Herman Feshbach: What it Meant to be a Physicist in the Twentieth Century

by

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ABSTRACT

This thesis is a biographical snapshot of physicist Herman Feshbach (1917-2000). Herman Feshbach was a nuclear physics that spent over three-quarters of his life at the Massachusetts Institute of Technology. His life is a window through which I analyze the changes experienced by the physics community throughout World War II and the postwar era. The events that I narrate are centered in New York, where Feshbach's early life unfolds, and in Cambridge, Massachusetts, where Feshbach matured as a scientist.

There are two recurring themes throughout this work.The first theme deals with the ways in which politics, wartime, and government funding place strains and provoke change in scientific practices. The second theme pertains to how scientists accommodate to the aforementioned strains, either through open political activism or changes within scientific institutions. Herman Feshbach's life is an excellent example of how these themes weave into each other, making the boundary between science and society more permeable and porous than it is usually presented.

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- Table of Contents -

- Acknowledgements -

In January 2012, I was in MIT's Building 34 listening to Professor David Kaiser give a lecture about Peter Galison's *Einstein's Clocks and Poincaré's Maps*. Three years later, I still remember that lecture as the event that sparked my interest in physics and the history of science. Since our conversation after that lecture, Professor Kaiser has been a role model and a mentor. His continued guidance has been vital for the production of this thesis, as well as his unfading willingness to read all of my drafts and his incredibly useful comments and suggestions.

I would like to give special thanks to Professor Rosalind Williams who encouraged me to chose Herman Feshbach as the subject of this thesis and who closely followed the beginning of this project. I am also grateful for Deborah Douglas' liveliness and passionate advice; it was during her course that I first encountered the intricate history of MIT. I am thankful for Professor Hanna Shell's guidance, especially because she has prompted me to think about the larger implications of Herman Feshbach's life and how his work makes part of the mangle of science. Professor Rochelle Ruthchild's recommendations for sources on the history of Russia and the Soviet Union have also been extremely helpful. I also want to thank Merritt Roe Smith for his words of wisdom, Kenneth Manning for introducing me to the genre of biographies, Michelle Baildon for her support as STS librarian, and Stephen Brophy for helping me improve my writing style.

Special thanks to Karen Gardner who has helped with all the administrative components of this project and who always greets me with a radiant smile. I am very appreciative of Robert Jaffe, Hale Bradt, Aron Bernstein, and Tatiana Yankelevish for their time and willingness to share their memories about Herman Feshbach. The MIT Institute Archives' staff also offered unstinting support for my research. Norah Murphy, in particular, always offered a helping hand. Finally, I would like to express my gratitude to Herman Feshbach's family who granted me access to his collection of papers.

This thesis would not have been possible without my family. My parents, Carlos and Claudia, have been a great source of unequivocal support and inspiration. Angel, my grandfather, deserves especial recognition for introducing me both to history and literature—without his influence I would have never made it to MIT. I want to thank my grandmothers, Yolanda and Josefina; they are both outstanding examples of hard work, dedication, and infinite love. I am also indebted to Brendan, my best friend and sweetheart, who has read each and everyone of my drafts and has survived endless conversations about Herman Feshbach.

This work is dedicated to my brother Carlos, whom I admire, love, and miss dearly.

- Introduction -

On August 6, 1945, at about 8:15am, the *Enola Gray* dropped the first atomic bomb over the city of Hiroshima. Three days later, the second bomb destroyed the city of Nagasaki. The explosions of "Little Boy" and "Fat Man" were catastrophic events in the history of humankind, marked by undeniable devastation and mass extermination. The creation of the atomic bomb is often attributed to the work of physicists within the Manhattan Project. Figures such as Robert Oppenheimer, director of the Manhattan Project, and Albert Einstein, known for his $E = mc^2$ formula, became popularized and presented as heroes.

The history of the Manhattan Project and the subsequent romanticization of physicists, however, is only one component of a much larger collection of interwoven events that permeated World War II and the postwar era. My goal is to encourage and contribute to a more panoramic vision of the challenges and changes experienced by the scientific community—during World War II and the postwar years—through the analysis of the life of nuclear physicist Herman Feshbach (1917-2000). Feshbach's life serves as a window to the events that took place during the second-half of the twentieth century, providing us with a vantage point to the multiple ways in which a scientists' research is entangled with their ideologies, beliefs, and political views.

A great deal of research has been performed on the history and sociology of science during World War II and the postwar era, some of which is worthwhile mentioning here. Historian David Kaiser, for example, has shown how the wartime discourse—which presented physicists as necessary assets to the Unite States' national security—extended through the 1950s and 1960s, giving rise to a nearly-exponential increase in demands for scientific manpower and research funding. Kaiser illustrates how the demand for physicists affected classroom sizes, teaching styles, and the kind of material that was considered appropriate for science textbooks.[1]

Historian Stuart Leslie has traced how manpower and research funds were distributed, allocated, and utilized within the Massachusetts Institute of Technology (MIT) and Stanford. Leslie shows how the emergent industrial-military-academic complex gave birth to interdepartmental laboratories and how within these spaces scientific practice was reformulated through the pushes and pulls of researchers, government agencies, and private companies.[2]

Sociologist Kelly Moore has studied the different ways in which scientists reacted to the presence of the interdepartmental laboratories in American universities. Focusing on specific organizations such as the Society for Social Responsibility in Science, the Citizens Committee for Nuclear Information, and the Union of Concerned Scientists (founded at MIT), Moore reveals how scientists grappled with questions regarding the "misuse of science." Scientists wondered: should the government dictate the nature of scientific research? Are scientists responsible for the applications of their research? Should scientists be actively involved in policy issues?[3]

The objective of my work is to demonstrate the synergistic link between these accounts and to further amplify the traditional narrative of the changes in twentieth century science through the lens of Herman Feshbach's life. Because of Feshbach's lifelong connection with

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[1] David Kaiser, *American Physics and the Cold War Bubble,* (Chicago: University of Chicago Press, forthcoming).

[2] Stuart Leslie, *Cold War and American Science,* (New York: Columbia University Press, 1993).

[3] Kelly Moore, *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, (*New Jersey: Princeton University Press, 2008).

MIT, this story is centered in Cambridge, Massachusetts; however, Feshbach's commitment to building an international community of scientists will take us as far as Tehran in Iran and Gorky —now known as Nizhny Novgorod—in Russia. Feshbach's longstanding research interest in theoretical physics forces us to oscillate around physics; nevertheless, we will experience deviations that will take us to questions regarding poverty, world hunger, anti-ballistic missiles, and climate change.

This work is divided into three chapters, each one further subdivided into three sections. Chapter I focuses on Feshbach's formative years. It begins by answering how and why Feshbach's parents, David and Ida Feshbach, emigrated to the United States from Russia in the 1910s. The brief description of the pogroms—organized attacks against Jews—and the challenges that Jewish people faced in the Russian Empire are intended first, to explain why Feshbach's parents decided to settle in the United States and second, to suggest Feshbach's possibly-first encounter with issues of human rights and international freedom.

The second section in chapter I deals with Feshbach's time as an undergraduate at the City College of New York (1933-1937). During this time, City College was characterized by student and faculty movements against war and violence, which might have influence Feshbach's own participation in the founding of the Union of Concerned Scientists in 1969.

The final section in chapter I comprises Feshbach's time as a graduate student at MIT (1938-1942) and the beginning of his career as a researcher and Instructor in MIT's Physics Department (1942-1946). Inescapably tainted by World War II, this section highlights Feshbach's role in educating the increasing number of civilian and military students at MIT and his deliberate interest in non-military problems in acoustics.

Chapter II begins with a section detailing the growth of physics in the postwar era from 1946 to 1969. It specifically follows the creation and subsequent expansion of MIT's Laboratory for Nuclear Science, of which Feshbach was a member. The first section discusses the publication of *Methods of Theoretical Physics* (1953) by Feshbach and Philip Morse and how this graduate textbook served as a medium to promote the idea that the tools (or methods) of theoretical physics could be applied to any problem—either military or non-military. Feshbach's contributions to nuclear physics, of which *Feshbach Resonance* is a primary example, are also discussed in this section.

The second section in chapter II is dedicated to the founding of MIT's Center for Theoretical Physics in 1968 and Feshbach's role in the creation of the center and later as its first director (1968-1973). The purpose of this section is to illustrate Feshbach's commitment to fomenting collaboration among theoretical physics and thereby solidifying the notion that theoretical physics was based on a common set of tools that could be applied in a variety of ways. The Center for Theoretical Physics was also important because it became the hub of an *elite* group of physicists concerned both with physics research and debates about the influence impinged by the militarily-driven government agencies on science.

The third section in chapter II expounds how this elite group, of which Feshbach was a key member, collaborated with other faculty members to create the Union of Concerned Scientists (UCS) in 1969. Gravitating around a research-stoppage organized at MIT on March 4th, this section brings to the fore two main questions that Feshbach grappled with: what problems should science be concerned with and how should efforts be distributed to solve these important problems?

The founding of the UCS was a decisive moment in Feshbach's career. It was the first (and certainly not the last) time he publicly voiced his opinions on the issues that troubled members of the scientific community. Chapter III is concerned with Feshbach's active work to highlight the importance of physicists' input on policy issues and to promote an international community of physicists. The first section narrates the short-lived Masters program in Nuclear Engineering (1976-1979) that Feshbach helped institute in collaboration with other members of the MIT community. Feshbach's participation and enthusiasm in the Masters program for Iranians is exemplary of his belief that science should be unconstrained by political, cultural, or ideological tensions.

The second section in chapter III focuses on the way in which Feshbach took advantage of his prominent position within scientific institutions to incentivize discussions to remodel the convoluted relationship between science and politics. Feshbach's role in the establishment of the Panel on Public Affairs (POPA) and his role as president of POPA(1976-1978) take center stage in this section, along with the creation of the Committee for the Freedom of International Scientists (CIFS) in 1979.

The third and final section in chapter III delves into Feshbach's fervent interest in the case of Soviet physicist Andrei Sakharov, who was in internal exile in Gorky between 1981 and 1986 because of his political activism and commitment to human rights. Feshbach personally helped Sakharov's family to emigrate to the United States and visited Sakharov in the Soviet Union after he was released from exile. Feshbach's personal involvement in Sakharov's case is evidence of his true devotion to solving the problems of the scientific community and his preference for action over discourse.

- 1 -

Early Life

1.1 Feshbach's Parents Emigrate From Russia

Herman Feshbach was born on Monday February 12, 1917 in New York City. His mother, Ida Feshbach, was twenty years old at the time and his father, David Feshbach, was twenty-two. Both of them were Jewish emigrants who had settled in the Bronx, New York in 1911 and 1912, respectively. New York was the single largest Jewish community in the United States, with almost 45 percent of American Jews living in the Lower East Side, Bronx, and Brooklyn neighborhoods.[4] New York was particularly attractive to immigrants from all around the globe because of the Erie Canal (open to transatlantic travel in 1825), which made New York the country's largest port and most important textile and financial center.[5] But it was particularly attractive to Eastern European Jews because the city offered opportunities—it was, for many, the beginning of a new life.

Between 1880 and 1924 nearly two and a half million Eastern European Jews migrated to the United States. The emigration was spurred by the organized, systematic, and government-tolerated violence against Jewish communities in the Russian Empire, which began with the assassination of Tsar Alexander II in 1881. Most Eastern European Jews, including Ida and

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[4] Ancestry.com. *1920 United States Federal Census* [database on-line], Provo, UT, USA: Ancestry.com Operations Inc, 2010. Hasia R. Diner, *A New Promised Land: A History of Jews in America* (Oxford: Oxford University Press, 2003), Kindle edition: Kindle Locations 546-47.

[5] Annie Polland and Daniel Soyer. *Emerging Metropolis: New York Jews in the Age of Immigration, 1840-1920* (New York: New York University Press, 2012), 2.

David Feshbach, arrived to America intending to stay. In fact, only 5.2 percent of the immigrant Jews who arrived to the United States between 1908 and 1924 returned to their home countries.[6]

The precarious situation the Feshbachs would have had to face back in their home country drove the family to settle indefinitely in the United States. A dreadful tradition of pogroms—organized attacks against Jews—had emerged in the Pale of Settlement in the Russian Empire beginning in the middle of the nineteenth century. The Pale of Settlement was a region where Jewish people had been confined since 1835, after the annexation of Poland. The cruelty and violence within the Pale was most intense after 1880.[7]

Anti-semitism and violence against Jews increased during periods of economic hardship in the Russian Empire. This was certainly the case for one of the strongest waves of anti-semitism, between 1903 and 1906. During this time, the Russian revolution against the Tsar was gaining momentum and many government officials blamed the Jews for the uprising of the working class. Government officials argued that Jewish religion was specifically inclined towards socialist views and, therefore, caused political unrest. Consequently, the government targeted Jews and turned a blind eye to local violence against them.[8]

The turn of the century in Russia was also characterized by a strong emphasis on the modernization of the Russian Empire. This project of modernization required new machinery and large quantities of food to feed workers. The money to buy modern equipment and the necessary

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[6] Polland and Soyer. *Emerging Metropolis*: 111-12.

[7] Hasia R. Diner, *A New Promised Land*: Kindle Locations 440-441.

[8] Sholomo Lambroza, "The Progroms of 1903-1906," in *Progroms: Anti-Jewish Violence in Modern Russian History*, ed. John Klier and Shlomo Lambroza195-242

food supplies largely came for peasant's agricultural output.[9] The use of the peasants' crops for feeding the engine of modernization was one of the causes for devastating famines in Russia's country side. Jews were, once again, unreasonably blamed for the famines and hungry peasant families began attacking them and stripping them from their food and property. Other events (that might seem unlinked to Jews) also galvanized the Russian population against the people in the Pale. Examples include the 1905 Russian Revolution, which failed to achieve its intended purposes and allowed Nicholas II's autocracy to extend for another twelve years, and Russia's defeat in the Russo-Japanese War, an event that further harmed the Russian economy and pride.[10]

The famines, the revolution, the subsequent restoration of Nicholas II's autocracy in 1905, and the defeat of Russia in the Russo-Japanese War joined together to give rise to massive violence against the Jewish population within the Pale. The unprecedented number of casualties —in a single pogrom in the city of Odessa, in 1906, for example, the casualties reached eight hundred Jews— explains why so many of the younger Jews decided to flee the Russian Empire and look for a fresh start in the United States.[11] Herman Feshbach's parents, David and Ida, were both victims of the pogroms and were part of the wave of mobilization of the nearly 76,000 Eastern European Jews that came to the United States between 1903 and the start of World War I.[12]

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[9] Michael Kort, *The Soviet Colossus: History and Aftermath,* (New York: Taylor and Francis, 2015) Kindle Edition, Kindle location 649.

[10] Hasia Diner, *A New Promised Land:* Kindle location 445-46.

[11] Hasia Diner, *A New Promised Land:* Kindle location 444.

[12] Hasia Diner, *A New Promised Land:* Kindle location 448-49

David traveled to the United States in 1912 when he was 13 years old and Ida traveled in 1911 when she was 12 years old. The couple married on December 2, 1916, and rented an apartment in an area with one of the densest concentrations of Jews in New York between the Crotona park and the Bronx River.[13] Like many immigrant Jews at the time, David focused on the garment industry, eventually becoming the owner of a fur shop in 40E-10th North Street.[14] The shop allowed David to provide for Ida, pay the rent for their home, and provide for his children. Although the revenues from the shop did not allow them to live in the more prestigious Grand Concourse Jewish quarter, it allowed them to live in an area of moderately priced apartment buildings.[15]

Five years after Ida and David's arrival in the United States, on February 12, 1917, their first son, Herman Feshbach, was born. Herman was soon joined by his sister Florence (born in 1920), his brother Bernard (born in 1922) and his youngest brother Sydney (born in 1930).[16] The four Feshbach children benefited from the strong Jewish community that pervaded the Bronx. Dozens of kosher butcher shops and bakeries enhanced the sense of community and connection to Jewish culture.[17] The children were, however, different from their parents; they studied in a secular public school in New York, where they learned English and were subject to "Americanization." They were not the only Jewish children to attend New York's public schools;

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[13] Ancestry.com. *New York, New York, Marriage Index 1866-1937* [database on-line]. Provo, UT, USA: Ancestry.com Operations, Inc., 2014.

[14] Ancestry.com. *1930 United States Federal Census* [database on-line]. Provo, UT, USA: Ancestry.com Operations Inc, 2010

[15] Polland and Soyer. *Emerging Metropolis*: 251-52.

