by an "organic necessity" which demands the freedom to explore any topic of interest: "if you are a scientist you cannot stop such a thing. If you are a scientist you believe that it is good to find out how the world works; that it is good to find out what the realities are..."[1] While Oppenheimer recognized that unbiased discovery was an integral part of scientific discovery, he criticized the "evil of secrecy." Oppenheimer believed that secrecy in science was incompatible and entirely contrary to the central purpose of science in modern society, which is to teach humanity about the world: "It is not possible to be a scientist unless you believe that the knowledge of the world, and the power which this gives, is a thing of intrinsic value to humanity."[2] The atomic bomb was created in an institution which demanded both secrecy and isolation. These demands allowed the paradigm to function, unhindered by the larger social world, and create a weapon of terrible destructive capability. Oppenheimer had come to realize that such science did not necessarily serve

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[1]Oppenheimer, p. 317
[2]Oppenheimer, p. 317

humankind, rather it served the abstract concept of progress and needed to be reformed.

Oppenheimer warned in his speech against the seductive nature of the paradigm. He suggested that most scientists accept the paradigm because it provides a stable foundation and allows for the greatest efficiency in scientific discovery. However, this type of blind acceptance of the paradigm can lead scientists to act in ways which benefit scientific progress but not the social world:

> "I would say that among scientists there are certain centrifugal tendencies which seem a little dangerous...One of them is the attempt to try, in this imperiled world, in which the very function of science is threatened, to make convenient arrangements for the continuance of science, and to pay very little attention to the preconditions which give sense to it. Another is the tendency to say we must have a free science and a strong science...The third is even odder, and it is to say, 'Oh give the bombs to the United Nations...and let us get back to physics and chemistry.'"[1]

Oppenheimer realized that scientists must participate in the political process and allow the social world to play a role in the scientific process. He urged that scientists be less aloof, isolated and absorbed in solely in their own work. He believed that a new restructured science, one which considered moral as well as scientific questions, would lead to a science which would always be a benefit to mankind. However, such a science would require a new type of scientist one who would be willing to speak out in a political context and attempt to relate to the larger social whole.

Oppenheimer offered in his lecture a hope for the future, a chance to alter the paradigm. He believed that scientists had the best chance to reform the paradigm because they "have perhaps a little greater ability to accept change, and accept radical change,

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[1]Oppenheimer, p. 322

because of their own experiences in the pursuit of science."[1] Oppenheimer wanted to employ elements of the paradigm to reform the paradigm. The impetus for this desire to reform the scientific paradigm was the explosion of the atomic bombs. Oppenheimer believed that the bomb had demonstrated the need to transform the relationship of science and society from its current position to a more meaningful one:

> "These things [creation of atomic weapons], as you know, forced us to reconsider the relations between science and common sense. They forced on us the recognition that the fact that we were in the habit of talking a certain language and using certain concepts, did not necessarily imply that there was anything in the real world to correspond to these."[2]

Science was, according to Oppenheimer, threatened by these new developments and unless change was enacted it would cease to serve humanity. Oppenheimer believed that creation of the atomic bomb was an example of both the power and the danger associated with modern science. Without change modern science would continue to discover things, like the atomic process, which could alter the face of the world but such discoveries would under the current scientific structure be unguided and therefore be detrimental to humankind.

The inability of scientists to participate in general discussion of the problems created by the bomb revealed the barriers which made interaction between science and society extremely difficult. The very existence of an atomic weapon, created by modern science, demanded, according to Oppenheimer, that scientists question their own actions. Oppenheimer expressed, in his speech, the need for communication and interaction between the scientific community

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[1]Oppenheimer, p. 317
[2]Oppenheimer, p. 315

and the social world: "share your knowledge...with anyone who is interested..."[1] He spoke of the need for scientists to break out from the narrow, focused nature of the paradigm and actively participate in the social world. He told his colleagues that they must destroy the artificial barrier between the sphere of science and the sphere of the social world. He believed that without conversations between the two worlds there could be no moral or ethical component:

> "we are not only scientists, we are men, too. We cannot forget our dependence on our fellow men...the value of science must lie in the world of men, that all our roots lie there. These are the strongest bonds in the whole world, stronger than those even that bind us to one another, these are the deepest bonds - that bind us to our fellow men."[2]

Oppenheimer attempted in his speech to remind his colleagues that they must consider the social whole when they did science. If they failed to consider the social world, then science would cease to be a progressive activity which improved humankind. Oppenheimer was never able to decide on a single path to transform the paradigm. He was always switching back and forth between his desire to reject the traditional paradigm and the hope that he might simply reform it. The result of this inability to make a firm decision was the lack of direction which would undermine his attempts at altering the paradigm.

Sakharov followed a similar path of gradual disgust for the structure of the scientific paradigm. He too found himself on an ethical journey searching for a system to replace the traditional scientific paradigm. Sakharov, however, developed a more radical outlook on the types of changes needed and this is reflected in his

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[1]Oppenheimer, p. 317
[2]Oppenheimer, p. 325

actions. After the successful test of the hydrogen bomb Sakharov began to dissent from the popularly held views on the value of the bomb and indeed the very relationship of science and society. At a party held after the test, he made a toast and said, "May all our devices explode as successfully as today's, but always over test cites and never over cities."[1] The table fell silent and a leading marshal rose, glass in hand and said, "Let me tell a parable. An old man wearing only a shirt was praying before an icon. 'Guide me, harden me. Guide me harden me.' His wife, who was lying on the stove, said, "Just pray to be hard, old man, I can guide it myself.' Let's drink to getting hard."[2] The point of this story was clear enough to Sakharov:

> "We, the inventors, scientists, engineers...had created this terrible weapon, the most terrible weapon in human history; but its use would lie entirely outside our control. The people at the top of the party...would make the decisions. Of course, I knew this already...but understanding something in an abstract way is different from feeling it with your whole being...The ideas and the emotions kindled at that moment have not diminished to this day, and they have completely altered my thinking."[3]

Sakharov began to call into question the organization of science and the relationship of science and society. He became aware of the fact that he had no control over his invention. Sakharov began to realize that there was no moral component in science that guided the applications of scientific discoveries in the modern world. He suddenly came to the realization of how isolated the scientific world was from the rest of the society.

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[1]Sakharov, p. 194
[2]Sakharov, p. 194
[3]Sakharov, p. 195

During the years following the 1955 test of the hydrogen device, Sakharov became more disenchanted with the properties of the scientific paradigm. He became interested in the moral implications of testing such weapons, especially with the biological effects of thermonuclear testing: "I worried more and more about the biological effects of nuclear testing. My concern was prompted by the course of events and by my own part in the testing program."[1] In 1957 Sakharov wrote "Radioactive Carbon from Nuclear Explosions and Non-threshold Biological Effects" which described the effects of a "clean" bomb, one which produced no radioactive fallout. He was supposed to denounce the new American development, without implicating the "conventional" nuclear weapons he and others in the Soviet Union were working on: "But after reading through the extensive humanistic, political, and scientific literature on the subject, I extended the article's scope and reached more balanced conclusions."[2] This article served to reinforce the idea that the responsible scientist needs to take a more complete view of his work. Sakharov began to conceive of a science which would avoid the confining nature imposed by the traditional paradigm and would be able to converse with the rest of society.

When in the summer of 1958, after an initial decision to stop testing nuclear weapons, the USSR decided to resume testing after the failure of Americans and British to follow their example, Sakharov was moved to action. He felt that this was an immoral decision: "I found what was happening completely unacceptable, both

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[1]Sakharov, p. 199
[2]Sakharov, p. 201

politically and morally..."[1] Sakharov then worked to use his influence to stop further testing of the hydrogen bomb. Thus, when in 1961 the next test was planed Sakharov attempted to intervene on a personal level. Sakharov, like Oppenheimer, still believed that he could use personal influence combined with technical arguments to control scientific policy. He had not yet fully realized the lack of power scientists had in the political arena. At a dinner with Khrushchev, Sakharov passed a note to comrade N.S. Khrushchev which questioned Soviet policy on nuclear testing:

> "I am convinced that a resumption of testing at this time would only favor the USA. Prompted by the success of our Sputniks, they could use the tests to improve their devices. They have underestimated us in the past...Don't you think that new tests will seriously jeopardize the test ban negotiations, the cause of disarmament and world peace?"[2]

Sakharov attempted to influence policy in a subtle way, but the reply he received was public and bitting. Scientists, according to the Soviet political system, were supposed to stay in their labs and leave politics to politicians. Khrushchev rose from the table and told Sakharov and all those seated at the table that Sakharov had "... moved beyond science into politics. Here he's poking his nose where it does not belong...leave politics to us. We're the specialists. You make your bombs and test them, and we won't interfere with you..."[3] Once again Sakharov was faced with the realization that scientists were expected to confine themselves in their scientific world and make great discoveries following the problem-solving model, as for

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[1]Sakharov, p. 207
[2]Sakharov, p. 216
[3]Sakharov, p. 216

what to do with those creations and discoveries those were not their concerns.