[16] Ancestry.com. *1930 United States Federal Census.* [database on-line]. Provo, UT, USA: Ancestry.com Operations Inc, 2010

[17] Hasia Diner, *A New Promised Land:* Kindle location 480-84; 569-570.

in 1917, 277,000 Jewish children studied in public schools while only 1,000 attended all-day Orthodox schools.[18]

David and Ida were both members of the *intelligentsia*—a social class that had emerged in the Russian Empire in the eighteenth century, characterized by its focus on science, culture, literature, arts, and political activism. The *intelligentsia* was a complex group of individuals who viewed science not only as the study of the natural world but also as the cornerstone of ideological and political projects.[19] These values, inculcated in Herman by his parents during his childhood, were important guiding principles for Herman throughout his life and career as a physicist. Education was particularly important for the *intelligentsia.* In fact, their traditional respect for learning is evidenced by the fact that in 1918, 53 percent of all New York high school students came from Jewish families.[20]

1.2 City College of New York

Education did not stop with high school for most young Jewish women and men. They viewed college as the route to a comfortable life, an improvement on their first-generation parents. Their aspirations, however, where hampered by the number of prestigious colleges that limited Jewish enrollment throughout the first-half of the twentieth century. During the 1920s and 1930s antisemitism had spread throughout the universities of the United States, setting a

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[18] Hasia Diner, *A New Promised Land:* Kindle location 592-93.

[19] For more on the Russian *intelligentsia* see Michael Gordin and Karl Hall, "Introduction: Intelligentsia Science inside and outside Russia," *Osiris* 23, no. 1 (2008): 1-19.

[20] Hasia Diner, *A New Promised Land:* Kindle Location 723-26.

limit to the number of Jewish students that Ivy League colleges admitted. In 1922, A. Lawrence Lowell, then president of Harvard University expressed concern that the university would become a "new Jerusalem," so he established a policy that limited Jewish enrollment to 10 percent.[21] Other universities followed, chilling the dreams of many high school Jewish students.

The City College of New York, where Herman was admitted in 1933 was different from Ivy League colleges.[22] City College had a predominantly Jewish student population and, moreover, it offered them a free education. Most young educated Jews aspired to gain access to City College—"the Cheder [Jewish school] on the Hill"—which was located in St. Nicholas Heights in Upper Manhattan just north of Columbia University.[23]

Jewish children had gained a reputation for intellectual precociousness, an image reinforced in retrospect by American Jews themselves. City College, for men, and Hunter College, for women, played an important role in the myth of Jewish intellectual accomplishment.[24] City College—the so-called "Proletarian Harvard"— became increasingly competitive, especially after the 1929 stock exchange crash that gave way to the Depression.[25] L. Shands described college life at City College during the depression. He wrote, "students are here [at City College] only a few hours and they are sucked back into the city from which they come.

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[21] A. Lawrence Lowell, as quoted in Hasia Diner, *A New Promised Land:* Kindle location 639-43.

[22] Donald A. Roberts, ed. *The Alumni Register: The College of the City of New York, 1853-1945.* (New York: The Associate Alumni of the College of the City of New York, 1945): 490.

[23] Jeffrey Gurock, *Jews in Gotham: New York Jews in a Changing City, 1920-2010.* (New York: New York University Press, 2012), 48-49.

[24] Polland and Soyer, *Emerging Metropolis*: 214-15.

[25] Jeffrey Gurock, *Jews in Gotham*: 48.

The boys at City College do not even drink, as all hilarious college cut-ups do. The reason is simple … They just can't afford it. Three-quarters of them work to keep themselves in school."[26]

Shands' hyperbolized account hints at some of the ways in which City College was different from the Ivy League schools. But City College's strenuous environment did not deter Herman. He began his studies in 1933 and promptly began working towards his undergraduate degree in physics. Like many of his classmates, Herman helped his father in the fur shop that had been relocated to 7th avenue in the garment district while completing his studies at City College.[27] These lessons of discipline and dedication would later become important in Herman's life as a scholar and politically engaged physicist.

Another meaningful experience that shaped Herman's future occurred during his time at City College, when a group of students—led by Irving Howe, Irving Kristol and Daniel Bell—gathered to fight against policies of war. The debates, usually in the alcoves of the City College's cafeteria, attracted many students. According to Kristol, the high level of attendance in the debates was due to the "kinds of kids that went there … the entire student body was to one degree or another political."[28] The degree of commitment to these movements was mixed, some students were ardent activists while others opted to passively support the cause by the Oxford Pledge (promising never to participate in foreign wars). Regardless of each student's level of commitment, the voice of protest was one to reckon with on campus.[29] Demonstrations were not

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[26] L. Shands, "The Cheder on the Hill," *Menorah Journal* (March 1929): 269, as quoted in Jeffrey Gurock, *Jews in Gotham*: 49-50.

[27] Ancestry.com. *1940 United States Federal Census*

[28] Irving Kristol quoted in Jeffrey Gurock, *Jews in Gotham:* 59-60.

[29] "The Struggle for Free Speech at CCYN 1931-42", online exhibit, http://www.virtualny.cuny.edu/gutter/panels/panel1.html, last accessed April 22, 2015.

uncommon at City College and frequent demonstrations had pervaded the campus the year before Herman began his studies. In 1932 the financially strapped US government began contemplating the introduction of a tuition of fifty dollars per year (about eight hundred dollars today) for all the city colleges.[30] The students at City College were outraged and argued that "establishment of fees would seriously cripple" the school's "enviable reputation" for "intellectual vigor."[31] Herman, along with many of his peers, greatly benefited from the protests against imposed tuition—the costs of tuition would have caused great economic strains in his family.[32]

Another major protest occurred during Herman's time at City College. In April 13, 1934, a nation-wide student strike against war was organized by the Student League for Industrial Democracy and the National Student League, both considered left-wing organizations. According to the *New York Times,* most demonstrations were peaceful, except at City College where "the police finally had to interfere to prevent a riot." The demonstrations at City College spurred counter demonstrations in universities such as Johns Hopkins and Harvard.[33]

Although it is not clear if Feshbach participated in these protests, he was probably aware of them and the effects they had on campus. Whether supportive or not of the political activism at City College, Feshbach remained close to his alma mater and many of his peers, including

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[30] Jeffrey Gurock, *Jews in Gotham*:48.

[31] Robert Cohen, *When the Old Left Was Young: Student Radicals and America's First Mass Student Movement, 1929-1941* (New York: Oxford University Press, 1993), 68-70.

[32] Ancestry.com. *1930 United States Federal Census*.

[33] "Nation's Students 'Strike' for Hour in Protests on War," *New York Times*, April 14, 1934. http://search.proquest.com/docview/101056971?accountid=12492.

Julian Schwinger, with whom he collaborated in several research papers.[34] After graduation in 1937, Feshbach worked at City College for one year as a tutor of "General Physics and Mechanics," until he decided to continue his physics education at MIT.[35]

1. 3 MIT & World War II

Herman Feshbach arrived at the MIT campus in August of 1938. At the time, MIT was primarily composed of undergraduate students, but the graduate student population was steadily increasing. In fact, Herman entered the largest class of graduate students since MIT opened its graduate school. Out of the 692 graduate students who entered in 1938, thirty joined Feshbach in the Physics Ph.D. program.[36] Although physics would gain extraordinary popularity in the years following World War II, at the time of Feshbach's matriculation, the number of students enrolled in the Physics Ph.D. program was less than half of the number of students enrolled for the Ph.D. program in Chemistry.[37]

Unlike many Ivy League schools, which had restricted the percent of Jewish students accepted, MIT did not limit the number of Jewish students that were admitted—moreover, accommodations allowing Jewish students to observe the Sabbath on Saturdays were sometimes

[34] Earle Lomon, "Herman Feshbach: 1917-2000," *National Academy of Sciences* (2010).

[35] Sydney Van Nort, e-mail to author, March 23, 2015

[36] *MIT Report to the President* (1939): 37. All editions of the *MIT Report to the President* can be found online at http://libraries.mit.edu/archives/mithistory/presidents-reports.html

[37] *MIT Report to the President* (1938): 37.

made.[38] The student population at MIT was more heterogeneous than that of most other academic institutions. Seventy-four percent of the 1938 incoming class had completed their undergraduate studies outside of MIT and within the incoming graduate class there were international students from 19 different countries.[39] Nonetheless, the change from City College's predominantly Jewish student body to MIT was not negligible.

The tuition at MIT was also much more expensive than the (free) tuition at Feshbach's undergraduate alma mater. For the full academic year of 1938, the tuition amounted to $600 dollars (the equivalent of $9,783 today) and from all the incoming graduate students, only 149 received MIT scholarships and fellowships.[40] It is not clear whether Feshbach was one of the recipients of these scholarships; nevertheless, an analysis of the economic circumstances of his family suggests that he either received a scholarship (or loan) or that his family made a substantial effort to pay for Feshbach's education. In 1940, Feshbach's Father, David, owned an $8,000 dollar house and reported earning $5,200 from his fur shop. Since David Feshbach was the only working member of the family, each family member—his wife Ida; their four children Herman, Bernard, Florence, and Sydney; and his twenty-year old nice Estelle Lapiner—could spend less than $750 dollars per year.[41]

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[38] Herbert Goldstein, an orthodox Jew from City College of New York, was admitted to MIT's Department of Physics in 1941. Professor John Clark Slater, acting as the head of the department, assured Goldstein that the department would be "very glad to arrange your schedule so that you will have no duties on Saturday." For this quote and more information on the particular case of Herbert Goldstein see Deborah Douglas, "MIT and War," in *Becoming MIT: Moments of Decision,* edited by David Kaiser (Cambridge:The MIT Press, 2010) Kindle edition, kindle location 875-886.

[39] *MIT Report to the President* (1938): 38.

[40] *MIT Report to the President* (1938):39.

[41] Ancestry.com. *1940 United States Federal Census* [database on-line]. Provo, UT, USA: Ancestry.com Operations Inc, 2010

With or without economic assistance, Herman began his graduate studies at MIT not knowing that the campus was about to suffer a dramatic change. The conflict in Europe, that had been boiling since 1933, when Adolf Hitler rose to power in Germany, exploded on September 1, 1939. The German invasion of Poland marked the beginning of the Second World War, which involved Britain, France, and the Soviet Union, among others. Initially the United States remained out of the conflict, but the war created a tension that spread throughout the United States government and the American population.[42]

In 1939, MIT president Karl T. Compton responded to this tension by presenting his concerns to the MIT Corporation in the MIT Report to the President. Compton wrote:

> Our first duty, in this time of turmoil and danger, is to carry on our normal education program as effectively as possible and with a minimum of confusion. Whatever course future events may take, the world will need young men versed in science and skilled in the arts of its application to promote human welfare.[43]

Compton's rhetoric changed dramatically as the European conflict progressed. Although the United States remained officially neutral, the country was becoming increasingly involved in the conflict through the provision of military equipment to the Allies.[44] MIT was also gradually becoming involved in the conflict. On September 19, 1940, for example, Compton attended a secret meeting with British and American scientists in Washington. During the meeting, the group discussed the most recent advancements in radar in Britain and the possibility of undertaking a full-scale research program on microwave technology in the United States. The

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[42] Eric Hobsbawm, *The Age of Extremes: A History of the World, 1914-1991*. (New York: Vintage Books, 1996).

[43] Karl Compton, "Report to the President" in *MIT Report to the President* (1939): 9.

[44] Douglas, "MIT and War," Kindle location 857.

British explained that they were not in a position to pursue such an extensive military research project and, therefore, necessitated MIT's assistance.[45]

The meeting led to the creation of MIT's Radiation Laboratory, which recruited over twenty physicists in less than four months and had an initial contract for $455,000 dollars per year (nearly $7.5 million in 2015).[46] The possibility of creating other advanced research laboratories—based on the model of the Radiation Laboratory—at MIT was presented to Compton, who was enthusiastic and willing to reformulate MIT's mission. In the President Report for the year 1940, Compton admitted that sacrifices in education needed to be made in order to put the Institute's services working towards national security:

> the progress of events has called for some new definitions of policy and modifications in procedure... We should make this possible by postponing less urgent research projects, by internal rearrangement of teaching schedules, and by carrying more than normal per capita burden of work.[47]

As a result of the report, in the winter of 1941 a new accelerated schedule was instituted, allowing students to graduate in three years instead of four.[48]

The changes outlined by Compton became even more important to MIT and the United States in general after the attack of Pearl Harbor on December 7, 1941 and the United State's official entry into the war. Physics, in particular, was about to change dramatically because of the series of informal bulletins entitled "A Physicist's War" written by Henry Barton. The first of these informal bulletins was published on January 12, 1942, only a moth after Pearl Harbor. The

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[45] Douglas, "MIT and War," Kindle location 881-886.

[46] Douglas, "MIT and War," Kindle location 914.

[47] Karl Compton, "Report to the President," in *MIT Report to the President* (1940).

[48] *MIT Report to the President* (1942): 36.

bulletin's main objective was to publicize the idea that physicists would be a greater asset to the nation in the laboratories rather than in the battle field. In the report, Barton emphasized the importance of securing draft deferments for physicists and ensuring that physics departments were prepared to receive an greater influx of physics students. In other words, that "scientific and technical manpower" was necessary for the survival of the American nation and its ideologies.[49]

Along with the need for more physicists came an escalation of the need for basic-level physics knowledge, especially among the military. To tackle this problem, the Navy created a program called V-12 and the Army a program known as ASTP. Both of these programs were intended to give young officers access to advanced education, which would allow them to use military weapons more effectively. It was decided that colleges and universities across the United States would be the the best locations for the officers to receive their training—and MIT was certainly not the exception.[50]

Although the number of civilian undergraduates and graduates began declining in January of 1943, the total number of students was leveled by the military students; indeed, by the winter 1943, the ratio of military and civilian students was 3 to 2.[51] The presence of the military on campus caused overall an increase in student density in chemistry, meteorology, aeronautical engineering, chemical engineering courses, and especially in physics courses.[52] The importance of education in physics gained momentum during this historical period. The influx of students

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[49] David Kaiser, "The Standing Army of Big Science," in Kaiser, *American Physics and the Cold War Bubble* (Chicago: University of Chicago Press, forthcoming): 3-11; 13.

[50] John Burchard and James Killian, *QED: MIT in World War II.* (Cambridge: The MIT Press, 1948): 280-289.

[51] Kaiser, "The Standing Army of Big Science," 17.

[52] Douglas, "MIT and War," Kindle location 940. Kaiser, "The Standing Army of Big Science," 17.

and the increasing interest in first-year general physics caused the beginning of what David Kaiser recognizes as a "massive training mission."[53]

To ensure that the training mission was fulfilled, the Institute had to make sure that their students were not drafted for war. Initially the policy was that deferments would be given to those undergoing technical training, which generally meant that students beyond their sophomore year were not drafted.[54] In 1943, the policy was expanded so that deferment would also be given to "full-time teachers" in physics.[55] Most graduated students, including Herman Feshbach, fell into either of these categories.

Despite being eligible for deferment, most students were not exempt from the anxieties of wartime. Students walking around would not be ignorant of the blackout shades and air-raid drills that enhanced MIT's militarized atmosphere.[56] Additionally, many of the students' friends and family members were being drafted and deployed to Europe. Bernard Feshbach, Herman's brother, for example, was drafted in 1943 to serve in the Army during and was wounded in his role as a Technician Fifth Grade (T/5).[57]

Indeed, the war was a shadow that followed Feshbach throughout his entire graduate studies at MIT. The outbreak of the war in Europe caught Feshbach in his first year of graduate school. When the United States officially entered the war, Feshbach was in his third year of

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[53] Kaiser, "The Standing Army of Big Science,"14.

[54] Douglas, "MIT and War," Kindle location 932.

[55] Kaiser, "The Standing Army of Big Science,"18.

[56] Douglas, "MIT and War," Kindle location 943.

[57] National Archives and Records Administration. *U.S. World War II Army Enlistment Records, 1938-1946* [database on-line]. Provo, UT, USA: Ancestry.com Operations Inc, 2005. Ancestry.com. *U.S., WWII Jewish Servicemen Cards, 1942-1947* [database on-line]. Provo, UT, USA: Ancestry.com Operations, Inc.

graduate studies and he had already published his first research paper. In 1942 he received his Ph.D. in Physics and was immediately appointed Instructor of physics at MIT. His duties as instructor were instrumental for the training mission. Feshbach helped with the teaching of the first-year physics courses, whose size had swelled because of the influx of military students.[58] Feshbach also contributed to the instruction of graduate students. In 1944, he was in charge of three graduate courses—Special Problems in Nuclear Research, Methods of Theoretical Physics, and Quantum Mechanics—and the following year he added to his teaching load two more courses—Introduction to Theoretical Physics I and II.[59] Feshbach's contribution to the nation was primarily in the classroom, alleviating the demand for physics instructors, instead of in the research laboratory developing military technologies.