Sakharov's actions became gradually radicalized and in 1962 when the Soviet government decided to test two devices, he made it his goal to stop the gratuitous second test. The first device had been created at Sakharov's installation while the second one had been built by a second, rival installation. The second weapon differed little from the first and was in fact heavier and therefore less useful than the first. Sakharov failed to stop the second test and this crystalized his belief that he could not function within the current paradigm. In his memoirs Sakharov comments that there was "no justification of the second test. I had given top priority to...avert this duplication. But in the process I found myself encroaching on powerful bureaucratic interests, and quickly realized that they held many of the cards."[1] The paradigm did not provided the scientist with a way of interacting with the social world; in fact, it hindered any interaction. In the Soviet Union the paradigm was further complicated by the nature of the society. The paradigm and the political environment worked together to leave the scientist with little or no control. It also caused most scientists to alter their views in the name of progress and monetary gain. The system worked so well that few of his fellow scientists would risk their comfortable jobs to support him and his actions.

Unlike Oppenheimer, Sakharov was able to break free from the paradigm. He was able to endorse a radical change and he did so by

[1]Sakharov, p. 226

acting in ways that were unacceptable, according to the traditional paradigm. Before the explosion science had been Sakharov's refuge from the problems living in a totalitarian state. After the bomb Sakharov realized that science did not exist outside of the social world and that he could no longer ignore the complex political world. This realization forced him to make a break from mainstream scientific life. Gradually, Sakharov began to act against the repressive forces of the government and other agencies who stood against scientific reform. In 1964, Sakharov made his first public stance against some Lysenkoites who were attempting to muscle their way into the Academy of Sciences. The meeting which had been called for the purpose of electing new members had gone normally until Sakharov had stood up and publicly denounced Nikolai Nuzhdin, a biologist and one of Lysenko's closest associates. After Sakharov's speech Lysenko reportedly yelled, "People like Sakharov should be locked up and put on trial."[1] His attack on Nikolai Nuzhdin was, according to Sakharov, "another landmark on my way to becoming active in civic affairs."[2] Sakharov latter commented that he spoke out against Nuzhin because of the "premium I place on the freedom and integrity of science; after all science remains a keystone of civilization, and any unwarranted encroachment on its domain is impermissible."[3] Sakharov loved science and it remained paramount to all of his other interests. However, he wanted a science which valued free participation and discussion not the closed society

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[1]Sakharov, p. 234
[2]Sakharov, p. 235
[3]Sakharov, p. 235

promoted by the paradigm. The response from the community for this action was one of criticism and slander. Khrushchev supposedly said, "First Sakharov tried to stop the hydrogen bomb and now he's poking his nose again where it doesn't belong."[1] Despite the forces lined up against him, Sakharov gradually broke away from his earlier views and attacked the structure of the scientific and political world in the Soviet Union.

These years, were according to Sakharov the turning point in his life. Although he was involved heavily in demanding research he was already planning a decisive break with the establishment. His experiences working with the hydrogen bomb had proved to him that " the technical, military, and economic problems are secondary; the fundamental issues are political and ethical. Gradually I was approaching an irrevocable step - a wide-ranging public statement on war and peace and other global issues."[2] The opportunity to make that public statement came in 1968, a month before the Soviet invasion of Czechoslovakia.

Sakharov's experience with the hydrogen bomb project fuelled his desire to address not only the problems of the scientific paradigm but issues in the social world which influenced science: "I felt a growing compulsion to speak out on the fundamental issues of our age. I was influenced by my life experiences and a feeling of personal responsibility, reinforced by the part I'd played in the development of the hydrogen bomb..."[3] Many in the Soviet scientific

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[1]Sakharov, p. 237
[2]Sakharov, p. 268
[3]Sakharov, p. 281

world criticized Sakharov for discussing things which did not directly concern his speciality. However, Sakharov felt that public discussion served an important role, especially in science: ""I believe that statements on public issues are a useful means of promoting discussion , proposing alternatives to official policy, and focusing attention on specific problems. They educate the public at large..."[1] Nikolai Dubinin, director of the Institute of Genetics, criticized Sakharov for mixing science and politics and when the state ministry learned of his statements they stated, "Sakharov is a good scientist...But as a politician he's muddleheaded, and we'll be taking measures."[2] The price Sakharov paid for his freedom from the concerns of the traditional paradigm and the Soviet society was the loss of his department chair and large reduction his salary.

After the Soviet invasion of Prague in 1968, Sakharov refused to play the assigned role of Soviet scientist. He was still active in attempting to solve certain scientific mysteries, but he consistently attempted play an active role as a political dissident. Sakharov's open criticism of the Soviet government led to his transfer from the Installation back to FIAN in May, 1969. During the years he was engaged in secret work, his professional contacts outside the Installation had been very limited.[3] After his transfer, Sakharov was finally able to participate in the larger community of scientists. He found these experiences to be useful and profited to an even greater degree from the personal meetings with the other

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[1]Sakharov, p. 271
[2]Sakharov, p. 275
[3]Sakharov, p. 295

Soviet scientists. These later experiences led him to believe that the traditional paradigm, with its emphasis upon the insular nature of the scientific community, eliminated the chance for the scientist to play a useful role in the world: "Scientists and engineers have a major role to play, but in the absence of an underlying spiritual goal any hope that we can use the tools of science to regulate progress is a delusion..."[1] Sakharov underwent a transformation from an archetypical scientist to a dissident. The change would cost him his job at FIAN, his medals, and later after 1974 his freedom. Despite these losses Sakharov never ceased fighting for a new world, one in which scientists played an important role in the development of society from both a political and scientific standpoint.

VI. Conclusion

The degree to which Sakharov and Oppenheimer successfully completed their individual ethical journeys depended on their ability to break from the comforting landmarks each had known since their earlier days at the university. The process of breaking from the social structure which surrounds the traditional paradigm was a difficult for both of the scientists. Rae Goodell describes in his book the Visible Scientists the dilemma of the scientist who is considering entering into a political debate: "While certain moral, political, and social concerns encourage scientists' participation in public issues other more pressing political, economic, social and

[1]Sakharov, p. 295

psychological needs mitigate against it."[1] Both of these men struggled to overcome their own immediate needs for personal success and attempted to direct their energies to the task of reforming the scientific paradigm. They differed, however, in the degree to which they believed it should change.

Sakharov was able to complete the ethical journey and break from the confining nature of the paradigm. He realized that the established scientific world had created a powerful system of social control which functioned by playing on scientist's fears and ambitions. This system of control, he realized, began the moment a person entered into the scientific world and while it kept science efficient it also kept its members isolated from society. These isolated scientists were unable to guide the direction of modern science and thus scientific policy was dictated by a collection of government leaders. Oppenheimer, however, was only able to perceive the problems created by a dependence on the traditional paradigm, but was unable to divorce himself completely from the familiar structures of the paradigm. Oppenheimer did attempt to reform the paradigm through his own personal power, but he was not successful. Sakharov realized the lack of political power that scientists possessed in his society had created a science which did not serve humankind and made a public declaration that the system needed to be changed. The illusion of control led to Oppenheimer's failure. Sakharov succeeded simply because he was unable to

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[1]Goodell, p. 91

possess any illusions that he had direct control over the policy situation.

In his memoirs Sakharov recalled his feelings the moment he learned that the United States had used the atomic bomb against Japan: "something new and awesome had entered our lives, a product of the greatest of the sciences..."[1]Despite the horrible destruction which was caused by the explosion of the atomic bomb, Sakharov was still impressed with the power that physics could unleash. Sakharov was not always opposed to the creation of atomic and hydrogen weapons. He admitted that during the 1950's his position on the need for the hydrogen bomb was much closer to Edward Teller's than to Oppenheimer's. Later in his life Sakharov was very aware of the similarities that existed between Oppenheimer and himself: "I cannot help but feel deeply for and empathize with Oppenheimer, whose personal tragedy has become a universal one. Some striking parallels between his fate and mine arose in the 1960's and later I was to go even further than Oppenheimer..."[2]

Sakharov's ability to break from his role as an "inside scientist" and supporter of the paradigm came, in part, from his understanding of the illusion personal power. The conversations he had with Khrushchev and with the marshall at the test site revealed the illusionary nature of personal influence and the problems associated with a scientific community based upon the current scientific paradigm. In many ways the structure of the paradigm in the Soviet scientific community and was crude and this enabled

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[1]Sakharov, p. 97
[2]Sakharov, p. 99

Sakharov to identify the problem areas. Oppenheimer was never able to perceive the controlling nature of the paradigm as he had great faith in his own personal power and influence. Oppenheimer believed that he could change policy simply by employing his knowledge of science to control politicians. Instead of controlling politicians, however, he found himself being controlled after the war. By the 1960's he had been used and discredited by the government through the security trial of 1955. The western version of the paradigm and its associated structures functioned in a much more refined manner than in the Soviet Union and this made dissent difficult.

The ethical journey enabled Sakharov to realize the need for interaction between scientists and their communities and the elimination of the "cult of research" which surrounded the traditional paradigm. He desired to see the creation of a new science which would balance research with social responsibility. The new science he envisioned would not become encumbered by politics because not all members of the scientific community would participate in the discourse. However, Sakharov believed that such a discourse would be open to any member of the society and would not be limited to those who worked on the "inside."