During the war—and perhaps due to the "A Physicists' War" report—many of the MIT physics faculty were called for important advising positions in the government or to serve as directors of laboratories in industry. Other faculty members were appointed directors of the military research laboratories at MIT.[60] The immediate consequence of this outpouring of physics professors was a dramatic decline in the professor to student ratio. Feshbach was, therefore, re-stabilizing the unbalance caused by the absence of MIT professors.

Aside from his teaching duties, Feshbach was devoted to research on nuclear physics and acoustics. Most of his work during the 1940s focused on theoretical research on acoustics, which resulted on the publication of several papers on the boundary conditions of sound waves. Many

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[58] *MIT Course Catalogue* (1942-43): 25. All editions of the *MIT Course Catalogue* can be found online at http://dome.mit.edu/handle/1721.3/81660.

[59] *MIT Course Catalogue* (1944-45): 129. *MIT Course Catalogue* (1945-46): 121.

[60] *MIT Report to the President* (1942): 60; 110.

of Feshbach's contemporaries had finished their graduate education and immediately joined the advanced laboratories on projects related to the military—Robert Seamans joined Draper's Laboratory, Jay Forrester joined the Servomechanisms Laboratory and later worked on Project Whirlwind, and Herbert Goldstein joined the Radiation Laboratory.[61] Unlike his contemporaries, however, Feshbach actively focused on projects that that were applicable outside the military and would directly benefit civilians.[62]

In 1941 Feshbach, along with A. M. Clogston, began working on the theory behind the perturbation of boundary conditions in acoustics. In 1942 they published a paper that applied theoretical methods to the study of room acoustics.[63] The citations in the paper show the targeted non-military applications behind their research. For example, the paper cited the work of R. M. Morris and G.M. Nixon on studio design in 1936, which had made explicit requests for theoretical formulations supporting specific design of broadcasting studios for the National Broadcasting Company (NBC).[64] Feshbach and Clogston also cited a paper by C.C. Portwin and J.P. Mayfield titled "A Modern Concept of Acoustical Design," published in the *Journal of the Acoustical Society of America* in 1939, wherein the authors note that "room acoustics, as a *science* and an art, is coming to be recognized as a vital element of effective architecture."[65]

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[61] Douglas, "MIT and War," Kindle location 902-1009.

[62] Douglas, "MIT and War," Kindle location 875.

[63] R. H. Bolt, H. Feshbach, and A. M. Clogston,"Perturbation of Sound Waves in Irregular Rooms." *Journal of the Acoustics Society of America,* vol. 13, (July, 1942): 65-73.

[64] Robert Morris and George Nixon, "NBC Studio Design," *Journal of the Acoustical Society of America.* vol. 8 (October, 1936): 81-91.

[65] Emphasis added, C. C. Portwin and J. P. Maxfield, "A Modern Concept of Acoustical Design," *Journal of the Acoustical Society of America,* vol. 11 (July, 1939): 48-56.

Feshbach's work sought to expand theoretical calculations of boundary conditions beyond symmetrical, ideal, rectangular rooms. To achieve this goal Feshbach used perturbative methods and free-wave diffraction calculations that allowed him to deal with certain types of architectural forms such as "small studios with walls and ceiling slightly skewed, rooms with splays, cylindrical sections or other sound diffusing forms applied to its walls". Feshbach also admitted that some "configurations [were] not amenable to analysis at all."[66]

Feshbach's sustained work on a perturbative approach to acoustics also resulted in the publication of a second iteration of "On the Perturbation of Boundary Conditions," in 1944, which described a new method of solving irregular boundary conditions using Green's functions. In his last paper on acoustics, published in 1946, Feshbach used theoretical calculations to show that in certain room configurations, sound quality is improved when absorbing materials are applied to the walls in a non-uniform way (using absorbing materials in only two walls, for example, is more effecting than using absorbing materials in all four walls).[67]

Feshbach's work on acoustics, that extended from the middle of his graduate studies until the first years as an instructor of physics at MIT, was supervised by Philip M. Morse. In fact, Feshbach's interest in acoustics was partly due to his close relationship with Morse, who had supervised Feshbach's 1941 Ph.D. thesis on the "Theory of the Hydrogen-Three Nucleus" and collaborated with Feshbach writing papers on acoustics.[68] Feshbach and Morse built a close

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[66] R. H. Bolt, H. Feshbach, and A. M. Clogston. "Perturbation of Sound Waves in Irregular Rooms." 65.

[67] H. Feshbach, "On the Perturbation of Boundary Conditions" *Physical Review,* vol. 65 (June 15, 1944): 308. Herman Feshbach and Cyril Harris, "The Effect of Non-Uniform Wall Distributions of Absorbing Material on the Acoustics of Rooms," *The Journal of the Acoustical Society of America.* vol. 18 (2) (October, 1946): 472-488.

[68] Herman Feshbach, "Theory of the Hydrogen-Three Nucleus,"

relationship and shared lecture notes for the Methods of Theoretical Physics I and II courses that they alternated in teaching. In 1945, Feshbach took over Morse's courses on Vibration and Sound, Experimental Acoustics, and Architectural Acoustics and in 1947 Feshbach and Morse began collaborating on the creation of their renowned textbook *Methods of Theoretical Physics*.[69]

Feshbach's chiefly non-military work on acoustics during the war, however, was a reflection of his own commitment to promote the use of science for the improvement of mankind rather than the destruction thereof. Because of the nature of his research, many of the mathematical calculations and results in his papers could be applied to military purposes. J.P. Kinzer and I.G. Wilson, for example, cited some of Feshbach's results and applied them to radar military technologies in their 1947 paper titled "Some Results on Cylindrical Cavity Resonators."[70] Although Feshbach could not control who cited his work and for what purposes, he keenly noted that he was trying to solve every-day, non-military problems. In his 1946 paper, Feshbach indicated that "a great many physical problems of interests have not been treated theoretically"[71]. This was the beginning of Feshbach's fight to promote and protect theoretical physics—a fight that would extend to the late 1980s.

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[69] H. Feshbach and A. M. Clogston. "Perturbation of Boundary Conditions." *Physical Review.* vol. 59, (January 15, 1941): 189-194. R. H. Bolt, H. Feshbach, and A. M. Clogston. "Perturbation of Sound Waves in Irregular Rooms," 65-73. Philip Morse and Herman Feshbach, *Methods of Theoretical Physics,* (Cambridge: Technology Press, 1953). Philip Morse, *In at the Beginnings: A Physicist's Life,* (Cambridge: The MIT Press, 1977): 221-223. *MIT Course Catalogue* (1945-46): 132

[70] J. P. Kinzer and I. G. Wilson, "Some Results on Cylindrical Cavity Resonators," *Bell System Technical Journal,* vol. 26, no. 3 (1947): 410-445.

[71] Feshbach, "On the Perturbation of Boundary Conditions," 307.

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Politics and Science

2.1 The Laboratory for Nuclear Science

The end of the war came along with a brief quieting of the military activities taking place across the MIT campus. Nevertheless, the impact of the war on Feshbach's environment was tangible. By the end of the war MIT had become the single-largest wartime research and development university contractor.[72] According to John Slater, Head of the Physics Department in 1946, "physics during the war achieved an importance which has probably never before been attained by any other science."[73]

Even though the war had increased the size of the Physics Department, it had also magnified some of the department's shortcomings. According to Slater, the department had placed too much emphasis on radar and electronics, causing stagnation in the area of nuclear physics. "The Institute, as the leading technical institution of the country and probably the world, should properly have a physics department unequaled anywhere," Slate proclaimed. For Slater, nuclear physics required the most attention because although "Professor Herman Feshbach has

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[72] Douglas, "MIT and War," Kindle location 1008.

[73] John Slater in *MIT President Report* (1946): 133; 137.

made significant contributions to nuclear theory… this program, extensive though it was, seemed far from large enough with the increased scale of importance of nuclear physics."[74]

By the academic year of 1946-47, Feshbach had published two papers on nuclear physics. The first paper, published in 1951, was titled "The Pair Production of Light Mesons by Electrons." This paper was the result of a collaboration with L. Tisza and it aimed to calculate the cross section for the pair-production of mesons from a source of electrons—Feshbach and Tisza calculated both the cross section for the case of scalar mesons and mesons with spin 1/2.[75] The second paper, co-authored with Robert Van de Graaff and W. Buechner, was published in 1945. In this paper, the authors presented the results of a scattering experiment using high-speed, high-intensity beams of electrons with the objective of gaining a deeper understanding of the forces between electrons and the nuclei at close distances.[76]

Yet, as Slater noted, these efforts were not at the level of the latest research in nuclear physics at the University of Chicago, Cornell University, and U.C. Berkeley. If MIT was to participate in top-notch nuclear research it needed both a nuclear physics laboratory and the appropriate funding, so that researchers like Feshbach (who was promoted to Assistant Professor in 1945) could delve into profound questions about the structure of the nuclei.[77] The Navy—looking for a way to break the Army's nuclear monopoly—became the Physics Department's best ally in this venture and offered to fund a new laboratory in nuclear science and engineering

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[74] John Slater in *MIT President Report* (1946): 133; 137.

[75] H. Feshbach and L. Tisza, "The Pair Production of Light Mesons by Electrons," *Physical Review* 68 (November 1945): 233.

[76] R. J. Van de Graaff, W. W. Buechner, and H. Feshbach, "Experiments on the Elastic Single Scattering of Electrons by Nuclei," *Physical Review* 69 (May 1946): 452-459.

[77] *MIT Course Catalogue* (1946-47): 18.

at MIT. Slater and the Dean of the School of Science, George Harrison, organized a Nuclear Committee in September 1945 to discuss the Navy's offer and the possibility of positioning MIT among the top-rank universities in nuclear research.[78]

The committee accepted the Navy's offer and instituted the Laboratory for Nuclear Science and Engineering (LNSE). Jerrold Zacharias, an MIT physics professor, was chosen as director of the laboratory, a position he held for ten years (1946-1956). Zacharias' first task was to recruit a group of prominent nuclear physicists to staff the LNSE. Among those recruited were theoretical nuclear physicist Victor Weisskopf and cosmic-ray specialist Bruno Rossi. The junior faculty members recruited included Bernard Feld, M. L. Sands, David Frisch, and Herman Feshbach, whom Slater had already identified as an up-and-coming figure in the field of nuclear physics.[79]

Although the idea of creating the LNSE came from the Physics Department, the laboratory was intended to be an interdepartmental effort. For this reason, a steering committee representing each of the departments—physics, chemistry, chemical engineering, electrical engineering, and metallurgy—became affiliated with the laboratory. The steering committee, headed by Zacharias, estimated an annual budget of $600,000 dollars ($7.7 million dollars in 2015), which would be provided by the Navy's Office of Research and Inventions.[80] Although Zacharias admitted that "collaboration with industry will be welcome, and sought," in the end, it was the military who provided most of the funding.[81]

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[78] Leslie, *Cold War and American Science,* 141.

[79] Leslie, *Cold War and American Science,* 142.

[80] Leslie, *Cold War and American Science,* 144.

[81] Jerrold Zacharias as quoted in Leslie, *Cold War and American Science,* 143.

In less than a year, the support from the Navy increased to $1.5 million dollars, which allowed the LNSE to increase its staff from 20 to 155 members, including 50 professors.[82] The Office of Naval Research's funds also allowed the laboratory to expand its facilities. In 1950, the department completed the construction of a 300-MeV accelerator that benefited experimentation in the area of high-energy physics. Later in 1962, a much bigger accelerator of 6-GeV was completed in collaboration with Harvard.[83]

In 1951, the LNSE realized that the research interests of scientists and engineers were increasingly divergent. As a consequence, the LNSE became the Laboratory for Nuclear Science (LNS) and the engineering component of the laboratory became part of the Chemical Engineering Department—by 1958, research on nuclear engineering had grown enough to have its own department.[84] The ties between the Nuclear Engineering Department and the LNS, however, remained close, and many professors affiliated with LNS collaborated with members of the Nuclear Engineering Department.[85]

The establishment of the LNS and the Navy's support provided Feshbach with the facilities and research funding he needed to shift focus from acoustics to nuclear physics. Although it is difficult to give an exact explanation for why Feshbach decided to transition from acoustics to nuclear physics, it is possible to speculate why this shift took place. Feshbach had demonstrated great skill in general theoretical physics throughout his graduate work at MIT, so

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[82] Leslie, *Cold War and American Science*, 145.

[83] Leslie, *Cold War and American Science*, 146.

[84] *MIT Reports to the President* (1958): 18.

[85] Leslie, *Cold War and American Science*, 157.

the transition from one field to the other would have been reasonably straightforward.[86] Feshbach's graduate thesis was on nuclear physics and his continued interest on the field is evidenced by his two publications mentioned earlier.[87] Additionally, the number of unanswered questions in the growing field of nuclear physics might have sparked Feshbach's interest. The absence of Philip Morse throughout the second half of the 1940s might have played a role as well. Morse had encouraged and supported Feshbach's work in acoustics and his leave from MIT's Physics Department might have given Feshbach the freedom to explore other areas of physics.[88]

Whatever the motivations, in 1946 Feshbach became part of the LNS and began working on theoretical nuclear physics. One of his first publications in nuclear physics (as a member of the LNS) was "Thresholds for Creation of Particles," which appeared in *Physical Review's* letters to the editor. In this short publication Feshbach and L. I. Schiff showed the step-by-step calculation of the "smallest energy that a particle need have in order that a given combination of particles can be created in a collision" in a high energy particle accelerator.[89] As Slater had noted in the *MIT Reports to the President* in 1946, Feshbach's work on nuclear physics was starting to develop.

In 1949, Feshbach collaborated with William Rarita from Brooklyn College on another paper on "Tensor Forces and the Triton Binding Energy." Published in *Physical Review,* this

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[86] Morse, *On In The Beginnings,* 213-221.

[87] R. J. Van de Graaff, et. al., "Experiments on the Elastic Single Scattering of Electrons by Nuclei," 452-459. H. Feshbach and L. Tisza, "The Pair Production of Light Mesons by Electrons," 233.

[88] Morse, *On In The Beginnings,* 213-221.

[89] Feshbach, H., and L. I. Schiff. "Thresholds for Creation of Particles." *Physical Review* 72, (August 1947): 254

paper noted that the introduction of tensor forces in the calculations of the binding energy for hydrogen-3 led to a contradiction with experimental values. Feshbach and Rarita used variational methods using the Hylleraas expansion for the trial wavefunctions to demonstrate that the methods that had been successful in finding theoretical values for the binding energy of the two-body problem failed in the three-body case.[90]

Under the LNS auspices, Feshbach continued working on the binding energy of hydrogen-3 (H^3) and expanded his work to include calculations on helium-3 (He^3). Despite Feshbach's efforts, his theoretical predictions continued to be in disagreement with experimental results. In collaboration with Robert Pease, also working in the LNS, Feshbach managed to calculate "the effective triplet range and the percentage *D* state" of helium-3, but their predictions for the Coulomb energy were still off by twenty-five percent. Feshbach and Pease admitted, "our results have a certain irreducible inaccuracy arising from, first, the possible existence of three-body forces, and second, the inaccuracy of the potential in the high energy domain."[91]

After a couple of years struggling with discrepancies between theoretical calculations and experimental results, Feshbach re-formulated his convictions about the purpose of theoretical physics. In 1954, Feshbach published a twenty-page paper on the "Model for Nuclear Reactions with Neutrons," co-authored with C. E. Porter and Weisskopf. This paper had the optimistic goal of creating a simple model "for the description of the scattering and the compound nucleus formation" due to interactions between nuclear particles and complex nuclei. The authors noted

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[90] Feshbach, H., and W. Rarita. "Tensor Forces and the Triton Binding Energy." *Physical Review* 75, (May 1949): 1384-1388.

[91] Robert Pease and Herman Feshbach, "The Theory of Hydrogen Three," *Physical Review* 88, (November 15, 1952): 945-950.

that "the purpose of the proposed approach is to connect some characteristic salient features of the nuclear cross section with simple nuclear properties rather than to construct a theory which will produce the exact quantitative details of the observation." If the theoretical and experimental values "do not agree too well but show a qualitative similarity," then Feshbach, Porter, and Weisskopf considered the model worthy of publication.[92]

The growth of the Laboratory for Nuclear Science was essential for Feshbach's research goals. His connection to the LNS allowed him to collaborate with experimental nuclear physicists at Brookhaven National Laboratory (BNL), Los Alamos, and Rice Institute. Moreover, membership in the LNS allowed Feshbach to benefit from generous government funding from the U.S. Office of Naval Research (ONR) and the Atomic Energy Commission (AEC) during the 1950s and 1960s.[93]

Many of Feshbach's contemporaries also benefited from the support of government agencies such as the ONR or the AEC. Government agencies were particularly interested in supporting research and education in physics because, as Henry DeWolf Smith from the AEC explained, "scientific manpower" was a "major war asset" that needed to be "stockpiled" and "rationed."[94] Although World War II had ended in 1945, the 1950s and 1960s were characterized by military confrontations in Korea and Vietnam and by the Cold War conflict between the United States and the Soviet Union. These events prolonged and endorsed the military language used to justify the driven, exponential growth of American physics.[95]

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[92] H. Feshbach, et. al., "Model for Nuclear Reactions with Neutrons," 448-464.