Sakharov's ability to break from the status-quo and Oppenheimer's inability could be attributed to the different natures of the two societies in which they lived. Sakharov lived in a what Vaclav Havel describes as a post-totalitarian society, a society which is characterized by a lack of freedom and a preponderance of regulations. Oppenheimer lived in a modern consumer-orientated democracy which offered the individual seeming endless freedom of

choice. Yet, the possibility of choice is illusionary in modern democracies and is used by the society as a subversive method of control: "People are manipulated in ways that are infinitely more subtle and refined than the brutal methods used in the post-totalitarian societies."[1] Oppenheimer derived a false sense of power and control from these supposed freedoms of Western society and thereby was not able to truly break from the paradigm. The over abundance of freedom undermined Oppenheimer's chance to disengage from the paradigm. Havel describes the dangerous undercurrent in Western society which keeps the individual trapped through the illusion of freedom: "It may even be said that the more room there is in the Western democracies for the genuine aims of life, the better the crisis is hidden from people and the more deeply do they become immersed in it."[2]

The post-totalitarian society offered concrete obstacles which stood in Sakharov's way. The Soviet society's attempts at control the individual are not subtle. Post-totalitarian culture is in many respects an extreme version of Western technological society: "the automatism of the post-totalitarian system is merely an extreme version of the global automatism of technological society."[3] Sakharov was aware of the forces that he had to fight in order to break free of the paradigm. As Havel notes, a person who opposes post-totalitarian society is distinctly aware of what she opposes while the Western individual is not: "If living within truth in the

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[1]Vaclav Havel, Living in Truth, ed. Jan Vladislav, (Boston: Faber and Faber, 1986) p. 116

[2]Havel, p. 116

[3]Havel, p. 115

post-totalitarian system becomes the chief breeding ground for independent, alternative political ideas, then all considerations about the nature and future of these ideas must necessarily reflect this moral dimension as a political phenomenon."[1] Only the member of the post-totalitarian scientific society could have enacted radical change, the Westerner will always dissuaded from such actions by both the forces of their professional community and the nebulous structures of the larger society . Besides as Rae Goodell pointed out, " a scientist who speaks out, particularly in a political context, risks antagonizing his employer or his funding agency, even losing his job."[2]

The reasons surrounding Sakharov's successful completion of the ethical journey were because he was aware from the beginning of what he was up against and thus could be a dissident in his society. The dissident according to Havel is "simply a physicist, a sociologist, a worker, a poet, individuals who are merely doing what they feel they must and, consequentially, who find themselves in open conflict with the regime. This conflict has not come about through any conscious intention on their part, but simply though the inner logic of their thinking, behavior, or work..."[3] Oppenheimer could not have been a dissident in a Western culture because the forces which he needed to oppose would be too subtle to characterize. In the post-totalitarian society, on the other hand, Sakharov, could easily identify the forces he was rebelling against.

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[1]Havel, p. 63
[2]Goodell, p. 91
[3]Havel, p. 78

Perhaps only a member of a post-totalitarian society can confront the forces of her society and undergo the radical transformation which is necessary to reform society; the individual of the West is, because of the illusive character of power in democracies, doomed to failure. The scientist in the democracy believes that she alone controls her future while the scientist in the a totalitarian society is always reminded how little control she has over her own destiny.

The creation of a relationship between science and society is important for the future success of modern science. In order for scientific discoveries to be the truly beneficial and thereby solve important problems which improve the quality of life for humankind, there needs to be interaction between the social and scientific worlds. Rae Goodell notes in his book that this is the one area which scientist have no rules to follow: "There is, however, one hole in the system's network of norms: how are scientists to handle relationships with the rest of society."[1] Therefore through the creation of rules which would guide such interactions the society would be able to determine together with the scientists the value of various scientific research. While the traditional paradigm functioned to make possible many incredible discoveries which fundamentally changed the way we understand our universe and our planet. It failed to produced scientists who were able to perform as leaders and not simply followed rules. The scientific community lost its leadership and its creativity. The atomic and hydrogen bombs serve as a reminder that science should not function in a vacuum and

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[1]Goodell, p. 90

that scientists need to consider the moral implications of their creations. They can do this, however, only if they operate in a structure which allows free interaction and mutual understanding between the social society and scientific society. While Havel may seem pessimistic about the chance for reform in Western democracies, his commentary serves to demonstrate the extent to which the Western nations must fight if they wish to overcome the dangerous controlling factors and posses a science which looks to champion research which will benefit society.

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