[93] H. Feshbach, et. al., "Model for Nuclear Reactions with Neutrons," 448.

[94] Henry DeWolf as quoted in Kaiser, "The Standing Army of Big Science," 3.

[95] Kaiser, "The Standing Army of Big Science," 3-38.

The Soviet advances in the Korean War, which had started in 1950, provoked a feeling of urgency and distress among government officials. As a consequence, analyst Nicholas DeWitt took on the task of comparing the scientific and technical manpower in the US and the Soviet Union. DeWitt published two reports: *Soviet Professional Manpower: Its Education, Training, and Supply* in 1955 and *Education and Professional Employment in the USSR* in 1961. The reports indicated that during the first half of the 1950s, the Soviets had graduated nearly 95,000 students in engineering and applied science. The United States, on the other hand, had graduated only 57,000 students–40 percent less than the Soviet Union.[96]

DeWitt warned that the numbers on his report could not be blindly trusted because of the Soviets' tendency to manipulate data. Moreover, DeWitt noted that the major differences between the US and Soviet higher-education systems made a purely numerical comparison unreliable—comparing the US and Soviet education systems was like comparing oranges to apples! Despite DeWitt's warnings, newspaper articles and government officials proliferated his results as if they were hard facts. In November 1954, for example, Benjamin Fine reported in the *New York Times* that "Russia is overtaking U.S. in training of technicians" and that, therefore, "the free world is in danger of losing the important technological race for trained scientists, engineers, and technicians." The launch of Sputnik in 1957 further emphasized the need to increase the number of trained scientists and engineers in the US—Sputnik suggested to many commentators and policy makers that any distraction or evidence of weakness could mean the "collapse of democracy."[97]

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[96] Kaiser, "The Standing Army of Big Science," 33-37. David Kaiser, "The Physics of Spin: Sputnik Politics and American Physics in the 1950s," *Social Research* 73 (Winter 2006): 1225-1252

[97] Kaiser, "The Standing Army of Big Science," 37. Benjamin Fine, "Russia is Overtaking U.S. in Training of Technicians, *New York Times* (November 7, 1954): 1.

As a consequence of the Red Scare and the military discourse, the demand for physicists in the United States increased by eighty percent between 1950 and 1960. By 1958 undergraduate enrollment in MIT's Physics Department had almost doubled since the end of World War II and graduate enrollment had increased from 180 to 210. George Harrison, Dean of the School of Science, noted that despite the pressure from the manpower race, the Institute had tried to limit growth by "assigning quotas from graduate enrollments." But even with limiting quotas, national statistics indicated that between 1948 and 1958, more Ph.D.'s in physics came from MIT than from any other single physics department in the United States—MIT graduated thirty to forty Ph.D.s a year, twice as many as Harvard, and as many as Berkeley and UCLA combined.[98]

Feshbach played a major role in the education of MIT's physics graduate students. Between 1950 and 1965 Feshbach taught multiple graduate courses, including Theory of Nuclear Structure, Advanced Quantum Mechanics, Relativistic Quantum Mechanics I and II, and Methods of Theoretical Physics I and II—the only year in which he did not teach courses was in 1955, when he took a sabbatical. Perhaps more importantly, in 1953 Feshbach and Morse published their two-volume textbook *Methods of Theoretical Physics*, on which they had been working since 1947. This textbook became the bible for the increasing number of US graduate students in the 1950s and 1960s.[99]

Philip Morse described *Methods of Theoretical Physics* as a treatise "about field theory—how to decide and solve the equations for the various acoustic, gravitational, thermal, or quantum fields." Echoing Feshbach's comments about the usefulness of theoretical physics to

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[98] George Harrison in *MIT Report to the President* (1958):151. *MIT Report to the President* (1962): 241. Leslie, *Cold War and American Science,* 134.

[99] *MIT Course Catalogue* (1950-1965). Morse and Feshbach, *Methods of Theoretical Physics*. Robert Jaffe, in conversation with the author, April 16, 2015.

solve every-day problems (such as architectural acoustics), the textbook was intended to provide a theoretical framework that could be applied to a wide variety of problems in different areas of physics.[100] Using differential equations, perturbative and variational methods, and delightful translations from one coordinate system to another, Feshbach and Morse produced a textbook that showed that the techniques behind theoretical physics "are essentially the same, whether the field under study corresponds to a neutral meson, a radar signal, a sound wave, or a cloud diffusing neutrons."[101]

Feshbach also made significant contributions to the field of nuclear physics as a whole. In 1958, he published the first paper of his trilogy on the "Unified Theory of Nuclear Reactions," which expounded the concepts and theoretical calculations behind nuclear resonance and what is now known as *Feshbach resonance.* The trilogy—funded by the LNS, the ONR, the AEC, and the Air Force Office of Scientific Research—had a holistic goal. Feshbach remarked that

> Since all the phenomena characterized by these concepts—compound nucleus, statistical hypothesis, optical model, and direct and surface interaction—are general properties of the many body system it should be possible to develop a theory of nuclear reactions from which each of these phenomena can be abstracted in a natural and straightforward fashion.[102]

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[100] Morse, *In at the Beginnings,* 271.

[101] Interestingly, *Methods of Theoretical Physics* was also known because "several figures in this work, which have to do with three dimensions, are drawn for stereoscopic viewing. They may be viewed by any of the usual stereoscopic viewers or, without any paraphernalia, by relaxing one's eye-focusing muscles and allowing one eye to look at one drawing, the other at the other." Recalling the "3-D illustrations that pepper the book," Frank Wilczek wrote that "long before the best-selling *Magic Eye* series, Morse and Feshbach invited you to relax, cross your eyes, and see strange shimmering stereoscopic objects leap off the page. The equipotentials in oblate spheroidal coordinates came to life. Really." Morse and Feshbach, *Methods of Theoretical Physics,* vii. Frank Wilczek, "Resonating with Feshbach," *MIT Physics Annual* (2006): 33.

[102] Herman Feshbach, "Unified Theory of Nuclear Reactions," *Annals of Physics* 5 (1958): 357.

Feshbach tackled this unification problem by deriving what he called a "generalized optical potential." Using this potential, Feshbach was able to show that his theoretical predictions on nuclear resonance were consistent with Wigner-Peierls' theory of the compound nucleus and with the *statistical hypothesis,* which had been put forth by Hans Bethe in 1937 and further elaborated in conjunction with Ewing and Weisskopf in 1940.[103]

The term *Feshbach resonance* was not proposed by Feshbach himself; in fact, it became widely used among physicists after 1980. To explain his theoretical predictions, Feshbach often used terms such as narrow isolated resonance, single-particle resonance, and giant resonance to differentiate among the different forms of resonance that his unified approach dealt with. Using more recent language Frank Wilczek, explained that Feshbach resonances occur "when the total energy of the objects [read particles] is close to the energy of the resonances." Usually, when this happens the total scattering cross section of the particles becomes very large. According to Wilczek, Feshbach showed that "if you could trade kinetic energy with excitation energy (e.g. internal vibrations)" then the motion of the particles would be minimized, leaving them bound together.[104]

The importance of the trilogy on the "Unified Theory of Nuclear Reactions" is undeniable. Part I of Feshbach's Unified Theory of Nuclear Reactions has been cited over 1,970 times, part II over 2,200 times, and part III (a short appendix) about 141 times.[105] This remarkable number of citations qualifies Feshbach's trilogy as a "renown" publication. This

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[103] Herman Feshbach, "Unified Theory of Nuclear Reactions," *Annals of Physics* 5 (1958): 357-390.

[104] Frank Wilczek, "Resonating with Feshbach," *MIT Physics Annual* (2006): 32-35.

[105] The number of citations have been found using Web of Science's science citation index. The citation counts do not include citations by Feshbach himself.

recognition, only given to papers that have been cited 500 or more times, is the highest possible rank a publication can attain. As of today, less than 0.3 percent of the papers in the Inspire database maintained by the Stanford Linear Accelerator Laboratory are considered "renowned" papers![106] Aside from being cited an outstanding number of times, Feshbach's trilogy is of great importance because of its scientific legacy. The concepts behind Feshbach Resonance are a central tool for today's physicists interested in research on ultra-cold atoms and Bose-Einstein condensates.

2.2 The Center for Theoretical Physics

Throughout the early 1960s government funding continued to provide support for the LNS and other MIT laboratories. The Institute had been growing at a steady rate and everything seemed to indicate that MIT's expansion would not stagnate in the near future.[107] For that reason, in the second half of the 1960s, MIT began a institute-wide project of major space renovations and utility expansions. By the end of the academic year of 1967-68, six new buildings were completed and occupied, including one graduate and one undergraduate dormitory.[108] In 1967 alone, MIT spent over $2,100,000 dollars (the equivalent of $35,222,000 in 2015 dollars) in renovations, among which the two largest projects were the relocation of the metallurgy facilities

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[106] For the list of possible ranks see https://inspirehep.net/search?of=hcs&action_search=Search. For more on citation trends and patterns see Sidney Redner, "Citation statistics from 110 years of Physical Review," *Physics Today* 58 (2005): 49.

[107] David Kaiser, "Elephant on the Charles," in David Kaiser ed., *Becoming MIT: Moments of Decision* (Cambridge: MIT Press, 2010): Kindle location: 1098-1279.

[108] *MIT Report to the President* (1968): 15.

from the Sloan Metals Processing Laboratory to Buildings 4 and 7 and the creation of the Center for Theoretical Physics in the third and fourth floors of Building 6.[109]

Feshbach played a very important role in the renovations that pertained to the Physics Department. In fact, he headed the project for the establishment of MIT's Center for Theoretical Physics (CTP). Feshbach's objective was to create a space where theoretical physicists could have more privacy to work on their research and at the same time enjoy communal areas ideal for collaboration and scientific exchange. Throughout the first stage of the project Feshbach faced many difficulties, especially because of time pressures—the expectation was to begin work in the Summer of 1967 and have the CTP finished by the Fall of 1968.[110]

With the guidance of Victor Weisskopf, the contributions of the architect Harry Ellenzweig, and the consistent work of the contractor Hawkins and Company, Feshbach managed to start the project in June 1967 and have the third floor finished on October 2, 1967 and the fourth floor 23 days later.[111] Feshbach's participation on the creation of the CTP went beyond directing the construction project; when the CTP was inaugurated in March of 1968, Feshbach (who had been promoted to Professor of Physics in 1955) became its first Director. He remained in this position for six years, until 1973 when he became Head of the Physics Department.[112]

The inauguration of the CTP was not a small ceremony. MIT organized a three-day symposium starting Wednesday March 20, 1968, to commemorate the inauguration of both the

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[109] *MIT Report to the President* (1967): 640.

[110] Herman Feshbach to Robert Simha on January 16, 1968, *MIT Institute Archives,* AC205, Box36.

[111] Herman Feshbach to Jerome Wiesner on November 29, 1967, *MIT Institute Archives,* AC205, Box 6.

[112] Herman Feshbach Curriculum Vitae, n.d. *MIT Institute Archives,* MC484, Box 1.

Center for Theoretical Physics and the Center for Visual Studies. During the inauguration speech, Jerome Wiesner, the MIT Provost, communicated to his audience (which included the Nobel prize winners Julian S. Schwinger of Harvard University, Hans Bethe of Cornell University, and Tsung-Dae Lee of Columbia University) that the objective behind joining the inauguration of the CTP with that of the Center for Visual Studies was to "encourage a dialogue between scientists and artists, who have more in common than it is generally recognized."[113] Wiesner explained that

> The connection [between science and art] is particularly evident in theoretical physics, where imagination must often be applied to abstract ideas and where such concepts as that of symmetry are not without esthetic significance. On the other hand, artists more and more are employing modern technology to develop new kinds of art and are seeking to express in tangible form ideas of science. [114]

This connection was expounded in the sessions on "Art, Technology, and Form" and "Art and Science," held at Kresge Auditorium. In addition to these art-science discussions, three sessions were devoted to the latest research on astrophysics, particle physics, and nuclear physics. The first session was chaired by I. I. Rabi from Columbia University and the speakers were Schwinger and Edwin Salpeter, from Cornell University. The second session's speakers were Bethe and Lee, with Rudolph Peierls from Oxford University as chairman. And the third session was based on papers by Gerald Brown of Princeton and Murray Gell-Mann of California Institute of Technology and the chairman was Léon Van Hove of CERN. These instructive and

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[113] Jerome Wiesner as quoted in "Dedication Set for Special Centers," *The Tech,* March 19, 1968. *MIT Report to the President* (1968): 386.

[114] Office of Public Relations, March 19, 1968, *MIT Institute Archives,* AC205, Box 36.

animated talks were followed by visits to the new facilities which, according to the *MIT Report to the President,* received over four hundred visitors during the three-day symposium. [115]

Although much was said about the "aesthetics of symmetry" in the symposium, Feshbach's intent to incorporate an artistic component in the CTP became tangible during the tours of the new center. The visitors found much more than just offices; the walls of the center were covered with paintings and etchings from a wide variety of styles ranging from Romanesque to Surrealist. It became evident that Feshbach and his collaborators had put a great deal of effort in making the center not just a quiet working space, but a visually pleasant environment.[116]

Two months before the symposium, on January 16, 1968, Feshbach had written a letter to the planning office emphasizing the importance of starting the work on the interior design of the CTP. Rattled by the fast approaching deadline, Feshbach had voiced his distress:"I am still quite disturbed [by the] little progress with regard to the decorative elements ... I am beginning to feel a sense of urgency. It can't wait much longer."[117] In less than fifteen days, Feshbach had quotes from three art shops located in the Boston area. Most of the works where either surrealist, modern, or abstract expressionist paintings, probably indicating Feshbach's own artistic preference. He was, nevertheless, appreciative of other forms and styles of art. In the postscript of his subsequent letter to the Planning Office Feshbach wrote: "several of us, and most important Professor Weisskopf, would like some photographs of Romanesque sculpture. He

[115] Office of Public Relations, March 19, 1963, *MIT Institute Archives,* AC205, Box 36. For the total number of visitors see *MIT Report to the President* (1968): 386.

[116] Wayne Andersen to MIT Planning Office, "Theoretical Physics Center Project: Account of Art Works Purchased," on March 26, 1968, *MIT Institute Archives*, AC205, Box 36.

[117] Feshbach to Simha on January 16, 1968.

[Weisskopf] is particularly fond of the sculpture form the Cathedral at Autumn and has offered his own collection."[118]

In the end, $4,200 dollars (the equivalent of $29,000 in 2015 dollars) were spent in art works for the CTP. The pieces installed included an etching from Francisco José de Goya ("Disparate the Carnival"), an etching from Joan Miró ("Nous Avons," 1959), and a gouache from the American sculptor Alexander Calder, one of the leading artists of the twentieth century working on kinetic sculptures—and, of course, Weisskopf's photographs of Romanesque sculpture.[119] The inclusion of artwork in the walls of the center was more than mere decoration, it was statement about what some physicists believed to be the simplicity and beauty in science and about the importance of theoretical physicists, which was worthy of such an investment.

Another celebrated feature of the CTP was its architectural design. Seen as an innovative "experiment," the recasting of the main corridor arrangement provided "congenial dialogue spaces surrounded by clusters of offices."[120] The architect, Harry Ellenzweig, found that the usual MIT corridors with offices scattered on each side did not encourage collaboration among scientists and engineers. Therefore, he proposed a solution where the offices would be arranged in clusters around discussion areas with blackboards on which physicists could scribble their calculations on pion scattering or in quantum electrodynamics. Commenting on Ellenzweig's work, Feshbach asserted that "the solution to the problem of converting MIT corridors into a desirable living and working space can be considered a model worthy of emulation throughout

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[118] Herman Feshbach to Robert Simha on January 30, 1968, *MIT Institute Archives*, AC205, Box 36.

[119] Marietta Millet to Harry Portnoy, "Theoretical Physics Center Art Installation—account transfers," May 23, 1968, *MIT Institute Archives,* AC205, Box 36.

[120] *MIT Report to the President* (1968): 417; 730.

the Institute … the way in which the Center is separated yet not divorced from the rest of the Institute showed real skill and good taste."[121]

Equipped with what *The Tech*, MIT's weekly newspaper, recognized as the "two essentials for scientists in the field—blackboards and quiet," the CTP hosted forty physicists, including the head of the Physics Department, Victor Weisskopf.[122] Before the arrival of the CTP, these theoretical physicists had been scattered across 12 MIT buildings; therefore, moving from their previously separated headquarters to the more cohesive space in Building 6 increased and stimulated collaboration among them. When Victor Weisskopf described the CTP in the Reports of the President, he noted that the most important feature of the center was that it "crosses all experimental lines, and aids each of the research divisions."[123]

Until 1967, the physics department had been divided into three: the division of nuclear physics, the division of astrophysics and space physics, and the division of solid state and atomic physics. Each of these divisions had its own head and was attached to specific laboratories and inter-disciplinary centers. The division of nuclear physics was attached to the Laboratory of Nuclear Science and frequently collaborated with Harvard in the use of the Cambridge Electron Accelerator facility. The astrophysics and space physics devision worked closely with the Center for Space Research and the Research Laboratory of Electronics. And the solid state and atomic physics division supported the work done at the National Magnet Laboratory, the Center for Material Science and Engineering and the Research Laboratory of Electronics.[124] With the

[121] Herman Feshbach to Jerome Wiesner, *MIT Institute Archives,* AC205, Box 6.

[122] "Dedication Set for Special Centers," *The Tech,* March 19, 1968.

[123] Victor Weisskopf in *MIT Report to the President* (1968): 382.

[124] *MIT Report to the President* (1967): 380-382; *MIT Report to the President* (1968): 448.

institution of the CTP, however, Feshbach created a new layer of division in the Physics department.

In the "Inventory and Review of Total Departmental Needs" published in 1968, the summary of physics spaces had seven categories: administration, shops, teaching, astrophysics division, atomic & solid state division, nuclear division, and theoretical division. Theoretical physics was no longer part of the astrophysics, atomic & solid state, or nuclear divisions; it was a separate component that corresponded to roughly 10% of all the Physics Department's activities.[125]

This was precisely what Feshbach had wanted to achieve. Back in 1953, when he had co-authored *Methods of Theoretical Physics* with Philip Morse, Feshbach had pointed out that the techniques for any theoretical work in physics were for the most part universal, independent of the specific context or area in which they were applied.[126] Following this logic, there was no need for theorists to be tied to a specific laboratory or project; a space where physicists could develop a deeper understanding of the methods and techniques for theoretical work and then apply them to *any* area was preferable. In this sense, for Feshbach, the CTP was the ideal space for theoretical physics to flourish.

The aggregation of theoretical physicists in the CTP, however, came at an unexpected price. Theories can hardly be stabilized if there is not experimental evidence to back them up, yet the symbiotic relationship between theorists and experimentalists in each of the Physics Department's divisions was gradually broken by the creation of the CTP. Aron Bernstein, an MIT

[125] "Inventory and Review of Total Departmental Needs" (1968), *MIT Institute Archives,* MC205, Box 36.

[126] Morse and Feshbach, *Methods of Theoretical Physics,* vi-viii.

experimental physicist who witnessed the creation of the center, noted that although the CTP allowed for a new form of collaboration between the theoretical physicists across all three divisions, it also "created a gap between the theorists and the experimentalists"—this gap, at first unnoticeable, later became undeniable.[127]

Additionally, the CTP became the hub of an *elite* group of theoretical physicists who not only collaborated in research papers but later became actively involved in political discussions about regarding the "misuse of science."[128] The permanent members of the CTP included Victor Weisskopf, Francis E. Low, Francis Cecil Jones, James Young, Feliz Villar, Earle Lomon, Arthur Jerman, Carl Shakin, William Bassichis, Philip Morrison, Leo Sartori, Gabriel Veneziano, Sergio P. Fubini, Kerson Huang, Ira Gerstein, Vigdor Teplitz, and, obviously, the Director, Herman Feshbach, who was working on developing a method for calculating and predicting the low-lying states of nuclei.[129] The CTP also attracted many faculty members from other universities. Steven Weinberg—who at the time was working on his first textbook on general relativity—was Visiting Professor in 1968 and 1969 and Kurt Gottfried of Cornell University also participated as Visiting Professor in 1969.

With the introduction of the CTP the theoretical division's space increased by 78 percent and it was projected that between 1968 and 1973 the Center would see an increase of 35 percent on the number of faculty members and researchers.[130] This statistics are evidence of the initial

[127] Aron Bernstein (Professor of Physics, *Emeritus,* MIT Department of Physics), in discussion with the author, March 9, 2015.

[128] Hale Bradt, in discussion with the author, on April 14, 2015.

[129] *MIT Report to the President* (1968): 430. *MIT Report to the President* (1969): 410-412.

[130] "Inventory and Review of Total Departmental Needs" (1968), *MIT Institute Archives,* MC205, Box 36.

effectiveness of the CTP and the optimism that prevailed among the faculty members and the administration. The great enthusiasm around the creation of the CTP was a reflection of the Physics Department as a whole, which was expecting a major increase its scope and size. A report produced by Victor Weisskopf anticipated that by 1973 the department would have 41 more faculty members, 40 new instructors, 37 more post doctoral or research associates, 50 more technical assistants, and about 37 more teaching assistants. Moreover, it was expected that, in average, all the department's divisions would experience growth of over 38 percent. These statistics were used to support the construction of a new building for physics and the proposed expansion of the Center for Theoretical Physics.

2. 3 The Union of Concerned Scientists

The exponential growth in research funding, faculty members, and student enrollment was not unique to the Physics Department. MIT as a whole had experienced an expansion that had completely changed the nature of the Institute. The reshaping of MIT dated back to World War II, when President Compton had placed all of the Institute's resources to the service of the nation. This line of action turned MIT into the largest nonindustrial defense contractor in the United States. In fact, by the end of the war, MIT had 75 defense contracts worth $117 million dollars (nearly $1.5 billion dollars in 2015) while Caltech and Harvard had contracts for a total of $83 million dollars and $31 million dollars, respectively.[131]

The dramatic growth of the Institute preoccupied Warren K. Lewis, a member of the Chemical Engineering Department. Lewis recognized that MIT could "[n]ever again be the same

[131] Leslie, *Cold War and American Science,* 14.

sort of place it was before the war," and that, as a result, measures needed to be taken to prevent "overexpansion." MIT needed to stabilize both research projects and student enrollment, Lewis argued.[132] These problems were further discussed by Lewis and the other members of the MIT Committee on Educational Survey, which met for the first time in 1947. In its official report, the Committee gave a detailed account of the state of campus facilities (ranging from classroom spaces to student dormitories), community life, and the relation between the military and the university. The report also suggested different methods to ease MIT's transition to the postwar economy.[133]

The Committee had based its extensive study on a particular projection of what the future would look like. The postwar landscape turned out to be very different from what the Committee had envisioned, however. The Korean War broke out on June 25, 1950—only three years after the Committee's first meeting—signaling a return to a war-based economy. In fact, the United States' participation in the Korean War prompted dramatic changes within MIT; the Institute's budget increased by 65 percent in 1950 and an additional 31 percent in 1951.[134] Even after the end of the Korean War in 1953, MIT's growth trend was sustained by other noteworthy events such as the launch of Sputnik, the Cold War and the Vietnam War.[135]

A large percent of MIT's budget came from government agencies, which strengthened the ties between MIT and the military—as was the case with the LNS and the Office of Naval

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132 Warren K. Lewis as quoted in Kaiser, "Elephant on the Charles: Postwar Growing Pains," Kindle location: 1080-1091.

133 Kaiser, "Elephant on the Charles: Postwar Growing Pains," Kindle location: 1090.

134 Kaiser, "Elephant on the Charles: Postwar Growing Pains," Kindle location: 1105.

135 For a more detailed account of MIT's expansion between 1945 and 1970 see Kaiser, "Elephant on the Charles: Postwar Growing Pains."

Research. MIT became so intertwined with the government that in 1962, the director of the Oak Ridge National Laboratories, Alvin Weinberg, noted you could no longer "tell whether the Massachusetts Institute of Technology is a university with many government research institutions appended to it or a cluster of government research laboratories with a very good education attached to it." For Weinberg, MIT's transformation into a "center of Big Science," was not only admirable but needed to be emulated. He proposed "a gradual conversion of our big federal laboratories, wherever possible, into M.I.T-type institutions."[136]

Not everyone shared Weinberg's passion and optimism; many scientists had misgivings about the detrimental effects of the industrial-military-academic complex. In his memoirs, Philip Morse recalled that throughout the 1960s he had warned that "if the military controlled most of the funds, the directions of research would inevitably be bent away from peacetime goals."[137] Morse's fears where not unfounded. By 1969, MIT had nearly 100 laboratories, out of which the two largest were the Lincoln Laboratory and the Instrumentations Laboratory (I-Lab). These two laboratories, also known as the Special Laboratories, had a combined budget of $200,000 dollars (about $1,320,000 dollars in 2015)—most of which came from the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD).[138]

The research undertaken by these laboratories, as Morse noted, was strongly linked to their military sponsors. The I-Lab, for example, had been involved in military projects such as the inertial guidance system for the Atlas Intercontinental Ballistic Missile (AIBM), the

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[136] Alvin Weinberg in Dorothy Nelkin, *The University and Military Research: Moral Politics at MIT,* (Ithaca: Cornell University Press, 1972): 24.

[137] Morse, *In at the Beginnings,* 216.

[138] Nelkin, *The University and Military Research,* 18.

intermediate range ballistic missile called THOR, the reentry system for long-range ballistic missiles called SABRE, and the Multiple Independent Reentry Vehicle (MIRV). The nature of these projects was undeniably military. MIRV, for instance, could carry multiple warheads—capable of hitting multiple targets from a distance of 100 miles—and up to three individual hydrogen bombs. The destructive potential of projects such as MIRV made some scientists concerned about the potential dangers behind the "misuse of science."[139]

The fact that many of the Instrumentation Laboratory's projects were classified was also a matter of concern. In 1968, out of the 86 reports produced by the lab, 16 were classified. In fact, nearly 28 percent of the laboratory's work was restricted to those with security clearances. Aside from having exclusive security clearances, several faculty members became actively involved with government agencies. A clear example was Jack Ruina, an MIT Professor and vice president of the Special Laboratories, who acted as assistant director of Defense Research and Engineering and director of the Advanced Research Project Agency of the DOD.[140]

The close association between scientific research and the military reached well beyond the boundaries of the MIT Campus. Federal funding for scientific research and education in the United States increased form 50 million dollars in 1939 to nearly 15 billion dollars in 1970. But this dramatic increase in funding came accompanied by an almost contradictory decrease in scientists' stature. Historian Kelly Moore has documented how the influx of dollars and the strong connection with the military gave rise to concerns regarding scientists' reputations: "once

[139] Nelkin, *The University and Military Research,* 40-48.

[140] Nelkin, *The University and Military Research:* 21-22.

lauded for their contributions to national security, scientists were now under fire for helping to perpetuate warfare."[141]

The political influence of scientists began decreasing without warning during the late 1960s. A case in point was the debate on the production of Anti-Ballistic Missiles (ABMs), which were new military gadgets intended to destroy incoming Intercontinental Ballistic Missiles (IBMs). Strategically placed near populated cities in the United States, ABMs brought military technologies too close to American homes. Not only were ABMs conspicuously military, they were also considered technically unnecessary by scientists. Moreover, ABMs had an estimated cost of $5 billion dollars (about $33 billion dollars in 2015), which would take away from the funds that usually went to university research. Scientists' opinions, however, were largely ignored and Congress approved $1.2 billion for a scaled-down version of the ABM system.[142]

The era of free-flowing federal research dollars and scientists' influence on political affairs was waning. The breach between scientists' opinions and governmental decisions impacted scientists across all disciplines, but physicists, who not so long ago had played a major role in numerous advising panels in Washington, were among the most affected.[143] This did not have an immediate detrimental effect on Feshbach's career because he had focused mainly on his academic duties throughout the 1950s and 1960s. Nevertheless, he carefully followed the development of the thorny relationship between scientists and the government and in the late

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[141] Kelly Moore, *Disrupting Science,* (New Jersey: Princeton University Press, 2008), 1-4.

[142] Moore, *Disrupting Science,* 135.

[143] Moore, *Disrupting Science,*, 132.

1970s he took action and promoted a re-strengthening of this relationship through the creation of the Panel on Public Affairs (POPA).[144]

While faculty members fought to have their voices heard on issues regarding the ABM system, students at MIT faced the consequences of the Vietnam War on a personal level. In October of 1968, an AWOL soldier was housed in MIT's Student Center for several weeks. His presence had an extraordinary effect on the campus community. Recalling the events of October, Noam Chomsky wrote that "MIT had practically shut down... all the whole student body was over there [at the Student Center], thousands of people, twenty-four hours a day. There was an endless stream of everything from political seminars and meetings to rock music... It just turned the whole institute around."[145]

The soldier's presence on campus galvanized students and stimulated discussions on the effects of the Vietnam War. Among the most engaged students were MIT physics graduate student Ira Rubhenztein, the visiting Cornell graduate students Alan Chodos and Joel Feigenbaum, and Jonathan Kabat, a graduate student in the MIT Microbiology Department. With the guidance of Kurt Gottfried (who was Visiting Professor in the CTP), David Frish, and Bernard Feld, these students formed a group that called itself the Science Action Coordination Committee (SACC).[146]

In January of 1969, SACC drafted a letter to Lee A. DuBridge, President Nixon's science advisor, voicing their preoccupation with the unhealthy influence of the military on the Institute.

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[144] Herman Feshbach papers on POPA, *MIT Institute Archives,* MC484, Box 9, Folder: POPA.

[145] Noam Chomsky, "The Cold War and the University," in Noam Chomsky et al., *The Cold War and the University: Toward an Intellectual History of the Postwar Years* (New York: New York University Press, 1997): 180.

[146] Moore, *Disrupting Science*, 138.

They declared that the status of MIT as "a center for scholarly research and productive social criticism," was in jeopardy.[147] The only way to save the Institute was to develop closer ties not with the Department of Defense but with the Departments of Health, Education and Welfare, Housing, and Urban Development and Transportation. The letter was distributed and signed by 181 MIT faculty members and graduate students, including Feshbach. Echoing his longstanding interest in applying science to solve every-day problems, Feshbach endorsed SACC's claim that MIT had "neglected social and environmental problems" for too long. These problems, the letter emphasized, required "the fullest attention of our intellectual and economic capabilities."[148]

A few days later, SACC came up with another method of publicizing and exploring the the close relation between universities and the military: a one-day research stoppage. The students shared the idea with MIT professors and received moderate support. Forty-eight faculty members, including Feshbach, Kurt Gottfried, Philip Morse, Victor Weisskopf, Francis Low, Steven Weinberg, and Bruno Rossi—at least 37 percent of the faculty members working in the CTP—signed a document in which they asserted that

> through its actions in Vietnam our government has shaken our confidence in its ability to make wise and humane decisions... The response of the scientific community to these developments has been hopelessly fragmented... We feel that it is no longer possible to remain uninvolved. We therefore call on scientists and engineers at M.I.T., and throughout the country, to unite for concerted action and leadership.[149]

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[147] Letter to Lee A. DuBridge as quoted in Moore, *Disrupting Science*, 139.

[148] "M.I.T. Group Urges New Science Goals," *New York Times,* January 21, 1969, 94.

[149] Bryce Nelson, "Scientists Plan Research Strike at M.I.T on 4 March," *Science* 163 (1969): 373.

Feshbach and the other faculty members that signed the statement noted that the one-day stoppage was intended "to devise means for turning research applications away from the present overemphasis on military technology," "to convey to our students the hope that they will devote themselves to bringing the benefits of science and technology to mankind," and "to express our determined opposition to ill-advised and hazardous projects such as the ABM system, the enlargement of our nuclear arsenal, and the development of chemical and biological weapons."[150]

The nucleus of supporting faculty members had its president in the "Group Delta," which had been established in the beginning of 1968 by "antiwar faculty" who were concerned with "the atmosphere of frustration, confusion, and hostility pervading America." As the student movement gained momentum, "Group Delta" refashioned itself as the Union of Concerned Scientists (UCS), with Feshbach as one of the founding members. The UCS became officially instituted in December of 1968 and it rapidly expanded to include a total of 300 members in the Boston area, 100 of which were MIT affiliated.[151] Today the UCS has more than 94,000 members and it addresses problems related to climate change, nuclear power, nuclear terrorism, oil usage, and the promotion of "healthier food."[152]

In early 1969, SACC and the UCS presented the idea of the research stoppage to the MIT administration and invited other universities and research institutes to join their cause. The organized symposium accompanying the stoppage was comprised of a series of lectures in

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150 Nelson, "Scientists Plan Research Strike at M.I.T on 4 March," 373.

151 Nelkin, *The University and Military Research*, 57.

152 *UCS Annual Report* (2014): 2. http://www.ucsusa.org/about/funding.html#.VTgmhlz2niY, accessed April 22, 2015.

Kresge Auditorium scheduled to begin on March 3, 1969 and continue through March 4. During the symposium, Senator George McGovern spoke on reconverting the U.S. economy from defense to domestic production, Hans Bethe from Cornell spoke on the problems with ABM systems, Matthew Meselson, a biologist from Harvard, spoke on chemical and biological warfare, Noam Chomsky spoke on intellectual responsibility, and George Wald of Harvard closed his speech by saying that scientists' "business is with life, not death."[153] Other panels discussed the world food crisis, urban planning problems, and the need for finding jobs for up-and-coming scientists outside the defense industry.[154]

Opinions on the March 4th events were divided. Jerrold Zacharias of the Physics Department, along with a group of 17 faculty members, declared that the stoppage was "an act of protest with an implied prejudgement of the questions at issue."[155] To show their disapproval, they organized a work-in on March 4, during which they remained in the laboratories and worked extra hours.

The March 4th lectures raised many questions and concerns, some of which SACC members personally presented to MIT President Howard Johnson. One of the group's requests was a moratorium on the I-Lab's research. Pressed by the political turmoil, Johnson appointed a panel to review MIT's relationship to the Special Laboratories. The panel was to be chaired by Williams Pounds, Dean of the Sloan School of Management, and included twenty-two members (10 factually members, 4 students, 4 members of the special laboratories, and 2 members of the

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[153] George Wald, "A Generation in Search of a Future" edited by Elijah Wald, http://www.elijahwald.com/generation.html, last accessed April 22, 2015.

[154] Nelson, "Scientists Plan Research Strike at M.I.T on 4 March," 373.

[155] Jerrold Zacharias as quoted in "Science Stoppage Pushed at M.I.T," *New York Times,* February 23, 1969, 72.

MIT Corporation)—Weisskopf, Head of the Physics Department and Feshbach's life-long colleague and mentor, participated in the Pounds Panel.[156]

On May 32, 1969, the Pounds Panel presented its final report along with four main recommendations. First, the MIT laboratory needed to "energetically explore new projects to provide a more balanced research program." Second, the educational benefits of the special laboratories' presence had to be expanded. Third, "there should be intensive efforts to reduce classification and clearance barriers in the Special Laboratories." Finally, a standing committee on the Special laboratories needed to be created to supervise the projects that were to take place at MIT. [157]

Although the panel had brought to the table many of SACC's and the UCS's concerns, the activists involved in the panel were not afraid to express their discontent with the panel's conclusions. Chomsky, Kabat, Jerome Lerman, and George Katsiaficas believed that the vagueness of the recommendations belied the initial intention to convert the special laboratories.[158] Overall, the Pounds Panel demonstrated that MIT was at a crossroad. Pressure from student and faculty members seeking reform called for divestment and change in the military, industrial, scientific complex. On the other hand, pressure from researchers, government agencies, and industry insisted on a continuation of MIT's relation to the special laboratories.[159]

MIT faced multiple difficulties implementing the suggestions of the Pounds Panel—committees, meetings, and sets of guidelines were created to no avail. In the end, the

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[156] Nelkin, *The University and Military Research,* 67-68.

[157] Nelkin, *The University and Military Research,* 80.

[158] Nelkin, *The University and Military Research,* 81.

[159] Nelkin, *The University and Military Research,* 82-85.

Instrumentations Laboratory was divested, while MIT preserved its ties with the Lincoln Laboratory. Sociologist Dorothy Nelkin explains that this was not an easy decision for MIT since "institutions have particular constraints… MIT's decisions were justified in terms of *obligations* to employees, *commitments* to contractors, and the *right* of an institution to hurt the capability of a laboratory."[160]

The creation of the Union of Concerned Scientists and the March 4th symposium were crucial in promoting a re-thinking of MIT's role in society. Without doubt, 1969 was a year of great change in Feshbach's life. During this time Feshbach thought deeply about the role of science—and the nature of physics research—and decided it was time to publicize and promote his opinions. It was a turning point in Feshbach's career; not because he had never been concerned with the industry-military-academic complex, with the effects of wartime, or with the relevant influence of the scientific community on society, but because from this point on he actively tried to have a significant impact on the world around him.

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[160] Nelkin, *The University and Military Research,* 147.

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Building a Community of Scientists

3. 1 The Iranian Nuclear Program

Feshbach became Head of the Physics Department in 1973, a position which he held for ten years. As Head of Department, Feshbach sought to actively promote an international community of scientists at MIT. One opportunity came on July 19, 1974, when Feshbach received a letter from Gholam Hossein Kazemian, the Minister Counselor for Cultural Affairs in Iran. In this letter, Kazemian informed Feshbach of the Iranian Government's interest in "launching a rather extensive program in the field of Nuclear Science and Technology."[161]

The Iranian program was being organized by the Deputy Prime Minister and Head of the newly created Atomic Energy Organization of Iran (AEOI), Akbar Etemad. Etemad was recruiting Iranians qualified for work in the newly established Atomic Energy facilities in Iran. The problem, however, was that Iran had a shortage of such experts, so the government needed to find a way to train young scientists in the area of nuclear engineering. One way to do this, Kazemian explained to Feshbach, was to put promising young Iranians in "a solid Master's program in the field of Nuclear Engineering in American universities."[162]

There was no doubt that MIT would be the best place for this program—at least that is what Kazemian and Etemad believed."Naturally," Kazemian told Feshbach," knowing of the

[161] Gholam Kazemian to Herman Feshbach on July 19, 1974, *MIT Institute Archives,* MC484, Box 3.

[162] Gholam Kazemian to Herman Feshbach on July 19, 1974, *MIT Institute Archives,* MC484, Box 3.

high reputation of your department and your own contribution to the field of nuclear technology in this country, I am writing to ask you if your department is willing to provide such training for our candidates." To make the program seem even more appealing to MIT, Kazemian noted that the Iranian Government was willing to pay all the expenses of the Master's program.[163] Ten days later, Feshbach sent a positive response to Kazemian, indicating that the Physics Department would gladly support the program. Feshbach promised that he would write back in less than two weeks with the details of a program suitable for the Iranian students.[164]

Edward A. Mason, the Head of the Nuclear Engineering Department, had received a similar letter but Mason, unlike Feshbach, had his reservations about the program.[165] Mason's response acknowledged the Nuclear Engineering Department's interest in working with the Iranian Government. But it also included some points of contention that needed to be discussed before contemplating the feasibility of the program."It will be important for us to learn what long range interest Iran has concerning the specific education programs desired as well as to gain a better understanding as to the eventual development of nuclear power in Iran so that we could assist in planning a suitable program," Mason alerted.[166]

Although this request for additional information would indeed help MIT create a more suitable program, it also hinted at the increasing tension in the relations between the United States and Iran. The complex US-Iran relation dated back to the years after World War II. According to historian Christian Emery, every United States president since Truman had viewed

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163 Gholam Kazemian to Herman Feshbach on July 19, 1974, *MIT Institute Archives,* MC484, Box 3.

164 Herman Feshbach to Gholam Kazemian on July 29, 1974, *MIT Institute Archives,* MC484, Box 3.

165 Gholam Kazemian to Edward A. Mason on July 19, 1974 *MIT Institute Archives,* MC484, Box 3.

166 Edward A. Mason to Gholam Kazemian on July 30, 1974, *MIT Institute Archives,* mc484, Box 3.

the close ties with Iran as a strategic move to prevent the oil fields of the Persian Gulf from falling into Soviet hands.[167]

Even though the United States had sought a close relationship with Iran, political changes within Iran prevented the ties between the two countries to strengthen. In the early 1960s, the Shah of Iran instituted an ambitious project of land reform and modernization that he coined the "White Revolution." With this program, the Shah wanted to remove support from the elite and the clerics and give preference to the peasantry and the urban proletariat. The White Revolution's rhetoric was reminiscent of the Bolshevik Revolution in 1917, during which the Bolsheviks endlessly proclaimed their slogan of "Land, Bread, and Peace." The promise of land appealed to the peasantry, the promise of bread appealed to the urban proletariat, and the promise of peace appealed to the population at large—a clear reflection of the Shah's intentions in the 1960s.[168]

The White Revolution was a matter of concern for the United States government because of its resemblance to the first steps toward communism in Russia. This concern was further intensified during the Nixon administration when the Shah's accruing oil wealth gave him increasing spending power. The Shah's wealth and his oil allowed him to see the United States not as a source of economic aid but as a potential costumer. As a result, the Shah gradually started approaching the American government with a more independent tone. Moreover, he

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[167] Christian Emery, *US Foreign Policy and the Iranian Revolution: The Cold War Dynamics of Engagement and Strategic Alliance,* (New York: Palgrave Macmillan, 2013): 19.

[168] Christian Emery, *US Foreign Policy and the Iranian Revolution,* (New York: Palgrave Macmillan): 21-55. Michael Kort, *The Soviet Colossus: History and Aftermath,* (New York: Taylor & Francis Group, 2010, Kindle Edition), kindle location: 2132.

began contemplating Iran's potential to become a regionally preeminent and a military self-sufficient power. [169]

In 1972, the Shah made a move toward his national vision. Taking advantage of Nixon's foreign policy, the Shah quadrupled the price of oil with the objective of transforming Iran into a world power. As the price of oil skyrocketed, the Iranian economy ballooned. Between 1970 and 1974, Iran's oil revenues went from $1.1 billion to $17.4 billion—an overwhelming growth that allowed the Shah to spend more than $9 billion in sophisticated weaponry from the United States.[170] The "extensive program in the field of Nuclear Science and Technology" was part of the Shah's grand scheme and the money to fund the program probably came from oil revenues.[171] The most important question, however, was whether this program was intended to provide Iran with the manpower and knowledge necessary to develop nuclear weapons.

On August 6, 1974, Feshbach and Mason met with Kazemian in Washington to iron out the details of the program and attempt to address the question of nuclear weaponry.[172] During the meeting, Kazemian stated that the Iranian government was mainly interested in reactor technology. Moreover, Kazemian claimed that Iran was not interested in *developing* reactor technology; they just wanted people who could man and run the nuclear power industry. In the final report sent to the Dean of Engineering, Alfred Keil, Kent Hansen, the Acting Head of the Nuclear Engineering Department in 1975, noted that "it was Ed's [Edward Mason's] impression

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[169] Emery, *US Foreign Policy and the Iranian Revolution,* 21-22.

[170] Jalal, "An Uncertain Trajectory,"329-330. Christian Emery, *US Foreign Policy and the Iranian Revolution,* 23.

[171] Gholam Kazemian to Herman Feshbach on July 19, 1974, *MIT Institute Archives,* MC484, Box 3.

[172] Edward A. Mason to Gholam Kazemian on August 7, 1974, *MIT Institute Archives,* MC484, Box 3.

that they [the Iranians] were not interested in training for the design of reactors, but rather for the operation of reactors in their system."[173]

When writing to the Dean, Hansen was nonetheless cautious. He expressed his desire "to present several possible alternative actions with respect to the narrow issue of the applicants to the Nuclear Engineering Department, without addressing the global issue of relations to the Institute's relations to Iran or indeed to international education." Moreover, Hansen added that "the Nuclear Engineering Department has received requests from the Governments of Spain, Brazil, and the Republic of China regarding sending students here for special training. Any decision made with respect to the Iranian students will carry with it a precedent which may influence additional decisions."[174]

The rhetoric of caution and vigilance was evident in most of the discussions that pertained to the Iranian Master's program. Interestingly, it was not present in any of the letters that Feshbach wrote to the Provost, Jerome Wiesner; the Dean of the Sloan School of Management, William Pounds; the Chancellor, Paul Gray; or to the Dean of the Graduate School, Irwin Sizer. Feshbach was more concerned about other issues, such as the English requirements for foreign students or the most suitable type of program—Master's degree, Nuclear Engineer's degree or Doctorate's degree in Nuclear Engineering.[175]

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[173] Kent Hansen to Alfred Keil on January 23, 1975, *MIT Institute Archives,* MC484, Box 3. Kent Hansen had temporarily taken up Mason's position as Head of the Nuclear Engineering Department because Mason was summoned to work as full-time in the Nuclear Regulatory Commission (NRC), see "Biography of Edward Mason," accessed April 10, 2015, http://www.nrc.gov/about-nrc/organization/commission/former-commissioners/mason.html.

[174] Kent Hansen to Alfred Keil on January 23, 1975, *MIT Institute Archives,* MC484, Box 3.

[175] Feshbach's correspondence about the Iranian program can be found in the *MIT Institute Archives,* MC484, Box 3, Folder: Iran.

Feshbach was also troubled by the size of the program. Initially, the Iranian Government wanted to send 30 Iranian students per year for a two year Master's program, which meant that the Nuclear Engineering Department would be hosting 60 Iranian students at a steady-state for an indeterminate number of years. Feshbach adamantly advised to start with a smaller group of four to six students because it would allow them to "discover any difficulties which would arise because of educational and cultural differences." Indeed, for Feshbach "any other course of action would open up the possibilities of a major disaster."[176]

It could be argued that Feshbach's disregard for political discussions was due to a lack of awareness about the fraying relation between the United States and Iran. This, however, is highly unlikely given that Feshbach had been attentive of the Korean War, the Vietnam War, and the ABM debates, among others. Moreover, between 1976 and 1978, he acted as chairman of the Panel of Public Affairs of the American Physical Society and throughout the late 1970s and 1980s he was engaged with the Human Rights movement and the fight for Intellectual Freedom of Scientists in the Europe, Asia, and Latin America. All of which shows that he was well aware of the political, social, and humanitarian activities that surrounded him.[177]

Another possible explanation would be that because the Iranian students were supposed to be admitted to the Nuclear Engineering Department, not to the Physics Department, it was not Feshbach's duty to raise questions about politics and other international affairs. Nevertheless, the Nuclear Engineering Department was rather new—the graduate program had started in 1958—and many of the department's professors had been members of Laboratory for Nuclear Science

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[176] Herman Feshbach to Jerome Wiesner on December 7, 1974, *MIT Institue Archives,* MC484, Box 3.

[177] Herman Feshbach, "Physics and the APS in 1980," *Physics Today* (April, 1981):37-40.

and Engineering, so the connection between nuclear engineering and physics was rather strong.[178] It is much more likely that Feshbach did not raise these issues because he believed that scientific knowledge should be universal, not constrained by political or economic hostilities. Indeed, in a report of the Panel of Public Affairs (POPA), Feshbach affirmed that the "application of political or ideological criteria to the evaluation of scientific research, or as a condition for employment violates the integrity of the scientific process and impedes the progress of science."[179]

In the end, Feshbach, Mason, and Keil managed to present the program as a positive and beneficial opportunity for MIT. An initial group of 20 Iranian students would be admitted to MIT for a two-year Master's program in the Nuclear Engineering Department and depending on the success of the students, the Institute would decide whether another cohort of students was to be admitted. The Iranian students would have to submit their applications and satisfy the same requirements as any other student but they would have to pay higher tuition.[180]

In the Summer of 1976, the first group of 20 Iranians arrived at the MIT campus. The group arrived a few months before the start of the term so that they could get adjusted to the campus and the department. During this time they found themselves surrounded by 150 regular graduate students and later in the Fall of 1976, 20 undergraduate students joined the Nuclear

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[178] *MIT Report to the President* (1958): 17. *MIT Report to the President* (1951): 184.

[179] Herman Feshbach, "Scientific Freedom and the American Physical Society," circa 1976, *MIT Institute Archives,* MC484, Box 7.

[180] MIT Report to the President (1976): 208. Kent Hansen to Alfred Keil on January 23, 1975, *MIT Institute Archives,* MC484, Box 3.

Engineering Department. This meant that out of the 190 students in the department, at least 10% were Iranian.[181]

The fact that the group made up a sufficiently large percent of the student body in the department eased the students' transition. Nevertheless, soon after their arrival, the new United States president, Gerald Ford, secretly conspired to break the agreements of the Organization of Petroleum Exporting Countries (OPEC) to reduce the price of oil. Ford made a deal with the Saudis, in which the latter gave the United States cheap oil in exchange for the opportunity to buy advanced weaponry. The breaking of OPEC's preeminent position caused a dramatic collapse of the Iranian economy, which set the stage for the Iranian Revolution.[182]

A second group of only 15 Iranian students managed to enroll in the Master's program in 1977.[183] The crumbling of the Iranian economy—accompanied with the Revolution that took place between January 1978 and February 1979 and the fall of the Shah—left the program without financial support.[184] The Nuclear Engineering Department which had a budget of only $1.7 million, was not willing to use its resources to finance the studies of new groups of Iranian students; consequently, after the 1977-78 academic year the Iranian program was phased out.[185]

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[181] *MIT Report to the President* (1976): 207. The percent of Iranian students was definitely greater because some of the 150 regular graduate students, including Ali Akbar Salehi (the current Head of the Atomic Energy Organization of Iran), were Iranians who had enrolled at MIT before the beginning of the special program.

[182] Daniel Sargent, "The Cold War and the international political economy in the 1970s," *Cold War History* 13, no. 3 (August 2013): 400-405. Patrick Sharma, "The United States, the World Bank, and the Challenges of International Development in the 1970s," *Diplomatic History* 37, no. 3 (June 2013): 584-604.

[183] *MIT Report to the President* (1977): 221.

[184] Peter Carroll, *It Seems Like Nothing Happened,* (New Jersey: Rutgers University Press, 1982): 230-31. *MIT Report to the President* (1976): 207-209.

[185] *MIT Report to the President* (1977): 222.

3.2 The Panel on Public Affairs

Feshbach's involvement in the Master's program for Iranian student was part of a much larger scheme to promote an international community of scientists that would not differentiate between races, nationalities, or gender. The best way to have a national and international impact, Feshbach thought, was through active participation of the scientific community in government policies. This idea, shared by many of Feshbach's contemporaries, materialized on October 25, 1974, when the APS council met in New York to discuss the need to create a "standing committee to initiate and organize APS activities pertaining to physics-related public and government affairs." After the meeting the council announced that the APS would have a new branch: the Panel of Public Affairs (POPA).[186]

The first chairman of POPA was Philip Morse, Feshbach's longstanding colleague and friend. Feshbach succeeded Morse on August 31, 1976 and acted as POPA's chairman until January 1978. Even before becoming an official member of POPA in 1976, Feshbach was deeply involved with the panel. In the Summer of 1974, for example, Feshbach had approached his junior colleague Robert Jaffe to take a position in Washington and serve as POPA's representative in the government.[187]

[186] For Feshbach's role in promoting an international community of scientists see Herman Feshbach papers in the *MIT Institute Archives,* MC484, Box 7, Folder: Committee on International Freedom of Scientists; Box 9, Folders: Committee on Status of Women, Equal Rights Amendment and Testimony—Women in Science. "Council Establishes Panel on Public Affairs," *Physics Today* vol. 28 no. 1 (1975): 115

[187] "Morse Elected Chairman of Panel on Public Affairs," *Physics Today* vol. 28, no.3 (1975): 67. Robert Jaffe, in conversation with the author, April 16, 2015. Jaffe refused Feshbach's proposal, but he continued to be deeply interested with policy issues; Jaffe became chairman of POPA in 2014.

During his position as chairman, Feshbach appealed for a long-range science policy that would "avoid rapid and large changes in funding, adjusting not only the magnitude but also the rate of funding so that a good match between needs and manpower and facilities is achieved."[188] These were problems that Feshbach had experienced himself. The sudden expansion of physics that led to the manpower shortage in the 1940s and 1950s, the substantial influx of funding followed by an abrupt cut in financial aid for the LNS in the late 1960s and early 1970s (which also affected the Physics Department's plans for expansion), and the precipitous termination of the Master's program for Iranian students are only a few examples of the "upswings" and "downswings" that Feshbach wanted to prevent through the creation of a long-range science policy.

Feshbach argued that the only way to accomplish this goal was to promote a close connection between scientists and policymakers, a task he took upon himself not only during his time in POPA but throughout the rest of his career.[189] Twenty years after the institution of POPA, Feshbach proposed the creation of an international agency that would deal with policy issues across the globe. "We must join together—nuclear physicists from Asia, Europe, North and South America, and Australia. There is no time to retire to one's own little empire and pay attention only to parochial policy issues," Feshbach declared. Moreover, Feshbach emphasized that to preserve "the health and vitality of nuclear physics research,"

> There needs to be a dialogue between administrators and the scientists. The scientists should be able to inform (in a convincing fashion!) the policy makers of their problems, and the policy makers should be able to question the scientists

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188 Herman Feshbach, "For Science Policy—An Opportunity," *Physics Today,* vol. 30, no. 5 (1977): 128.

189 "Council Votes Feshbach New POPA Chairman," *Physics Today* vol. 29 no. 7 (1976): 59. Feshbach, "For Science Policy—An Opportunity," 128.

> regarding matters on which they feel they need advice before they can make policy decisions.[190]

Feshbach's time as chairman of POPA was also characterized by open discussions about international scientific freedom. "Regardless of the structure of repression," Feshbach commented, "the effect on science has been destructive. German science was almost completely destroyed by the Nazis... The Soviet experience with Lysenko is an example of another kind... Argentinian science is surely being destroyed and the great promise it once held will never be fulfilled as long as the suicidal policies of its government continue in their present course." For Feshbach, these phenomena of repression that seemed so pervasive through the second half of the twentieth century had to be stopped.[191]

Feshbach expounded that the "application of political or ideological criteria to the evaluation of scientific research, or as a condition for employment violates the integrity of the scientific process and impedes the progress of science." Therefore, if the APS wanted to promote science, it needed to take an international stance; the APS could and would not remain silent. There had been many international movements that had promoted laws to improve human rights and in particular the rights of scientists. In 1948, for example, the General Assembly of the United Nations had unanimously adopted the Universal Declaration of Human Rights. Later in 1953, the Council of Europe held the first European Convention on Human Rights. The Helsinki agreement had been put forward in 1975 and had been signed by 35 nations, while the United

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[190] Herman Feshbach, "Internationalizing Nuclear Physics," *Nuclear Physics News,* vol. 5, no. 2, (1995): 4.

[191] Feshbach, "Scientific Freedom and the American Physical Society."

Nations had sponsored the International Covenant on Civil and Political Rights.[192] But for Feshbach, neither of these international agreements "relied upon the good will of the governments involved and upon public opinion."[193]

Feshbach identified that this was where the APS could make a difference. The society could transmit scientific opinion to the public, to the government of the United States, and to the countries that violated the scientists' rights. POPA was already immersed in policy issues within the United States, so Feshbach promoted the establishment of a new organization: the Committee on International Freedom of Scientists (CIFS), which became instituted in 1979.[194]

Even though Feshbach stepped down from POPA in January 1978, he remained engaged with the intellectual freedom of scientists and human rights movements. In December of 1977, for example, Feshbach was invited by Laurie Wiseberg of the Department of Political Science at the University of Illinois, to join the "Human Rights Internet." The Internet was "an effort at triangulated communication between scholars, activists, and policy members in the human rights field."[195] With more than 400 members the Human Rights Internet published information on the activities of NGOs, changes on international legislation, the formation of new working groups that activists and scholars were invited to join, new job offers related to human rights movements, etc. In addition, the Human Rights Internet organized conferences in which papers from human activists around the globe were discussed.[196]

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[192] Feshbach, "Scientific Freedom and the American Physical Society."

[193] Feshbach, "Scientific Freedom and the American Physical Society."

[194] Edward Gerjuoy to Members of CIFS on October 30, 1979, *MIT Institute Archives,* MC484, Box 7. Minutes of CIFS meeting on April 12, 1980, *MIT Institute Archives,* MC484, Box 7.

[195] Laurie Wiseberg to Herman Feshbach on December 8, 1977, *MIT Institute Archives,* MC484, Box 7.

[196] "The Human Rights Internet Newsletter," April-May 1978, *MIT Institute Archives,* MC484, Box 7.

Although the Internet was intended, as the name suggests, to deal primarily with international issues, it also found itself addressing repression in United States. The Internet reported the case of Ilie Vrancuta, a physicist working on nuclear research and gamma-ray scanning theory in Chicago. He had been exiled from Romania with his wife in 1976, and had decided to migrate to the United State in search for better living conditions. When he arrived at the United States, Vrancuta devoted himself to physics research and to write about Communism and his experience in Romania. Vrancuta had been distributing copies of his recently finished book "The Reign of Terror," until he received a letter warning him to stop publicizing his recollections. On February 22, 1979, Vrancuta was found bleeding and unconscious in a Hospital bathroom. According to Vrancuta the perpetrator had been "a professional agent from the Communist system."[197]

Feshbach, who at the time was acting as Vice President of the American Physical Society, drafted a letter of support for Vrancuta, where he denounced the measures taken by the secret police of the Soviet Union. Vrancuta expressed his gratitude towards Feshbach and affirmed that for Soviet physicists it was "very difficult to survive without support and understanding, especially [because] we are hunted by the communists like wild animals."[198]

Feshbach continued voicing his opinions and concerns about the different forms of repression against scientists, especially when he became the President of APS in 1980. Feshbach's outspokenness was evidenced on May 12, 1980, when he broadcast a statement commemorating the 4th anniversary of the formation of the Moscow Helsinki Watch Committee.

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197 "Exile 'Stabbed' by Communist," *San Jose News,* February 23, 1979.

198 Ilie Vrancuta to Herman Feshbach on April 17, 1980, *MIT institute Archives,* MC484, Box 7.

In his speech, Feshbach affirmed APS's solidarity with the Moscow Helsinki Watch Committee and its founder Yuri Orlov, a physicist who was subjected to twelve years of labor camp and stripped from membership in the Armenian Academy of Sciences. Another important figure that Feshbach mentioned was Sergei Kovalev, a biophysicist who was arrested by the KGB in 1974 and Andrei Sakharov, a nuclear physicist whose work on human rights and whose opposition to the anti-ballistic missile program in the Soviet Union led to his internal exile in Gorky, in 1980.[199]

Aside from these already prominent scientists, Feshbach noted that many aspiring Soviet physicists also saw their dreams curtailed by Soviet oppression. These young physicists were denied access to scientific publications and could not publish their research in science journals. Feshbach, who was fully committed to helping them, often arranged clandestine rendezvous between American physicists (going to conferences in the Soviet Union) and Soviet physicists to exchange published papers and manuscripts. For Feshbach these measures were necessary, especially because he believed that "free and full discussion with peers are an essential part of the scientific method." Moreover, Feshbach exclaimed that "results which have not been published might just as well not have been obtained!"[200]

As President of APS, Feshbach was able to publicize human rights abuses and encouraged American physicist to actively voice their opinions against the KGB, whose actions "deprived the international scientific community of the significant contributions which the

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[199] Herman Feshbach, "Statement to BBC and Voice of America" on May 12, 1980, *MIT Institute Archives,* MC484, Box 7. Kurt Gottfried, "CIFS Human Rights Cases," (1980), *MIT Institute Archives,* MC484, Box 7, Folder: Committee on International Freedom of Scientists (CIFS).

[200] Interview with American physicist, April 2015. Feshbach, "Scientific Freedom and the American Physical Society."

excellent Soviet Physicists can make."[201] Feshbach was convinced that "only when scientific freedom prevails can a community of physicists possibly realize their potential and maximize their contributions to the advancement of physics."[202] After Feshbach stepped down from APS, he continued to contribute to the activities of the APS—POPA and CIFS, in particular. He often attended POPA meetings and whenever this was not possible he made a special request to keep all the minutes of the meetings. Whether he read all of the reports is unclear, but he certainly made comments and corresponded with the members of both POPA and CIFS, especially in cases that were related to Andrei Sakharov.

3.3 Andrei Sakharov's Case

Sakharov was Feshbach's contemporary, they were both physicists and they shared a strong interest in intellectual freedom. However, their lives were vastly different. Sakharov was born in the Soviet Union in May 21, 1921 and was a member of the *intelligentsia,* which allowed him to receive the education necessary to become a physicist. In the Summer of 1950, after earning his Doctor of Science degree from the University of Moscow, Sakharov was summoned by the Soviet government to work on thermonuclear weapons for the military.[203]

During the eighteen years he worked on nuclear weapons for the military, Sakharov realized the dangers of large-scale nuclear tests and the health problems occasioned by radioactivity. Sakharov tried voicing his concerns about nuclear tests to Nikita Khrushchev, but

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[201] Herman Feshbach, "Physics and the APS in 1980," *Physics Today* 34, no. 4 (April 1981): 38.

[202] Feshbach, "Physics and the APS in 1980," 38.

[203] Andrei Sakharov, *Memoirs,* Translated by Richard Laurie, (New York: Knopf, 1990): 26-42.

his words were not taken into consideration. Why, Sakharov asked, must a physicist remain silent about important problems such as the dangers of nuclear weapons or antiballistic missiles? Sakharov's deep preoccupation with these problems materialized in the public sphere with the publication of his *Reflections on Progress, Coexistence, and Intellectual Freedom*. This work was published in the *New York Times* on July 22, 1968, and in *Technology Review,* MIT's monthly publication, in June 1969.[204] The publication of Sakharov's *Reflections* was rather timely, just a few months after the March 4th events in Kresge Auditorium. The *Reflections* discussed the importance of focusing on problems of hunger, over population, nuclear weapons, anti-defense missile programs, and intellectual freedom, from the perspective of a Soviet scientist.[205]

Although Sakharov's *Reflections* were well received in American universities, the Soviet government was not so thrilled. Although, after the publication of the *Reflections,* Sakharov helped found the Human Rights Committee and received the Nobel Prize for Peace in 1975, the Soviet government did not allow him to leave the country to receive the Nobel Prize. Sakharov rapidly became a public figure in the human rights movement, but as his popularity grew so did the Soviet secret police's suspicions towards him. This was the beginning of a process of oppression, silencing, and isolation that affected Sakharov until the 1980s.[206]

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204 Andrei Sakharov, "Progress, Coexistence and Intellectual Freedom." *New York Times,* July 22, 1968. Andrei Sakharov, "Progress, Coexistence and Intellectual Freedom." MIT Technology Review. (June, 1969)

205 Dorothy Nelkin, *The University and Military Research: Moral Politics at MIT,* (Ithaca: Cornell University Press, 1972): 54-62.

206 Andrei Sakharov, "Acceptance Speech," (December 10, 1975) read by Elena Bonner Sakharova, http://www.nobelprize.org/nobel_prizes/peace/laureates/1975/sakharov-acceptance.html, last accessed April 21, 2015

In the early 1970s, Sakharov's step-daughter, Tatiana Yankelevish, was expelled from college and her husband was fired from his job. The KGB made sure that neither of them had access to education or a job because they saw them as leverage to silence Sakharov.[207] In 1973, Sakharov decided to contact Victor Weisskopf (whom he had met in a conference in Armenia in 1970) to ask if MIT could receive Tatiana and her husband as students or research assistants.[208] Like Weisskopf, Feshbach was interested in helping Sakharov's family, so he presented the case to the MIT president, Jerome Weisner, and together they extended a formal invitation. The U.S. State Department, however, failed at securing permission for Sakharov's family to leave the Soviet Union.[209]

In December 1977, the family decided that it was time to emigrate, with or without permission. Tatiana Yankelevish remembers the day she and her husband arrived at the United States. Feshbach was the first person to receive them and he showed them their new home in Boston (for which he had arranged); he also brought them their luggage which had been sent in advance to his house. Feshbach helped Tatiana's husband apply for a grant for a position as a technical assistant at MIT for two years, showing his sympathy for the family and his support for Sakharov's stand in issues of intellectual freedom and the repercussions of the arms race between the U.S. and the U.S.S.R.. Sakharov and his family were always grateful for Feshbach's friendship; his support not only with words but with actions was unusual.[210]

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[207] Tatiana Yankelevich, in discussion with the author, February 10, 2015.

[208] Sakharov, *Memoirs,* 313-314.

[209] Tatiana Yankelevich, in discussion with the author, February 10, 2015. Herman Feshbach was particularly interested in the Sakharov case, as evidence are the hundreds of newspaper articles, reports, and letters concerning Sakharov that he assembled; these can be found in Herman Feshbach papers, *MIT Institute Archives,* MC484, Box 9, Folder: Andrei Sakharov. Sakharov, *Memoirs,* 381.

[210] Tatiana Yankelevich, in discussion with the author, February 10, 2015.

In 1980 Sakharov was confined to internal exile in the city of Gorky, which was off-limits to foreigners. For almost a decade Sakharov had been prevented from leaving the Soviet Union, but in Gorky, he was even more isolated. He was still able to receive some scientific publications but only after an inspection by members of the KGB; consequently, not many papers reached Sakharov's hands. For all intents and purposes, Sakharov was a lonely scientist, not working with anyone, just thinking and reading.[211]

Writing in *Physics Today* and with Sakharov in mind, Herman Feshbach wrote that the Soviet Union had a harmful stance "on the freedom to publish in the scientific literature and have access thereto, on the freedom to attend scientific conferences, on the freedom to pursue their scientific interests and to communicate with other physicists via normal channels including international travel."[212]As president of the American Physics Society, Feshbach actively protested repressive actions to the political authorities in the USSR. He prompted physicists to make "strong statements on the lack of compliance of the Soviet government with the provisions of the Helsinki Final Act at the Hamburg meeting in 1979 and the Madrid meeting in 1980."

Feshbach was not alone in this endeavor. A group of physicists from Berkeley's Lawrence Laboratory, lead by Morris (Moishe) Pripstein, founded an organization named SOS to help dissident Soviet scientists. Initially SOS stood for Scientists for Orlov and Scharansky (a computer scientists who was also a member of the Moscow Helsinki Watch Group), but it was soon expanded to Scientists for Sakharov, Orlov, and Scharansky. One of the most successful,

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[211] Sakharov, *Memoirs,* 519-560.

[212] Feshbach, "Physics and the APS, 1980," = 40.

and controversial, actions of this group was the creation of a voluntary moratorium of scientific exchanges with the Soviet Union, in which 8,000 scientists from 44 countries participated.[213]

Feshbach was not personally involved in the moratorium. In fact, in a statement presented to the Committee on Foreign Relations of the United States Senate, Kurt Gottfried—endorsed by Feshbach—said that "our concern of the welfare of Sakharov, Orlov, and Shcharansky rests on the recognition that their heroic struggle is of universal significance. We would make a mockery of their sacrifices were we to shut our eyes to brutal repression."[214] It was not clear to Feshbach that "such extreme confrontational tactics will have the desired effect," since they were "taken as a last resort."[215] Nevertheless, Feshbach understood the reasons that motivated the SOS group. Feshbach emphasized, "we must continue to let our Soviet colleagues know, as well as the Soviet authorities, that [their] actions encourage the growth of the boycott movement and eventually may very well lead to the effective exclusion of official Soviet science from the international world of science."[216]

The political situation changed in the second half of the 1980s with the fall of Khrushchev. After several hunger strikes and six years of exile, on December 19, 1986, Sakharov was finally granted release from internal exile by Mikhail Gorbachev and once again allowed to interact with his colleagues. Several physicists and humanists around the world visited him and complimented his work both in physics and humanitarian causes—Feshbach himself traveled all

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[213] Herman Feshbach, "Let's not Boycott Soviet Physicists," *Physics Today*, editorial, (March 1980): 160.

[214] Kurt Gottfried, "Scientists for Sakharov, Orlov, and Shcharansky" on April 14, 1981, *MIT Institute Archives.* MC484, Box 7.

[215] Feshbach, "Scientific Freedom and the American Physical Society."

[216] Feshbach, "Physics and the APS in 1980," 39.

the way to Moscow in 1987 to meet with Sakharov. In the article "A Meeting with Sakharov," published in *Physics Today*, Feshbach admitted: "It was a very moving experience for me."[217] After long years of struggle, Sakharov was finally able to openly partake once again in the international community of physicists. In 1989 Sakharov came to the United States to see his daughter and visit MIT. "Of course," Sakharov's daughter remembers, "Herman was waiting for him in the airport."[218]

- Conclusion -

Feshbach's life was filled with actions towards the development of an international community of scientists, the rebalancing and reformulation of the relationship between physicists and the government, and the rethinking of scientists' role as members of society. Throughout most of his career, Feshbach was accompanied by Sylvia Harris, whom he had married in 1939. The couple had a daughter, Rachael, and two sons, Mark and David.[219] Feshbach died on December 22, 2000 of a heart failure at Youville Hospital in Cambridge, Massachusetts.[220] However, Feshbach's thoughts, ideas, and actions were immortalized through his contribution to the scientific community and to society.

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[217] Herman Feshbach, "A Meeting with Sakharov," *Physics Today* 40 (April 1987): 7.

[218] Tatiana Yankelevich, in discussion with the author, February 10, 2015.

[219] Ancestry.com. *United States Obituary Collection* [database on-line]. Provo, UT, USA: Ancestry.com Operations Inc, 2006.

[220] Ancestry.com. *U.S., Find A Grave Index, 1600s-Current* [database on-line]. Provo, UT, USA: Ancestry.com Operations, Inc., 2012.

His work as a founding member of the Union of Concerned Scientists (still in place today) and his support for the Science Action Coordination Committee prompted discussions about the pervasiveness of the government funding within MIT and other academic institutions. His active role in the creation of the Panel of Public Affairs and the Committee for the Freedom of International Scientists allowed Feshbach to have a stronger impact on political discourse during the 1970s and 1980s. Similarly, his desire to unify the basis of theoretical physics resulted in the publication of *Methods of Theoretical Physics,* a textbook that is considered a masterpiece in analysis of field theory through variational methods—not to mention the textbook's excellent examples on the transition between coordinate systems. His contributions to nuclear physics were praised by his contemporaries and remain incredibly relevant for research on condensed matter physics.

Aside from the snapshots to Feshbach's life included within this text it is important to note that Feshbach acted as Vice-President of the American Academy of Arts and Sciences (AAAS) between 1973 and 1976, and later as President between 1982 and 1985. He was a member of the National Academy of Sciences and a fellow of the American Association for the Advancement of Science since 1969. He was chairman of the Nuclear Science Advisory Committee of the National Science Foundation (NSF) between 1979 and 1982.[221] And he was highly involved with the inclusion of women in physics through the American Physical Society's Panel on Faculty Position for Women Physicists and the Committee on the Status of Women.[222]

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[221] Earle Lomon, "Herman Feshbach: 1917-2000," *National Academy of Sciences* (2010).

[222] Herman Feshbach papers, *MIT Institute Archives,* MC484, Box 7-9.

Feshbach's career is filled with instances that illustrate how science, in the second-half of the twentieth century, was a Gordian knot. Yet we can take this analysis a step further and wonder whether the problems that Feshbach grappled with in the last century are still relevant today. When confronted with questions related to the influence of the military on science research students and faculty at MIT will often offer a default response: military-based projects more often than not give birth to commercial spin-offs. It seems as if the military-industrial-academic complex that troubled scientists in the late 1960s and 1970s is a solved problem that no longer requires our attention, but have we truly addressed this problem? Without knowledge of the *actual* ratio of military vs. civilian applications of science, we are left in a blind alley, ignorant of the influence of war-related projects on academic institutions.

Feshbach was also committed to promote an international community of scientists during the 1970s and 1980s. The political climate has significantly changed since then—the Soviet Union collapsed in 1991 and with it a re-shuffling of power dynamics around the globe took place. Even though the oppression and violation of human rights that troubled Feshbach has significantly decreased, more work remains to be done to create a free international community of scientists. Students from Russia who want to enroll in academic institutions for undergraduate or graduate work are given visas that last only six months, forcing them to return to Russia frequently (and request new visas from the US consulate) and preventing them from easily getting internships or training jobs during the summer.[223] Within MIT, the majority of international undergraduate students come from China, Canada, and countries in Europe. Very

223 This information is based on the author's informal discussions with several current MIT students who come from Russia, whom the author has met through her work as coordinator of MIT's International Orientation.

few students from countries such as Iran, Iraq, and Afghanistan enter the ranks of MIT students —not because they are intellectually incapable, but because of a lack of opportunities.[224]

If we truly want an international community of scientists that is working towards the improvement of humankind (in the sense discussed during the March 4th events) then we need to bring these issues back to the table for discussion. Just as *Feshbach resonance* is still widely used among physicists to explore the intricate nature of ultra-cold atoms, we need to start pondering over the moral and ethical implications of scientific practice—only then will we fully expound science's potential.

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[224] Based on data made available to the author as coordinator of MIT's International Orientation

- Appendix -

Throughout the twentieth and the beginning of the twenty-first century historians, philosophers, sociologists, anthropologists, and science and technology scholars have been puzzled by questions such as what qualifies as science, what are the implications of having a community of scientists, what is the difference between experience and experiment, what is a scientific fact, what is the relation between science and society, and how do humans and non-humans interact within the context of knowledge production.

Although some of the aforementioned scholars have been trained as scientists, many of them have chosen to distance themselves from scientists, viewing the latter only as subjects of study and not as productive and valuable thinkers. In this appendix, I will draw on the works of Robert Merton, David Bloor, and Bruno Latour. And I will connect their theories with specific moments of Herman Feshbach's life. Using Herman Feshbach's life as an example, my goal is to show that scientists are not oblivious to questions about the intricate, entangled, convoluted, and bewildering nature of scientific practice, which have thus far troubled historians, philosophers, sociologists, anthropologists, and science and technology scholars.

One of the cornerstones of Herman Feshbach's work was his belief in an idealized notion of how science should be and how the members of the scientific community should behave. In *On Social Structure and Science*, Robert Merton portrayed the scientific community as a group of exemplary individuals that shared values (or institutional imperatives) such as universalism, communism of intellectual property, disinterestedness, organized skepticism, and humility.[225] Merton's notion of universalism implied that "the acceptance or rejection of claims entering the list of science is not to depend on the personal or social attributes of their protagonists; their race, nationality, religion, class and personal qualities are as such irrelevant."[226]

Throughout his life, Feshbach viewed universalism as the ideal that the scientific community should aspire to. Feshbach took a major step towards the promotion of universalism at MIT in 1974, when he helped organize the Master's program for Iranian students in the Nuclear Engineering Department. The program was intended to bring students from Iran to MIT for a two-year program, in order to give them the necessary training to work on Iran's future nuclear reactor. The decision to implement the program was convoluted because of the increasing tension between the US and Iran. In his discussions with other members of the MIT community, Feshbach never mentioned the political tensions between the US and Iran (or the possibility that the Iranians were trying to build a nuclear weapon), suggesting that he desired to follow the universalism ideal where political problems and nationalities are divorced from science.[227]

Another example of Feshbach's commitment to the fostering of universalism was evident in his article "Physics and the APS in 1980," where he denounced the actions of the KGB because they "deprived the international scientific community of the significant contributions

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225 Robert Merton, *On Social Structure and Science,* (Chicago: University of Chicago Press, 1996), 268. Published in its current form in 1996, Robert Merton's *On Social Structure and Science* is a collection of essays published between the 1940s and 1970s.

226 Robert Merton, *On Social Structure and Science,* 269.

227 See chapter 3, section 1 "Iranian Nuclear Program," 58-65.

which the excellent Soviet Physicists can make."[228] In this article, Feshbach made similar statements about scientists in Argentina and Afghanistan—clarifying that for him the nationality or race of scientists did not increase or decrease the validity of their theories. In fact, Feshbach's contributions to the creation of the Committee on the International Freedom of Scientists (CIFS) was precisely an effort to analyze the cases of oppressed scientists throughout the world and vouch for their human rights and intellectual freedom in order to make science impermeable to political and ideological conflicts.[229]

In various instances, Feshbach noted that the "application of political or ideological criteria to the evaluation of scientific research, or as a condition for employment violates the integrity of the scientific process and impedes the progress of science."[230] He also asserted that "only when scientific freedom prevails can a community of physicists possibly realize their potential and maximize their contributions to the advancement of physics."[231] From these statements and Feshbach's particular interest in helping Andrei Sakharov (a Soviet physicist in internal exile) we can see that Feshbach envisioned an ideally, politically-isolated community of scientists.[232]

Feshbach differed from Merton in one important way: while Merton described the ethos of science as the real nature of scientific practice, Feshbach viewed these notions only as ideals. Feshbach was well aware that throughout the second-half of the twentieth century science had become entangled with politics. In *Knowledge and Social Imagery*, published in 1976, David

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[228] Herman Feshbach, "Physics and the APS in 1980," *Physics Today* 34, no. 4 (April 1981): 38.

[229] See chapter 3, section 2, "Panel on Public Affairs."

[230] Feshbach, "Scientific Freedom and the American Physical Society."

[231] Feshbach, "Physics and the APS in 1980," 38.

[232] See chapter 3, section 3, "Sakharov's Case."

Bloor was particularly interested in "how knowledge is transmitted, how stable is it, what processes go into its creation and maintenance, how is it organized and categorized into different disciples or spheres?" To tackle this questions Bloor proposed to analyze science not as a practice independent from social factors, but as the product of culture because "features of culture which usually count as non-scientific greatly influence both the creation and the evaluation of scientific theories and findings."[233]

The questions that Bloor asked in *Knowledge and Social Imagery* in 1976 and his emphasis on the importance of political forces and social tensions on the nature of science, are reminiscent of the issues discussed by scientists during the March 4th research-stoppage in 1969. The research stoppage, along with the foundation of the Union of Concerned Scientists, was the result of scientists' concern with the detrimental influence of government funding on the nature of scientific research. Philip Morse, one of Feshbach's mentors and colleagues, cleverly noted that "if the military controlled most of the funds, the directions of research would inevitably be bent away from peacetime goals."[234]

Further emphasizing the inevitable entanglement between science and what Bloor calls "culture," Feshbach noted that the state of affairs between the 1970s and 1990s required an active involvement of scientists in policymaking. A clear example of Feshbach's interest in improving the dialogue between scientists and policy makers was the creation American Physical Society's Panel on Public Affairs (POPA), which incentivized scientists to take a stance on public

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[233] David Bloor, *Knowledge and Social Imagery*, (Chicago: University of Chicago Press, 1976): 3-16.

[234] Morse, *In at the Beginnings,* 216. For more on the March 4th events and the UCS see chapter 2, section 3, "Union of Concerned Scientists," 46-67.

affairs.[235] This was particularly important for Feshbach because he believed that the "health and vitality of nuclear physics research" depended on a "dialogue between administrators and the scientists." Moreover, in 1995, he made the following international invitation: "we must join together—nuclear physicists from Asia, Europe, North and South America, and Australia. There is no time to retire to one's own little empire and pay attention only to parochial policy issues."[236]

Feshbach and his colleagues realized that science is contingent on the social factors and the context in which research takes place around the same time that Bloor put forward his *strong program* for the sociology of scientific knowledge. Even though Feshbach aspired to a Mertonian ideal and actively tried to pursue the development of a community of science that functioned under the *ethos of science,* he became increasingly aware of the inevitable interconnectedness of science, politics, economics, and ideologies. Feshbach's recognition of this mélange (which Bruno Latour would identify as the reason why "we have never been modern") illustrates scientists' capability to reflect on the nature of scientific practices.[237]

Let us now transition from the *ethos of science* and the *social construction of scientific knowledge* to a more tangible and material component of scientific practices: scientific papers and publications. In *Laboratory Life: The Construction of Scientific Facts,* published in 1979, Bruno Latour explored how scientific facts are cemented through the process of writing and publishing scientific work. Through ethnographic methods Latour found that "the whole series of

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[235] See chapter 3, section 2, "Panel on Public Affairs," 65-72.

[236] Herman Feshbach, "Internationalizing Nuclear Physics," *Nuclear Physics News,* vol. 5, no. 2, (1995): 4.

[237] Bruno Latour, *We Have Never Been Modern,* (Cambridge: Harvard University Press, 1993).

transformations, between the rats from which samples are initially extracted and the curve which finally appears in publication, involves an enormous quantity of sophisticated apparatus."[238] The apparatus, which Latour calls "inscription devices," transforms pieces of matter into written documents. By the addition or deletion of certain words (or modalities) these written documents become black-boxed and accepted as "objective facts of nature."[239]

Unlike Latour, Feshbach did believe that scientific practice was about uncovering truths of nature. Nevertheless, Feshbach was in line with Latour when he identified the intricate connection between the publication of papers and the acceptance of statements as true facts. In "Scientific Freedom and the American Physical Society," Feshbach exclaimed that "results which have not been published might just as well not have been obtained!"[240] In fact, Feshbach adhered so much value to the role of scientific publications in strengthening scientific facts that during the 1970s and 1980s he took risks to ensure that manuscripts from Soviet physicists reached the United States and were subsequently published in American journals.[241]

Contrasting Feshbach's writings and actions with the works of Robert Merton, David Bloor, and Bruno Latour, demonstrates that scientists are more perceptive than historians, philosophers, sociologists, anthropologist, and STS scholars have sometimes made them to be. A possible reason why scientists have been marginalized as solely subjects of study is because science scholars have focused mainly in their work within the laboratory. If we expand our

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[238] Bruno Latour and Steve Woolgar, *Laboratory life: The construction of scientific facts*. Princeton University Press, 2013, 50.

[239] Latour, *Laboratory Life,* 80.

[240] Interview with American physicist, April 2015. Feshbach, "Scientific Freedom and the American Physical Society."

[241] See chapter 3, section 2, "Panel on Public Affairs," 65-72.

analysis of scientists's activities and allow ourselves to migrate and transition to all the components of scientists' lives, we can begin to understand how scientists grapple with questions about the nature of science and what it means to be a scientist. Of course, as Donna Haraway suggests, we must situate knowledge and remember that we are analyzing scientists' thoughts about their own scientific practices.[242] But once we have equipped ourselves with Haraway's forewarning, we can give scientists their voices back and make use of scientists' own insights about what qualifies as science, what are the implications of having a community of scientists, and what is the relation between science and society.

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[242] Donna Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective," in Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature, (*New York: Routledge, 1991).

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